

UNITED NATIONS DEVELOPMENT PROGRAMME



Tender And Contract

Documents

GENERAL SPECIFICATIONS – CIVIL WORKS

VOL 3 OF 4



General Specifications Section A Civil Works –Nablus Court

TENDER NO.

DATE: **June / 2021**

CONSULTANT: **SAFFARINI & ASSOCIATES**

CONTRACTOR: _____

Vol III
SPECIFICATIONS

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SECTION-B: GENERAL

B1 **SCOPE OF WORK**

These Specifications cover the construction, renovation, completion, and maintenance of Nablus Court Project, together with all external works and services and any other works as directed by the Engineer.

B2 **DRAWINGS**

A list of Contract Drawings (for tendering) available at the date of tender is included on the front page of the Drawing Books and at the end of these Specifications.

B3 **CONTRACTORS PRICE**

The Contractor's price shall include for all material delivered to the site, labour and plant requirements necessary for the completion of the Contract in accordance with the Contract Drawings and Specifications and B.O.Q.

B4 **USE AND PROTECTION OF SITE**

The Contractor shall take such measures and exercise such care 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 building and work areas such as Site Offices, Workshops, Store Building 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 areas of all rubbish and debris to the satisfaction of the Engineer.

Upon completion of the Contract, the Site and any adjacent areas affected by the building operations 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.

B5 **MATERIALS FOUND ON SITE**

Any sand, gravel or other building materials 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.

B6 **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 excavations and make good all works disturbed.

B7 **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 a specific part of the works, shop drawings are necessary, these drawings shall be prepared by the Contractor and submitted to the Engineer for approval at no additional cost to the client. 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 the Engineer approves these shop drawings.

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 two (2) 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.

B8 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 dully 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.

B9 SCAFFOLDING

The Contractor shall provide, erect, maintain, dismantle and clear away at completion proper and adequate scaffolding including that required for Sub-Contractors and Specialists. Put 10gm 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.

B10 PROTECTION

In 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 from the weather and from damage by his own or other workmen performing subsequent operations. He shall provide all necessary dust sheets, 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 that 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.

B11 SEPARATE CONTRACTS

The Employer reserves the right to let other separate contracts in connection with this 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 any defects if 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.

B12 **DEFINITIONS**

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

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

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

"Or approved equal" means that materials of different manufacturers may be substituted if prior 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.

B 13 **STANDARDS**

In this 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 Standards and Codes.
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 Normenusschuss
NEMA	Means the National Electrical Manufacturers Association
NEPA	Means the National Fire Protection Association
VDE	Means the Verband 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.



B 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 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, to ensure that he is carrying out the works in accordance with their recommendations.

B 15 MATERIALS TO BE IMPORTED

The Contractor is required to take the necessary measures to obtain materials or items which are not obtainable on the local market and which have to be ordered from abroad.

No claim will be considered for extension of the Contract Period due to non-availability of materials.

B 16 CONTRACTOR TO VERIFY SITE MEASUREMENTS

The Contractor shall check and verify all site measurements to enable him to prepare shop drawings, and wherever requested by other specialist contractors or by nominated or other sub-contractors to enable them 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 on shall be given to the Engineer.

B 17 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 therewith paid by the Contractor.
- b) Duplicate final approved samples, in addition to any required for the Contractor's use, shall be



- furnished to the Engineer.
- c) Samples shall be furnished so as not to delay fabrication allowing the Engineer reasonable time for consideration of the sample submitted.
 - d) Each sample shall be properly labeled 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.

B 18 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.

B 19 SITE OFFICES, LATRINES, ETC.

The Contractor shall provide and maintain on the Site for the duration of the Contract the following Consultant office and is to submit layout to consultant for approval:

- a) A temporary office of 70m2 area for the accommodation of 6-7 members of the Consultants Supervision Team. The office shall include AC system hot and cold, lighting fixtures and installations, toilet, kitchenette with tea boy, telephone –2lines. Also included are the following office equipment: Copier, 4 Pcs, fax with line. Such office shall be open at all reasonable hours to relieve instructions, notices or other communications.
- b) Adequate fire fighting equipment to the approval of the Local Fire Authority and the Engineer.
- c) An approved sign board, written in Arabic and English. The size of the Sign Board and lettering including the wordings shall be as directed by the Engineer.

All offices, latrines, Sign-Boards and other temporary works shall be dismantled and removed from the site on completion of the whole Contract and the Site shall be made good and left clean and tidy to the satisfaction of Engineer.

B 20 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, telephone charges and the remuneration of the tea boy and 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 watchmen for these purposes.

B 21 TESTING

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

B 22 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 that 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.

B 23 TEMPORARY WORKS AND REINSTATEMENT

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 require 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 own cost 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, facsimile and electric cables or wires, sewers, water, or other pipes, except where the Public Authority or Private Party owning 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 on demand.

All injury to the surface of the land, to the beds of watercourses, projecting banks, etc., where disturbed by the works (other than where specifically ordered by the Engineer) shall be repaired by the Contractor of 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.

B 24 WATER FOR THE 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 later adapt and maintain temporary work as necessary remove and make good at completion.

B 25 ELECTRICITY FOR THE WORKS

The Contractor shall make all necessary arrangements and provide all artificial lighting and power for the proper execution and security of 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.

B 26 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 other wise) and allow for altering, adapting and maintaining them in good condition as necessary and eventually removing from site and making good.



B 27 TEMPORARY BARRIERS, FENCING ETC...

The contractor is to provide all temporary barriers, fencing, hoardings, 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.

B 28 NAME BOARD

If instructed by the Engineer, the Contractor shall provide, erect and maintain a name board at the entrance of the Site bearing the Employer's and Consultant's name, the name of the Project and his name, his Sub-Contractor's names and such other names and information as the Engineer may direct to be inserted upon it. The name board shall be not less than 3000 x 2000mm lettered in Arabic and English and in an approved form. The Contractor shall remove such name board from the Site on completion of the Works.

B 29 PROTECTIVE CLOTHING

The Contractor shall provide and maintain all necessary protective and safety clothing and equipment for the operatives and Site Staff.

B 30 INCONSISTENCY IN CONTRACT DOCUMENTS

The Contractor shall execute the Works according to 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. If the work is foreseen by an experienced Contractor, the Engineer shall 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.

B 31 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.



B 32 SITE MEETINGS

During the course of the work, Site progress meetings shall be held at regular intervals at least once every week 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 Client for costs incurred by him in changing the method of working or in the provision and use of other additional plant.

B 33 DAILY REPORTS

The Contractor shall deliver 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 delivered to the Site during the day.

B 34 PHOTOGRAPHS AND ADVERTISING

The Contractor shall supply once a week as directed by the Engineer unmounted three copies of an average of 20 photographs of a size not less than 250 x 200mm of such portions of the Works completed and in progress as may be directed by the Engineer. The negatives of the photographs shall be the property of the Engineer and no prints from these negatives may be supplied to any person unless under the authority of the Engineer.

The Contractor shall not display or permit advertisements to be displayed on the Site without consent of the Resident Engineer.

The Contractor shall treat all details related to the Contract as confidential. No photographs or other documents may be used for advertising or other purposes without the written authority of the Employer, which authority shall not be unreasonably withheld.

B 35 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.

B 36 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 Resident Engineer.

The Contractor shall set out and level the Works and obtain the approval of the Engineer's Representative before commencing construction.

B 37 PROGRAM TO BE FURNISHED

The Contractor shall prepare a program for the Works, including the work of sub-contractors and other work concurrent with the Contract, using the critical path network method (CPM).



The Contractor shall submit three (3) copies of program to the Engineer within seven (7) days of the date of the Engineer's Order to Commence the Works and shall keep one copy in the site office.

Submission of program will not relieve the Contractor of his obligations to apply in writing for instructions as required by the Conditions of Contract.

Receipt of programs 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 program once each month to take account of any circumstances that arise affecting the progress of the Works, and shall produce a revised program and submit copies to the Engineer.

B 38 OVERTIME

If the Contractor deems it necessary to execute work outside normal working hours in order to complete the Works by the agreed date, or for any other purpose, he shall obtain the consent of the Engineer before doing so. Such work shall be entirely at the expense of the contractor who shall comply in all respects with the requirements of any local labour code. The Contractor shall meet at his own expense all wages and expenses due to the Engineer or his supervisory staff as a result of working overtime.

B 39 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 workmen 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 due 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.

B 40 DELAYS

The Contractor will be deemed to have allowed for all delays 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.

B 41 NON-PRODUCTIVE TIME

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

B 42 SAFETY, HEALTH AND WELFARE

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

B 43 CONTRACTOR'S SITE REPRESENTATIVE

The Contractor's Site Representative in charge of the Works shall be a duly graduated Civil Engineer having at least twelve (12) years experience in the superintendence of similar works and shall be required to have a proper command of the Arabic and English Languages. Also a Civil Engineer of 5-7 years experience and site civil foreman with ten (10) years experience. Also, an electrical engineer of not less than 8 years experience. Also, a mechanical engineer of not less than 8 years experience.



B 44 ATTENDANCE

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

B 45 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 Government or any person authorized by the Government wishing to view or inspect any part of the works or the materials to be incorporated therein.

B 46 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, goods and plant (including those of 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 of such damage and loss.

B 47 WORK AT COMPLETION

The Contractor shall clean the Works thoroughly inside and out removing all splashes, deposits, rubbish and surplus materials.

The Contractor shall remove all temporary markings, coverings and protective wrappings unless otherwise instructed.

The Contractor shall touch up minor faults in painted surfaces carefully matching color 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 operation.

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 retaining duplicate schedule signed by the Employer as receipt.



SECTION-C: EXCAVATIONS AND EARTHWORKS

C 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.

C 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.

C 3 MATERIALS

C 3.01 BACKFILL AND FILL

All fill material should be as specified in section "B6".

C 3.02 Water

Water shall be clean potable water as specified under "Concrete Work"

C 3.03 Concrete

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

C 3.04 Hardcore

Hardcore under floor paving, etc... (where shown on the Drawings) shall consist of tough, sound and durable rubble stones (maximum 150mm), free from coatings, dries, seams or flows of any character. Fine aggregate for blinding the interstices of hardcore bed shall be as described in "Concrete Work".

C 3.05 Gravel and Sand Fill

Gravel fill shall consist of graded gravel 50mm. down to 20mm. and blinded with clean coarse sand.

C 4 SITE PREPARATION

C 4.01 Existing Utilities

The Contractor shall ascertain the whereabouts of all existing 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.

C 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 or surplus materials shall be disposed off the Site in a satisfactory manner at the Contractor's expense.



C 4.05 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 leveled to approved dumps as directed by the Engineer.

C 5 SETTING-OUT

The Contractor shall stake-out the work as shown on the Drawings and secure the Engineer's approval of his stake-out 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-out for further approval in accordance with the relevant Clause of the Conditions of Contract.

C 6 EXCAVATION

C 6.01 General

Excavate 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.

Completely remove all existing obstructions in the line of excavations such as walls, 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.

The Engineer's Representative shall approve bottoms of excavations 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.

C 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, slogging or barring or breaking up with power-operated hand 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 explosives in a place far from any person's reach.
3. Taking all necessary precautions in compliance with the regulations pertinent to the use of Explosives.
4. Any damage that may occur due to 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.

C 7 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 and workmanship will be considered in this respect.

In the event of any collapse occurring during 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.

C 8 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.

C 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 over-loading and prevent cave-ins or mixing with the concrete during the construction of foundations.

C 10 DISPOSAL OF UNSUITABLE 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.

C 11 EXCAVATION FOR FOUNDATIONS AND SUB-STRUCTURE

The levels to which the Contractor shall excavate are shown on the Drawings. Should it be found necessary to reach more suitable strata, the Contractor shall perform all additional excavations. The difference in approved quantities or excavations, concrete and reinforcement shall be adjusted and paid for at the Contract Unit Rate.

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, leveled and well cleaned before pouring any concrete.

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 nature of the foundation material.



C 12 EXCAVATION FOR TRENCHES

C 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.

C 12.02 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 bore-holes and for proper sealing of joints. Bell-holes and depressions for joints shall be dug after the trench bottom has been graded.

Care shall be taken not to excavate below the depths indicated. Where rock is encountered, the 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 backfilled with concrete class "B" as specified under "Concrete Work" and when in earth, shall be backfilled 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 backfilled 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 200mm 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.

Trenches 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 extent 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 and shoring timbers which may be used to protect the banks.

C 13 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 250mm thick and compacted with compaction equipment or mechanical tampers when not possible to use such compaction equipment, to the satisfaction of the Engineer. Moisture content shall be adjusted as directed by the Engineer and 95% of dry weight compaction accordance with standard Proctor Compaction Test ASTM 698 shall be achieved.

Materials to be used for filling behind basement walls, shall be:

- One- Soil or soil-rock mixture which is free from organic matter or other deleterious substances.
- Two- Shall not contain rock or lumps over 15cm in greater dimension, and not more than 15% larger than 7cm.

The Contractor shall obtain all required fill from approved sources 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 shall not 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 used, care must be taken to prevent direct contact with the pipe

C 14 **BED OF HARDCORE**

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



SECTION-D: CONCRETE WORK

D 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 program 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 24 hour advanced written notice of the intention to pour.

D 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 uninterrupted progress of concrete works according to the approved project schedule of works under the Contract, the samples shall be approved and sent to the laboratories for testing.

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. The Contractor shall, at his own expense, supply all test samples. Samples shall be obtained in accordance with the latest editions of the American Society for Testing and Materials (ASTM), American Concrete Institute (ACI) Code or any equally approved standard.

D 3 MATERIALS

D 3.01 Cement

(A) General

Cement shall be Portland Type, originating from approved manufacturers, obtained in sealed and labeled bags, each 50kgs. net 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 ASTM Designation: C 150 - 74 Type I - for use in general concrete construction.

(B) Storage of Cement

All cement shall be stored in suitable weatherproof and approved storage sheds that will protect the cement from dampness. These storage sheds shall be erected in locations approved by the Engineer. Provisions 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 the Engineer at the expense of the Contractor orders a retest.

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) Alkali Content

The total alkali content ($\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$) shall not be in excess of 0.60 percent by weight of cement when tested in accordance with "Standard Method for Chemical Analysis of Hydraulic Cement ASTM C 114-69".

(D) Expansion due to Sulfate Exposure

The expansion in fourteen (14) days shall be less than 0.045 percent when tested in accordance with "Standard Method of Test for Potential Expansion of Portland Cement Mortars exposed to Sulfate ASTM C452-68".

(E) Heat of Hydration

The heat of hydration shall not exceed 70 calories per gram and 80 calories per gram at seven (7) days and twenty-eight (28) days respectively when tested in accordance with "Standard Method of Test for Heat of Hydration of Portland Cement ASTM C186-68".

(I) Autoclave Expansion

The autoclave expansion shall not exceed 0.80 percent when tested in accordance with "Standard Method of Test of Autoclave Expansion of Portland Cement ASTM C151-68".

(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 retest of soundness at the time of delivery of the cement to the Site.

Packages 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. The Contractor shall remove such consignment 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 that for any reason has become partially set, or contains lump or caked cement, shall be rejected.

D 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.



D 3.03 Fine Aggregate

(A) General Requirements

All fine aggregate for concrete shall conform to Standard Specification for Concrete Aggregates of ASTM Designation: C -33 and also to the detailed requirements given in Table 300 A (appended herebelow). It shall not contain harmful materials such as iron pyrites, coal, mica, 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 purpose 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 300A

Grading Sieve:	Percent Passing
3/8	100
No. 4	95-100
8	80-100
16	50-85
30	25-60
50	10-30
100	2-10
200	0-3
Fineness modulus	2.5-2.15

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 indilute: 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 sulfur trioxide (SO₃).

Silt: Not more than 2 percent.

Mortar strength: Compression ratio not less than 95 percent.

Soundness: Weighted average loss when subjected to 5 cycles of the soundness test using Magnesium sulfate, not more than 10 percent.



D 3.04 Coarse Aggregates

(A) General Requirements

All coarse aggregate for concrete shall conform to Standard Specifications for Concrete Aggregates of ASTM Designation: C-33. Coarse aggregate shall consist of gravel, crushed 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 form 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:

Max. Permissible Limit Percent by Weight

- Soft fragments.....2.0
- Coal and lignite.....0.5
- Clay lumps.....1.0
- Materials passing the No. 200 sieve.....1.0
- Thin or elongated pieces (length greater than 5 times average thickness).....40
- Other local deleterious substances.....0
- Chlorides soluble in dilute Nitric acid when expressed as sodium Chloride (NaCl)..... 0.1
- Total acid soluble sulphates when expressed as sulfur trioxide (SO₃)..... 0.5

(C) Percentage of Wear

Coarse aggregate shall conform to the following requirements:

Percentage of wear, Los Angeles test, not more than 30

(D) Soundness

When the coarse aggregate is subjected to five alternations of the sodium sulfate soundness test, the weighed loss shall not exceed 10 (ten) percent. In the event of failing to obtain a satisfactory result it shall be subjected to an alternate freezing thawing test.

(E) 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 I

ASTM		PERCENTAGE BY WEIGHT PASSING		
	Grading (¾" to No. 4)	Grading (1" to No. 4)	Grading (2" to No. 4)	
2 ½ inch	-	-	100	
2 inch	-	-	95-100	
1 ½ inch	-	100	-	
1 inch	100	95-100	35-70	
¾ inch	90-100	-	-	
½ inch	-	25-60	10-30	
3/8 inch	20-55	-	-	
No. 4	0-10	0-10	0-5	
No. 8	0-5	0-5	-	
No. 200	0-1	0-1	0-1	



(F) Combined Aggregate

Approved fine and coarse aggregate in 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 3/4-in. to No. 4 gradation shall be used for concrete members with reinforcement too close to 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.

D 3.05 Aggregate for Mortar

(A) General Requirements

Aggregate for mortar 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.

(B) Organic Impurities

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

D 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 700ppm. nor sulphates such as sodium sulphate in excess of 500ppm. It shall not contain any impurities in an 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 1 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 at the Contractor's expense.

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

D 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-494-92 for Water Reducing and Retarding Admixtures, and C-260-94 for Air-entraining Admixtures for Concrete.

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.

Admixtures that contain relatively large amounts of chloride that accelerate corrosion of reinforcing steel shall be rejected.

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 thereof. Similar information shall be provided in the shipping advises accompanying packaged or bulk shipments of admixtures.

The admixtures 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 and are deemed to be included in the Concrete unit price.

D 4 **COMPOSITION OF CONCRETE**

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

The weight of fine and coarse aggregate given in Table II are based on the use of aggregates having bulk specific gravities, in a saturated surface dry condition, of 2.65. For reasonably well graded materials of normal physical characteristics, the use of the Table II 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 aggregates having specific gravities outside the ranges indicated in Table II, the weights shall be corrected by multiplying the weights shown in Table II by the ratio 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 are based on the use of a 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 be used. Any change in weight of fine aggregate made by the Engineer for the purpose of adjusting workability should always be compensated for by changing the weight of coarse aggregate in the opposite direction by a corresponding amount.

Table I

Class of Concrete	Compressive Strength At 28 Days (in Kg/cm ²) cylinder	Minimum Cement Content (Kgs)	Coarse Aggregate Size	Max. Water Content (Liters Per Bag)	Maximum Water-Cement Ratio, By Weight, Normal Weight Aggregate concrete	Consistency Range in Slump (mm)	
						Vibrated	Non Vibrated
F'c 320	320	400	¾ " or 1" – No. 4 as required by C.M.	25	0.45	50-100	75-125
F'c 250	250	375	Ditto	27	0.50	50-100	75-125
F'c 210	210	350	Ditto	27	0.50	50-100	75-125



Table II

Class of Concrete	Cylinder Compressive Strength At 28 Days (Kg/cm ²)	Approximate Weight (Saturated Surface – Dry) of Fine and Coarse Aggregate Per Sack (50 Kgs) of Cement			
		Rounded Aggregate		Angular Aggregate	
		Rounded (Kgs.)	Coarse (Kgs.)	Fine (Kgs.)	Coarse (Kgs.)
F'c 320	320	75	150	80	140
F'c 250	250	85	170	95	150
F'c 210	210	95	180	100	160

Table II is given for indicative purposes and is not binding.

Total chloride content (as NaCl) of any mix, including any chloride present in the other materials and in the mix water, shall not exceed 0.35% by weight of cement in the mix.

Total sulfate content (as SO₃) of any mix, excluding that present in the cement but including any present in the other materials, shall not exceed 2.5% by weight of cement in the mix.

D 5 PROPORTIONS

D 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.

D 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) at the Contractor's expense. For the proportions which will be made for the required strengths, the cement content shown in Table I is considered to be the minimum cement content required, 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 workability without exceeding such maximum allowable water content. No additional compensation will be made for the increase in quantity of cement required.

D 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.

D 5.04 Batch Weights

Since the proportions are designated in terms of aggregates 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.

D 6 CONCRETE COMPRESSION AND SLUMP TESTS

D 6.01 Test Cylinders



The compression tests shall be performed as based on standard specification for compressive strength of cylindrical concrete specimens of ASTM Designation: C-39. Test cylinders made in the field shall have a diameter of 6" and a length of 12" in accordance with ASTM Designation: C-31

In order to determine the crushing strength and density measurements of the concrete during construction operation, at frequency intervals during the conduct of the work, the Contractor shall make and cure test cylinders from the concrete as mixed for the work which shall be tested in accordance with ASTM Designation C-39, after seven and twenty eight days or as directed by the Engineer. Concrete test specimens shall be made and cured in accordance with the current issue of ASTM Designation C-31 for field cured cylinders, and ASTM Designation C192 for laboratory cured cylinders. The specimens cured under the laboratory conditions are for acceptance of the concrete in the structure so represented. The field-cured cylinders shall be used for the control of curing and to determine when the structure may be put in service.

If the average strength tests of the specimens cured under laboratory conditions falls below the minimum allowable compressive strength at twenty-eight days, the concrete mix shall be redesigned. If the average strength of the specimens cured under field conditions for the concrete placed in the structure falls below the minimum allowable compressive strength required, the concrete shall be removed and replaced to secure the required strength. In the determination of the average compressive strength of the specimens, no single cylinder specimen shall have strength less than eighty five (85%) of the specified strength.

The Contractor shall provide, at his own expense, three (3) sets of four (4) cylinders for each one hundred (100) cubic meters of concrete or fraction thereof, placed during a single day run of any one pour forming a unit or work, or as deemed necessary by the Engineer or Engineer's Representative.

All tests shall be carried out on dry specimens after seven and twenty eight days of curing and such sampling and testing shall be carried out in a laboratory approved by the Engineer at the Contractor's own expense.

The Engineer may request extra cylinders to be made for testing at three days whenever he deems necessary. All such tests are at the Contractor's own expense.

In case test cubes will be used for the daily testing of concrete, then the contractor shall submit test results for the trial mixes using both cylinders and cubes to develop the correlation factor between test results between test cylinders and test cubes for each type of concrete at least 10 days prior to commencement of work. This does not relieve the Contractor from conducting cylindrical tests at the request of the Engineer, the cost of which falls at the Contractor and is deemed to be included in the concrete unit price.

D 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

D 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.

D 7 MEASUREMENT OF MATERIALS

Materials shall be measured by weight, except as otherwise specified or where the Engineer specifically authorizes other methods. 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 percent 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.

D 8 MIXING OF CONCRETE

D 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.

D 8.02 Mixing at Site

Concrete shall be thoroughly mixed in a batch mixer conforming to the requirements of B.S. 1305 Batch type concrete mixers which will insure a uniform distribution of the materials throughout the mass.

The mixer shall be equipped with adequate water 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. No mixer having a rated capacity of less than a 1-bag batch shall be used nor shall a mixer be charged in excess of its rated capacity.

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 mixing, the mixer shall operate at the speed for which it has been designed, but this speed shall not be less than 12 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.

D 8.03 Truck Mixing

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 insure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured in accordance with section B.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 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.

Not 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 15 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.

D 8.04 Partial mixing at the Central Plant

When a truck mixer provided with adequate mixing blades is used for transportation, 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 B.8.3. for truck mixing.

D 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. Ready-mix concrete suppliers shall be approved by the Engineer prior to commencement of works, and in compliance with the concrete specifications.

D 8.06 Time of Holding 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.

D 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 that will facilitate placing with the minimum of rehandling and without damage to the structure of the concrete.

D 8.08 Retempering

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

D 9 HANDLING AND PLACING CONCRETE

D 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. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the 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 inferior quality of concrete is produced by the use of such conveyors, the Engineer may order discontinuance of their use and the substitution of a satisfactory method of placing.

Open trough 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 1/2



horizontal) to permit flow requiring a slump greater than that specified or required for placement.

All chutes, troughs and pipe shall be clean and free from coatings 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 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 that project.

D 9.02 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:

- The 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 a mass concrete of 25mm slump over a radius of at least 500mm.
- The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms.
- Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and imbedded 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 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 vibrations 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
- Vibrators shall be supplemented by such spading as is necessary to insure smooth surface and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.
- The use of implement such as compressors that 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 except 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 that has taken initial set.

The top surface of the concrete slabs shall all be smoothed with a mechanical trowelling machine, manual trowelling will not be accepted.

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to



retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete.

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.

D 10 CONSTRUCTION JOINTS

D 10.01 General

Construction joints shall be made only where located on the Drawings. If not detailed on the drawings, or in the case of emergency, construction joints shall be placed as directed by the Engineer. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or bond the two sections together.

D 10.02 Bonding

Before depositing new concrete on or against concrete that has hardened, the forms shall be retightened. The surface of the hardened concrete shall be roughened as required by the Engineer, in a manner that will not leave loosened particles of aggregate or damaged concrete at the surface. It shall be thoroughly cleaned of foreign matter and laitance, and saturated with water. To insure an access of mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and saturated surfaces including vertical and inclined surfaces, shall first be thoroughly covered with a coating of mortar or neat cement grout against which the new concrete shall be placed before the grout has attained its initial set.

The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints that are exposed to view shall be carefully finished true to line and elevation

D 11 FORMWORK

D 11.01 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. The Contractor shall be responsible for the haulage, installation, removal, and maintaining of the waffle moulds that are provided by the owner, the cost of such work is deemed to be included in the unit price of the concrete works. The concrete quantity shall be measured net. Plastic chamfers of standard size shall be used for all corners

All exposed concrete should be fair face finish as specified in Section C14.

D 11.02 Material

All forms shall be 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.

Where formwork happens to fall above existing structures and/or buildings, the Contractor shall, at his own expense and responsibility, design and install a formwork system to be approved by the Engineer, that does not transfer any loads to the existing structures and/or buildings. The cost of such formwork shall be deemed to be included in the Unit Prices of "CONCRETE WORK".



D 11.03 Workmanship

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

The number and 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 that are unsatisfactory in any respect shall not be re-used.

Metal ties or anchorages within the form shall be so constructed as to permit their removal to a depth of at least 40mm from the face without 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 an approved oil to prevent the adherence of concrete.

Any material that will adhere to or discolor 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.

D 11.04 Removal of Formwork

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 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 manner as to avoid injurious stresses in any part of the structure.

The Contractor shall include in his prices for any formwork that may have to be left in position due to the impossibility of removal of same. The cost of such formwork shall be deemed to be included in the Unit Prices of "CONCRETE WORK".

D 12 REINFORCEMENT

D 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 that shall in no way relieve 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 the 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 centroid part shall be in actual contact with the bars, around which they are intended to fit.

D 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 2800 Kg/cm² (40,000 psi) for Concrete Reinforcement of ASTM Designation (A-615) or equivalent.

B -Deformed Steel rods and Bars

Deformed Steel rods 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. All steel subject to be tested for the required strength whenever deemed by the Engineer to be necessary. All such tests to be are on the Contractors own expense.

D 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 than 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.

D 12.04 Order Lists

Before ordering material, all order lists and bending diagrams detailed in accordance with the latest revision of ACI 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.

D 12.05 Protection of Material

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

D 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.

D 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, block ties, hangers, or other approved supports. Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shapes and dimensions or approved metal chairs. Metal chairs that 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.

D 12.08 Splicing

All reinforcement shall be furnished in the full lengths indicated on the Drawings. Splicing of 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.

D 13 CURING AND PROTECTION

The method, procedure materials, and equipment for curing shall be approved by the Engineer. Curing may be accomplished by any of the following methods or combination thereof, as approved.

D 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 contained as on the unformed surfaces. When burlap, sand or other approved fabric materials are used, they shall not cause any undesirable finish such as rough surface and discoloring 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 that is designed to avoid such an eventuality. 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 C3.6.

D 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 surfaces by means of a sprayer, roller or lamb's wool applicator and shall be sprayed on. Ample time shall 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 labeled 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.

D 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".

D 14 EXPOSED CONCRETE (FAIR FACE) SURFACES

D 14.01 Formwork

All exposed concrete surfaces shall be fair face. Formwork for exposed concrete surfaces shall conform to the applicable requirements in section C11, in addition to these specifications

All concrete surfaces that are to be left exposed to view as a finished surface shall be produced by

3A-30



vertical wooden shuttering.

The quality of the surface of concrete exposed to view shall be consistent throughout the works and the following methods shall be adopted to obtain the required finish:

Metal forms of an approved type for precast units and circular columns.

Wooden boards, each 100mm wide for cast-in-situ concrete members, treated and lined to produce fair face finish.

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 fair face concrete work including details of horizontal and vertical construction joints. Sample panels shall be constructed for all fair 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.

D 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.

D 14.03 Construction Joints

Construction joints, if they are not clearly indicated on the Drawings shall not be allowed. Construction joints, in cases where weather conditions so require shall be studied in detail ahead of time and the joint shall be grooved in a predetermined pattern approved by the Engineer at no additional cost to the owner.

D 14.04 Samples and Workmanship

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

The quality of the finished work shall be measured against the quality of the approved sample panel and the work of inferior quality shall be repaired as directed by the Engineer without any additional cost.

The quality of the finished surfaces shall be uniform in color and consistency, whether in color or in texture, in any of the finished surfaces, the Engineer may order the repair or the demolition of that 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.

D 15 MONOLITHIC SMOOTH FINISH SURFACES

All concrete surfaces which are not in acceptable 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 approved material. A cement wash shall 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 struck 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.



SECTION - E: STONE WORK

E 1 **SCOPE**

These specifications cover stonework facing intended to be used for external walls, required for the works in accordance with the Drawings; Bills of Quantities and as directed in writing by the Engineer.

E 2 **MATERIALS**

Stone building and / or facing to walls shall be of durable, local stone, "Mizzi" of type, dimensions as shown on tender documents, approved by the Engineer and of quality suitable to ensure permanence in the structure. It shall be even grained, free from cracks, seams, holes, shakes, objectionable irregularities of colour, impurities, structural weaknesses and other defects that would tend to increase unduly the deteriorations from natural causes. All stones for facing shall be selected well in advance of time required. Samples of stone materials and dressing shall be submitted for the Engineer's approval 30 days before delivery of such material to site.

Joints shall not exceed 10 mm and shall be grooved recessed and pointed with non-staining mortar tinted to match colour of stone. Grooves shall be filled with same tinted mortar. Mortar for all masonry shall consist of slaked lime putty or dry hydrated lime and cement and sand mixed in the following proportions. The sand and lime being mixed first and cement then added.

- 1 White cement
- 2 Parts of fine crushed stone sand

Stone shall be "Mofajjer", "Mussamsam", and "Mattabeh". Beds and joints shall be sufficiently bush-hammer dressed for an approximate depth of 10mm from the face of the stone at the edge to provide regular course of different heights and to ensure stones fit reasonably close together when built.

The width of horizontal beds shall be as shown on Drawings whereas the vertical joints shall be as inconspicuous as possible and shall not exceed 10 mm in width.

The stone facing shall be fixed to the structure as detailed on the Drawings and as per approved method of installation. Insulation between internal wall and stone facing shall be polystyrene or equal approved by the engineer.

Stone properties shall be as follows:

White Stone matching the Main Building Existing Stone:

- Flexure strength shall not be less than 12 N/mm²
- Parallel to rift modulus of rupture shall not be less than 50.00 N/mm²
- Perpendicular to rift modulus of rupture shall not be less than 60.00 N/mm²
- Bulk Specific Gravity shall not be less than 2.60 Gr/cm³
- Absorption shall not exceed 0.80 % of weight.

Stone stated in the tender documents "matching Salem House" shall be Jerusalem Gold Stone with the following properties:

- Flexure strength shall not be less than 11.00 N/mm²
- Compressive strength shall not be less than 110.00 N/mm²
- Bulk Specific Gravity shall not be less than 2.60 Gr/cm³
- Absorption shall not exceed 1.10 % of weight.
- Abrasion (Hd) shall not exceed 12.30.
- Knoop hardness 310.00 kg/mm².
- Mohs Hardness 3.4-3.9 Hd.



E 3 STONE FLOOR TILE

Stone tiles for flooring, coping, stair treads, risers and skirting shall be local of stone, "Mizzi" obtained from an approved source.

The stone tiles shall be of the dimensions and thicknesses shown on the Drawings and in the Bills of Quantities and shall be uniform in color and texture, smooth and free from voids and shall be of an approved colour and to the pattern and sizes shown on the Drawings. Sample of stone tiles shall be submitted to the Engineer for approval prior to order.

Mortices shall be carefully cut without causing any damage to the tiles, and rebates shall be carefully formed by special machines to the width and depth required to the satisfaction of the Engineer.

E 4 WORKMANSHIP

Walls shall be carried up in a uniform manner, no one portion being allowed to rise more than four courses above another at one time and any such rising shall be regularly stepped for bonding. The total thickness of stone facing and mortar backing shall be as shown on Drawings.

All stone shall be hand placed. Courses shall be bedded solidly 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 non-staining hardwood wedges to ensure close and regular fitting between beds and joints. All stones shall be solidly bedded and jointed in mortar.

The mortar backing shall be worked into crevices at the back and around every stone in such a manner to eliminate all voids and bond perfectly with the facing stone to form a homogeneous solid mass. Particular care shall be taken during tamping to ensure that facing stones are not displaced from their correct positions. Concrete backing in all masonry walls, shall be poured behind not more than one-course height of stone per day.

At completion of masonry walls the horizontal joints of all stone faced walls shall be raked out to a depth of 10 mm cleaned wetted and pointed with mortar composed 1 part white cement and 2 parts very fine sand tinted to the color selected by the Supervising Engineer.

The Contractor when executing pointing 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 mortar in the faces of the stones. The Contractor shall set up samples for the Engineer's approval before executing any pointing.



SECTION - F: BLOCKWORK

F 1 **SCOPE**

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

F 2 **MATERIALS**

F 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. Cement shall originate from an approved manufacturer, obtained in sealed and labeled bags, each 50kgs. net capacity, name and brand of the manufacturer shall plainly be identified thereon and delivered to the Site in good condition.

All cement shall be stored in suitable weatherproof and approved storage sheds that will protect the cement from dampness. These storage sheds shall be erected in locations approved by the Engineer. Provisions 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 the Engineer at the expense of the Contractor orders a retest.

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.

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 retest of soundness at the time of delivery of the cement to the Site.

Packages 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. The Contractor shall remove such consignment 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 that for any reason has become partially set, or contains lump or caked cement, shall be rejected.

F 2.02 **Aggregates**

(A) **General Requirements**

Aggregate for mortar 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.

(B) **Organic Impurities**

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

F 2.03 **Water**

**(A) Quality of Water**

Water for mixing of mortar 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 700ppm. nor sulphates such as sodium sulphate in excess of 500ppm. It shall not contain any impurities in an 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 1 percent compared to results obtained with distilled water.

The pH of the water for mixing and curing of mortar 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 Mortar, as specified in B.S. 3148: 1959 Tests for Water for Making Mortar at the Contractor's expense.

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

F 2.04 Lime

Lime shall be non-hydraulic lime complying in all respects with B.S. 890, 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 quick-lime shall be slaked, run to putty and matured for not less than two (2) weeks.

F 3 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, rectangular shape, clean with well defined arises, free from cracks 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 pressure 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 honey-comb fashion after curing. The blocks shall not be used prior to one (1) month after the date of manufacture, nor 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% Tolerance.

Width = As required + 1% Tolerance.

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

b) **Non-Load-Bearing Walls**

30 Kgs/cm² average of 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)mm. 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.

Where Pumice block is specified, it shall use Lava aggregate, and weight of 100mm wide block shall not exceed 6 Kg.

F 4 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) mix, 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 case 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 (30) minutes after mixing. Hardened mortars shall not be



used in the work and shall, upon the request of the Engineer, be immediately removed from the Site.

F 5 WORKMANSHIP

All blockwork shall be set out built to the respective dimensions, thicknesses 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 20mm., no one portion being raised more than 1.00 meter above another at one time, and wall of partition necessarily left at different levels, must be racked back. All perpend, 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 reinforced concrete column and the remainder set into the blockwall 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.

All walls and partitions shall be properly cured by sprinkling water for a period of 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 door and window lintels. No hollow blocks shall abut any built-in fixtures e.g. door and window frames, apertures, louvres, etc.

The cavity between skins of blockwork shall be 100mm (nominal) wide and kept clear of mortar droppings 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.



SECTION - G: ROOFING, WATERPROOFING & EXPANSION JOINTS

G 1 SCOPE

These specifications cover waterproofing and roofing systems intended 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.

G 2 MATERIALS

G 2.01 Vapor Barriers

The vapor barrier for use in damp-proofing and waterproofing under R.C. sub-floors shall comprise of Polyvinyl Chloride membrane such as manufactured by the British "Cellophane Ltd." or manufactured by Serviced Division of "W.R. Grace Ltd." and/or other approved equivalent.

The waterproofing under floor tiling of the kitchens and toilets shall be similar to "Tretolastic Damp Surfaces Primer with two coats of Tretol 202 T Bitumen Solution as manufactured by Tretol Buildings Products, Ltd., England" or "No. 5 Pluvex Bitumen Sheeting as manufactured by Ruberoid Building Products Ltd." and/or other approved equivalent.

G 2.02 Primer

The material used as a primer shall conform to ASTM Specifications D 41, for Primer for use with Asphalt in Damp-proofing and Waterproofing below or above ground level for application to concrete and masonry surfaces.

G 2.03 Bitumen

The bitumen for damp-proofing and waterproofing shall be a soft, adhesive "Self-healing" asphalt which flows easily under the mop and which is suitable for use below ground level on horizontal and vertical surface under uniformly moderate temperature conditions both during the process of installation and during service.

The bitumen shall be homogeneous and free from water and shall conform to the requirements of ASTM Specifications D449-73 "Type A".

The bitumen for built-up felt roof shall comply with B.S. 1162:1966 or B.S. 988:1966 Mastic Asphalt for Roofing and B.S. Code of practice C.P. 144, Part 4: 1966 Mastic Asphalt.

G 2.04 Mastic Asphalt

Mastic asphalt for damp-proofing and waterproofing shall comply with B.S. 1097, B.S. 1418 and with B.S. Code of Practice C.P. 102- Protection of buildings against water from the ground.

Mastic asphalt for roofing purposes shall comply with B.S. 988. B.S. 1162, 2nd with B.S. Code of Practice C.P. 144, Part 4-Mastic Asphalt.

G 2.05 Roofing Felt

The roofing felt for built-up roofing shall comply with B.S. 747: Part 2: 1970 (Metric Units) Roofing felt, class 1A and as described in B.S. C.P. 144 : Part 3 : 1969.

G 2.06 Brush Paint Waterproofing Membrane

Waterproofing membrane shall be brush painted type where specified, and shall be of the rubberized bitumen emulsion type. Application shall be in accordance with the manufacturer's instructions. A minimum application of two coats is required, with the coats applied at right angles to each other, to



provide the minimum required thickness, which shall not in any case be less than 500 microns for underground retaining walls, and 250 microns for above ground surfaces.

Prior to application, surfaces must be clean, dry, and free from dirt, dust, oil or grease. All loosely adhering particles such as rust, scale, cement laitence shall be removed prior to application of waterproofing coats as well. All organic growth shall be removed using a fungicidal wash, followed by a thorough washing with clean water.

G 3 WORKMANSHIP

G 3.01 Damp-proofing and waterproofing

(A) Vapor Barriers

The vapor barrier, where shown on the Drawings or stated in the Bills of Quantities, for use in damp-proofing and waterproofing shall be laid in strict conformity with the manufacturer's instructions.

(B) Primer and Asphalt

The primer and asphalt, as specified under "Materials" shall be used as a damp-proof and waterproof course to accessible underground surfaces of reinforced concrete structures and internal surfaces of flower boxes to the extent shown on the Drawings, and shall consist of one coat of primer and two coats of asphalt.

All surfaces to be damp-proofed and waterproofed shall be properly prepared by brushing, cleaning and leaving the surfaces free from dirt, dust, grease, loose or projecting particles of mortar or concrete, all traces of salt shall be thoroughly sprayed with water and allowed to dry and disappear from the surfaces before the application of the priming coat.

Asphalt shall be applied hot in two coats for both horizontal and vertical work. Each coat of asphalt shall be allowed to dry for a period of at least 24 hours before the second coat is applied. Warm, clean and properly make good in junctions between horizontal and vertical asphalt, with two coats angle fillets at all internal angles.

(C) Storage and Handling for Materials

Rolls of felt and containers of bitumens shall be stored on end. Rolls of felt shall be properly covered and all materials shall be kept clean and dry. In cold weather, plied felts shall not be thrown or dropped since the shock of impact can fracture adhesive between plies causing them to separate. Such a condition, often considered a factory defect, more frequently is caused by rough handling.

(D) Preparation of Materials

Bitumen shall be placed in kettles, melted and frequently stirred to prevent burning. Cutting back, adulterating or fluxing of bitumen with any other material shall not be allowed.

Felts shall be unrolled, turned over, piled up and permitted to flatten. Then they shall be re-rolled in the opposite direction before application.

(E) Application of Materials

Before work is started all rubbish shall be removed and, during the work, the deck shall be maintained clean and free of loose or foreign materials and obstructions other than tools and appliances of the roofer.

Decks that are scaling or that are covered with dust shall not be primed until thoroughly cleaned. Leaky containers for bitumen shall not be used since splashes seldom can be removed entirely.

A sufficient quantity of bitumen shall be used so that it will flood ahead of the roll in an unbroken line



so that the felt will be completely embedded.

The felts shall be rolled closely behind the mop so that at no time shall the mopping be more than one meter broomed in while the bitumen is still hot. The stable type of broom or suitable squeegee shall be used for this purpose.

In applying felts on built-up roofs it is important that they be laid so that the flow of water is over or parallel to (never against) the laps of the finishing felts. Care shall be taken to ensure that all surfaces upon which felt is to be laid are dry, smooth and clean.

Felts shall be applied in three layers of felt, lapping each felt 600mm over the preceding one. Mop the full width under each felt with the asphalt.

The felt shall be dressed and bonded into mouths of rainwater outlets and well fitted and sealed around openings.

When roofing abuts against vertical surfaces such as walls or parapets, it shall be carried up for a minimum height of 150mm and 150mm back off the walls or parapets forming triangular fillets as a skirting or base continuous with the roof membrane.

Pipes and other structures piercing the roof shall be primed with a bitumen solution and shall have a collar of hot bitumen formed up to them at 45°. The roofing felt shall be dressed up and capping layer of flashing felt shall be dressed over the collar, bonded to the pipe and secured with four turns of stout copper wire.

At angles or other obstacles wherever felt needs cutting, a mastic joint or seal shall be used to ensure the continuation of the waterproofing membrane.

All roof finishes shall be carefully worked or fitted around pipes or openings. On completion all roofs are to be left sound and water tight and in a neat and clean condition.

(F) Minimum materials required per 9 square meters of waterproofing area :

	Approx.
Prime Coat :	As recommended by the asphalt manufacturer.
Felts :	3 layers of saturated asphalt felt 20 Kgs
Bitumen :	Mastic asphalt for mopping each layer of felt 10 kgs
	For flood coat to receive chippings 136 Kgs

They shall include all enclosure fittings. Wooden strips shall be as specified under JOINERY AND IRONMONGERY.

Care shall be taken during installation not to cause any damage to the waterproofing material laid on roof deck.

G4 EXPANSION JOINTING MATERIAL

Expansion joint filler shall be of a preformed type in fibrous materials with a cellular structure, impregnated with a tar distillate or cutback bitumen compressible without extrusion or elastic so that after repeated compression to 50% thickness it is capable of recovering at least 7.5% of its original



thickness. The filler shall be obtained from Expadite Ltd., W.R. Grace Ltd., Fosroc, of England, Sica, of Italy, or equal and approved by the Engineer.

Exposed edges of joints are to be pointed with a polysulfied synthetic rubber joint sealing compound of proven suitability in the prevailing climatic conditions, and shall be used strictly in accordance with the manufacturer's instructions.

SECTION H – CARPENTRY, JOINERY, AND IRONMONGERY

H 1 GENERAL

Joiner's work shall be carried out in accordance with the drawings and the principles of first class joinery construction. Unless specifically stated otherwise, sizes on drawings are finished sizes and the Contractor must allow for wrought faces.

H 2 TIMBER, GENERAL

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 sample 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 splits, ring shakes and soft pith
- Checks exceeding 300mm long
- 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
- Loose knots
- 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. 1186 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 of timber 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 shall have all surfaces of the same species and same character of grain running in the same direction.

Timber connector's 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 rawl-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 editions.

Timber to be used for each position of the works shall be as indicated on the drawings and as stated in the Bills 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.

H 3 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.

H 4 HARDWOOD

Hardwood shall be of the type indicated on the drawings, first grade dense timber and approved.

H 5 PLYWOOD

Plywood shall consist of an odd 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 hot pressed during adhesion and shall have a finished thickness as shown on the Drawings, or shall be prefinished plywood 7mm thick such as obtained from Virus-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 plywood.

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 pine worm holes through face veneers only), fungal attack and from discoloration 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 "Play-wood manufactured from tropical hardwoods" and B.S. 3493 "Information about plywood".

H 6 BLOCKBOARD OR LATTE LAMINBOARD

Blockboard 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".

H 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 aminoplastic) and shall ensure proper adhesion between plies.

H 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 water proof heat resistant adhesive of a type recommended by the plastic laminate manufacturer.

H 9 MANUFACTURE AND WORKMANSHIP

H 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 tenoned, 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.

H 9.02 Doors

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

Flush doors shall be core framed up in softwood or prefabricated hollow tube compacted chipboard filling 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 ribeted to take the edge of the plywood facing. Lock rails of fixingblocks shall be built in to the framing and their positions marked on the facing.

Glazing beads shall be of hardwood (of same type, colour, and grain as hardwood or veneer indicated on drawings) 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.

H 9.03 Fittings, General

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.

Blockboard in shelves, divisions, counter tops, panels, drawers and the like shall have hardwood lipping 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 blockboard in prefabricated fittings and fixture 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.

H 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 blockboard. 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".

H 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.

H 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 at the Site.

H 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 of the Engineer and work disturbed made good at the Contractor's expense.

H 13 IRONMONGERY

Ironmongery shall be first quality to be obtained from an approved manufacturer and shall comply with the appropriate B.S. listed hereunder:

- | | |
|-------------|---------------------------------|
| - B.S. 455 | - Locks and latches for doors |
| - B.S. 1227 | - Hinges |
| - B.S. 1228 | - Door bolts |
| - B.S. 1331 | - Builders hardware for housing |
| - B.S. 2088 | - Performance tests for locks. |

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.

H 14 MASTER-KEYING

The Contractor shall set up the locks for a system of master-keying. Three change keys shall be furnished for each lockset, in addition to 3 master keys for each section.

H 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 handing over, the Contractor shall ensure that all the 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 overhauled, eased and oiled before handing over and all paint, etc., shall be removed and left in a clean and perfect working order.

H16 FLAT CLADDING PANELS (INTERIOR AND EXTERIOR)

A Material properties

Properties	Value	Unit	Unit	Standard
Physical properties				
Specific gravity	> 1,350		Kg/m ³	ISO 1183
Dimensional stability	<2.5		mm/m	-
Water absorption	< 1.0		% weight	EN 438
Optical properties				
Colour stability	4-5 (2,500 hrs; Xenon test)		Grey Scale	ISO 105A 02-93
Mechanical properties				
Modulus of elasticity	≥ 9,000		N/mm ²	ISO 178
Tensile strength	≥ 70		N/mm ²	ISO 527-2
Flexural strength	≥ 120		N/mm ²	ISO 178
Surface impact resistance	≥40		N	EN 438
Scratch resistance	≥3.5		N	EN 438
Thermal properties				
Thermal conductivity	± 0.3		W/mK	DIN 52612
Chemical properties				
SO ₂ -Resistance	4-5 (50 cycles; approx. 0.0067%)		Grey Scale	DIN 50018
Fire behaviour				
Fire classification	Type FR: Class 0 Type Standard: Class 2/3			BS 476 Parts 6-7 Building regulations

B Physical Properties:

Flat panel, based on thermosetting resins, homogenously reinforced with wood fibers and manufactured under high pressure temperatures, using a proprietary technology (EBC). The panels have an integrated decorative surface.

C Fabrication and installation:

Optimizing: Arrows on the back side of the full size panels should be applied to indicate the direction the sheets have been produced.

Fixing: When cutting the sheets, temporarily mark the original production direction on the visible side of the individual panels may be made. All instructions for processing and fixing are as per manufacturer recommendations.

Naturals corner profiles: Corner profile and sheet lengths have corresponding direction.

D Quality:

Environmental Considerations:

Panels consist of approximately 70% softwood fiber and 30% thermosetting resin. The wood fiber comes from pine wood.

Panel material to be certified according to ISO 14001.

At end of their life cycle panels can be thermally recycled with energy recovery locally in an industrial incinerator as they contain no heavy metals, halogens or biocides.

E Weather Resistant:

Extremely weather resistant. Neither sun, rain -including acid rain – nor moisture should have any effect on the panel's surface or core. Both the UV resistance and colour stability should be high with a 4-5 classification on the international Grey scale (ISO 105 A 02). Large or rapid temperature fluctuations from 20C to + 80C should not affect the properties, stability or appearance of the panel. Colours should not change significantly for a least ten years, even under the most server climate conditions, or in heavily polluted industrial areas.

F Keep Clean:

The smooth panel surface should have a closed non-porous structure ensuring that practically no dirt accumulates. Neither the surface nor the sawn edges need to be painted or provided with a protective cover. Completely unaffected by household cleaning agents or strong organic solvents.

G Vandalism:

Panel material should be highly impact resistant by combination of flexural strength and elasticity. It is therefore highly suitable for application in environments that are exposed to vandalism.

H Safe fire behavior:

In a fire, panels should not melt, drip or explode and retains its stability for a long time.

J Fire Precautions:

Systems should be able to prevent fire, and should be constructed with incombustible insulation materials and continuous horizontal stainless steel fire breaks; panels contribute to the required resistance of fire breaking through.

K Joints:

The following guidelines apply to joints and panel connections:

- The panels should be able to move 2.5mm per meter in the length and the width. Therefore sufficient space should be allowed for around the panels.
- Panel should be able to move, therefore a minimum joint width of 10mm is required.
- Insects and vermin may nestle behind the façade cladding, therefore joints that are larger than 10mm should be fixed with grilles, wire netting, etc.

L Joint profiles:

Joints to be closed by fixing metal, plastic or rubber profiles and to Engineer instructions. The profiles should not impede the movement of the panels and should be fixed free of tension.

M Corner Solutions:

Special corner profile must be used at the corners of the building with standard dimensions of 3650x300x300mm with 20mm radius, and 8mm thick for internal elevations and 10mm for external facades. No allowances are to be made for the corner pieces.

N General Guidelines Facade Cladding:

The following aspects should receive attention when a façade construction consisting of Panels, subframes and fixings are dimensioned:

- The panels should be suitable for use as self-supporting façade cladding.
- When combined with the subframe the panel strength and rigidity should be sufficient to withstand normal loads such as wind, dead weight and / or impact, without being damaged.
- The façade cladding should not have a structural function.
- If heavy objects are to be suspended from the panels, additional facilities are usually required.
- The maximum permissible impact loads on the panels and subframes can be determined by means of specific tests (Usually the Sandbag Swing Test).

O General Guidelines fixing systems:

Panels should be assembled with corrosion resistant fixings on a suitable subframe in such a way that the panels are not under tension and are able to move freely. When determining the subframe the following should be kept in mind:

- Wind loading.
- The maximum fixing centers for the panels.
- The required ventilation provisions.
- Unimpeded movement of the panels.
- The available panel dimensions.
- The anchoring possibilities in the structural (wall) construction.
- Legal requirements.

P Fixing:

Panels may be fixed by the means given below. Variations and combinations of the methods are optional. The details in this brochure give the principles of the fixing systems and do not refer to trade names. Trading of panel edges is not required as shown in the details.

Fixing system must be invisible way for exterior and interior elevations Using:-

1. Steel screws or inserts fixed on Aluminium subframes; for external elevations.
2. Adhesive, steel screws and timber subframes; to internal elevations.

Invisible Fixing with Screws, Inserts and adhesive:

- 10mm thickness panels should be installed by fixing metal hanging brackets with inserts or screws to the back of the panel. The panels are fixed to Aluminium subframe. Each panel has two adjusting points and a fixed point at the top; so adjusting is possible and unwanted movement of the whole panel can not happen. (For external facades).
- 13mm thickness panels should be installed to wood frames by adhesive and screws. (For internal elevations).

A Fixing and edge clearances:

- Minimum 80mm.
- Maximum 10 x panel thickness.

Lower brackets fixed higher at such a level as to facilitate downward panel movement (2.5mm/m2).

Maximum fixing centers (in mm)	panel thickness (in mm)
	10
2 fixings in one direction	600
3 or more fixing in one direction	750

B Fixing Detail:

Fixing method (see also chapter "Accessories")

- Straight insert.
- Thread Cutting Screw.
- Conical Insert.

Remaining panel thickness: at least 2.5mm.

Anchoring depth: panel thickness 3mm.

END OF SECTION

3 A-48

SECTION-J: METALWORK & GLAZING

J 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.

J 2 MATERIALS

J 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).

J 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.

J 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. 4320. "Metal washers for general engineering purposes".

J 2.04 Galvanized Steel Pipes

Galvanized steel pipes shall conform to the requirements of B.S. 1378 - I.S.O. "Medium Series".

J 2.05 Paint

Paint for Metalworks shall comply with the applicable requirements as specified under "PAINTING".

J 2.06 Aluminum

All aluminum elements shall be manufactured by "NAPCO" of Palestine, or equivalent imported section, and shall be of extruded sections of aluminum alloy, mechanically jointed. Fittings shall be aluminum alloy in accordance with B.S. 1331 the latest edition.

All parts and members shall be of aluminum 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 free from defects, and shall be light etched and anodized in the specified finish as shown on Drawings and as directed in writing by the Engineer.

Aluminum shall be treated to comply with B.S. 1615 and B.S. 3987 to provide an anodization not less than 60 microns thickness, and 80 micron thickness for powder coating, using powder coat paint with the following properties:

- Mechanical Tests
 - Flexibility ISO1519 (cylindrical Mandrel): Pass Qualicoat class 2 requirements
 - Adhesion ISO2409 (2mm crosshatch): Gt0
 - Erichsen cupping ISO1520: Pass Qualicoat class 2 requirements
 - Impact ASTM D2794: Pass Qualicoat class 2 requirements
 - Buchholz hardness ISO2815: >80
- Chemical Tests
 - Acetic acid salt spray ISO9227: <16 mm² corrosion/10cm, 1000 hours
 - Constant humidity ISO6270: No blistering, creep <1mm (1000 hours)
 - Sulphur dioxide ISO3231: Pass 30 cycles – no blistering, gloss loss or discoloration
 - Permeability EN12206-5.10: Pressure Cooker – pass 1 hour no defects
 - Chemical resistance: Generally good resistance to acid, alkalis and oil at normal temperatures
 - Mortar resistance EN12206-1: No effect after 24 hours
 - Exterior durability ISO2810: Meets Qualicoat class 2 requirements after 3 years Tropical
 - Meets AAMA 2604-13 requirements after 5 years Tropical
 - Accelerated weathering ISO 11341 (1000 hrs) QUV B 313 (600 hrs): Gloss retention ≥90%
Gloss retention ≥50%

All aluminum sections shall present clear straight and sharply defined lines and shall be free from defects and imperfections that may impair their strength. Minimum section thickness for curtain walls 3mm.

All screws, bolts and other necessary accessories shall be of aluminum or other non-corrodible material and shall match in color and consistency the finish of the anodized aluminum.

Aluminum 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 threaded or interlaced at points of intersections and machine tenonned to frame.

Prints of Shop Drawings for aluminum windows, doors, frames etc... showing the dimensions, sizes, thicknesses, materials, finishes, joining, 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 aluminum 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 aluminum units is fixing in position and glazing. The finished surfaces shall present a clear surface free from alloy defects, scratches, or other surface blemishes.

J 3 MANUFACTURE

J 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 the Contractor has obtained in writing the approval of the Engineer of the above Drawings.

The steel sections where specified to be factory rustproof shall be rustproofed by hot dip galvanized, metalizing or sherardizing 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 the original thickness to the satisfaction of the Engineer.

J 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.

J 3.03 Hollow Metal Door Frames

Hollow metal doorframes shall be purpose made to the profiles and sizes shown on the drawings and obtained from an approved manufacturer. The door frames shall be from 1.5mm thick twice laminated steel sections and be delivered to site complete with a factory applied anti-corrosive plastic coating, ties cast on to backs of frames for building in and rubber silencers on the locking stile.

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, splits, and cracks and any defective frames shall be made good or replaced at the Contractor's own expense.

J 3.04 Aluminum Windows, Doors Fittings

The aluminum windows and doors etc... shall have all necessary accessories and fittings which shall be of European manufacture, and shall be of the pattern, design, dimensions and thickness shown on the Drawings.

J 4 WORKMANSHIP

J 4.01 Steel Elements

All steel parts shall be accurately set out, cut, galvanized, 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 epoxy 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 (800)mm.

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 true. 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 walls, 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.

J 4.02 Aluminum Windows and Doors

The Contractor shall furnish and install all aluminum units as indicated on the Drawings. Workmanship and installation shall be in accordance with recommended standards of First Class Aluminum Manufacturing.

All aluminum work shall be performed in a shop where grade of metalwork is of recognized quality acceptable to the Engineer. All items shall be installed plumb, straight, square, level and in proper elevation, plane location 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 aluminum surfaces come in contact with metals other than stainless steel, zinc, white bronze or small areas of other metals compatible with aluminum 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 aluminum metal-and-masonry paint or other suitable protective coating, excluding those containing lead pigments or a non-absorptive tape or gasket shall be placed between aluminum and dissimilar metals. Steel anchors and connecting members shall be hot dip galvanized or zinc plated after fabrication.

Aluminum 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.

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

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

The aluminum work shall be designed and anchored so that the work will not be distorted nor the fasteners overstressed from the expansion and contraction of the metal.

Before shipment from the factory, aluminum surfaces requiring protection shall be given a coating which will protect the metal during construction in areas where appearance of the finish on aluminum 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 aluminum 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 aluminum 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 aluminum work as required by removing protective tape or other coating, using mild soap or detergents and clear petroleum spirits.

Acids, caustics and abrasives shall not be used. Where cleaners are used to remove excess sealing 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 aluminum work until the completion of the works, and only units in perfect working order and in perfect condition shall be accepted.

J 4.03 Hollow Metal Door Frames

Hollow metal door frames shall be fixed as 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.

J 5 BALUSTRADES AND RAILINGS

Balustrades and railings shall be of the materials and made to the sizes, dimensions and designs shown on the drawings.

J 6 GLASS AND GLAZING

GENERAL

1.01 Description

This section includes supply and installation of glass, but is not limited to, the following works as indicated on drawings and specified herein:

- Aluminium Doors, windows and curtain walls
- Tempered glass doors.

- Glass as detailed in respective sections.

1.02 System Description

Tolerances

Deviation from flatness (overall bow and warped) of tempered glass surfaces shall not exceed the following dimensions:

Length of Surface Span in mm thickness	For 6mm glass Thickness	For 12mm and greater glass thickness
- 499	3 mm	1 mm
500 - 899	4 mm	1 mm
900 - 1199	5 mm	2 mm
1200 - 1499	6 mm	2 mm
1500 - 1799	8 mm	3 mm
1800 - 2099	10 mm	3 mm
2100 - 2399	12 mm	4 mm
2400 - 2699	15 mm	5 mm
2700 - 2999	19 mm	6 mm
3000 - 3299	-	8 mm
3300 - 3600	-	10 mm

For heat strengthened glass, in order to control the flatness, the glass supplier must ensure and if requested by the owner, demonstrate that the Compressive Surface Stress levels are between 3,500 and 7,000 psi.

1.03 Quality Assurance

Glazing Standards:

Comply with the recommendations of Glass Association of North America (GANA) "Glazing Manual" with except where more stringent requirements are indicated. This publication shall be referred for definitions of glass and glazing terms not otherwise defined.

Full quality assurance manufacturing process documentation shall be provided at regular intervals agreed with the Engineer for verification by the Engineer.

Safety Glazing Standard:

Required safety glass complying with ANSI Z97.1 and testing requirements of 16 CFR Part 1201 for Category II materials shall be provided.

Insulating Glass Certification Program.

Provide insulating glass units permanently marked with appropriate certification label of Insulating Glass Certification Council (IGCC) for inspecting and testing.

Glazier Qualifications:

Employ an experienced glazier who has completed glazing similar in material, design, and extent to that indicated for this project with a record of successful in service performance.

Single Source for Glass:

To ensure consistent quality of appearance and performance, provide materials produced by a single manufacturer or fabricator for each kind and condition of glass.

1.04 References

The following reference standards included in this section shall apply as specified:-

American National Standards Institute

ANSI Z97.1-1984, Safety Performance specifications and methods of test, glazing materials used in buildings.

The American Society for Testing and materials

ASTM C509-00, Elastomeric Cellular Preformed Gasket and Sealing Material.
ASTM C864-99, Dense Elastomeric Compression Seal Gaskets, Setting Blocks.
ASTM C1036-91(1997), Specification for Flat Glass.
ASTM C1048-97b, Heat Treated Flat Glass-Kind HS, Kind FT Coated and Uncoated.
ASTM E774-84a, Classification of the Durability of Sealed Insulating Glass Units.

British Standard Specification :-

BS 952, Glass for glazing.
Part 1: 1995 Classification.
Part 2: 1980 Terminology for work on glass.
BS 2571: 1996 General Purpose Flexible PVC Compounds for Moulding & Execution.
BS 3734: Rubber, Tolerances for Products.
Part 1: 1997 Dimensional tolerances
BS 4255 : Rubber used in preformed gaskets for weather exclusion.
Part 1: 1992 Non-cellular gaskets.
BS 5713 : 1994 Hermetically Sealed Flat Double Glazing Units.
BS 5889 : 1989 One part gun grade silicone based sealants.
BS 6206 : 1994 Impact Performance Requirements for Flat safety Glass and Safety Plastics
for use in Buildings.
BS 6262 : 1982 Code of Practice for Glazing for Buildings.
Part 4: 1994 Safety Related to Human Impact.

Federal Specification (U.S.A):

FS DD-G-451 D, Glass, Float or Plate, Sheet, Figured FS, Mirrors, Glass.
FS TT-S-001543A, Sealing Compound : Silicone Rubber Base

Glass Association of North America (GANA).

Glazing Manual 1880.

Glazing Sealing System manual 1990.

UNE : SPANISH STANDARD for bullet proof glazing

1.05 Submittals

Submit the following:

- Product Data: Manufacturer's technical data for each glazing material and fabricated glass product required, including installation and maintenance instructions. Indicate glass thicknesses to be used.
- Samples: 300mm square samples of each type of glass indicated, and 300mm long samples of each colour of gasket and sealant.
- Certificates: Certificates from respective manufacturers attesting that glass and glazing materials furnished for project comply with requirements of agencies having jurisdiction.
- Separate certification will not be required for glazing materials bearing manufacturer's permanent labels that represent a quality control program of a certification agency or independent testing laboratory acceptable to authorities having jurisdiction.
 - Certification that glass does not exceed the permissible stress by analysis.
- Compatibility and Adhesion Test Report:
- Statement from sealant manufacturer that glass and glazing materials have been tested for compatibility and adhesion, with interpretations and recommendations for primers and substrate preparation.

1.06 Site Conditions

Environmental Conditions.

Adapt techniques approved by the Engineer to ensure that storage, handling and execution methods suit environmental conditions that are encountered at the site, and cause no damage to the products specified in this section or to the performance of these products in use.

Follow recommendations of the supplier of the products.

Environmental conditions shall include, but shall not be limited to, ambient temperature; humidity; moisture in the air and on the products and surfaces with which they are in contact; moisture content of the products and the materials with which they are in contact.

All components will be marked indicating their location.

Check material upon handling.

Cover with waterproof paper or polythene sheeting.

1.07 Warranty

The Contractor shall submit warranties to repair or replace defective glass and glazing materials or workmanship for a period of 10 years after date of issue of the Substantial Completion Certificate, or longer where specified. Defects include, but are not limited to the following:

- Glass breakage due to pressures up to specified values, thermal stress, manufacturing defects and damage to glass.
- Spontaneous breakage of heat treated glass.
- Loss of effective glass bite due to shifting of glass.
- Loss of effective glass bearing on setting blocks due to shifting of glass and/or blocks.

2 PRODUCTS

2.01 Manufacturer

AGC, Guardian, PPG, St. Gobain or Approved Equivalents

2.02 Materials

Glazing materials shall be incorporated in glazing system only if they are compatible with each other and they are suitable for substrate material and conditions as recommended by sealant manufacturer.

Unit rates include the following:

- All glazing shall be soft coated Low E by authorized factory.
- Where coated or painted glass is required, paint coat shall be ceramic paint to the required color.
- Ceramic dot shading shall be applied to the sections as directed by the engineer and to the required intensity.
- All glazing panels shall provide acoustic performance so that interior noise shall be limited to maximum 35 DB, irrelevant of external noise level. The contractor shall, within the unit rate prices, adjust the thickness, number of layes, and the required gap / gaps, to arrive at the requested DB level.

Label each piece of glass, and each container of glazing compound or sealant to indicate manufacturer, type, and quality. Leave labels on glass until final cleaning. Blue and clear Tempered glass LE 40, clear toughened glass, versalux blue RC reflective with black opaquing film, annealed glass, shall have permanent identification imprinted at an inconspicuous corner of each glass panel.

2.03 Primary Float Glass Products

Float Glass ASTM C1036, Type I (Transparent glass, flat Class as indicated below, and Quality q3 (glazing select).

- Class 1 unless otherwise indicated.
- Class 2 toughened glass.

Refer to coated glass product requirements for tint colour and performance characteristics of coated tinted glass for monolithic glazing relative to visible light transmittance, U- values, shading coefficient, and visible reflectance.

Refer to requirements for sealed insulating glass units for performance characteristics of assembled units composed of tinted glass, coated or uncoated, relative to visible light transmittance, U-values,

shading, coefficient, and visible reflectance.

2.04 Heat-Treated Float Glass Products

Fabrication Process: by horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as indicated, unless otherwise indicated. Tong-held method is not acceptable.

Uncoated, Clear, Heat-Treated Float Glass: ASTM C 1048, Condition A (uncoated surfaces), Type I (transparent glass, flat), Class 1 (clear), Quality q3 (glazing select), kind as indicated below:

- Kind HS (Heat Strengthened) where indicated.
- Kind FT (Fully Tempered) where indicated.

Coated, Clear, Heat-Treated Float Glass: ASTM C 1048, Condition C (other coated glass), Type I (transparent glass, flat), Class 1 (clear), Quality q3 (glazing select), with coating type and performance characteristics complying with requirements specified under coated glass products; kind as indicated below:

- Kind HS (Heat Strengthened) where indicated.
- Kind FT (Fully Tempered) where indicated.

Tempered glass shall comply with ANSI Z97.1 and shall be heat checked or heat soaked.

2.05 Heat Soaking of Tempered Glass

All tempered glass shall be subject to heat soaking tested prior to delivery to site. The Contractor shall provide documentary evidence of heat soaking testing duly certified by the agency conducting the heat soaking.

2.06 Types of Glass used

A. G1:

Glass used for Curtain walls and windows

Thermal heat insulation and solar control with Medium light transmittance; please find below the glass specs:

Color : As directed by the engineer
Reflectivity : Low
Light transmission : Medium
Energy transmission : Low
UV transmission : Low

The glass composition will be as follows

6mm clear tempered glass
16mm Argon gas filled space
6mm clear annealed glass

Parameters	Solar E
Light transmittance	27%
Solar Energy Transmittance	22%
Solar Energy Reflection	16%
Light Reflection - In	10%
Light Reflection - Out	15%
U-Value Winter	1.3 W/m ² /K

B. G2:

Glass used for Glass walls (Single Point Fixing System or Glass Clamp Mounting System)

Medium light transmittance; please find below the glass specs:

Color : As directed by the engineer
Reflectivity : Low
Light transmission : Medium
Energy transmission : Medium
UV transmission : Low

The glass composition will be 12mm or 10mm tempered glass with holes.

Parameters	NN-40 on Blue
Light transmittance	28%
Solar Energy Transmittance	25%
Solar Energy Reflection	17%
Light Reflection - In	10%
Light Reflection - Out	15%
U-Value Winter	5.3W/m ² /K

2.07 Mirrors

The glass shall comply with B.S. 952, with pre-drilled fixing holes. Silvering shall be protected against moisture by an electro-copper shellac varnish and painted backing. Mirrors shall have aluminium frames, fixed with 2mm galvanized steel hooks plate glued to back of mirror, 2mm bent galvanized sheet mirror hook support, 6mm x 60mm lug screws with plastic lug and self adhesive as shown on Detailed Drawing. Thickness of mirror shall be 6mm.

2.08 Glazing Sealants

General: Comply with the following requirements:

Elastomeric Sealant Standard:

- Provide elastomeric sealant which complies with ASTM C 920 requirements.
- Structural sealant : Tremco Proglaze II or Dow Corning 983 or GE Ultra glaze SSG 4200.
- Non-Structural sealant: Tremco Spectrem 2 or Dow Corning 791 or 795 or GE Sil-pruf.

2.09 Miscellaneous Glazing Materials

Glazing Tape

Preformed macropolyisobutylene with continuous integral shim, to meet specified requirements of ASTM C509, with Shore 'A' hardness of 40 to 60, and constructed so that tape compresses to shim without great force being applied or glass breakage occurring. Tape type and colour shall be as approved by Engineer.

Compression Seal Gaskets

Preformed neoprene, EPDM or thermoplastic polyolefin rubber of hardness required to maintain complete seal under conditions of use for each application, and to meet specified requirements of ASTM C864.

Cleaners, Primers and Sealers

Type recommended by sealant manufacturer.

Setting Blocks

Neoprene, EPDM or silicone blocks as required for compatibility with glazing sealants, 80 to 90 Shore A durometer hardness, 100mm minimum length by width to suit glass thickness.

Shims and Spacers

Shims and spacers used with setting blocks shall be of the same material, hardness, length and width as the setting blocks.

Edge Blocks

Same material as setting blocks, of 50 to 60 Shore A durometer, of size to limit lateral movement of glass.

2.10 System Performance Requirements

Provide glazing systems that are manufactured, fabricated, and installed to withstand normal thermal movement, wind loading, and impact loading (where applicable), without failure including

loss or glass breakage attributable to the following: defective manufacture, fabrication, and installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; and other defects in construction.

2.11 Glass Design

Glass thicknesses indicated on the drawings and herein are the minimum thicknesses required. Confirm glass thicknesses by analyzing project loads, and in-service conditions. Provide as deemed included in the unit rates glass for the various size openings in the thicknesses and strengths (annealed heat-strengthened or fully tempered) to meet or exceed the following criteria:

Minimum glass thicknesses for exterior conditions shall be determined utilizing the methods of ASTM E1300 and the test methods of ASTM E997 and E998.

Minimum thickness shall be determined using the most stringent of these requirements and based on a maximum deflection of 3mm.

Minimum glass thicknesses, whether composed of annealed or heat-treated glass, are selected so that the worst-case probability of failure does not exceed the following:

- a) 8 lites per 1000 for glass set vertically or not over 15 degrees off vertical and under wind action.
- b) 1 lite per 1000 for lites set over 15 degrees off vertical and under action of wind.

Normal thermal movement resulting from a maximum change (range) of 50 degree C in ambient and surface temperatures acting on glass-framing members and glazing components, based on engineering calculation on actual surface temperatures of materials due to both solar heat gain and night time sky heat loss.

Provide glass types as shown on the Architectural drawings as follows:

- a) All vision glass to be insulated except where supported on two edges only.
- b) All glass in doors, adjacent to doors, or within 800mm of a walking surface to be Fully Tempered or Laminated Safety Glass.

3 EXECUTION

3.01 Installation

General

Install materials in accordance with manufacturer's specifications, and specified Flat Glass Marketing Association manuals or BS 952 and 85 6262. Ensure that each material in a glazing system is compatible with the others.

Ensure that projections have been removed from rebates and that sufficient width and depth clearances are provided for specified glass.

Remove stops and store during glazing to avoid damage to them.

Remove excess glazing sealant from adjacent surfaces, including glass, during working life of material and by methods not harmful to the surfaces.

Collect broken glass and cuttings in boxes and remove from site.

Do not set any glass without glazing beds or gaskets.

Securely anchor in place, level, spacing between glazing units and concrete.

3.02Glass

Cut glass to fit openings and to allow clearances which will ensure that glass is held firmly in place and is not subjected to stresses.

Ensure that glass edges are clean cut, not nipped or seamed.

Do not cut or nip tempered glass to fit. Replace oversize or flared lites with entirely new units of proper dimensions.

3.03Preparation and Methods

Clean glazing rebate surfaces of all traces of dirt, dust, or other contaminants.

Use glazing sealants without addition of thinners and from only containers with seals unbroken until opened for use.

Prime all glass rebates except for aluminum unless specified otherwise by the manufacturer of the sealant utilized. Primer shall be suitable for materials affected.

Ensure that glazing sealants and tapes are in full contact with glazing surfaces.
Tool gunned sealants with a slight bevel, away from glass faces.

3.04 Tape Bedding at Fixed Stops

Cut tapes of full depth of stop accurately to length on a work table. Set sill and head tapes first at full length of rebated opening. Butt jamb tapes into sill and head tapes tightly to weld them together. Remove protective paper backing only when glass is ready for setting, and ensure that butted joints of tape are positively filled with applied sealant.

3.05 Tape Bedding at Stop Beads

Apply tape to removable stops as specified for fixed stops. Press stops into place and fasten if design requires.

3.06 Protection

Promptly protect installed glass from breakage with crossed streamers attached to framing and held away from glass. Do not apply markers to surfaces of glass. Remove non-permanent labels and clean surfaces.

Protect glass from contact with contaminating substances. If contaminating substances do come into contact with glass, remove immediately as recommended by glass manufacturer.

Following glazing, Mark each light of glass, except heat absorbing, to indicate its presence with a material, easily removable and harmless to glass.

3.07 Adjustment and Cleaning

Replace scratched, etched, or defective glazing resulting from manufacture, setting, handling, or storage before or during installation. Glass accidentally broken or physically damaged, by other than faulty glazing or materials, after glazing by this section has been completed shall be replaced as specified.

Final Cleaning of glass to be as specified.

Remove stains, deposits, marks or blemishes caused by this section from surfaces of all materials exposed to view. Replace materials that cannot be cleaned as new. Operation of windows should allow for cleaning from inside.

Wash glass on both faces not more than 4 days prior to date scheduled for inspections to establish date of issue of the Substantial Completion Certificate in each area of the Project. Wash glass as recommended by glass manufacturer.

3.08 Glazing Schedule

Various types of glazing shall be used as detailed hereunder and as indicated on drawings (LEGEND) and specified in this section and other relevant sections.

Type "a" Insulating Glass Units – Vision Panel

Outer lite - minimum 6mm (1/4') thick clear annealed glass Low E coated.

Air Space - 16 mm (5/8").

Inner lite - minimum 6mm (1/4') thick clear annealed glass.

Type "b" single tempered Glass Units

Outer lite - minimum 12mm (1/2') thick tempered white glass, frameless.

All glazing to be safety glass up to minimum height of 800mm from floor level and next to openings in accordance with BS 6262 Part 4.

END OF SECTION



SECTION-K: FLOOR, WALL AND CEILING FINISHINGS

K1 GENERAL

This Section of the Specifications covers plasterwork and other floor, wall and ceiling finishes intended for the works all in accordance with the Drawings, Bills of Quantities and as directed by the Engineer.

The Contractor shall attend upon other trades and protect all works specified under this section from damage during subsequent operations, make good any defects, clear away debris upon completion clean throughout and leave all work in perfect condition to the satisfaction of the Engineer's Representative.

The Contractor shall be responsible for the design and stability of the scaffolding and for all safety precautions in connection with works specified under this section.

Damaged or defective materials shall not be used in the Works. Any defective materials or material damaged during or after installation shall be removed and replaced at the Contractor's expense.

K2 MATERIALS, GENERAL

The cement and water used for plastering shall be as before described in Section C - Concrete Work, and the sand shall be as before described in Section D - Blockwork.

White (nonstain) cement for tinted plaster shall conform to the requirements of the Standard Specification for Masonry Cement of the ASTM Designation (C-91) latest edition.

Lime shall be imported and of the hydrate type complying with Class B of B.S. 890.

Marble chippings shall be irregular in size and roughly cubical in shape. Samples shall be submitted to the Engineer for approval. Sizes shall be as required by the Engineer and as selected from the following table:

Sizes			Percentage Passing by weight
B.S. Sieve No.	Approximate mm	Inches	Marble Chippings
	13.00	1/2	-
	10.00	3/8	95-100
	5.00	3/16	25-60
7	2.40	0.095	5-30
14	1.20	0.047	0-10
25	0.60	0.024	-
52	0.30	0.012	-
100	0.15	0.006	-

Any pigments or coloring materials incorporated in mortar shall comply with B.S. 1014: 1961.

Waterproofer additives shall be to the approval of the Engineer. The materials shall be delivered in containers bearing the name of the manufacturer and the instructions for use.

Angle beads, casing beads and shop beads where shown on the drawings shall be galvanized steel 26 gauge or pressed steel 24 gauge complying with B.S. 1246.



Metal lath for use in plaster shall be plain expanded metal type complying to B.S.1369, weighing not less than 1 Kg/sq.m. All metal lathing shall be zinc coated.

Metal lath shall be secured to the carcass and blockwork by means of galvanized steel nails. If the wire for securing metal lath is to be used, it shall be of zinc coated wire not less than 1.2mm. in diameter.

Plaster expansion joint strips, where shown on the Drawings or indicated in the Bills of Quantities, shall be of aluminum channels maximum size 20 x 20 mm. and 1 mm. thick and shall be perforated at sides to form a suitable bond to plaster.

K 3 PLASTERWORK

K 3.01 Mixing of Ingredients

Except where hand mixing of small batches is approval by the Engineer, mechanical mixers of an approved type shall be used for the mixing of plaster.

Frozen, caked or lumped materials shall not be used.

Mechanical mixers, mixing boxes and tools shall be cleaned after the mixing of each batch and kept free of plaster from previous mixes. Plaster shall be thoroughly mixed with the proper amount of water until uniform in color and consistency. Retempering will not be permitted and all plaster that has begun to stiffen shall be discarded.

All plastering shall be executed in a neat workman like manner and internal and external angles shall be true, straight and plumb. Plaster shall be made good adjacent to wood or metal frames, skirtings and around pipes or other fittings at no extra cost.

All tools, implements, vessels and surfaces shall at all times be kept scrupulously clean and strict precautions shall be taken to avoid the plaster or other materials becoming contaminated by pieces of partially set material which would tend to retard or accelerate the setting time.

K 3.02 Preparation of Surfaces

All surfaces to be plastered shall be clean and free from dust, grease, loose or projecting mortar and all traces of salts are to be thoroughly sprayed with water, but all free water shall be allowed to dry and disappear from the surface before the plaster is applied.

Plastering shall not be commenced until the background has been suitably prepared. Blockwork joints shall be deeply raked out, efflorescence brushed off and all dust and foreign matter removed.

Before plastering is commenced all junctions between differing materials shall be reinforced. This shall apply where walls join columns and beams, particularly where flush, and similar situations where cracks are likely to develop and as directed by the Engineer. The reinforcement shall consist of strip of galvanized wire mesh (10 to 15mm hexagonal mesh) 15 cm wide which shall be plugged, nailed or stapled as required at intervals of not exceeding 45cm at both edges. The reinforcement is to be included in the plastering unit price.

On all external surfaces and on all smooth internal surfaces, spatter dash of cement and sand that shall contain 500 kgs of cement per one-meter cube of sand shall be applied and allowed to dry before rendering is



commenced. All surfaces of walls shall be wetted immediately prior to applying the first coat of rendering and this shall be allowed to thoroughly dry out before the next coat is applied.

The Contractor shall form vertical guide screeds 5 cm wide. The spacing shall not exceed 1.50 meters.

The screeds shall be plumb and in the same plane with each other. The sides of the screed shall be left rough to bond with plaster, the surface shall be smooth.

The finished surface shall be true to shape and angle and even in all directions, with straight arises free from cracks and trowel marks and to the entire satisfaction of the Engineer.

K 3.03 Application of Coats

a) Base-Coat (Rendering)

After the application of the spatterdash "Rasheh" the base coat shall be applied after the spatterdash coat has set but in no case earlier than 24 hours after the application of the spatterdash coat.

When applied to masonry or to concrete surfaces the base coat shall be applied with sufficient force to prevent air pockets and to secure a good bond.

The base coat shall be lightly scratched in both directions to provide a key for the finishing coat and shall be kept moist with a fog spray for 2 days and then allowed to dry out.

b) Finishing Coat

Shall not be applied until the rendering or base coat has seasoned for seven days; just before the application of the finish coat, the rendering or base coat shall be wetted evenly with a fog spray. Where cement plaster with a smooth trowelled finish is specified or indicated on the drawings, the finish coat shall be first floated to a true even surface, then trowelled in a manner that will force the sand particles down into the plaster and with the final toweling, leave the surface finished smooth and free from rough areas, trowel marks, checks or other blemishes.

Cement plaster in all other spaces, where a smooth finish is not specified or noted on the drawings, shall be given a sand float finish or a uniform texture, as approved by the Engineer.

The finish coat shall be kept moist with a fog spray for at least two days, and thereafter shall be protected against rapid drying until properly and thoroughly cured.

Plaster shall be made good up to frames and skirting and around fittings and pipes. Angles shall not be rounded.

K 3.04 Proportions for Internal and External Plaster

Internal and external plaster shall be composed of 400 kg of cement per one cubic meter of salt free sand.

Plastering shall be applied in two (2) coats unless otherwise specified or indicated on the drawings.

Finishing coat shall have a reasonably uniform thickness of approximately 2mm.

Screeds shall be laid and ruled as necessary to allow for a total thickness of 15mm for external and internal plaster and the rendering shall be applied to the required thickness.



K 3.06 Metal Lath

At all junctions of dissimilar materials (i.e. concrete and blockwork or steel elements the joint shall be covered by metal lath strips not less than 200mm in width securely fixed to the surface.

K 4 TYROLEAN PLASTER (FINE GRAIN)

K 4.01 General

The Tyrolean plaster shall be executed to the extent shown on the Drawings and as directed by the Engineer.

The Contractor shall provide sample (s) of Tyrolean plaster for the approval of the Engineer prior to commencement of Tyrolean work.

K 4.02 Mixing

Cement and aggregate for each batch shall be accurately measured and mixed dry until evenly distributed and the mass is uniform in color. All batches shall be of such size that they can be entirely used within half an hour. Mechanical mixers of an approved type shall be used for mixing Tyrolean plaster, except when hand mixing of small batches is specifically approved by the Engineer. Mechanical mixers, mixing boxes and tools shall be cleaned after mixing each batch and kept free of Tyrolean mortar from previous mixes. Water content shall be maintained at a minimum. Mixing shall be continued until plasticity is obtained.

K 4.03 Proportions

Proportions of materials for Tyrolean, by volume shall be as follows:-

a) Scratch Coat

- 1 part ordinary Portland Cement
- 2 parts fine aggregate

b) Finish Coat

- 1 part of white Portland Cement
- 2 parts fine selected aggregate

No lime shall be allowed in either scratch or finishing coat, scratch coat shall be set on spatterdash.

K 4.04 Application of Tyrolean

a) Workmanship

Surfaces to receive Tyrolean shall be clean, free from dust, dirt, oil, or other particles that might interfere with a satisfactory bond. Surfaces to receive Tyrolean shall be evenly dampened (not soaked) with a fog spray before Tyrolean is applied. If surfaces become dry in spots, the dry areas shall be dampened again to restore uniform suction. Tyrolean coats shall be applied continuously in one general direction without allowing mortar to dry at edges. Edges to be jointed shall be dampened slightly to produce a smooth confluence. Tyrolean, unless otherwise shown or specified shall be two coats work not less than 20mm. thick (i.e. spatterdash, scratch coat and one time tyrolean coat).

All exterior corners of tyrolean shall be slightly rounded. Tyrolean on soffit surfaces shall be pitched forward to form a drip.



b) **Scratch Coat**

Shall be approximately 14 mm. thick and shall be applied under sufficient pressure to form good keys and shall be brought to a plumb, true even surface. The scratch coat shall be damp-cured 48 hours before the finish coat is applied.

c) **Finish Coat**

Shall be approximately 6mm, thick. Surfaces of the scratch coat shall be dampened several hours before the finish coat is to be applied. Additional dampening at time of application shall be by fogspraying. Dampening by brush will not be permitted. When measured with a 2 meter long, straight-edge applied in all directions, the finish surface shall not vary from a true plane by more than 1.5mm. The finishing coat shall be applied by means of a proper spraying machine and the degree of the finishing coat shall be determined by the Engineer. The Contractor shall set up samples of different degrees of fineness for the Engineer's approval. The Engineer may choose different degrees of fineness for different parts of the works and the Contractor shall allow for this in his rates.

d) **Curing**

As soon as the finish coat has taken its initial set, the Tyrolean shall be protected against direct rays of the sun or rapid drying for at least 10 days.

During this time Tyrolean shall be kept moist by frequent fog, spraying. Care shall be taken to prevent staining of the Tyrolean.

c) **Acceptance and Repairing**

Tyrolean with cracks, blisters, pits, checks or discolorations will not be accepted. Tyrolean shall be clean and sound and in accordance with the requirements of the Specifications. After all other related work has been completed, pointing around trim and set work and repairing of damaged portions shall be performed to the satisfaction of the Engineer. Repairs shall match existing Tyrolean in texture and color to the satisfaction of the Engineer.

K 5 BEDS, AND BACKINGS

Cement and sand beds and bedding under floor finishings and backing behind wall and column finishings shall be cement and sand (1: 3) mix by volume unless otherwise specified.

K 6 CEMENT SCREED TO CHANNELS

Cement screed shall, unless otherwise ordered by the Engineer, consist of one part of ordinary Portland Cement to four parts of sand by volume. The ingredients shall be proportioned and mixed as specified under Concrete Work and laid to falls with smooth trowelled finish as shown on the drawings.

K 7 PRECAST CONCRETE PAVING

K 7.01 General requirements :

In addition to the requirements of Section C-Concrete Work, precast concrete tiles shall comply with the following :

- Mix design shall be approved by the Engineer before placing concrete.
- Compressive strength of precast concrete shall be not less than 270 Kg/cm² at 28 days.
- Slump shall not exceed 7.5 cm.
- Color of top surface shall be uniform throughout the paved areas for each type of paving, as color additive is



not acceptable.

For each type of paving the Contractor shall submit samples together with the mix design for approval and the approved samples shall be used as the standard color throughout the job.

K 7.02 Fabrication

Concrete shall be mixed and handled as specified in Section C-Concrete Work.

Moulds shall be metal or high density plywood or plastic and shall be watertight and rigid to produce the required shape, size and wearing surface.

Slabs shall be reinforced; details of reinforcement shall be submitted to the Engineer for approval.

Where slabs are required to have a non-slip wearing surface, the wearing surface shall contain non-slip aggregate such as sintered aluminum oxide, carborundum or other equal and approved. The wearing surfaces of slabs shall be not less than 10 mm. thick and shall be backed with concrete backing of a mix as to withstand the use to which the slabs would be subjected.

The abrasive aggregate shall be soaked in water overnight before use and all surface water shall be drained before the aggregate is to be incorporated into the wearing surface.

The abrasive aggregate shall be incorporated uniformly into the wearing surface at the rate of not less than 1.22 kgs/m² of surface.

The slabs shall be cast in such a way that the nonslip aggregate will be as near the wearing surface of the slab as possible.

After curing the slabs shall be laid out and floated with power floats or screeders so as to remove the cement grout from the surface of the slabs.

The finished wearing surface shall be such as to enable bare footed persons to walk without there being any danger of slipping.

All wearing surfaces of slabs shall be even in color and consistency so that when laid in position all paved areas present uniformity in color and grain free from discoloration.

Edges of all slabs shall be straight and perfectly at right angles with the wearing surface free from weaviness, chipped arises and other defects.

Curing: All slabs shall be cured by totally immersing them in water for at least 24 hours after the initial set has taken place and allowed to mature for a period of 28 days before transporting and laying.

K 7.03 Laying

The design of the pattern of precast concrete paving shown on drawings shall be accurately adhered to when laying slabs.

Mortar setting bed shall be composed of 1 part cement to 4 parts sand and mortar shall be applied over sand



bed underlay of the required thickness to bring the top surfaces of the slabs to the required level. Mortar setting bed shall only be applied to an area which can be covered with slabs before mortar reaches its initial set. Minimum thickness of mortar shall be 30 mm.

Sand underlay and setting bed shall be tamped to true planes level or pitched to drains as required and as shown on drawings so that the wearing surface of the completed paving will be at elevations and grades indicated on drawings.

Slabs shall be laid on a full mortar bed with joints of uniform width and to patterns shown on drawings. If no pattern is indicated all slabs shall be laid with continuous joints running in both directions.

All slabs shall be pointed on completion with cement and sand mortar 1: 3 to match the color of the wearing slab surface. The mortar shall be of such a consistency as to fill the joints thoroughly throughout their depth, any raking out of joints shall be carefully performed so as not to damage the edges of slabs.

K 8 Terrazzo Tiles

Terrazzo tiles shall be formed with a (1:2 1/2) mix of white or coloured cement or white cement with a colour pigment added and granular marble chippings applied as a facing not less than 5 mm thick to a Portland cement and sand (1:5) mix backing.

The tiles shall be cast in heavy metal moulds under pressure to the proportions and sizes shown in the following table.

Terrazzo Tile Dimensions

Size mm	Size tolerances mm	Minimum total thickness mm
200x200	0.5	20
250x250	0.5	25
300x300	1.0	25
400x400	1.0	30

Tiles shall be cured as for cement and sand tiles and then ground, filled, polished, and cured before distribution to site.

Grinding shall be done wet by means of a No. 80 carborundum stone. Filling shall be carried out with a neat cement grout of the same colour as the facing mix and this shall be worked into the surface with a wooden shaper to fill all voids and air holes.

Surplus grout shall be removed with a dry cloth. After a minimum period of 24 hours polishing shall be carried out wet by means of a No. 140 carborundum stone.

Terrazzo skirtings 100mm or 200mm high with chamfered top edges shall be produced in the same way as for tiles using the same mixes.

Terrazzo tiles shall be laid and bedded direct onto a sand layer with a cement and sand (1:4) mix mortar. This mortar shall be 25mm thick in the case of 25mm tiles and 30mm thick in the case of 20mm tiles. The total thickness of the cement and sand screed and tiles shall not exceed 50 mm.



All tiling shall be grouted up on completion; care being taken to fill all joints completely. The grout shall consist of neat cement of a colour to match the tiling. Any surplus grout shall be cleaned off the face of the tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned off.

All terrazzo surfaces shall be polished on completion. Large areas such as floors shall be wet polished by means of approved machines using No. 140 carborundum wheel. Any surface too small for convenient machine polishing may be polished by hand using a No.140 carborundum stone and water. Care must be taken during any polishing operation not to damage any of angles or arises.

Terrazzo covering to items such as sills, treads and risers to steps, skirtings etc., shall generally be applied in accordance with the foregoing specification except that the thickness of the facing shall be at least 10 mm (marble can be used if approved by the Engineer).

K 9 PORCELAIN (STONEWARE)

A GENERAL

A.1 Description

Porcelain tiles shall be supplied and fixed for flooring and where designated in the Drawings. It shall be obtained from Italian quarries, cut and polished to sizes and thicknesses indicated on the Drawings and as scheduled in the Bills of Quantities. The Engineer shall be responsible for selecting for colour and figuration and, once selected, the consistency of quality and colour shall be maintained throughout the whole Contract. No allowance shall be made for tiles rejected because of surface deficiencies, and filling of holes shall not be allowed.

All Porcelain tiles shall be full bodied, rectified to the dimensions on the drawings.

All dressing and polishing of the porcelain shall be carried out at an approved factory and samples for approval by the Engineer shall be submitted. When approved, the samples shall be retained on Site in the Site Engineer's office and checked against all porcelain supplied for quality of workmanship. Tiles flooring shall be delivered to the site having a final polished surface finish, further polishing on site shall only be required if the surface finish is impaired by construction traffic or materials.

Extreme care shall be taken to protect the polished surface finish during handling and fixation. After tiles are fixed to the floors, the entire tiled area shall be covered with protective sheeting until such time when the Engineer will order the removal of cover.

A.2 PORCELAIN PROPERTIES

Polished porcelain tiles used shall comply with the characteristics given in the following tables.
(Porcelain)

Legend

A.	Quarrying Location	:	Italian
B.	Prevailing Applications	:	Interior
	Bending strength	:	50N/mm ²
C.	Resistance to deep abrasion	:	128 mm ³



D.	Thermal expansion coefficient	:	6.2 MK
E.	Thermal shock resistance		resistant
F.	Water Absorption	:	0.01% to 0.05%
E.	Frost resistance		Frost proof
F.	Chemical resistance		Unaffected
G.	Color resistance to light		No change in brightness or color
H.	Stain resistance	:	Resistant to stain

K 10 Ceramic Floor Tiling

Ceramic floor tiles shall be first quality vitreous clay non-slip tiles with keyed backs and a minimum 8 mm thick of the sizes indicated on the drawings to comply with B.S. 1286 type B and shall be obtained from an approved manufacturer. The color and pattern of the ceramic tiles shall be as shown on the drawings and as stated in the bills of quantities. Samples shall be submitted to the Engineer for his approval prior to order.

Ceramic floor tiles shall be laid on top of cement sand screed (1:3) mix of predetermined level such that total thickness of screed bonding layer and tiles shall be as shown on the drawings or mentioned in the Bills of Quantities with a minimum of cutting. The tiles shall be thoroughly soaked in water for a minimum of twenty four (24) hours before laying. Tiles and skirtings shall be bedded in cement and sand (1:3) mix with addition of approved plasticisers.

All joints shall be as uniform as possible and spacers shall be used to width as shown on drawings or directed by the engineer and shall in no case be less than half (0.5) mm in width on face. Tiles shall be neatly cut and fitted around pipes and other obstructions.

A thick creamy slurry of neat white or tinted cement mixed with sufficient water shall be brushed over the floor until all joints are thoroughly filled.

The surface of the floor shall be very gently rubbed with a wood block to bring tile surface to true planes, excess slurry shall be removed, and the floor shall be rubbed with burlap to clean the tiles and finish the joints to the satisfaction of the Engineer.

K 11 Granite Porcelain Wall Tiles

Glazed tiles shall be best quality white or colored glazed porcelain wall tiles to the sizes stated on the drawings conforming to B.S. 1281 and shall be obtained from an approved manufacturer. Colored or patterned tiles shall be as shown on the drawings and as stated in bills of quantities.

Cement and sand (1:4 nominal mix) plaster eight (8) mm thick shall be laid as base for wall tiling. The surface of plaster shall be scratched in an approved manner, when nearly set, to form key. The surface of the plaster shall be well wetted before the tiling is applied. Plaster shall be cured for five (5) days before starting application of tiling.

Tiles shall be set in cement and sand mortar (1:3) mix, to a true vertical face with continuous horizontal and vertical joints. Joints shall be straight, level, perpendicular and of even width not exceeding 1.0 mm. The vertical joints shall be maintained plumb for the entire true level and plane by uniformly applied pressure under a straight-edged or rubber-faced block, misfits as well as damaged or defective tiles shall be removed and



replaced by and at the Contractor's expense.

The external, internal angles, top edges and side edges of glazed wall tiling shall be formed with roundly edged tiles.

All joints shall be as uniform as possible and spacers shall be used to width as shown on drawings or directed by the engineer and shall in no case be less than half (0.5) mm in width on face. Tiles shall be neatly cut and fitted around pipes and other obstructions.

Joints shall be grouted with a factory made, colored, anti-bacterial mix, immediately after a suitable area of tile has been set.

The joints shall be tooled slightly concave and the excess mortar shall be cut off and wiped off with a damp cloth from the face of tile, before it sets hard.

Interstices or depressions in the mortar joints after the grout has been cleaned from the surface shall be roughened at once and filled to the spring line of the cushion edge before the mortar begins to harden.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes, etc., it shall be carefully cut and fitted to form a close neat joint. Open irregular joints filled with cement and sand or plaster will not be permitted.

Immediately after the grout has had its initial set, glazed wall tile surfaces shall be given a protective coat of non-corrosive soap or other approved method of protection and joints cured for 72 hours.

K 12 MARBLE TILING & STAIRS

Marble for tiling and stair treads, risers, skirtings, and the like shall be first quality marble of the type, color, and dimensions as stated on the drawings and bills of quantities, obtained from an approved supplier.

The marble slabs shall be of the dimensions and thicknesses shown on the drawings and in the Bills of Quantities and shall be uniform in color and texture, smooth and free from voids, earth veins, lamination and the like, and shall be of an approved color and to the pattern and sizes shown on the drawings.

Samples of marble slabs shall be submitted to the Engineer for approval prior to order.

Marble slabs shall be cut square, true and shall be uniform in shape and thickness. Mortices shall be carefully cut without causing any damage to marble, and rebates shall be carefully formed by special machines to the width and depth required to the satisfaction of the Engineer.

Marble slabs and marble treads shall be laid on a bed of sand with white cement and sand mortar (1:3) mix.

All marble slabs shall be backed with stain proofing in accordance with the manufacturer's instructions.

Marble skirtings and risers shall be bedded with same mix as for floor marble but without the bed of sand.

All joints shall be as uniform as possible and shall in no case exceed half (0.5) mm in width on face. Tiles shall be neatly cut and fitted around pipes and other obstructions.



All joints shall be thoroughly grouted with unstained cement and cleaned well before it sets hard.

All exposed faces and edges of marble shall be polished smooth, free from scratches or other defects and properly protected from damage by means of timber casings.

All workmanship shall be of the best of its kind and shall be carried out in a manner satisfactory to the Engineer.

K 13 MARBLE THRESHOLDS

Unless otherwise shown on the drawings or stated in the Bills of Quantities, marble thresholds shall be first quality marble as shown on drawings obtained from an approved manufacturer. Thresholds shall be of the thickness and widths shown, of one piece and full length of the opening, leveled on both sides with hone finish on all exposed surfaces, Ends of thresholds shall be fitted accurately to jambs. Color as stated on the drawings and bills of quantities.

K 14 TILE AND MARBLE JOINTS

Joints, after the edges of tiles have been thoroughly wet, shall be grouted with a factory made, colored, anti-bacterial mix, immediately after a suitable area of tile has been set.

K 15 PROTECTION AND CLEANING MARBLE

Great care shall be taken to protect delivered and erected marble from chipping and staining during the course of the work. Delivered marble shall be stored in a water free area on raised platforms and shall be covered with tarpaulins or similar material until required for use.

Erected work shall be protected at corners, etc., with non-staining wood formwork, boards, etc. Floors shall be protected with suitable boarding, etc. after laying. Any work damaged or stained at the time of handing over shall be replaced or cleaned as required by the Engineer.

After completion of setting, all marble work shall be thoroughly cleaned by scrubbing with fiber brushes and mild alkaline solution that contains no caustic or harsh fillers. The use of wire brush or acid solution will not be permitted. Cleaning shall begin at the top of the building and proceed downwards. Upon completion all marble shall be left clean and free from stains or traces of cleaning fluid and with all joints pointed and to the entire satisfaction of the Engineer.

K 16 FLOOR DRESSING

The granular abrasive powder shall be trowelled into the finishing surfaces of the screed applied as desired hereinabove, working out of the dressing shall strictly conform to the method of application recommended by the manufacturer of material.

K 17 FLOOR SEALING

The floor seal shall be applied on the surface of screed which have been prepared and applied as described hereinabove. Screed shall be cured for a minimum of five (5) days before application of floor seal.

The priming and the working out of the floor seal shall strictly conform to the method of application



recommended by the manufacturer of the material.

K18 FLOORINGS

K 18.01 Heavy Traffic and Extra Duty Unbacked Matting

A General

A.1 Summary

Section includes rubber mat with recessed aluminum frame.

A.2 Submittals

- a- Shop Drawings: Indicate dimensions, special crest inlay design.
- b- Product Data: Submit data indicating mat characteristics, component dimensions, recessed frame and details.
- c- Samples: Submit one sample, (300 x 300mm) in size illustrating pattern, color, finish and edging.

B Products

B.1 Components

Rubber Mat: hard wearing roll up entrance matting with aluminum profile 22mm height to rubber; color as selected size as indicated in drawings

B.2 Fabrication

- a- Construct recessed rubber mat frames square, tight joints at corners, rigid. Coat surfaces with protective coating where in contact with cementations materials.
- b- Fabricate mats in single unit sizes; fabricate multiple mats where indicated.

C Execution

C.1 Examination

Verify floor opening for mats are ready to receive work.

C.2 Preparation

Verify size of floor recess before cutting mats.

C.3 Installation:

- a- Install mat frames to achieve flush plane with finished floor surface.
- b- Install mats in floor recess flush with finish floor level after cleaning or finish flooring.

C.4 ADJUSTING

Adjust floor mats and frames to prevent tripping hazard.

K19 ACCESS FLOORING

PART 1: GENERAL

A SUMMARY

Section includes access flooring and accessories.

B REFERENCES

A European Standard for Raised Access Floors:

- a- BSEN 12825

B American Society for Testing and Materials:

- a- ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

C Ceilings and Interior Systems Construction Association:

- a- CISCA - Acoustical Ceilings: Use and Practice.



- D National Electrical Manufacturers Association:
 - a- NEMA LD3 (National Electrical Manufacturers Association) - High Pressure Decorative Laminates.
- E National Fire Protection Association:
 - a- NFPA 75 (National Fire Protection Association) - Protection of Electronic Computer/Data Processing Equipment.
 - b- NFPA 99 - Health Care Facilities.
- F Underwriters Laboratories Inc.:
 - a- UL - Fire Resistance Directory.

C DESIGN REQUIREMENTS

- A Access flooring system to achieve finished floor elevation 300 mm nominal height above building structural floor.
- B Floor Panel Size: 600 x 600 mm.

D PERFORMANCE REQUIREMENTS

- A Pedestals:
 - a- Maximum Axial Load: 2 000 kg without permanent deformation.
 - b- Ultimate Strength: Not less than twice design load.
- B Floor Panels: Conform to the following:
 - a- Panel Thickness: 33 mm
 - b- System Weight: 63 kg/m².
 - c- Panel Weight: 22.5 kg/m².
 - d- Ultimate Load: 5 KN.
 - e- Maximum Deflection: 2.0 mm.
 - f- Uniformly Distributed Load: 20 KN/m² at any location with maximum deflection of 2.0 mm.
 - g- Ultimate Strength: Not less than twice design load.
 - h- Class of fire resistance: A 1/Class 0.
 - i- Thermal Conductivity: W/mK 1.25
 - j- Lateral Stability: Design system for lateral stability in all directions, with or without panels in place.

E SUBMITTALS

- A Shop Drawings: Indicate floor layout, interruptions to grid, panels requiring drilling or cut-out for services, appurtenances or interruptions, edge details ...etc.
- B Product Data: Submit data for grid system, panels, and accessories; electrical resistance characteristics and ground connection requirements.
- C Samples: Submit one 600x600 mm in size of floor grid and panel, illustrating finishes and color.
- D Manufacturer's Installation Instructions: Submit special procedures, perimeter conditions requiring special attention.
- E Manufacturer's Certificate: Certify products meet or exceed specified requirements.

F CLOSEOUT SUBMITTALS



- A Operation and Maintenance Data: Submit Operation and Maintenance Data.

G QUALITY ASSURANCE

- A Perform Work in accordance with BSEN 12825 and BS 7671.
- B Conform to code for flame resistance of panels and electrical ground resistance.
- C Electrical Grounding Connection: Listed and classified by testing firm acceptable to authority having jurisdiction as suitable for purpose specified and indicated.
- D Maintain one copy of each document on site.

H QUALIFICATIONS

- A Manufacturer and Installer: Company specializing in manufacturing Products specified in this section with minimum three years experience.
- B Design floor system structure layout for this Project under direct supervision of Professional Engineer experienced in design of this Work.

I QUALIFICATIONS

- A Humidity should not exceed 75%.
- B The sub-floor temperature should not be below 5 °C in order to allow adhesive to cure.
- C Loose laid floor coverings should not be installed in atmospheric conditions which would result in moisture being trapped between the floor covering and the panels.
- D Sub-floor should be reasonably flat and smooth for satisfactory seating of the pedestals support base plates. Discrepancies in the level of the sub-floor shall not exceed the standard tolerance adjustment provided by the pedestal support.

J MOCKUP

- A Construct mockup, 1.2 m long by 1.2 m wide, with specified accessories installed.
- B Locate where directed by Engineer.
- C Remove mockup when directed by Engineer.

K EXTRA MATERIALS

- A Furnish 5 of each size of floor panel.
- B Furnish 10 spare pedestals.
- C Panel Lifting Devices: Two of manufacturer's standard.

PART 2: PRODUCTS

A ACCESS FLOORING

- A Manufacturers:
 - a- MERO System or approved equivalent. Approval of the manufacturer or product must be obtained before proceeding with associated work.
- B Product Description: Raised floor access panel, complete with factory applies vinyl or carpet to the requirements of BSEN 12825.



B COMPONENTS

- A Pedestals: single galvanized steel pedestals, adjustable in height. Pedestal head plate shall be provided with a conductive layer for sound insulation.
- B Floor Panels:
 - a- Sendzimir zinc-coated dieformed steel pan filled with non- combustible anhydrite AB 20 to DIN 4208.
 - b- Surface shall be coated with conductive primer for loosely laid floor covering tiles.
 - c- Floor panels lay loosely on steel pedestals.
 - d- Angle precision of the panel is max. ± 0.3 mm along the edge.
- C Floor Panel Finish Adhesive: type recommended by floor finish manufacturer.

C ACCESSORIES

- A As needed and recommended by manufacturer.
- B Facia Panels:
- C Front facia as access floor closure, consisting of coated chipboard panel, 19 mm thick, with aluminum profile for nosing of stairs.
- D Sealant: type as specified by manufacturer.

D FACTORY FINISHING

- A Floor Panel Finish:
 - a- Color and pattern as selected by the engineer.

E ELECTROSTATIC

- A The access floor construction must achieve the upper value of the E-volume resistance of the covering (DIN 51953).
- B Connection of the access floor to the earth potential is done by specialists.

F SOUND INSULATION

- A Sound Insulation: R L.W.P. = 53 dB.
- B Horizontal sound reduction value: L N.W.P. = 48 dB.
- C Vertical Sound Reduction Value: Δ L.W.P. = min. 24 dB.

G FABRICATION TOLERANCES

- A Floor Panel Flatness: Plus or minus 0.5 mm in any direction.
- B Floor Panel Width or Length from Specified Size: Plus or minus 0.5 mm.
- C Floor Panel Squareness: Plus or minus 0.8 mm difference between opposite diagonal dimensions.



PART 3: EXECUTION

A EXAMINATION

- D Verify field measurements are as instructed by manufacturer.
- E Verify required utilities are available, in proper location, and ready for use.

B PREPARATION

- F Vacuum clean substrate surfaces.

C INSTALLATION

- A Secure pedestal base plate to subfloor with adhesive and/or dowels.
- B Install additional pedestals where grid pattern is interrupted by room appurtenances or at cut-outs.
- C Install floor panels on pedestals with full bearing.
- D Close field cut floor panels with edge trim.
- E Cut ten holes in floor panels to accommodate Owner's equipment. Provide cable cut-out protection.
- F Provide positive electrical earth grounding of entire floor assembly in accordance with NFPA 75.
- G Install facia panels at exposed sides.
- H Secure panels to clip angles attached to structural floor and edge of floor panels.
- I Install metal trim at intersection of facia panels and access floor and at abutting walls and columns.

D ERECTION TOLERANCES

- A Maximum out of Level Floor Panel Tolerance: 1.6 mm in 3 m, non-cumulative.

E ADJUSTING

- A Adjust pedestals to achieve level floor and to assure adjacent floor panel surfaces are flush.

F PROTECTION OF INSTALLED CONSTRUCTION

- A No traffic should be allowed on the floor for 48 hours after installation, whilst the pedestal is curing.



K 20 SUSPENDED CEILINGS

K 20.01 General

The contractor shall provide shop drawings to show the final layout and sizes of members of all suspension systems and to co-ordinate the design and work of suspended ceilings with other trades to provide for the reception and installation of outlets, fixtures, diffusers, etc., pertaining to mechanical or electrical work, all to the Engineer's approval before any work is commenced.

K 20.02 Materials

a) Acoustical Materials

Acoustical materials shall be non-combustible conforming with the requirements of the American Federal Specifications SS-A-118b and shall be as described in the Current Acoustical Materials Association Bulletin, Sound-Absorption Coefficients of Architectural Acoustical Materials.

Acoustical ceiling tiles or panels shall be as manufactured by "Ecofon" Focus E 20mm thick size 600x600 mm with Tegal edges all around or approved equivalent.

Acoustical ceiling tiles or panels shall be of the size, thickness, whether perforated or non-perforated, design and finishes shown on the Drawings and/or stated in the Bills of Quantities.

Samples of acoustical ceiling tiles or panels in suspension system members, with catalog data, shall be submitted to the Engineer for approval.

b) Aluminum Ceiling Panels

Aluminum ceiling panels shall be similar to "Luxalon Aluminum Panel Ceiling, the product of "Hunter Douglas" or "MIRAWAL - DAMPA Aluminum Acoustical Ceiling Systems, the product of MIRAWAL COMPANY" and/or approved equivalent.

Aluminum ceiling panels shall be of the size, thickness, whether perforated or non-perforated, design or type and finishes shown on the Drawings and/or stated in the Bills of Quantities.

Samples of aluminum ceiling panels with carriers shall be submitted to the Engineer for approval prior to order.

c) Gypsum Board

GYPSUM BOARD ASSEMBLIES ON METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

- A. Description of Work: Work of this section includes, but is not limited to, the following:
1. Gypsum board and accessories
 2. Veneer plaster
 3. Metal studs and furring
 4. Metal shaftwall systems
 5. Metal suspension systems
 6. Sound-rated construction and accessories
 7. Gypsum board finishing
 8. Trim and accessories



1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications and installation instructions with project conditions and materials clearly identified or detailed for each required system.

1.4 SYSTEM REQUIREMENTS

- A. Performance Requirements: Fabricate and install systems as indicated but not less than that required to comply with ASTM C754 under the following conditions:
 - 1. Gypsum board partitions:
 - a. Standard systems: Maximum deflection of 1/240 of partition height.
 - b. Systems to receive water resistant gypsum board or backer board: Maximum deflection of 1/360 of partition height.
 - 2. Cavity shaftwall systems: Withstand minimum positive and negative pressure of 5 psf.
 - 3. Interior suspended ceilings and soffits: Maximum deflection of 1/360 of distance between supports.
 - 4. Exterior soffits: Withstand minimum positive and negative pressure of 20 psf with maximum deflection of 1/360 of distance between supports.

Seismic Compliance

- A. Nonstructural components that are permanently attached to structures and their support attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance to local jurisdiction.
- B. Fire Resistance Ratings: Where fire resistance classifications are indicated, provide materials and application procedures identical to those listed by UL or tested according to ASTM E119 for type of construction shown.
- C. Acoustical Ratings: Where sound ratings are indicated, provide materials and application procedures identical to those tested by manufacturer to achieve Sound Transmission Class (STC) scheduled or indicated in accordance with ASTM E90.

1.5 QUALITY ASSURANCE

- A. Reference Standards:
 - 1. Applicable requirements of ASTM C754 for installation of steel framing.
 - 2. Install gypsum board in accordance with applicable requirements and recommendations of Gypsum Association GA 216, "Recommended Specifications for the Application and Finishing of Gypsum Board" except for more stringent requirements of manufacturer.
 - 3. Apply acoustical sealant in accordance with applicable requirements of ASTM C919.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Delivery:
 - 1. Deliver material to site promptly without undue exposure to weather.
 - 2. Deliver in manufacturer's unopened containers or bundles, fully identified with name, brand, type and grade.
- B. Storage:
 - 1. Store above ground in dry, ventilated space.
 - 2. Protect materials from soiling, rusting and damage.
 - 3. Store board to be directly applied to masonry walls at 70°F for 24 hours prior to installation.



1.7 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not install gypsum board when ambient temperature is below 40°F.
2. For adhesive attachment of gypsum board, and for finishing of gypsum board, maintain ambient temperature above 55°F from one week prior to attachment or joint treatment, and until joint treatment is complete and dry.

1.8 ALTERNATE CONSTRUCTION WASTE DISPOSAL

A. Reuse:

1. Separate clean waste drywall pieces from contaminants for landfilling or recycling. Do not include vinyl-faced, mold-resistant or asphalt impregnated gypsum boards. Pulverize and apply to site soil in accordance to landscape specifications. Protect scrapes and pulverized material from moisture and contamination. Alternate to on-site soil amendment, work to supply local farming granular material for their use.

B. Recycle:

1. Separate clean waste drywall pieces from contaminants for landfilling or reuse. Working with local waste hauler and local drywall manufacturer, provide proper storage of waste for pickup and return. Protect scrapes material from moisture and contamination.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MANUFACTURERS

- A. Gypsum Board and Accessories: Listed products establish standard of quality and are manufactured by United States Gypsum Company (USG), Chicago, IL, Orbond, or equal approved.
- B. Steel Framing and Furring: Company acceptable to installer.
- C. Grid Suspension Assemblies: Listed products establish standard of quality and are manufactured by United States Gypsum Company (USG), Chicago, IL. Or equal approved.

2.2 BOARD MATERIALS

A. Gypsum Board:

1. ASTM C1396 (Section 5), regular type [except where Type X fire-resistant type is indicated or required to meet UL assembly types].
2. Edges: Tapered.
3. Thickness: 12 mm.
 - a. Where curved gypsum board construction is indicated, use 9 mm thick flexible facing board.

B. Ceiling Board:

1. ASTM C1396 (Section 12), non-sag type.
2. Thickness: 12 mm.

C. Water-Resistant Gypsum Board:

1. ASTM C1396 (Section 7), regular type except where Type X fire-resistant type is indicated or required to meet UL assembly types.
2. Edges: Tapered.
3. Thickness: 12 mm, unless otherwise indicated.

C. Moisture & Mold Resistant:



1. ASTM C1396 (Section 5), regular type except where Type X fire-resistant type is indicated or required to meet UL assembly types.
2. Edges: Tapered.
3. Thickness: 12 mm

D. Shaftwall:

1. Liner boards:
 - a. ASTM C442, Type SLX.
 - b. Edges: Beveled.
 - c. Thickness: 25 mm.
2. Face boards:
 - a. ASTM C1396 (Section 5), Type X.
 - b. Thickness: 12 mm, unless otherwise indicated.

E. Exterior Soffit Board:

1. Manufacturer's special weather and sag-resistant gypsum board manufactured specifically for use in exterior soffit applications with indirect exposure to weather; complying with ASTM C1396(Section 8).
2. Edges: Eased and tapered.
3. Thickness: 12 mm, except as otherwise indicated.

F. Cement Backer Board:

1. Aggregated Portland cement board with woven glass fiber mesh facing; complying with ANSI A118.9.
2. Thickness: 12 mm.

G. Veneer Plaster Partitions:

1. Base: Manufacturer's standard size gypsum base sheets in maximum available lengths to minimize end-to-end joints; manufacturer's standard edge profile.
 - a. Comply with ASTM C588.
 - b. Regular type except where Type X fire-resistant type is indicated or required to meet UL assembly types.
 - c. Thickness: 12 mm, unless otherwise indicated.
2. Bonding agent: Plaster Bonder.
3. Plaster basecoat: Ready-mixed material, mill-prepared, high-strength gypsum veneer plaster for two-coat application. Acceptable product: Equivalent to DIAMOND Basecoat by USG or equal approved.
4. Plaster finish coat: Ready-mixed material.

2.3 METAL FRAMING AND FURRING MATERIALS

A. Metal Studs and Runners:

1. ASTM C645, "C" shaped, gauge:
 - b. Provide studs with thickness not less than 0.6 mm.
 - c. At door [and borrowed light] frames, provide (2) minimum studs at each jamb.
 - d. Provide studs at walls to receive cement backer board and water resistant gypsum board with ceramic tile facing.
 - e. Provide runner gauge as recommended by stud manufacturer.



2. Depth of sections: 70 mm.
3. Corrosion protection: G40 hot-dipped galvanized coating per ASTM A525.
- B. Shaft Wall Supports:
 1. Conform to ASTM A446, Grade A, with G40 hot-dipped galvanized coating per ASTM A525.
 2. Studs:
 - a. Shape: "CH", "J" or "E" or as standard with manufacturer.
 - b. Gauge: As required to fulfill performance criteria, minimum 0.6 mm. same for jamb and lintel components.
 - c. Size: As indicated.
 - d. J runners: 0.6 mm thick, size as required for coordination with studs.
 - e. Jamb struts: 0.6 mm thick with 70mm back leg for use at elevator frames.
- C. Metal Furring Channels:
 1. Hat-shaped:
 - a. ASTM C645, 7/8 inch high, 25 gauge, with G40 hot-dipped galvanized coating per ASTM A525.
 - b. Provide 0.6 mm thickness at furring to receive tile backer board.
 2. Z-shaped: ASTM C645, depths as indicated, 0.6 mm minimum thickness, with G40 hot-dipped galvanized coating per ASTM A525.
 3. Resilient: Manufacturer's standard type designed to reduce sound transmission; 12 mm deep, 0.6 mm thick steel with G40 hot-dipped galvanized coating per ASTM A525.

2.4 CEILING AND SOFFIT SUPPORT MATERIALS

- A. Hanger Anchorage Devices: Screws, clips, bolts or other devices compatible with indicated structural anchorage for ceiling hangers and whose suitability has been proven through standard construction practices or by certified test data.
- B. Powder-Actuated Fasteners in Concrete: Fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers [and with capability to sustain, without failure, a load equal to 10x calculated loads].
- C. Post-tensioned Concrete Slabs:
 1. For inserts placed in post-tensioned concrete work, maintain 70 mm clearance between inserts and prestressing strands.
 2. If insert is in conflict with strand, insert must be moved to avoid strand. Do not move strands to avoid inserts.
- D. Hangers:
 1. Steel wire or rods, sizes to comply with requirements of ASTM C754 for ceiling or soffit area and loads to be supported.
 2. Wire: ASTM A 641, soft, Class 1 galvanized.
 3. Rods and flats:
 1. Mild steel components.
 2. Finish: Galvanized or painted with rust-inhibitive paint for interior work; galvanized for exterior work.
- E. Framing System:
 1. Main runners:
 1. Cold-rolled, "C" shaped steel channels, 0.6 mm minimum thickness.
 2. Finish: Galvanized with G40 hot-dip galvanized coating per ASTM A525 [for exterior work]; galvanized or painted with rust-inhibitive paint for other interior work.



3. Form to required radius at curved ceilings.
 2. Cross furring: Hat-shaped steel furring channels, ASTM C645, 22 mm high, 0.6 mm thick, galvanized.
 3. Furring anchorages: 0.6 mm galvanized wire ties, manufacturer's standard wire-type clips, bolts, nails or screws recommended by furring manufacturer and complying with ASTM C754.
 4. Provide compression posts and other accessories as required to comply with seismic requirements.
- F. Proprietary Framing System:
1. Framing system for gypsum board panels consisting of cold-rolled steel members conforming to ASTM C635, with exposed surfaces finished in manufacturer's standard enamel paint finish.
 2. Fire rating: 1 [1-1/2] [2] [3] hour rating in accordance with UL assembly indicated.
 3. Components: Main tees, furring cross channels, furring cross tees, and cross tees.
 4. Accessories:
 - a. U-shaped channel molding.

Main Tees: Fire-Rated Heavy Duty classification **Cross Members:** Fire-Rated members with knurled face.
Cross Tees: quick release cross tee ends for positive locking and removability without tools.

Accessory Cross Tees: Cross tees must have knurled faces and quick release cross tee ends for positive locking and removability without tools.

2.5 ACCESSORIES

- A. Metal Trim for Gypsum Board:
1. Conform to profile and dimensions indicated.
 2. Material for interior work: Galvanized steel, 0.6 mm minimum thickness.
 3. Corner beads
 4. Casing beads (edge beads).
 5. Control joints:
 - a. Roll-formed zinc with perforated flanges.
 - b. Size: 1-3/4 inch wide, with 1/4 inch wide center channel.
 - c. Provide with removable tape strip over channel.
- B. Paper-Faced Metal Trim for Gypsum Board:
1. Conform to profile and dimensions indicated.
- Material for interior work: Comply with ASTM C1047.
Outside corners: Paper Faced Metal Bead and Trim.
Outside Bullnose corners: Paper Faced Metal Bead and Trim.
Inside corners: Paper Faced Metal Bead and Trim.
- C. Metal Trim for Veneer Plaster:
1. Conform to profile and dimensions indicated.
 2. Material: Galvanized steel, 0.6 mm thickness minimum.
 3. Corner beads.
 4. Casing beads (channel-type edge) or (angle edge).
 5. Control joints: Roll-formed zinc with perforated flanges.
- D. Trim for Exterior Soffits: Rolled zinc complying with ASTM C1047.
- E. Special Trim and Reveals: Extruded aluminum alloy 6063-T5, profiles as indicated.
- F. Molding and Trim for Vinyl-Faced Panels:
1. Manufacturer's standard rigid plastic molding.



2. Include inside corners, end caps, battens and ceiling drive-in trim, as indicated.
 3. Color: As directed by the engineer [Factory-laminated with matching vinyl].
- G. Backer Plates:
1. Steel, galvanized; 150 mm wide x 0.6 mm thickness minimum x lengths to suit size of items to be attached; fastened to studs for attachment of surface mounted fittings and accessories.
 2. Elimination of backer plates or direct attachment of accessories or equipment to studs will not be allowed.
- H. Hanger Wire Sound Isolators: Provide where indicated for sound-rated suspended ceilings.
- I. Adhesives and Joint Treatment Materials:
1. Conform to requirements of ASTM C475.
 2. Joint compounds:
 - a. Drying-type (ready-mixed): Equivalent to SHEETROCK® brand taping joint compound and topping joint compound.
 - b. Setting (chemically-hardening) type: Equivalent to SHEETROCK® brand setting-type joint compound by USG.
 - c. Primer-surfacer: Finish Level 4 (GA-214/ASTM C-840) drywall surface with vinyl acrylic latex-based coating to achieve Level 5 gypsum board finish.
 - d. Laminating adhesive for multiple layers: Special adhesive or joint compound specifically recommended for laminating gypsum boards.
 - e. Laminating adhesive for direct application: Special adhesive or joint compound specifically recommended for laminating gypsum boards and for adhering gypsum boards to solid substrates.
 - f. Reinforcing joint tape:
 1. ASTM C475, 2 inch nominal width.
 2. For backer board, provide fiberglass tape as recommended by board manufacturer [and acceptable to manufacturer of ceramic tile setting materials].
- J. Gypsum Board Screws: Self-drilling, self-tapping steel screws.
1. Comply with ASTM C954.
 2. Provide Type S or Type S-12 screws.
- K. Backer Board Accessories: Provide accessories and corrosion-resistant-coated steel screws as recommended by backer board manufacturer and required for complete installation.
- L. Acoustical Sealant.
- M. Sound Attenuation Blankets:
1. Mineral fiber, conforming to ASTM C665, Type I.
 2. Surface burning characteristics per ASTM E84:
 - a. Flame spread: 15 or less.
 - b. Smoke developed: 0.
 3. Thicknesses: As indicated.
 4. Acceptable product and manufacturer: Equivalent to Thermafiber or equal approved Sound Attenuation Fire Blankets SAFB (Fire Safety FS-15 Blankets).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and adjoining construction and conditions under which work is to be installed. Do not proceed with work until unsatisfactory conditions are corrected.



3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install in accordance with reference standards and manufacturer's instructions [and as required to comply with seismic requirements].
- B. Tolerances:
 - 1. Do not exceed 1/8 inch in 8'-0" variation from plumb or level in exposed lines of surface, except at joints between gypsum board units.
 - 2. Do not exceed 1/16 inch variation between planes of abutting edges or ends.
 - 3. Shim as required to comply with specified tolerances.
- C. Install framing to comply with ASTM C754 and with ASTM C840 requirements that apply to framing installation.
- D. Install supplementary framing, blocking and bracing at terminations in gypsum board assemblies to support fixtures, equipment, heavy trim, grab bars, toilet accessories, furnishings or similar construction.

3.3 METAL SUPPORT INSTALLATION

- A. Metal Runners:
 - 1. Align and secure runner tracks accurately to partition layout at both floor and ceiling spaces.
 - 2. Provide fasteners appropriate to substrate construction as recommended by manufacturer.
- B. Metal Studs:
 - 1. Position metal studs vertically in the runners, spaced not more than 400 mm o/c.
 - 2. Place studs so that flanges face in same direction.
 - 3. Cut studs ½ inch short of full height to provide perimeter relief.
 - 4. Align and plumb partition framing accurately.
 - 5. Where partitions abut ceiling or deck construction or vertical structural elements, provide slip or cushion type joint between partition and structure as recommended by stud manufacturer to prevent transfer of structural loads or movements to partitions, and to provide lateral support.
 - 6. Provide horizontal bracing where necessary for lateral support.
 - 7. Chase walls:
 - a. Position steel studs on opposite sides of chase directly across from each other.
 - b. Cut cross-bracing from gypsum board 12 inches high by chase wall width.]
 - 8. [Backer plates and blocking:
 - a. Where handrails, grab bars, cabinets, wall-mounted door stops, or other wall-hung items are attached to partitions, install backer plates or wood blocking accurately positioned and firmly secured to metal studs, whether or not such backer plates or blocking are indicated on Drawings.
 - b. Do not use wood blocking in fire-rated construction.]
 - 9. Curved partitions:
 - a. Cut top and bottom runners through leg and web at 2-inch intervals for arc length.
 - b. Bend runners to uniform curve of radius indicated and locate straight lengths tangent to arcs.
 - c. Support outside (cut) leg of runners by clinching a 1-inch high x 25 gauge thick sheet steel strip to inside of cut legs using metal lock fasteners.
 - d. Attach studs to runners with 3/8 inch long pan head framing screws.
 - e. On straight lengths at ends of arcs, place studs 6 inches on center with last stud left free standing.]
- C. Hat Channel Furring:



1. Attach hat-shaped furring channels either vertically or horizontally with fasteners through alternate wing flanges (staggered).
 2. Space furring channels at 24 inches on center, unless otherwise indicated. Where furring is indicated to receive backer board, water resistant gypsum board with ceramic tile, or veneer plaster, space at 16 inches on center.
 3. Install furring channels within 4 inches of floor line and ceiling line.]
- D. Z-Furring:
1. Securely attach narrow flanges of members to wall with concrete stub nails or power-driven fasteners, except as otherwise indicated.
 2. Sequence furring installation with installation of insulation.]
- E. Ceiling and Soffit Support Systems:
1. Secure hangers or rods to structural support by connecting directly to structure where possible; otherwise connect to inserts, clips or other anchorage devices or fasteners indicated.
 2. Space main runners, hangers and furring according to requirements of ASTM C754, except as otherwise indicated, with spacing between runners not less than 400 mm wide..
 3. Where spacing of structural members, or width of ducts or other equipment, prevents regular spacing of hangers, provide supplemental hangers and suspension members and reinforce nearest affected hangers to span extra distance.
- Limitations**
1. Steel studs are not designed to carry live loads, mechanical equipment or material storage.
 2. Maximum spacing: 70 mm cold-rolled channels and hangers 400 mm on center. For single-layer panels, maximum steel stud and furring channel spacing is 600 mm on center for perpendicular application and 400 mm on center for parallel application. For panels used as base for spray-applied ceiling texture finish, maximum frame spacing is 400 mm on center for 12 mm thick panels perpendicularly applied (parallel panel application not recommended); 600 mm on center for 16 mm thick panels perpendicularly applied, 400 mm on center for parallel application.
4. Attach directly to structural elements only; do not attach to metal deck. Loop hangers and wire-tie directly or provide anchors or inserts.
 5. Install compression posts, splay wires and other accessories as required to comply with seismic requirements.
 6. Extend runners to within 6 inches of walls.
 7. Wire-tie or clip furring members to main runners and to other structural supports indicated. In fire resistance rated assemblies, wire-tie furring members; do not clip.
 8. Do not permit furring or runners to contact masonry or concrete walls.
 9. Provide 1 inch clearance between furring or runners and abutting walls and partitions.
 10. For proprietary framing system, comply with manufacturer's instructions.
 11. Curved (vaulted) applications:
 - a. Install furring channels to provide indicated radius for finished ceiling.
 - b. Space furring channels maximum 16 inches on center. Provide closer spacing if recommended by manufacturer for veneer base thickness and application method.
- F. Shaftwall:
1. Provide slip or cushioned joints to isolate shaftwall system. Comply with manufacturer's instructions.
 2. Seal joints and penetrations on both sides of shaftwall system.



3. Elevator shaft requirements:
 - a. Support elevator hoistway door frames independently of shaftwall framing system, or reinforce system in accordance with system manufacturer's instructions.
 - b. Where shaftwall system cannot be positioned within 2 inches of shaft face of structural beams, floor edges and similar projections into elevator shaft, provide continuous 5/8 inch gypsum board cants to cover tops of projections.]

3.4 BOARD INSTALLATION

A. Single Layer Gypsum Board on Metal Studs:

1. Loosely butt gypsum board joints together and neatly fit.
2. Do not place butt ends against tapered edges.
3. Maximum allowable gap at end joints: 1/8 inch.
4. Stagger joints on opposite sides of partitions.
5. Apply ceiling boards first where gypsum board ceilings and wall occur.
6. Cut openings in gypsum board to fit electrical outlets, plumbing, light fixtures and piping snugly and small enough to be covered by plates and escutcheons. Cut both face and back paper.
7. Screw board in place securely with screws spaced according to manufacturer's recommendations.

B. Single Layer Gypsum Board on Furring:

1. Apply gypsum board with long dimension at right angles to furring channel.
2. Center end joints over channel web; stagger end joints from those in adjacent rows of board.
3. Fasten boards to furring channels with screws spaced according to manufacturer's recommendations.

C. Double Layer Gypsum Board:

1. Fasten base layer to studs or furring with screws, and attach face layer using laminating adhesive and screws, applied according to manufacturer's instructions.
2. Offset face-layer joints at least 10 inches from parallel base-layer joints.
3. Screw both layers to metal supports at double layer ceiling applications and where required for fire-rated construction.

D. Direct Gypsum Board Adhesive Application:

1. Apply adhesive with manufacturer's recommended spreader to backs of gypsum boards in band of four beads each to center of each board and along edges.
2. Position boards vertically and press firmly in place to insure good bond.
3. Fasten top and bottom of board if required.

E. Water-Resistant Gypsum Board:

1. Complete plumbing rough-in before gypsum board panels are erected.
2. Separate gypsum panels from rough-in and fixtures by 1/4 inch space.
3. Make necessary cut-outs and seal cut or exposed panel edges with thinned-down ceramic tile adhesive or with waterproof flexible sealant, as recommended by gypsum board manufacturer.
4. Install water-resistant board horizontally.
5. Do not place water-resistant board directly over vapor retarder.



6. Prior to tile application, fill openings around pipes, fittings, fixtures, interior angles and other penetrations with waterproof flexible sealant, as recommended by gypsum board manufacturer. Do not fill 1/4 inch gap at bottom of panels.
- F. Cementitious Backer Board Installation:
1. Install as indicated to comply with ANSI A108.11 and in accordance with manufacturer's instructions.
 2. Complete plumbing rough-in before boards are erected.
 3. Separate board from rough-in and fixtures and fill space as recommended by manufacturer.
 4. Securely fasten boards to substrate as required.
 5. Follow manufacturer's instructions for treatment of edge terminations.
 6. At joints and corners, embed fiberglass tape in skim coat of mortar.
- G. Exterior Soffits:
1. Apply soffit board with long dimension across supports.
 2. Position end joints over supports.
 3. Allow at least 1/4 inch between edge of soffit board and adjacent construction, unless otherwise indicated.
 4. Fasten with corrosion-resistant screws.
- H. Gypsum Shaftwall:
1. Erect gypsum board shaft liner for use as temporary shaft enclosure.
 2. Screw attach base and face layers according to manufacturer's instructions, for both vertical (shaft enclosure) and horizontal (duct enclosure) applications.
 3. Seal perimeters and openings to provide airtight installation.
 4. Install sloped gypsum board cants on hoistway side of shaftwall where slabs or beams project beyond shaftwall.
- I. Curved Gypsum Board:
1. Provide board length such that one single board covers curved surface. Provide board thickness as recommended by manufacturer for minimum bending radius.
 2. Install boards perpendicular to framing.
 3. On concave installations, start fastening board at center of curve and work outward to ends of boards.
 4. On convex installations, begin board installation at one end of curved surface and fasten board to framing as it is wrapped around curve.
 5. Do not cut openings for penetrations until boards are installed and thoroughly dry.]

Curved Partitions

Panels are horizontally applied, gently bent around framing and securely fastened to achieve the desired radius.

3.5 VENEER PLASTER INSTALLATION

- A. Base:
1. Install gypsum base in accordance with ASTM C844. Apply gypsum base with face side out.



2. Butt and fit abutting edges and ends together for light contact; do not force into place.
3. Do not locate fasteners closer than 3/8 inch from ends or edges of sheets. Set heads slightly below surface of gypsum base, but do not break paper face.
4. Drive screws with power screwdriver.

B. Single Layer Applications:

1. Position edges over support flanges.
2. To maintain true surface plane for installation on studs, arrange direction of application so that leading edge of base is attached first to open edge of stud flange.

OR

B. Double Layer Applications:

3. Apply gypsum base layer and face layer with long dimension parallel to supports. Offset joints of face layer at least 16 inches from base layer joints.
4. Fasten both base and face layers separately to supports.
5. Stagger and space fasteners in accordance with gypsum base manufacturer's instructions.

C. Curved Applications:

1. Provide sheet length such that one single sheet covers curved surface. Provide sheet thickness as recommended by manufacturer for minimum bending radius.
2. Install sheets perpendicular to framing.
3. On concave installations, start fastening sheet at center of curve and work outwards to ends of sheets.
4. On convex installations, begin sheet installation at one end of curved surface and fasten sheet to framing as it is wrapped around curve. Do not cut openings for penetrations until sheets are installed and thoroughly dry.

D. Ceilings:

1. Install gypsum base sheets with long direction at right angles to furring channels with end joints occurring over channels.
2. Stagger end joints.
3. Install ceiling boards prior to adjoining partition boards where feasible.
4. Fasten at not less than 12 inches on center at furring channels.
5. Double layer applications:
 - a. Apply base layer prior to base layer application on adjoining partitions; apply face layers in same sequence.
 - b. Apply gypsum base layer and face layer with long dimension parallel to supports. Offset joints of face layer at least 16 inches from base layer joints.
 - c. Fasten both base and face layers separately to supports.
 - d. Stagger and space fasteners in accordance with gypsum base manufacturer's instructions.
6. Vaulted (curved) applications:
 - a. Provide sheet length such that one single sheet covers curved surface. Provide sheet thickness as recommended by manufacturer for minimum bending radius.
 - b. Install sheets perpendicular to furring channels.
 - c. Start fastening sheets at center of curve and work outwards to ends of sheets.
 - d. Do not cut openings for ceiling penetrations until sheets are installed and thoroughly dry.



3.6 SOUND-RATED CONSTRUCTION

A. Insulation:

1. Install sound attenuation blankets in sound-rated partitions and ceilings where indicated.
2. Completely fill space between studs and framing to full height of partition wall or full area of ceiling.
3. Fit carefully behind electrical outlets and other work penetrating sound-rated construction.
4. Install sound attenuation blankets in gaps between steel deck flutes and tops of sound-rated partitions, which are not fire-rated. Attach blankets in accordance with manufacturer's instructions.

B. Gypsum Board:

1. Install gypsum board same as for interior partitions and ceilings.
2. Coordinate with installation of perimeter sealants.

C. Acoustical Sealant:

1. At partition walls, provide continuous beads of acoustic sealant at juncture of both faces of runners with floor and ceiling construction, and wherever gypsum board abuts dissimilar materials, prior to installation of gypsum board.
2. At ceilings, provide continuous beads of sealant wherever gypsum board abuts dissimilar materials.
3. Provide continuous bead of sealant behind faces of control joints prior to installation of control joint accessories.
4. After installation of gypsum board base layers, cut face layer sheets $\frac{1}{2}$ inch less than floor-to-ceiling height and position with $\frac{1}{4}$ inch open space between gypsum board and floor, ceiling and dissimilar vertical construction. Fill $\frac{1}{4}$ inch open space with continuous sealant beads after installation of face layer.
5. At openings and cutouts, fill open spaces between gypsum board and fixtures, cabinets, ducts and other flush or penetrating items, with continuous bead of sealant.
6. Seal sides and backs of electrical boxes to completely close off openings and joints.

D. Sound Flanking Paths:

1. Where sound-rated partition walls intersect non-rated gypsum board partition walls, extend sound-rated construction to completely close sound flanking paths through non-rated construction.
2. Seal joints between face layers at vertical interior angles of intersecting partitions.]

3.7 ACCESSORY INSTALLATION

A. Trim:

1. Use same fasteners to anchor trim accessory flanges as required to fasten gypsum board to supports, unless otherwise recommended by trim manufacturer.
2. Install metal corner beads at external corners.
3. Install metal casing bead trim whenever edge of gypsum board would otherwise be exposed or semi-exposed.

B. Control Joints:

1. Install control joints at junction of gypsum board partitions with walls or partitions of other finish material.



2. Install control joints within long runs of partitions, ceilings or soffits at approximately 30'-0" on center or as indicated.
3. Where gypsum board is vertically continuous, as at stairwells, provide horizontal control joints at each floor level.

C. Special Trim: Install as indicated on drawings and in accordance with manufacturer's instructions.

3.8 FINISHING

A. Provide levels of gypsum board finish for locations as follows, in accordance with Gypsum Association GA 214.

1. Level 1: Ceiling plenum areas and concealed areas, except provide higher level of finish as required to comply with fire resistance ratings and acoustical ratings.
Level 2: Gypsum board substrate at tile [stone], except remove tool marks and ridges.
Level 3: Gypsum board surfaces, where textured finishes or heavy vinyl wall papering will be used [High-build Primer required].
4. Level 4: Gypsum board surfaces, except where another finish level is indicated [High-build Primer required].
5. Level 5: Gypsum board surfaces requiring extra smooth surface for critical light, where indicated using spray-applied Primer-Surfacer, [or watered-down joint compound skim coat over whole surface and High-build Primer required].

Surface Preparation: Complete gypsum board surface to Level 4 before applying primer-surfacer.

Primer-surfacer, Application: Machine apply with airless sprayer in conformance with manufacturer's application instructions to a wet film thickness of 15 to 20 mils [9-12 mils dry film thickness]. Surface may be painted after overnight drying.

Airless spray application only. Use professional equipment that meets or exceeds the following rating when spraying through 50 ft. of 1/4" i.d. high-pressure hose: output at least 1 gallon per minute; pump pressure rated at 2700-3000 psi; and accommodates a 0.031" spray tip at 2000 psi. Use a 30-mesh filter located in the high-pressure manifold. Use a spray tip orifice between 0.023" to 0.031". A heavy-duty texture spray gun that accommodates a matching tip shall be used.

Test the spray pattern prior to application. To apply, hold spray gun perpendicular to the surface approximately 12 to 18 inches away. Move the gun parallel to the surface at a steady rate. Lap each stroke approximately 50% over the previous stroke for uniform paint thickness. Spray from left to right to scratch in the initial coat at approximately half of the desired thickness. Then crosshatch spray up and down as the double-up coat to the desired thickness. When painting corners, aim the gun toward the center of the corner to ensure both sides are sprayed evenly. When used in lieu of a skim coat of joint compound and paint primer coat in a Level 5 gypsum board finish, apply to a minimum Wet Film Thickness (WFT) of 15 mils. In all applications a wet film thickness in excess of 20 mils is not recommended. Use a wet film thickness gauge to ensure proper application thickness and maximum performance. During and after application, avoid drafts and maintain 55 °F (13 °C) minimum product, air and surface temperatures until surface is dry.

B. Interior Gypsum Board:

Prefill only eased & tapered edge gypsum board;

1. Prefill:



- a. Use setting-type joint compound. Mix joint compound according to manufacturer's directions.
- b. Fill joints between boards flush to top of eased or beveled edge.
- c. Fill joints of gypsum board above suspended ceilings in fire-rated partitions.
- d. Wipe off excess compound and allow compound to harden.]

Taping (Level 1):

- a. Use taping or all-purpose lightweight compound.
 - b. Butter taping compound into inside corners and joints.
 - c. Center tape over joints and press down into fresh compound.
 - d. Remove excess compound.
 - e. Tape joints of gypsum board above suspended ceilings.
3. First coat (Level 2):
 - a. Use taping or all-purpose lightweight drying-type compound, or setting-type joint compound.
 - b. Immediately after bedding tape, apply skim coat of compound over body of tape and allow to dry completely in accordance with manufacturer's instructions.
 - c. Apply first coat of compound over flanges of trim and accessories, and over exposed fastener heads and finish level with board surface.
 4. Second coat (Level 3): Use all purpose or topping lightweight drying type joint compound. After first coat treatment is dried, apply second coat of compound over tape and trim, feathering compound 50 mm beyond edge of first coat.
 5. Third coat (Level 4):
 - a. Use all purpose or topping lightweight drying type joint compound.
 - b. After second coat has dried, sand surface lightly and apply thin finish coat to joints, fasteners and trim, feathering compound 2 inches beyond edge of second coat.
 - c. Allow third coat to dry. Apply additional compound, and touch-up and sand, to provide surface free of visual defects, tool marks, and ridges, and ready for application of finish.
 6. Skim coat (Level 5):
 - a. Apply skim coat of all-purpose (conventional weight) drying-type compound or spray-applied Primer-Surfacer, over exposed surfaces of gypsum board.
 - b. After skim coat has dried, touch-up and sand to provide surface free of visual defects, tool marks, and ridges, and ready for application of finish.

C. Water-Resistant Gypsum Board: Treat fastener heads and joints with setting-type joint compound.

1. For joints to be covered with tile, apply tape and joint compound bedding coat and skim coat only; do not apply finish coats.
 - a. Do not crown joints or leave excess compound on panels.
 - b. Remove tool marks and ridges.
 - c. For fastener heads to be covered with tile, apply one coat of joint compound.

D. Cementitious Backer Board: Prepare and finish joints in accordance with manufacturer's instructions.

E. Exterior Gypsum Board Soffits:

1. Use setting-type joint compound.
2. Prefill:



- a. Fill joints between boards with joint compound.
 - b. Wipe off excess compound and allow to harden.
 3. Taping:
 - a. Cover joint with thin layer of joint compound.
 - b. Center tape over joints and press down into fresh compound.
 - c. Remove excess compound.
 4. First coat:
 - a. Immediately after bedding tape, apply skim coat of joint compound over body of tape and allow to dry completely in accordance with manufacturer's instructions.
 - b. Apply first coat of compound over flanges of trim and accessories.
 - c. Smooth tool lap marks and other imperfections prior to hardening action of compound.
 5. Second coat:
 - a. After first coat treatment has dried, apply second coat of joint compound over tape and trim, feathering compound 2 inches beyond edge of first coat.
 - b. Spot fasteners with second coat of compound.
 - c. Smooth tool lap marks and other imperfections prior to hardening action of compound.
 6. Third coat:
 - a. After second coat has dried, apply thin finish coat to joints and fasteners, feathering compound 2 inches beyond edge of second coat.
 - b. Smooth tool lap marks and other imperfections prior to hardening action of compound.
- F. Veneer Plaster Finishing: Reinforcing Tape:
1. Install full length over all gypsum base and cement board joints, including internal corners. Do not overlap at intersections.
 2. Butter joints with setting-type joint compound, press Sheetrock Joint Tape into compound; apply skim coat of compound over tape.
- G. Joint Compound:
1. After skim coat sets, apply finish coat of compound feathering 75 mm to 100 mm beyond tape edges.
 2. Feather coats onto adjoining surfaces so that camber is maximum 0.8 mm.
 3. Allow joint compound to completely set before applying veneer plaster finish.
- H. Trim:
1. Use same fasteners to anchor trim accessory flanges as required to fasten gypsum board to supports, unless otherwise recommended by trim manufacturer.
 2. Install metal corner beads at external corners.
 3. Install metal casing bead trim whenever edge of gypsum base would otherwise be exposed or semi-exposed, and where gypsum base terminates against dissimilar material.



- I. Control Joints: Install where indicated and specified.
- J. Special Trim and Reveal Joints: Install as indicated on drawings and in accordance with manufacturer's instructions.

3.9 VENEER PLASTER APPLICATION

- A. Apply veneer plaster in accordance with ASTM C843, except for more stringent requirements of manufacturer or these specifications. Apply 1 or 2-coat system of uniform thickness as indicated.
- B. Mixing:
 - 1. Use mechanical mixers for mixing plaster in accordance with USG recommendations.
 - 2. Clean mechanical mixers, mixing containers and tools after mixing each batch; keep free of plaster from previous mixes.
 - 3. Thoroughly mix plaster with proper amount of water until uniform in color and consistency.
 - 4. Retempering not permitted; discard plaster that has begun to stiffen.
- C. Base Coat:
 - 1. Trowel apply base coat plaster over gypsum base to 1/16 to 3/32 inch thickness.
 - 2. Where plaster is flush with metal frames, groove at junction to reduce possibility of chipping. Cut plaster free from these metal sections before plaster sets.
- D. Finish Coat:
 - 1. Trowel apply finish coat plaster to a maximum 1/16 inch thickness over basecoat plaster.
 - 2. Scratch finish coat in thoroughly over dry base coat and immediately double back to true even surface.
 - 3. Finish surface to flat, smooth, hard trowel finish.

OR

 - 3. Finish surface to uniform float texture
- E. Perform cutting, patching, repairing and pointing-up operations neatly and thoroughly. Repair cracks and indented surfaces by moistening plaster and filling with new material, troweled flush with adjoining surfaces.]

3.10 ADJUSTING

- A. Correct damage and defects which may telegraph through finish work.
- B. Leave work smooth and uniform.

d) Metallic Gird, Hangers and Fixing Accessories

Metal Hangers for Acoustic Tiles

PART 1 GENERAL

1- Related Requirements:

- 1) ASTM C635 - Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings.
- 2) ASTM C636 - Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.
- 3) ASTM E84 - Standard Method for Surface Burning Characteristics of Building Materials.
- 4) ASTM E580 - Standard Practice for Application of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions.
- 5) 2015 International Building Code - Section 1613, 1704, 1705, & 1706.
- 6) 2013 California Building Code, chapters 8, 16, 16A and 25.
- 7) ASCE/SEI American Society of Civil Engineers 7-10: Minimum Design Loads for Buildings and Other Structures.
- 8) CISCA Ceilings & Interior Systems Construction Association.
 - a) Ceiling Systems Handbook
 - b) Seismic Construction Handbook
- 9) International Code Council ICC-ES Evaluation Report ESR-1222 issued December 2016.



2.INFORMATIONAL SUBMITTALS

- a.Product Test Reports: Provide test reports for each acoustical ceiling panel, performed by NVLAP certified testing agency.
- b.Evaluation Reports: For each ceiling suspension system, submit ICC-ES 1222 report showing compliance.

PART 2 PRODUCTS

2.SEISMIC PERFORMANCE REQUIREMENTS

- a.Seismic Performance: Suspended grids and ceiling panels shall be installed in accordance to ASTM C636, ASTM E580 (including approved alternate methods).
- b.Ceiling design shall comply with ASCE/SEI American Society of Civil Engineers 7-10: Minimum Design Loads for Buildings and Other Structures

2.5 METAL SUSPENSION SYSTEM FOR ACOUSTICAL CEILING PANEL

- c.Narrow Face, Double-web design; Bottom face with (6mm) center recessed section, Cold Rolled Steel Suspension System as defined by ASTM C635, commercial quality pretreated and painted hot-dipped galvanized cold-rolled steel, exposed surfaces prefinished in manufacturer's standard corrosion resistant enamel paint finish: as directed by the engineer.

1) Structural Classification: [heavy duty].

2) Tee Profile: Narrow Face (15 mm) wide.

3) Tee Height: (45 mm).

4) Grid Module: [As noted on drawings].

5) Fire Rating: Class A.

6) Color: As directed by the engineer.

7) Post-Consumer Recycled Content: [57%].

8) Total Recycled Content: [65%].

9) Seismic Criteria:

a) Reference Seismic standards per ASTM E580 and CISC guidelines.

b) Seismic Design Category as defined by the IBC (International Building Code): [A-C].

d.Accessories.

- 1) Wall molding: Inside Corner: Field-mitered joints at wall molding. Prefabricated corner cap; formed to 90° angle; hemmed edge; size and finish to match wall molding. Outside Corner: Prefabricated corner cap; formed to 90° angle; hemmed edge; size and finish to match wall molding.

a) Angle shape; 9/16 in. mounting flange by 15/16 in. vertical flange; hemmed edges; exposed surface pre-finished to match suspension system components.

b) Angle shape; 7/8 in. minimum mounting flange by 7/8 in. vertical flange; hemmed edges; exposed surface pre-finished to match suspension system components.

c) Angle shape; 2 in. mounting flange by 1 in. vertical flange; hemmed edges; exposed surface pre-finished to match suspension system components.

- 2) Shadow Molding: Formed steel section; exposed surfaces prefinished to match suspension system components.

a) 9/16" thick exposed flange; 3/8" x 3/8" reveal; 7/8" vertical flange.

b) 1 1/4" exposed flange; 9/32" x 3/4" reveal; 7/8" vertical flange.

- 3) Note to Specifier: For Alternate Seismic Solutions for categories C & D-F use the paragraph below:

- 4) Seismic Attachment Clip: Used to attach tees ends to perimeter angle for seismic design C D E F categories.

5)

- 6) Molding Attachment Clip: 2 in. x 1/2 in. x 1-5/8 in.; for Fineline Suspension System. Used to attach cross tees and main tees to walls/ wall molding.

a) Molding Attachment Clip: 9/16 in. for SQ panels or FL panels.

- 7) Stabilizer bars:

a) Panels with a length equal to or greater than 60" shall require stabilizer bars at the midpoint to secure suspension grid to the ceiling panel.

- 8) T-Bolt: Used to bolt-attach partitions, signage, or pendant-mounted indirect lighting.

a) 7/16" thick x 5/8" head, 1" x 1/4" -20NC bolt; for Fineline Suspension System.



9) Partition Attachment Clip: Snap fit clip, prefinished to match suspension system components.

a) Utilize TEK S/2 fastener, #6-20 in. x 3".

10) Note to Specifier: For Seismic category D E F applications use the paragraphs below:

11) Seismic Separation joint accessories: Tee sleeves to accommodate movement: Snap fit sleeve, prefinished to match suspension system components.

12) Four way Seismic Separation joint clip: Connects 4 way intersection: Snap fit sleeve with optional screw/fixing holes.

13) Compression Posts for bracing of ceiling applications:

a) Adjustable 18" to 30", Adjustable 30" to 48", Adjustable 48" to 84, Adjustable 84" to 102", Adjustable 102" to 120", Adjustable 120" to 144".

e. Suspension System Attachment devices.

1) Hanger: Galvanized carbon steel; soft temper; pre-stretched; yield stress load at least three times the design load but not less than 12-gauge.

a) Spacing and gauge per IBC, UL and CISCA design.

b) Supplied and installed by ceilings subcontractor.

K 20.03 Workmanship

Acoustical materials shall be installed under temperature and humidity conditions similar to those which will exist when the building is occupied. They should not be installed when buildings are damp and cold or dry and hot. Plastering, floor and wall cladding shall be completed and allowed to dry before the installation of acoustical materials commences. All windows and doors shall be in place and glazed. Poured or precast concrete or similar roof decks shall be thoroughly dry.

Buildings shall be examined before beginning work to determine that it is properly enclosed and the structure is in proper condition to receive acoustical material and/or suspension system. Areas shall be broom cleaned and uninterrupted for free movement of rolling scaffold.

All products covered by these specifications shall be installed in accordance with the latest edition of the approved manufacturer's specifications.

All acoustical materials and suspension systems shall be installed by skilled labor, thoroughly experienced with this type of installation and in strict conformity with the manufacturer's specifications and to the approval of the Engineer.

Suspended ceilings shall be constructed in accordance with the detail and instructions supplied by the manufacturer and approved by the Engineer. The grid shall be constructed to true level and to produce a perfect alignment of the joints truly parallel to the buildings lines, and completely free from waviness.

Special access hatches as required shall be provided next to air conditioning and ventilation units and wherever required by the Engineer. Mounting details shall be applied for the surrounding edge of lighting fixtures and air inlets and outlets and edge of ceiling.

After the installation of the panel carriers for the aluminum ceiling panels, the panels shall be clipped on-to the carriers without the use of any tools.

Plain asbestos cement panels for closing and gaps of suspended ceilings and access panels to gear boxes or ducts shall be cut to true sizes and screwed to galvanized steel angle framing in accordance with the manufacturer's directions and to the satisfaction of the Engineer.

Following installation, the Contractor shall clean soiled or discolored surfaces of units, remove and replace any unit which is damaged or improperly installed to the satisfaction of the Engineer.



K 21 PROTECTION AND CLEANING

All wall, floor and ceiling finishes shall be protected from damage until the completion of the Works. Should any damage be caused it shall be made good to the satisfaction of the Engineer at the Contractor's expense.

All floors, skirtings and unpainted wall finishings shall be cleaned and left perfect on completion.

K 22 TOILET COMPARTMENTS

PART 3 General

3.1 Section Includes

- A. Solid Color Reinforced Composite (SCRC) Substrate:
 - 1. Toilet partitions.
 - 2. Urinal privacy screens.
 - 3. Dressing compartments.
 - 4. Shower dividers.

3.2 Submittals

- A. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- B. Certificate of Origin: Manufacturer shall supply with first submittal, an example of their Certificate of Origin declaring toilet compartments are wholly manufactured and assembled specifically in the United States, including city and state locations. A notarized Certificate of Origin shall be provided with closeout documents.
- C. Shop Drawings: Submit manufacturer's shop drawings for each product specified, including the following:
 - 1. Plans, elevations, details of construction and attachment to adjacent construction.
 - 2. Show anchorage locations and accessory items.
 - 3. Verify dimensions with field measurements prior to final production of toilet compartments.
- D. Selection Samples: For each finish product specified, two complete sets of color chips representing manufacturer's full range of available colors and patterns.
- E. Verification Samples: For each finish product specified, two samples, minimum size 6 inches (150 mm) square representing actual product, color, and patterns.

3.3 Quality Assurance

- A. Manufacturer Qualifications: Minimum 10 year experience manufacturing similar products.
- B. Installer Qualifications: Minimum 5 year experience installing similar products.
- C. Single Source Requirements: To the greatest extent possible provide products from a single manufacturer.
- D. Accessibility Requirements: Comply with requirements applicable in the jurisdiction of the project, including but not limited to ADA and ICC/ANSI A117.1 requirements as applicable.
- E. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
 - 1. Finish areas designated by Architect.
 - 2. Do not proceed with remaining work until workmanship is approved by Architect.
 - 3. Refinish mock-up area as required to produce acceptable work.

3.4 Pre-Installation Meetings

- A. Convene minimum two weeks prior to starting work of this section.

3.5 Delivery, Storage, And Handling

- A. Deliver and store products in manufacturer's unopened packaging bearing the brand name and manufacturer's identification until ready for installation.
- B. Handling: Handle materials to avoid damage.

3.6 Project Conditions

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits



recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

3.7 Sequencing

- A. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

3.8 Warranty

- A. Manufacturer's Warranty: Manufacturer's standard 25 year limited warranty for panels, doors, and stiles against breakage, corrosion, delamination, and defects in factory workmanship. Manufacturer's standard 1 year guarantee against defects in material and workmanship for stainless steel door hardware and mounting brackets.

PART 4 Products

4.1 Manufacturers

- A. Acceptable Manufacturer: Bobrick Washroom Equipment, Inc., or equal approved.

4.2 Solid Color Reinforced Composite (SCRC) Substrate

- A. Solid Color Reinforced Composite (SCRC) Toilet Partitions.
 - 1. Design Type:
 - a. Maximum Height.
 - 1) Door/Panel Height: (183 cm).
 - 2) Floor Clearance: (10 cm).
 - 2. Gap-Free interlocking design.
 - 3. Mounting:
 - a. Floor-mounted.
 - 1) Stile Maximum Height: (198 cm).
 - b. Floor-mounted, overhead-braced with satin finish, extruded anodized aluminum headrails, (1.65 mm) thick with anti-grip profile.
 - 1) Stile Maximum Height: (211 cm).
 - c. Floor-to-ceiling.
 - 1) Stile Maximum Height: As required (305 cm) maximum.
 - d. Ceiling-hung.
 - 1) Stile Maximum Height: as required (305 cm) maximum.
- B. Solid Color Reinforced Composite (SCRC) Urinal Screens:
 - 1. Mounting Configuration:
 - a. Floor-to-ceiling.
 - 1) Screen Height: (178 cm) with floor clearance: (30 cm)
 - 2) Stile Height: As required up to (305 cm) maximum
 - b. Floor-to-ceiling maximum privacy.
 - 1) Screen Height: (183 cm) with floor clearance: (11 cm)
 - 2) Stile Height: As required up to (305 cm) maximum
 - c. Post-to-ceiling.
 - 1) Screen Height: (178 cm)
 - 2) Floor Clearance: (30 cm)
 - 3) Post Height: Up to (305 cm) maximum
 - d. Post-to-ceiling maximum privacy.
 - 1) Screen Height: (183 cm)
 - 2) Floor Clearance: (11 cm)
 - 3) Post Height: Up to (305 cm) maximum
 - e. Wall-hung.
 - 1) Screen Height: (122 cm) with (30 cm) floor clearance.
- C. Solid Color Reinforced Composite (SCRC) Dressing Compartments AND/OR Shower Dividers:
 - 1. Design Type:
 - a. Maximum Height.



- 1) Door/Panel Height: (183 cm).
 - 2) Floor Clearance (10 cm).
 2. Gap-Free interlocking design.
 3. Mounting Configuration:
 - a. Floor-mounted, overhead-braced with satin finish, extruded anodized aluminum headrails, 0.065 inch (1.65 mm) thick with anti-grip profile and integral curtain tracks and hooks for compartments without doors.
 - 1) Vinyl curtains.
 - 2) Stile Maximum Height: 83 inches (211 cm)
- D. Materials: Solid color reinforced composite (SCRC) material for stiles, panels, doors, and screens with coating, thermoset and integrally fused into homogenous piece; high density polyethylene (HDPE), high density polypropylene not acceptable.
 1. Composition: Dyes, organic fibrous material, and polycarbonate/phenolic resins.
 2. Surface Treatment: Non-ghosting, graffiti resistant surface integrally bonded to core through a manufacturing steps requiring thermal and mechanical pressure.
 3. Edges: Same color as the surface.
 4. Color:
 - a. As selected by Architect.
 5. Acceptable SCRC Products: Or manufacturer approved equal.
 - a. Ultimate Corian System by Shower Shapes.
 - b. WilsonArt Gibraltar Material.
 - c. WilsonArt EarthStone Material.
- E. Performance Requirements:
 1. Graffiti Resistance (ASTM D 6578): Passed cleanability test; 5 staining agents.
 2. Scratch Resistance (ASTM D 2197): Maximum load value exceeds 10 kilograms.
 3. Impact Resistance (ASTM D 2794): Maximum impact force exceeds 30 inch-pounds.
 4. Smoke Developed Index (ASTM E 84): Less than 450.
 5. Flame Spread Index (ASTM E 84): Less than 75.
 6. National Fire Protection Association/International Building Code Interior Wall and Ceiling Finish: Class B.
 7. Uniform Building Code: Class II.
- F. Finished Thickness:
 1. Stiles and Doors: (19 mm).
 2. Panels and Screens: (13 mm).
- G. Stiles: Floor-anchored stiles furnished with expansion shields and threaded rods.
 1. Leveling Devices: 7 gauge, (5 mm) thick, corrosion-resistant, chromate-treated, double zinc-plated steel angle leveling bar bolted to stile; furnished with (10 mm) diameter threaded rods, hex nuts, lock washers, flat washers, spacer sleeves, expansion anchors, and shoe retainers.
 2. Stile Shoes: One-piece, 22 gauge (0.8 mm), 18-8, Type 316 stainless steel, (102 mm) height; tops with 90 degree return to stile. One-piece shoe capable of adapting to (19 mm) or (25 mm) stile thickness and capable of being fastened (by clip) to stiles starting at wall line.
- H. Wall Posts: Pre-drilled for door hardware, 18-8, Type 316, 16 gauge (1.6 mm) stainless steel with satin finish; (25 mm) x (38 mm) x high (1473 mm).
- I. Anchors: Expansion shields and threaded rods at floor connections as applicable. Threaded rods secured to supports above ceiling as applicable. Supports above ceiling furnished and installed as Work of Section 055000.
- J. Hardware: Chrome-plated "Zamak", aluminum, extruded plastic hardware not acceptable.
 1. Compliance: Operating force of less than 5 lb (2.25 kg).
 2. Emergency Access: Hinges, latch allow door to be lifted over keeper from outside compartment on inswing doors.
 3. Materials: 18-8, Type 304, heavy-gauge stainless steel with satin finish.
 4. Doorstops: Prevents inswinging doors from swinging out beyond stile; on outswing doors,



- doorstop prevents door from swinging in beyond stile.
5. Fastening: Hardware secured to door and stile by through-bolted, theft-resistant, pin-in-head Torx stainless steel machine screws into factory-installed, threaded brass inserts. Fasteners secured directly into core not acceptable.
 - a. Threaded Brass Inserts: Factory-installed; withstand direct pull force exceeding 1500 lb (680 kg) per insert.
 6. Clothes Hooks: Projecting no more than 1-1/8 inch (29 mm) from face of door.
 7. Door Hardware Type:
 - a. Institutional Hardware
 - 1) Latching: 14 gauge (1.8 mm) sliding door latch, 11 gauge (2 mm) keeper; latch slides on a shock-resistant nylon track.
 - 2) Hinges: 16 gauge (1.6 mm) stainless steel, self-closing, 3 section hinges.
 8. Fittings:
 - a. Institutional Hardware
 - 1) Mounting Brackets: 18 gauge (1.2 mm) stainless steel and extend full height of panel.
 - 2) U-Channels: Secure panels to stiles.
 - 3) Angle Brackets: Secure stiles-to-walls and panels to walls.
- K. Fire Resistance:
1. National Fire Protection Association/International Building Code Interior Wall and Ceiling Finish: Class B / Uniform Building Code: Class II.
 - a. Flame Spread Index (ASTM E 84): 30 for panels and stiles.
 - b. Smoke Developed Index (ASTM E 84): 55 for panels, 20 for stiles.National Fire Protection Association/International Building Code Interior Wall and Ceiling Finish: Class A / Uniform Building Code: Class I.
 - c. Flame Spread Index (ASTM E 84): 15 for panels and stiles.
 - d. Smoke Developed Index (ASTM E 84): 25 for panels, 20 for stiles.

PART 5 Products

5.1 Preparation

- A. Prepare substrates including but not limited to blocking and supports in walls and ceilings at points of attachment using methods recommended by the manufacturer for achieving the best result for the substrates under the project conditions.
 1. Inspect areas scheduled to receive compartments for correct dimensions, plumbness of walls, and soundness of surfaces that would affect installation of mounting brackets.
 2. Verify spacing of plumbing fixtures to assure compatibility with installation of compartments.
- B. If preparation is the responsibility of another installer, notify Architect in writing of deviations from manufacturer's recommended installation tolerances and conditions.
- C. Do not proceed with installation until substrates have been properly prepared with blocking and supports in walls and ceilings at points of attachment and deviations from manufacturer's recommended tolerances are corrected. Commencement of installation constitutes acceptance of conditions.

5.2 Installation

- A. Install products in strict compliance with manufacturer's written instructions and recommendations, including the following:
 1. Verify blocking and supports in walls and ceilings has been installed properly at points of attachment.
 2. Verify location does not interfere with door swings or use of fixtures.
 3. Use fasteners and anchors suitable for substrate and project conditions
 4. Install units rigid, straight, plumb, and level.
 5. Conceal evidence of drilling, cutting, and fitting to room finish.
 6. Test for proper operation.

5.3 Adjusting, Cleaning And Protection

- A. Adjust hardware for proper operation after installation. Set hinge cam on in-swinging doors to



hold doors open when unlatched. Set hinge cam on out-swinging doors to hold unlatched doors in closed position.

- B. Touch-up, repair or replace damaged products.
- C. Clean exposed surfaces of compartments, hardware, and fittings.

END OF SECTION



SECTION-M: PAINTING

ALIPHATIC ACRYLIC-POLYESTER POLYURETHANE PAINT FOR STEEL AND GALVANIZED STEEL WORKS

A GENERAL SPECIFICATIONS

- A.1 Description
High build low sheen finish that has excellent resistance to corrosion, chemicals and abrasion. It shall provide very good weathering performance.
- A.2 Features
1. Outstanding performance properties in both mild and aggressive environments.
 2. High-build, two-coat systems
 3. Suitable for application direct to inorganic zincs
- A.3 Primers
Prime with specific primers as specified in clause 0802 hereafter and recommended by manufacturer
- A.4 Dry Film Thickness
75-125 microns per coat. Dry film thickness in excess of 175 microns per coat is not recommended
- A.5 Solid Content
By volume: 57% \pm 2%
- A.6 Dry Temperature Resistance
- a- Continuous: 93 °C
 - b- Non-Continuous: 121°C
 - c- Discoloration and loss of gloss is observed above 93°C.

B SUBSTRATES AND SURFACE PREPARATION

- B.1 General
Surfaces must be clean and dry. Employ adequate methods to remove dirt, dust, oil and all other contaminants that could interfere with adhesion of the coating.
- B.2 Steel
SSPC-SP6 with a 37.5-62.5 micron surface profile for maximum protection. SSPC-SP2 or SP# as minimum requirement. Prime with specific primers as specified below and recommended by manufacturer.
- B.3 Galvanized Steel
SSPC-SP1 and prime with specific primers as specified below and recommended by manufacturer.

C Applications

C.1 Application Conditions

Condition	Material	Surface	Ambient	Humidity
Normal	18° – 29 °C	18° – 29 °C	18° – 29 °C	35 – 60 %
Minimum	4 °C	4 °C	4 °C	0 %
Maximum	38 °C	43 °C	43 °C	90 %

Substrate temperature should be 3°C above the dew point.

Application should not be done when humidity above the maximum, or exposure to moisture from rain or dew.

C.2 Curing Schedule

Surface Temp. & 50% relative humidity	Dry to Handle	Dry to Recoat	Final Cure



4 °C	20 Hours	20 Hours	28 Days
10 °C	12 Hours	12 Hours	14 Days
24 °C	5 Hours	5 Hours	7 Days
32 °C	1 Hour	1 Hour	4 Days

These times are based on 75-125 micron dry film thickness. Higher film thickness, insufficient ventilation or cooler temperatures will require longer cure times and could result in solvent entrapment and premature failure.

D Manufacturer

Supplier: **Dulux** or Approved Equivalent

E ALIPHATIC ACRYLIC-POLYESTER POLYURETHANE PRIMERS FOR STEEL AND GALVANIZED STEEL WORKS

GENERAL SPECIFICATIONS

E.1 Description

High solids corrosion resistant primer and intermediate. Used either as a primer or an intermediate coat over steel and inorganic zinc primers.

E.2 Features

- 1- Excellent corrosion protection
- 2- Excellent film build and edge protection
- 3- Used as a primer or an intermediate coating
- 4- Good abrasion resistance

E.3 Coats

Acrylics, Alkyds, Epoxies, Polyurethanes

E.4 Dry Film Thickness

- 1- 75 microns for mild environments and as an intermediate coat over inorganic zincs.
- 2- 100-150 microns for more severe environments.
- 3- Do not exceed 250 microns in a single coat. Excessive film thickness over inorganic zincs may increase damage during shipping or erection

E.5 Solid Content

By volume: 77% ± 2%

E.6 Dry Temperature Resistance

- 1- Continuous: 93 °C
- 2- Non-Continuous: 121°C
- 3- Discoloration and loss of gloss is observed above 93°C.

F SUBSTRATES AND SURFACE PREPARATION

F.1 General

Surfaces must be clean and dry. Employ adequate methods to remove dirt, dust, oil and all other contaminants that could interfere with adhesion of the coating.

F.2 Steel

SSPC-SP6 with 25-50 micron surface profile.

G Application

G.1 Application Conditions

Condition	Material	Surface	Ambient	Humidity
Normal	16° – 29 °C	16° – 29 °C	16° – 32 °C	0 – 80 %
Minimum	10 °C	10 °C	10 °C	0 %
Maximum	32 °C	57 °C	43 °C	90 %

Substrate temperature should be 3°C above the dew point.



Application should not be done when humidity above the maximum, or exposure to moisture from rain or dew. This can cause flash rusting on prepared steel and interfere with proper adhesion to the substrate.

G.2 Curing Schedule

Surface Temp. & 50% relative humidity	Dry to Touch	Dry to Handle	Dry to Topcoat
10 °C	5 Hours	16 Hours	24 Hours
16 °C	4 Hours	12 Hours	16 Hours
24 °C	3 Hours	6 Hours	8 Hours
32 °C	2 Hour	3 Hour	4 Hours

These times are based on 100 micron dry film thickness. Higher film thickness, insufficient ventilation or cooler temperatures will require longer cure times and could result in solvent entrapment and premature failure. Excessive humidity or condensation on the surface during curing can interfere with the cure, can cause discoloration and may result in a surface haze. Any haze or blush must be removed by water washing before recoating. During high humidity conditions, application to be done while temperatures are increasing.

H Manufacturer

H.1 Supplier: Dulux or Approved Equivalent

J Weathershield Smooth Paint

J.1 General

Smooth Exterior paint formulated with acrylic resin and should be specially designed to give 15 years all-weather protection guaranteed.

J.2 Surface Preparation

All surfaces to be painted should be sound, clean and dry (new surfaces particularly must be fully dry)

Remove any loose or flaking paint. Areas affected by mould, lichen, algae or moss should be treated with a suitable fungicidal wash.

J.3 Application

Two full coats of Weathershield Smooth Exterior paint are required.

Weathershield Smooth Exterior paint should contain algacide and fungicide to inhibit mould and algal growth that can damage the paint film.

J.4 Precautions

Do not use or store the paint in extremes of temperature. Do not use outside when there is a likelihood of rain, fog or frost both during and after application, as this will affect the drying process. Protect from frost.

J.5 Health & Safety

Ensure good ventilation during application and drying.

J.6 Manufacturer

Supplier: **DULUX** or Approved Equivalent

END OF SECTION

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SECTION-N: STEEL STRUCTURE WORK

N 1 SCOPE

This section describes and specifies work required for the steel structure, including materials, built-up sections, intended to be used for the Project under the Contract in accordance with the Drawings, Bills of Quantities and as directed by the Engineer.

N 2 APPLICABLE TESTS AND CODES

Prior to commencement of Steel 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 uninterrupted progress of concrete works according to the approved project schedule of works under the Contract, the samples shall be approved and sent to the laboratories for testing.

The Contractor shall have the tests made, at his own expense in the laboratories approved by the Engineer.

The Contractor shall, at his own expense, supply all test samples.

N 3 MATERIALS

N 3.01 Structural Steel

Material conforming to one of the following standard specifications (latest date of issue) is approved for use under this Specification:

Structural Steel, ASTM A36

Welded and Seamless Steel Pipe, ASTM A53, Grade B

Certified mill test reports or certified reports of tests made by the fabricator or a testing laboratory in accordance with ASTM A6 or A568, as applicable, and the governing specification shall constitute sufficient evidence of conformity with one of the above ASTM standards. Additionally, the fabricator shall, if requested, provide an affidavit stating that the structural steel furnished meets the requirements of the grade specified.

Structural steel member shall be shot-blasted and cleaned to Swedish standard SA 2 ½ by automatic-shot blasting machine to reach white steel prior painting.

Three coats of Epoxy paint shall be applied to all structural steel members with total dry-film thickness of 150 micro, since the powder coated system cannot be applied in your case.

N 3.02 **Bolts**

Steel bolts shall conform to the following standard specifications, latest edition:

Low-Carbon Steel Externally and Internally Threaded Standard Fasteners, ASTM A307

High Strength Bolts for Structural Steel Joints, Including Suitable Nuts and Plain Hardened Washers, ASTM A325

Quenched and Tempered Steel Bolts and Studs, ASTM A449

Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints, ASTM A490

In connections, A449 bolts may be used only in bearing-type connections requiring bolt diameter greater than 1 ½ inches. A449 bolt material is also acceptable for high-strength anchor bolts and threaded rods



of any diameter.

Manufacturer's certification shall constitute sufficient evidence of conformity with the standards.

N 3.03 Filler Metal and Flux for Welding

Welding electrodes and fluxes shall conform to one of the following specifications of the American Welding Society, latest adoption, as appropriate:

Specification for Mild Steel Covered Arc-Welding Electrodes, AWS A5.1

Specification for Low-Alloy Steel Covered Arc-Welding Electrodes, AWS A5.5

Specification for Bare Mild Steel Electrodes and Fluxes for Submerged-Arc Welding, AWS A5.17

Specification for Mild Steel Electrodes for Gas Metal-Arc Welding, AWS A5.18

Specification for Mild Steel Electrodes for Flux-Cored Arc Welding, AWS A5.20

Specification for Bare Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding, AWS A5.23

Manufacturer's certification shall constitute sufficient evidence of conformity with the specifications.

N 3.04 Stud Shear Connectors

Steel stud shear connectors shall conform to the requirements of Articles 4.26 and 4.27, *Structural Welding Code*, AWS D1.1-77, of the American Welding Society.

Manufacturer's certification shall constitute sufficient evidence of conformity with the code.

N 4 PLANS AND DRAWINGS

N 4.01 Shop Drawings

Shop drawings, giving complete information necessary for the fabrication of the component parts of the structure, including the location, type, and size of all rivets, bolts, and welds, shall be prepared in advance of the actual fabrication. They shall clearly distinguish between shop and field rivets, bolts, and welds.

Shop drawings shall be made in conformity with the best modern practice and with due regard to speed and economy in fabrication and erection.

N 4.02 Notation for Welding

Note shall be made on the plans and on the shop drawings of those joints or groups of joints in which it is especially important that the welding sequence and technique of welding be carefully controlled to minimize welding under restraint and to avoid undue distortion.

Weld lengths called for on the plans and on the shop drawings shall be the net effective lengths.

N 5 TYPES OF CONSTRUCTION

Type 2, commonly designated as "simple framing" (unrestrained, free-ended), assumes that, insofar as gravity loading is concerned, the ends of beams and girders are connected for shear only, and are free to rotate under gravity load.

N 6 PLATE GIRDERS AND ROLLED BEAMS

N 6.01 Stiffeners

Bearing stiffeners shall be placed in pairs at unframed ends on the webs of plate girders and, where required, at points of concentrated loads. Such stiffeners shall have a close bearing against the flange, or flanges, through which they receive their loads or reactions, and shall extend approximately to the edge of the flange plates or flange angles. They shall be designed as columns subject to the provisions of Sect. 1.5.1, assuming the column section to comprise the pair of stiffeners and a centrally located strip of the web whose width is equal to not more than 25 times its thickness at interior stiffeners or not more than 12 times its thickness when the stiffeners are located at the end of the web. The effective length shall be taken as not less than $\frac{3}{4}$ of the length of the stiffeners in computing the ratio l/r . Only that portion of the



stiffeners outside of the flange angle fillet or the flange-to-web welds shall be considered effective in bearing.

N 7 GROSS AND NET AREAS

N 7.01 Pin-Connected Members

Eyebars shall be of uniform thickness, without reinforcement at the pin holes. They shall have “circular” heads in which the periphery of the head beyond the pin hole is concentric with the pin hole. The radius of transition between the circular head and the body of the eyebar shall be equal to or greater than the diameter of the head.

The width of the body of the eyebar shall not exceed 8 times its thickness, and the thickness shall not be less than 1/2-inch. The net area of the head through the pin hole, traverse to the axis of the eyebar, shall not be less than 1.33 nor more than 1.50 times the cross-sectional area of the body of the eyebar. The diameter of the pin shall not be less than 7/8 the width of the body of the eyebar. The diameter of the pin hole shall not be more than 1/32-inch greater than the diameter of the pin. For steels having a yield stress greater than 70 ksi, the diameter of the pin hole shall not exceed 5 times the plate thickness.

In pin-connected plates other than eyebars, the tensile stress on the net area, traverse to the axis of the member, shall not exceed the stress allowed in Sect. 1.1.5.1 and the bearing stress on the projected area of the pin shall not exceed the stress allowed in Sect. 1.5.1.5.1. The minimum net area beyond the pin hole, parallel to the axis of the member, shall not be less than 2/3 of the net area across the pin hole.

The distance transverse to the axis of a pin-connected plate or any individual element of a built-up member, from the edge of the pin hole to the edge of the member or element, shall not exceed 4 times the thickness at the pin hole. The diameter of the pin hole shall not be less than 1.25 times the smaller of the distances from the edge of the pin hole to the edge of a pin-connected plate or separated element of a built-up member at the pin hole. For pin-connected members in which the pin is expected to provide for relative movement between connected parts while under full load, the diameter of the pin hole shall not be more than 1/32-inch greater than the diameter of the pin.

The corners beyond the pin hole may be cut at 45° to the axis of the member, provided the net area beyond the pin hole, on a plane perpendicular to the cut, is not less than that required beyond the pin hole parallel to the axis of the member.

Thickness limitations on both eyebars and pin-connected plates may be waived whenever external nuts are provided so as to tighten pin plates and filler plates into snug contact. When the plates are thus contained, the allowable stress in bearing shall be no greater than as specified in Sect. 1.5.1.5.1.

N 7.02 Fillet Welds

The effective area of fillet welds shall be considered as the effective length times the effective throat thickness.

The effective length of fillet welds, except fillet welds in holes and slots, shall be the overall length of full-size fillet, including returns.

The effective throat thickness of a fillet weld shall be the shortest distance from the root to the diagrammatic weld, except that, for fillet welds made by the submerged arc process, the effective throat thickness shall be taken equal to the leg size for 3/8-inch and smaller fillet welds, and equal to the theoretical throat plus 0.11-inch for fillet welds over 3/8-inch.

For fillet welds in holes and slots, the effective length shall be the length of the center line of the weld through the center of the plane through the throat. However, in the case of overlapping fillets, the effective area shall not exceed the nominal cross-section area of the hole or slot, in the plane of the faying surface.

N 8 RIVETS AND BOLTS

N 8.01 High-Strength Bolts

Except as otherwise provided in this Specification, use of high-strength bolts shall conform to the provisions of the *Specifications for Structural Joints Using ASTM A325 or A490 Bolts*, latest edition, as approved by the Research Council on Riveted and Bolted Structural Joints.

If required to be tightened to more than 50 percent of their minimum specified tensile strength, ASTM A449 bolts in tension and bearing-type shear connections shall have a hardened washer installed under the bolt head, and the nuts shall meet the requirements of ASTM A325.



N 8.02 Minimum Spacing

The distance between the centers of standard, oversized, or slotted fastener holes shall be not less than $2/3 d$, where d is the nominal diameter of the fastener, inches, nor less than that required by Sect. 9.01.1, if applicable.

N 8.02.1 Along a line of transmitted force, the distance between the centers of holes shall not be less than the following:

1. Standard Holes:

$$2P/F_u t + d/2$$

where

P = force transmitted by one fastener to the critical connected part, kips

F_u = specified minimum tensile strength of the critical connected part, kips per square inches

t = thickness of the critical connected part, inches

2. Oversized and Slotted Holes:

The distance required for standard holes in subparagraph 1, above, plus the applicable increment C_1 in Table 1.16.4.2, but the clear distance between holes shall not be less than one bolt diameter.

N 8.03 Minimum Edge Distance

The distance from the center of a standard hole to an edge of a connected part shall be not less than the applicable value in Table 8.03-1 nor the value from Sect. 8.03.1 or 8.03.2, as applicable.

N 8.03.1 Along a line of transmitted force, in the direction of the force, the distance from the center of a standard hole to the edge of the connected part shall be not less than $2P/F_u t$ where P , F_u , and t are defined in Sect. 9.02.1

N 8.03.2 At end connections bolted to the web of a beam and designed for beam shear reaction only (without use of an analysis which accounts for the effects induced by fastener eccentricity), the distance from the center of the nearest standard hole to the end of the beam web shall be not less than

$$2P_R/F_u t$$

where P_R is the beam reaction, in kips, divided by the number of bolts, and F_u and t are defined in Sect. 9.02.1. Alternatively, the requirement of Formula 9.03.2 may be waived provided the bearing stress induced by the fastener is limited to not more than $0.90 F_u$.

Table 8.03.1
Minimum Edge Distance, Inches
(Center of Standard Hole^a to Edge of Connected Part)

Nominal Rivet or Bolt Diameter (Inches)	At Sheared Edges	At Rolled edges of Plates, Shapes, or Bars or Gas Cut Edges ^b
1/2	7/8	3/4
5/8	1 1/8	7/8
3/4	1 1/4	1
7/8	1 1/2 ^c	1 1/8
1	1 3/4 ^c	1 1/4
1 1/8	2	1 1/2
1 1/4	2 1/4	1 5/8
Over 1 1/4	1 3/4 x Diameter	1 1/4 x Diameter

^a For oversized or slotted holes, see Sect. 9.03.3

^b All edge distances in this column may be reduced 1/8-in. when the hole is at a point where stress does not exceed 25% of the maximum allowed stress in the element.

^c these may be 1 1/4-in. at the end of beam connection angles.



N 8.03.3 The distance from the center of an oversized or slotted hole to an edge of a connected part shall be not less than that required for a standard hole by Sect. 9.03, as applicable, plus the applicable increment C_2 in Table 1.16.5.4

N 8.04 Maximum Edge Distance

The maximum distance from the center of any rivet or bolt to the nearest edge of parts in contact with one another shall be 12 times the thickness of the connected part under consideration, but shall not exceed 6 inches.

N 9 WELDS

N 9.01 General

All provisions of the *Structural Welding Code*, AWS D1.1-77, of the American Welding Society, except 2.3.2.4, 2.5, 8.13.1.2, and section 9, as appropriate, apply to work performed under this Specification.

N9.02 Minimum Size of Fillet Welds and Partial-Penetration Welds

The minimum size of fillet weld shall be as shown in Table 1.17.2A. The minimum effective throat thickness of a partial-penetration groove weld shall be as shown in Table 1.17.2B. Weld size in determination by the thicker of the two parts joined, except that the weld size need not exceed the thickness of the thinner part joined unless a larger size is required by calculated stress. For this exception, particular care shall be taken to provide sufficient preheat for soundness of the weld.

N9.03 Maximum Size of Fillet Welds

The maximum size of fillet weld that may be used along edges of connected parts shall be:

1. Along edges of material less than $\frac{1}{4}$ -inch thick, not greater than the thickness of the material.
2. Along edges of material $\frac{1}{4}$ -inch or more in thickness, not greater than the thickness of the material minus $\frac{1}{16}$ -inch, unless the weld is especially designated on the drawings to be built out to obtain full throat thickness.

N9.04 Length of Fillet Welds

The minimum effective length of a fillet weld designed on the basis of strength shall be not less than 4 times the nominal size, or else the size of the weld shall be considered not to exceed $\frac{1}{4}$ of its effective length.

If longitudinal fillet welds are used alone in end connections of flat bar tension members, the length of each fillet weld shall be not less than the perpendicular distance between them. The traverse spacing of longitudinal fillet welds used in end connections shall not exceed 8 inches, unless the design otherwise prevents excessive transverse bending in connection.

N9.05 Intermittent Fillet Welds

Intermittent fillet welds may be used to transfer calculated stress across a joint or faying surfaces when the strength required is less than that developed by a continuous fillet weld of the smallest permitted size, and to join components of built-up members. The effective length of any segment of intermittent fillet welding shall be not less than 4 times the weld size, with a minimum of $1\frac{1}{2}$ inches.

N9.06 End Returns of Fillet Welds

Side or end fillet welds terminating at ends or sides, respectively, of parts or members shall, wherever practicable, be returned continuously around the corners for a distance not less than 2 times the nominal size of the weld. This provision shall apply to side and top fillet welds connecting brackets, beam seats, and similar connections, on the plane about which bending moments are computed. End returns shall be indicated on the design and detail drawings.



N 10 BUILT-UP MEMBERS

N 10.01 Open Box-Type Beams and Grillages

Where two or more rolled beams or channels are used side-by-side to form a flexural member, they shall be connected together at intervals of not more than 2 feet. Through-bolts and separators may be used, provided that, in beams having a depth of 12 inches or more, no fewer than 2 bolts shall be used at each separator location. When concentrated loads are carried from one beam to the other, or distributed between the beams, diaphragms having sufficient stiffness to distribute the load shall be riveted, bolted, or welded between the beams. Where beams are exposed, they shall be sealed against corrosion of interior surfaces or spaced sufficiently far apart to permit cleaning and painting.

N 10.02 Compression Member

At the ends of built-up compression members bearing on base plates or milled surfaces, all components in contact with one another shall be connected by rivets or bolts spaced longitudinally not more than 4 diameters apart for a distance equal to $1 \frac{1}{2}$ times the maximum width of the member, or by continuous welds having a length not less than the maximum width of the member.

The longitudinal spacing for intermediate rivets, bolts, or intermittent welds in built-up members shall be adequate to provide for the transfer of calculated stress. However, where a component of a built-up compression member consists of an outside plate, the maximum spacing shall not exceed the thickness of the thinner outside plate times $127/(F_y)^{1/2}$



SECTION : 15

ASPHALT WORKS

1 GENERAL

The Contractor shall construct the area to be paved in accordance with the applicable specifications stipulated herein after, in conformity with the alignment, dimensions, and typical sections shown on the Drawings, or as directed by the Engineer .

2 TYPE OF WORK

For the purpose of these specifications, the following type of asphalt works is designated :

- Preparing and leveling of existing base - course .
- Compacting of existing base - course .
- Prime coat .
- Single asphalt surface layer .

3 BASE - COURSE

General

The Contractor shall provide only an aggregate material for the base-course consisting of hard, durable, crushed limestone or crushed wadi gravel, provided that the crushed aggregates retained on sieve No. 4 shall have 80% by weight of at least two fractured faces , which have to be crushed by approved crushing plant and shall be free from any organic matter or any other deleterious substances and also free from clay balls .

Base - course aggregate shall conform to the following gradation :

Sieve Size	Percent Passing
1 1/2 inch (38.10 mm)	100
1 inch (25.40 mm)	75-100
3/4 inch (19.10 mm)	60-90
1/2 inch (12.70 mm)	45-80
3/8 inch (09.52 mm)	40-70
No.4 (04.76 mm)	35-65
No.10 (02.00 mm)	20-40
No.40 (00.42 mm)	8-20
No.200 (00.075 mm)	5-10

The fraction passing No. 200 sieve shall not be greater than 70% of the fraction passing No. 40 sieve .

Base - course aggregates shall confirm to the requirements of the following standard tests :-

Los Angeles Abrasion	(AASHTO -T- 96) 35 max .
Liquid Limit	(AASHTO -T- 89) 25 max .
Plasticity Index	(AASHTO -T- 90) 2 min . 6 max .
Flaky & Elongated Particles	(B.S.812) 15% max. each .

The base-course shall be compacted to not less than 100% of the density obtained at optimum moisture content as determined by ASTM-DT 99C.

The following test shall also be performed :

- a) Gradation tests shall be performed on samples of base - course taken after mixing with water and spreading before compaction and shall have a maximum % passing sieve No. 200 of 10% .



b) Gradation tests shall be performed on samples of base - course taken after compaction and the maximum material passing sieve No. 200 shall not exceed 10% .

The thickness of the compacted layer shall be measured and recorded when performing filed density tests and sieve tests on samples taken from compacted layers in place .

Construction

Aggregate for base-course shall be delivered to the area to be paved as a uniform mixture and shall spread in layers .

Segregation shall be avoided and the base-course shall be free from pockets of coarse or fine materials. The base-course shall be spread by a grader or any other mechanical method, approved by the Engineer, watered, shaped and compacted to the required grade and cross section .

The finished surface of the base-course shall not vary at any point by more than 1 cm below the grade established by the Engineer, and the total thickness of the base-course shall not vary by more +0.50 cm . In addition to level checking, longitudinally the surface shall be checked with a straight edge (4m long), where irregularities in this direction shall not vary by more than 1cm .

A minimum of (4) levels of the base at the total longitudinal side shall be taken and if (2) or more of these levels exceed the tolerance given the Contractor shall re-grade the entire length of the area. If one of these levels exceeds the tolerance then the Contractor shall make good this point .

The aggregate base shall be compacted to not less than 100% of the maximum density determined in accordance with the latest modified AASHTO T-191,T-205 or T-205 and T-239.

The base-course shall be maintained in a condition satisfactory to receive surfacing material . Aggregate base-course which does not conform to the above requirements, shall be reshaped or reworked, watered and thoroughly re-compacted to conform to the specified requirements at the Contractors own expense .

Method of Measurement

Base-course shall be measured per cu.m in place, acceptably laid and compacted according to the dimensions shown on the Drawings .

Method of Payment

Payment shall be made at the Contract unit rate for "compacted aggregate base-course" per cu.m. This price shall constitute full compensation for furnishing and placing all materials including watering , compacting, shaping and all labour, equipment, tools, supplies, tests, and incidentals necessary to complete the work .

4 PRIMECOAT

General

Liquid asphalt for prime coat shall be medium curing grade MC70, in conformance with AASHTO standard M82, or emulsion type SS1, SS2 or equivalent according to the manufacturer instructions and lab tests results.

The surface to be treated shall be smooth, compact and tight. It shall be true to grade , and cross-section where dust shall be removed by brooming .

Equipment

The equipment used by the Contractor shall include a power broom or a power blower or both; a self - propelled , pneumatic roller, or steel-wheeled tandem (5 to tons) or both; mechanical or self-propelled aggregate spreading equipment that can be adjusted to spread accurately the specified amounts per square meter, a pressure distributor and equipment for heating the asphalt material. Pneumatic - tired rollers shall have a total compacting width of not less than 120 cm and shall have minimum contact pressures of 2.8



kg/cm² or as specified by the Engineer. Other equipment are to be used in addition to, or in lieu of the specified equipment when approved by the Engineer .

The pressure distributor shall be designed and operated to distribute the asphalt material in a uniform spray with atomisation, in the amount and between the limits of temperature specified. It shall be equipped with a tachometer having a dial registering feet or meters of travel per minute . The dial shall be visible to the truck driver so he can maintain the constant speed required for application at the specified rate . The pump shall be equipped with a bitumetre having a dial registering litres, or gallons per minute passing through the nozzles. The dial shall be readily visible to the operator .

Means for indicating accurately the temperature of the asphalt material at all times shall be provided . The thermometer reservoir shall not be in contact with a heating tube .

The spray bar shall be adjustable to a reasonable width. A hose and spray nozzle attachment shall be provided for applying asphalt material to paths and areas inaccessible to the spray bar .

The distributor shall be provided with heating attachments and the asphalt material shall be circulated during the entire heating process .

Application of Primecoat

The Engineer will select the rate of application for the asphalt primer to be used . The Contractor shall keep a record of the application rates selected . Tentatively an application rate of 1.0-1.5 Kg/m² of MC 70 shall be used .

Application of the asphalt prime shall be made uniformly at this rate with the pressure distributor. The asphalt prime shall be applied at the temperature specified by the Engineer . When heating is required, precautions shall be taken to avoid fire hazard .

Application shall be made when the surface is dry or slightly damp and , unless otherwise permitted by the Engineer, when the air temperature in the shade is not less than 10C. After application of the asphalt prime , at least forty - eight (48) hours shall elapse before further applications are made .

Before beginning application , building paper shall be spread over the surface , from the joint back, for a sufficient distance for the spray bar to begin spraying and be operating at full force when the surface to be treated is reached. After the asphalt is applied the building paper shall be removed and destroyed .

The spray bar shall be shut off instantaneously at each construction joint to assure a straight line and the full application of asphalt prime up to the joint . If necessary to prevent dripping, a drip pan shall be inserted under the nozzle when application is stopped . A hand spray shall be used to apply primer material necessary to touch up all spots unavoidably missed by the distributor .

Following the application , the primed surface shall be allowed to dry for a period of not less than 48 hours without being disturbed or for such an additional period of time as may be necessary to permit the drying out of the prime until it will not be picked up .

The surface shall then be maintained by the Contractor until the surfacing has been placed and no traffic (other than that necessary for the Contractor) shall be allowed on the primed surface before placing of the surface treatment .

Method of Measurement

The quantities to be paid for shall be the total quantity in sq.m. of the primed surface area, actually applied, and shall be based on the approved records of the application rates as selected by the Engineer .

**Method of Payment**

Payment shall be based on the Contract unit rate for "Prime Coat" per sq.m.

5 HOT MIX ASPHALT SURFACING**Scope**

Furnishing and mixing non plastic aggregate crushed limestone and asphalt binder at a central mixing plant, spreading and single layer surface course .

Construction shall be in accordance with these specifications and in conformity with lines, grades and thickness as shown on drawings or established by the Engineer .

Composition of Mixes of Mixes

The paving mix shall be Composed of specified aggregates and asphalt cement within the limits of the following table :

Standard Sieve Size	Percent Passing Surface Course
1 inch (25.40 mm)	100
3/4 inch (19.10 mm)	90-100
3/8 inch (90.52 mm)	56-80
No.4 (04.76 mm)	35-65
No.8 (02.00 mm)	23-49
No.50 (00.42 mm)	5-19
No.200 (00.075 mm)	2-8

Asphalt to be added by weight of total weight according to design .

The aggregate shall have a percentage of wear of not more than 35% in 500 revolutions as determined by AASHTO T96. The sand equivalent shall be 50 minimum according to AASHTO T-176. Aggregate shall in all respects comply with the relevant standards. Aggregate limestone to be used be fresh mechanically crushed coarse aggregate . Materials on sieve No.4 shall have 90% by weight of at least two fractured faces .

Filler Material

When the combined grading of the coarse and fine aggregate is deficient in material passing No. 200 sieve , a filler conforming to the requirements specified hereafter shall be added .

Mineral filler shall comply in all respects with AASHTO Standard Specification M17.

The amount of commercial filler to be added shall be only that amount necessary to make the combined grading of the material comply with the grading requirements for the complete mixture .

In no case shall the amount of commercial filler added exceed three percent (3%) , sample obtained from hot bins , by weight of the combined aggregate , The material passing No. 200 sieve may consist of fine particles of the aggregates or mineral filler, or both .It shall free from organic matter and clay particles .

Job Mix Formula

The Contractor shall submit for the Engineer's approval a job mix formula within the limits of these specifications.

The maximum permissible variation from the job mix formula within the specification limits, shall be as follows :



Standard Sieve Size	Permissible Variation Percent by Weight of Total Mix
3/8 inch and larger	+ 5.00
No. 4 to No. 80	+ 4.00
No. 200	+ 1.00
Asphalt	+ 0.30

Mix Test Criteria

Test requirements and criteria for the paving mixes prepared these specifications shall be as follows :

Surfacing

No. of compactive blows each end specimen	75
Minimum Stability (Kg)	900
Flow (1/100")	2-4
Percent air voids	3-5
V.M.A. using bulk S/Gr. (Tolerance - 1%)	min. 14%
V.F.B.	60-75 %
Loss of stability (soaking 24 hours compared with 30 min. at 60OC for all specimens in water bath).	max. 25
Plasticity Index for material passing sieve No.40(from hot bins)	non plastic uncoated
Stripping Test(ASTM D1664)	aggregate

Laboratory test specimens of paving mixes, combined in the proportions of the job mix formula, shall be prepared and tested in accordance with the procedures of the Marshall method of mix design as detailed in the 'Asphalt Institute Manual - MS2' and ASTM method of Test D 1559 .

General Equipment Requirements

All equipment furnished by the Contractor shall meet the requirements of this section and shall be maintained in its best mechanical condition . Equipment shall be serviced and lubricated away from the paving site; units drip fuel, oil, or grease shall be removed from the site until such leakage is corrected .

Elements for All Plants

Uniformity

The plants shall be designed, co-ordinated and operated to produce a uniform mix within the specified job mix tolerances .

Job Mix Formula

The Engineer will make frequent gradation analyses of the hot aggregates and of the completed mix to be certain that the materials being used and produced are within the tolerances of the job mix formula and the specifications of the mix number being used .

If the mix is found to be outside the job mix formula tolerances or outside of the specification limits, correction shall be made in quantities measured from the hot bins and adjustments made the cold bin feeders and the Contractor shall submit a new mix design .

Sampling and Testing



Stockpiles and bins will be sampled for gradation analyses and examined for dust coating and for other purposes, in compliance with stated requirements . Gradation analyses of each hot bin will be performed and a combined analysis conducted at least twice a day once in the forenoon , and once in the afternoon . If materials do not run uniform, more frequent tests will be made .

When requested by the Engineer, the Contractor shall provide representative samples by taking aggregate from each bin through the mixing chamber (without asphalt) into a truck or other receptacle .

At least one sample shall be taken from each truck of the hot mix being delivered to the site. Samples will be used to determine compliance with general and special requirements set forth in these specifications .

Construction Method

Weather Limitations

When the moisture of the aggregate in the stockpile or from the dryer in the plant interferes with the quality of mix production, or with normal plant operations, or when pools of water are observed on the base, then mixing and placing of hot-mix asphalt will not be permitted .

The temperature of the surface on which the hot-mix asphalt is placed shall not be less than 5oC When the surface temperature on which the material is to be placed falls below 10oC, precautions shall be taken to compact the mix before it cools too much, to obtain the required density .

All truck loads shall be delivered continuously and immediately spread and compacted . In cold weather and for shall be delivered at a temperature within 8oC of that temperature specified by the Engineers Representative .

Preparation of Area

The area to be paved shall be true to line and grade, and have a dry and properly prepared surface prior to the start of paving operations . It shall be free from all loose screenings, and other loose or foreign material .

The surface shall be primed as specified. The surface of structures in actual contact with asphalt mixes shall be painted with a thin, complete coating of asphalt material to provide a closely bonded water - tight joint .

Proportioning and Mixing

To aid in determining the proper temperature of the completed batch, current viscosity data shall be available at the plant at all times .

With information relative to the viscosity of the particular asphalt being used, the temperature of the completed mix at the plant and at the paver shall be designated by the Engineer's Representative after discussing with the Contractor the hauling and placing conditions .

The asphalt shall be heated so that it can be distributed uniformly throughout the batch . For mixing applications, the specified temperature will generally be such that the asphalt viscosity is within the range of 150-300 centistokes (75-150 seconds, Saybold Fuyol). The material shall be sufficiently fluid to produce a complete coating on every particle of aggregate within the specified mixing time . The temperature of the aggregates and asphalt immediately prior to mixing shall be approximately that of the completed batch .

When the mix is produced in a batch type plant the aggregate shall be weighed accurately in the designated proportions to provide the specified batch weight . The temperature of the aggregate at the time of introduction into the mixer shall be as directed by the Engineer's Representative with a tolerance of + 8OC. In no case , however , shall temperature of the mixture exceed 165OC .



Transportation of Mix

The mix shall be transported to the job site in vehicles and painted, or sprayed, with a limewater, soap or detergent solution , at least once a day or as often as required .

After this operation the truck bed shall elevated and thoroughly drained ; no excess solution shall be permitted. The dispatching of the vehicles shall be so scheduled that all material .

Delivery of material to the paver shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment .

Spreading and Finishing

Spreading and finishing shall be conducted in the following manner :

Mechanical Paver

The binder and surface courses shall be spread and struck-off with a mechanical paving machine connected with an automatic sensor . The paving machine connected with an automatic sensor. The paving machine shall be operated so that material dose not accumulate and remain along the sides of the receiving hopper .

Equipment which leaves tracks or indented areas which cannot be corrected in normal operation, or which produces flushing or other permanent blemishes or fails to produce a satisfactory surface shall not be used .

Lines for the paver to follow will be established by the Engineer's Representative parallel to the centreline of the proposed roadway . The paver shall be positioned and operated to follow closely the established lines .

In backing trucks against the paver , care shall be taken not to jar it out of its proper alignment .

As soon as the first load of material has been spread, the texture of the unrolled surface shall be checked to determine its uniformity .

Segregation of materials shall not be permitted If suspended until the cause is determined and corrected .
Transverse joints in succeeding courses shall be offset at least 60 cm .

Any irregularities in alignment left by the paver shall be corrected by trimming directly behind the machine. Immediately after trimming , the edges of the course shall be thoroughly compacted by tamping . Distortion of the pavement during this operation shall be avoided .

Edges against which additional pavement is to be placed shall be straight and immediately vertical . A lute or covered rake shall be used immediately behind the paver when required to obtain a true line and vertical edge. Any irregularities in the surface of the pavement course shall be corrected directly behind the paver . Excess material forming high spots shall be removed by a shovel or lute . Indented areas shall be filled with hot mix and smoothed with the back of a shovel being pulled over the surface .
Fanning of material over such areas shall not be permitted .

Hand Spreading

In small areas where the use of mechanical finishing equipment is not practical , the mix may be spread and finished by hand, if so authorised by the Engineer's Representative . Wood or steel form, approved by the Engineer's Representative, rigidly supported to assure correct grade and cross-section, may be used. In such instances, measuring blocks and intermediate strips shall be used to aid in obtaining the required cross-section. Placing by hand shall be performed carefully, the material shall be distributed uniformly to avoid segregation of the coarse and fine aggregate



Broadcasting of material shall not be permitted . During the spreading operation, all materials shall be thoroughly loosened and uniformly distributed by lutes or covered rakes. Material that has formed into lumps and dose not break down readily shall be rejected.

Following placing and before rolling, the surface shall be checked with templates and straight edges and all irregularities shall be corrected .

Heating equipment used for keeping hand tools free from asphalt shall be provided. Caution shall be exercised to prevent high heating temperatures which may burn the material. The temperature of the tools when used shall not be greater than the temperature of the mix being placed . Heat only shall be employed to clean hand tools; petroleum oils or solvents shall not be permitted .

Compaction General General

Except for small jobs, such as driveways, at least two rollers shall be required at all times. As many additional rollers shall be used as necessary to provide specified pavement density .

During rolling , the roller wheels shall be kept moist with only sufficient water to avoid picking up the material .

After the edges have been compacted rolling shall start longitudinally at the sides and gradually progressing toward the centre of the pavement .

The rollers shall move at a slow but uniform speed with the drive roll or wheel nearest the paver . The speed shall not exceed 5 kph for steel-wheeled rollers or 8 kph for pneumatic - tired rollers .

The line of rolling shall not be changed suddenly . If rolling causes displacement of the material, the affected areas shall be loosened at once with lutes or shovels and restored to the original grade of the loose material before being re-rolled .

Heavy equipment or rollers should not be permitted to stand on the finished surface before it has been compacted and has thoroughly cooled .

Rolling shall be in the following order :-

- a) Transverse joints .
- b) Outside edge
- c) Initial or breakdown rolling , beginning on the low-side and progressing toward the high side
- d) Second rolling , same procedure as (c)
- e) Finish rolling .

The compaction temperature (laboratory) shall be (viscosity) of bitumen is 280+30 centistoke, as follows :
148+30C for 60/70 penetration .

Transverse Joints

Transverse joints shall be held to a minimum and thoroughly compacted to provide a smooth riding surface.

Joints shall be straight edges and string - lined to assure smoothness and true alignment . If a joint is formed with a bulkhead , such as a board , to provide a straight line and vertical face, it shall be checked with a



straight edges before fresh material is placed against it to complete the joint . If a bulkhead is not used to form the joint and the roller is permitted to roll over the end of the new material , the line shall be located back of the rounded edge a sufficient distance to provide a true surface and cross-section . If the joint has been distorted by traffic or by other causes, it shall be trimmed to line .

In either case, the joint face shall be painted with a thin coating of asphalt before fresh material is placed against it .

To obtain through compaction of these joints, material placed against the joint shall be tightly crowded against the vertical face of the joint .

To accomplish this, the paving machine shall be positioned so that the material shall overlap the edge of the joint by 3 to 5 cm. The depth of the overlapped material shall be kept uniform .

The coarse aggregate in the overlapped material that was dislodged through raking or luting shall be removed from the pavement surface and discarded .

A tandem roller shall be placed on the previously compacted material transversely so that no more 15 cm of the rear rolling wheel rides on the edge of the joint .

The roller shall be operated to pinch and press the mix place at the transverse joint . The roller shall continue to roll along this line, shifting its position gradually across the joint, in 15 to 20 cm P17 increments , until the joint has been rolled with the entire width of the roller wheel. Rolling joint is obtained

Edges

Care shall be exercised in consolidating the course along the entire length of the edges . Before it is compacted, the material along the unsupported edges shall be slightly elevated with a tamping tool or lute.

This will permit the full weight of the roller wheel to bear on the material to the extreme edges of the mat . In rolling pavement edges, roller wheels shall extend 5 cm to 10 cm beyond the pavement edge .

Breakdown Rolling

Breakdown rolling shall commence at a temperature of not less than 120OC and immediately follow the rolling of the longitudinal joint and edge. Rollers shall be operated as close to the pavement as necessary to obtain adequate density without undue displacement . The breakdown roller shall be operated with the drive roll or wheel nearest the finishing machine . Exceptions may be made by the Engineer's Representative when working on steep slopes .

When both three-wheeled rollers and tandem rollers are used, the three-wheeled rollers shall work directly behind the paver following by the tandem rollers . Only experienced roller operators shall be used for used this work .

Second Rolling

Pneumatic-tired rollers shall be used for the second rolling . The second rolling shall follow the breakdown rolling as closely as possible and while the paving mix is still of at a temperature that will result in maximum density from this operation .

Pneumatic-tired rollers shall be continuous (at least three complete coverages) after the initial rolling until all of the mix placed rollers on the hot paving mix which causes undue displacement will not be permitted .

Finish Rolling



The finish rolling shall be accomplished with two-axle tandems or three-axle tandems while the material is still warm enough for the removal of the rollers marks. If necessary to obtain the required surface finish, the Engineer's Representative shall specify the use of pneumatic - tired rollers . All rolling operations shall be conducted in close sequence .

In places inaccessible for the operation of standard rollers as specified , compaction shall be performed by trench rollers or others. The trench roller shall be operated at the direction of the Engineer's Representative until the course is thoroughly compacted. Hand tamping, manual or mechanical , may be used in such areas if it proved to the Engineer's Representative that such operations will give the desired density .

Shoulder

The shoulder material shall not be placed against the edges of the pavement until the rolling of the surface course has been completed.

Adequate precaution shall be taken to prevent distortion of the pavement edge from specified line and grade.

When the rolling of the surface course has been completed and the edges have been thoroughly compacted , shoulder material shall be immediately placed against the edges and rolled .

Density and Surface Requirements

The completed pavement shall have a relative compaction equal to or greater than 98% (from daily Marshall) of a laboratory specimen prepared as specified in Section A, "Test Methods and Definitions" , and made form plant mix conforming to the result of density from samples taken on site .

The final surface shall be of uniform texture and shall conform to line and grade shown on the plans. Before final acceptance of the project, or during the progress of the work, the thickness of all courses will be determined by the Engineer's Representative .

All unsatisfactory work shall be repaired, replaced or corrected .

Both density and thickness shall be carefully controlled during construction and shall be in full compliance with the plans and specifications. During compaction, preliminary tests as an aid for controlling the thickness , shall be made by inserting a flat blade , correctly graduated, through the material to the top of the previously placed base , or by other means approved by the Engineer's Representative

In checking compacted depth , the cutting of the test holes, refilling with acceptable materials, and proper compaction shall be done by the Contractor under the supervision of the Engineer's Representative .

For the purpose of testing the surface on all courses, a 3- meter long aluminum straight edge at the longitudinal direction shall be used.

Any irregularities which vary more than 0.5 cm in 3 meters shall be corrected . Irregularities which vary may develop before the completion of rolling shall be remedied as may be required .

Should any irregularities or defects remain after the final compaction , the surface course shall be removed promptly and sufficient new material laid to form a true and even surface . All minor surface projections, joints, and minor honeycombed surfaces shall be ironed smooth to grade as may directed by the Engineer's Representative .

Method of Measurement

Asphalt concrete shall be measured by square meters of the actual area paved and accepted in place including the bitumen according to the dimensions shown on the Drawings .

Edge slopes shall be done but will not be measured for payment .



Basis of Payment

Payment shall be based on the Contract unit rate for "Asphalt mix surface thickness 0.06m" per square meter, complete in place including bituminous material . No payment shall be made for extra width or for extra thickness .

The required compacted thickness is the minimum acceptable and tolerance shall be on the plus side .

Payment may also be based on the unit linear meter of road excavation according to B.O.Q. where thickness of asphalt mix shall remain as 0.06m , and the Contractor shall follow all above mentioned specifications .

UNITED NATIONS DEVELOPMENT PROGRAMME



Tender And Contract

Documents

GENERAL SPECIFICATIONS – ELECTRICAL WORKS

VOL 3 OF 4



BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 General Instructions

1.1.1 Works under this section shall be governed by conditions of contract.

1.2 Scope

1.2.1 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:

Electric Power System
Lighting System
Telephone System
Fire Alarm System
Earthing System

Other Misc. Systems

1.3 Codes and Standards

1.3.1 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 (MEW) and Civil Defence Administration.

1.3.2 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.

1.3.3 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 Euronorm specifications unless otherwise specified or approved.

1.4 Abbreviations

1.4.1 In addition to abbreviations covering the standards described in SECTION 01 42 00 of the SPECIFICATIONS, the following abbreviations shall have the significance set forth opposite each:-

- 1.4.2 NEC : National Electrical Code (Standard 70) (USA).
- 1.4.3 IEC : International Electrotechnical Commission.
- 1.4.4 BS : British Standards.
- 1.4.5 IEE : Institution of Electrical Engineers (UK).
- 1.4.6 EN : Euronorm (European Harmonized Standards).
- 1.4.7 UL : Underwriters Laboratories.
- 1.4.8 VDE : Verband De Utscher Elektro Techniker.
- 1.4.9 NFPA : National Fire Protection Association.
- 1.4.10 IEEE : The Institute of Electrical & Electronic Engineers (USA).
- 1.4.11 NEMA : National Electrical Manufacturers' Association (USA).
- 1.4.12 ANSI : American National Standards Institute (USA).
- 1.4.13 DIN : German Industrial Standards.

1.5 Interference and Erroneous Locations

- 1.5.1 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.
- 1.5.2 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 acceptable manner.

1.6 Climatic Conditions

- 1.6.1 Materials and equipment shall be suitable in all respects for operation on electrical systems under following climatic conditions:-
- 1.6.2 Temperature - 40 degree C. Max.
- 1.6.3 Relative Humidity - 60 percent Max.

1.7 Local Electrical Authorities' Requirements

- 1.7.1 The Contractor shall attend to and afford all facilities to the Local Electrical Authorities and shall provide oil 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.
- 1.7.2 The Contractor shall be responsible for preparing any workshop drawings 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.

1.8 Electrical Service

- 1.8.1 The electrical power system will operate on 230 Volt/400± 10% Volt, 3-phase, 4-wire, 50 Hz system.
- 1.8.2 The low current systems shall operate on the voltages specified or as recommended by the respective system manufacturer to the acceptance of the Engineer.
- 1.9 Terminology
 - 1.9.1 The attention of the Contractor is directed to Section 01 10 00 of the SPECIFICATIONS for meanings of certain contractual terms.
 - 1.9.2 Terminology is used in the sense outlined in the Regulations and in FIDIC – Conditions of Contract.
- 1.10 Shop Drawings, Samples and Other Submittals
 - 1.10.1 The Contractor shall submit shop drawings and samples as called for in SECTION 01 33 00 of the SPECIFICATIONS and the CONDITIONS OF CONTRACT under the relevant heads. 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.
 - 1.10.2 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.
 - 1.10.3 Two copies of the brochures submitted shall be originals as published by the Manufacturer. Other copies may be clear plain paper copies.
 - 1.10.4 Submitted brochures shall include at least two copies of Manufacturer's original publications, other copies may be clear plain paper copies.
- 1.11 "As-Built" Drawings
 - 1.11.1 "As Built" drawings shall be submitted as called for in SECTION 01 33 00 of the SPECIFICATIONS, under "AS-BUILT DRAWINGS".

PART 2 PRODUCTS

- 2.1 Material
 - 2.1.1 All electrical materials and equipment to be used for the project shall be new and shall be manufactured by one of the manufacturer listed in acceptable manufacturers' list in relevant section. Materials proposed to be used shall fulfil the following conditions:-
 - 2.1.1.1 Local availability of spare parts.
 - 2.1.1.2 Local technical support with factory trained technicians.
- 2.2 Equipment supplied and installed by others

- 2.2.1 Certain items of control and other equipment pertaining to plumbing, air conditioning, etc indicated "by others" on the Electrical Drawings are shown for connection only. Such items are not supplied as a part of the Electrical Work, but all connections including power and control to such equipment shall be done under this Section.
- 2.3 Equipment Not in Contract (NIC)
- 2.3.1 Equipment so indicated or noted will not be in contract. Connections to such equipment will not be carried out by the Contractor unless otherwise indicated or noted.
- 2.4 Nameplates
- 2.4.1 Nameplates in 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.
- 2.4.2 Nameplates shall be made of laminated sheet plastic, 2.5 mm thick, or of anodised aluminium, approximately 1.5 mm thick, engraved to provide black letters on a white background, and fastened in place with corrosion-resistant screws, or as specified by local authorities. Name plates for IP55 panels shall be fixed with adhesives.
- 2.4.3 Nameplates shall also be provided on all manufactured assemblies to identify the assembly as well as feeders, circuits, compartments, switches, internal components, etc.
- 2.4.4 Nameplates shall be located in a position to be easily readable after completion of the installation of the equipment.
- 2.4.5 Nameplates for equipment weighing more than 15 kgs. shall be marked giving the approximate weight to the nearest + or -5%.

PART 3 EXECUTION

- 3.1 General requirements
- 3.1.1 The Contractor shall supply all necessary labour and material, and shall install, complete and make 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.
- 3.1.2 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.
- 3.1.3 All equipment and material supplied for this project shall be manufactured in strict compliance with the standards listed in the following clauses, or acceptable equal.

- 3.1.4 The Contractor's attention is directed to the requirements of the GENERAL CONDITIONS OF CONTRACT and Division 01 of the SPECIFICATIONS as applicable to the Electrical Work.
- 3.1.5 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 acceptable of the Engineer and as approved relevant Local Authorities.
- 3.2 Engineer's Drawings
 - 3.2.1 The Engineer's Drawings issued with these Specifications are complementary to these Specifications.
 - 3.2.2 These Drawings indicate the approximate location of all-electrical devices and equipment. The exact and final location shall be subject to the prior acceptance of the Engineer on Site.
 - 3.2.3 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 written permission on necessary adjustments before any installation work is started.
 - 3.2.4 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.
 - 3.2.5 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.
- 3.3 Modifications
 - 3.3.1 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.
- 3.4 Protection of Electrical Equipment
 - 3.4.1 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.
 - 3.4.2 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 an uniformly distributed source of heat to prevent condensation.
 - 3.4.3 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.

- 3.4.4 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.

3.5 Acceptance Tests

- 3.5.1 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.

3.6 Operation, Maintenance and Spare Parts Manuals.

- 3.6.1 The Contractor shall provide the Employer with 2 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.

3.7 Warranty

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

- 3.7.2 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

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

End of Section

WIRES & CABLES

PART 1 GENERAL

1.1 General Instructions

1.1.1 Works under this section shall be governed by conditions of Contract.

1.2 Scope

1.2.1 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.

1.2.2. Current ratings for calculating the size of the underground cables shall be those contained in the relevant tables of ERA report No. 69-30, part I, II, III or IV, as may be appropriate to the type of cable being used. The ratings shall be and adjusted where necessary to comply with the recommendations of ERA report No. F/T186.

1.3 Applicable Standards

1.3.1 Single Core Cables : BS 6004

1.3.2 XLPE Armoured Cables, 600V/1000V : BS 5467

1.3.3 Insulated Flexible Cords : BS 6500

1.4 Approved Manufacturers

1.4.1 Refer to approval Electrical manufacture list at the end of Electrical specification.

PART 2 PRODUCTS

2.1 Single Core and Multi-core cables

2.1.1 Cables shall be one, three or four core consisting of 99% conductivity, plain annealed stranded copper conductors rated at a normal maximum operating temperature of 90 degrees C.

2.1.2 Provide a PVC overall jacket on all cables, with a durable marking on the surface of the jacket at intervals not exceeding 610mm. marking shall include manufacturers name, conductor size and voltage class of cable.

2.1.3 Cable ampacity and electrical characteristics shall conform to specified codes and standards.

2.1.4 Provide a ground wire with each circuit sized as indicated on drawings. Ground wire shall be bare, concentric lay copper.

2.1.5 The core insulation of cables shall be coloured as follows:

Cable	Colour
Single core	Brown
2 core	One Brown and one Blue
3 core	Brown, Brown/Orange, Brown/Black
3½ core or 4 core	Brown, Brown/Orange, Brown/Black, Blue

2.1.6 Conductors shall be either plain or annealed tinned copper complying with BS 6360. .

2.1.7 The insulation of the cable shall be PVC, polythene, XLPE, EPR or LSF materials as described in the schedules or indicated on the drawings.

2.1.8 Where armoring is required, it shall be aluminum wire armour (AWA) on single core cables and galvanized steel wire armour (SWA) on multi-core cables.

2.2 Cables - Lighting & Power

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

2.2.2 Cable size used for lighting shall not be less than 3x1.5 mm².

2.2.3 Cable size used for power shall not be less than 3x2.5 mm².

2.2.4 All cables for lighting and power systems pulled inside conduits shall be cable three core, insulated with PVC compound, of grade not less than 450/750 volts, to BS 6004.

2.2.5 Conductors shall be solid-stranded.

2.2.6 Flexible cords for connection of fixtures to circuit-wiring shall have finely stranded copper Conductor with a PVC insulation, type NYFAF, 415 V grade.

2.3 Flexible Cords

2.3.1 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 chlorosulphonated

polyethylene (EPR CSP), 300/500 V rated, and shall withstand an operating temperature of 85°C, to BS 6500.

2.3.2 Cords used for pendant lighting points and between lighting outlet above false ceiling to lighting fixture shall be circular three core (1.5 mm²) shall have PVC Type TI3 insulation, PVC Type TM3 sheath and shall withstand an operating temperature of 105°C, to BS 7655.

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

2.4 Wires and Cables - Telephone

2.4.1 Wires and cables shall be supplied and installed to the approval of Local Telephone Company, unless otherwise specified in the drawings. The Contractor shall attend and afford all facilities to the Telephone Company and shall take prior written approval of the adequacy for the proposed conduits for the telephone system before installation of the conduit system.

2.5 Cables - Central Antenna System

2.5.1 If required, 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.

2.5.2 Characteristic impedance shall be 75 ohms.

2.5.3 Inner conductor shall have a minimum of 0.7 mm diameter.

2.5.4 Overall diameter of cable shall not be less than 7 mm.

2.5.5 Cable shall have a tensile strength on outer conductor of 20 kgf for one minute.

2.6 Cables - Interphone & Bells

2.6.1 Wires shall be rated for a minimum 250 volts service. The conductor shall be tinned annealed 1 strand, high conductivity copper, insulated with 0.5 mm thick PVC compound. Conductor shall have a minimum of 0.7 mm² cross-section.

2.7 Fire Alarm Cables/Wiring

2.7.1 Cables of the Fire alarm system shall be of high grade fire cell and fire resistant cables complying with the local authorities, regulations, BS Standards. BS 6387:1994 category (BZW) & BS 6425: Part 1 : 1990, and all cable sheathes shall be LSF grade (Low smoke and fumes) complying with BS 6425: Part 1 : 1990 & certified by BASEC & LPCB.

2.7.2 All detectors/loops shall be wired in 1.5 mm² fire proof cables and cables for sounders circuits shall be with 2.5 mm² fire proof cables as specified above in item (1) and

wired directly from the Control Panels or through local interface units, with monitoring battery back up power supply.

2.7.3 At all the termination points, cable shall be provided with an approved cable connection to outlet boxes, panels, devices or fire alarm equipment, fittings, etc., the same shall be of fire rated threaded gland type with locknut and shall be made according to manufacturers instructions.

2.7.4 G.I. conduits shall be used wherever the cable is used exposed to vision or above false ceiling void and non-metallic rigid PVC conduits may be used where embedded in walls or slabs to the approval of local fire authorities and acceptance of Engineer.

2.8 Cables - Sound System

2.8.1 Wires for loudspeakers shall be rated for a minimum 250 volts service. The conductor shall be tinned annealed 1 strand, high conductivity copper, insulated with 0.5 mm thick PVC compound. Conductor shall have a minimum of 0.7 mm square cross-section.

2.8.2 Cables for microphone shall be 2 x 0.5 mm square, screened.

2.8.3 Where sound system is used as a voice alarm, cabling of the system shall have fire retardant sheathing and of the same fire resistance degree of the fire alarm cables.

2.9 Control Cables

2.9.1 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.

2.9.2 Number of conductors shall be equal to the maximum number of functions plus 20% spare.

2.9.3 Cable shall be 300/500V insulation grade.

2.9.4 Junction boxes shall include all necessary terminal connector boards of DIN rail Viking Terminal type with proper labels.

2.9.5 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.

2.9.6 Control cables where used in ducts underground or in conduits above ground shall comprise stranded annealed copper conductor of minimum 1.5 mm² cross-section for cables in ducts and 0.75mm² for cables in conduits insulated with high dielectric polyvinyl chloride, and PVC sheathed.

2.10 Connectors and Terminal Blocks

2.10.1 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 utilised for all splices or joints.

2.10.2 For the wiring of circuits consisting of wire sizes 10 mm² and larger shall be of the bolted pressure type, DIN rail Viking model and with a pre-insulated sleeve.

2.10.3 Connectors shall be manufactured from high conductivity copper, electro tin-plated.

2.10.4 Connector bodies shall be manufactured from Polyamide.

2.11 Cable Ladders

2.11.1. Cable ladders shall be manufactured from 14 Swg Mild steel, with hot-dip galvanised finish.

2.11.2 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.

2.12 Cable Glands

2.12.1 Cable glands shall be provided at the termination of armoured cables at the enclosure of a distribution board or any other equipment.

2.12.2 Whether installed indoors or outdoors, all cable glands shall provide protection to IP 55 as a minimum.

2.12.3 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.

PART 3 EXECUTION

3.1 Installation of Wires & Cables

3.1.1 All wires shall be installed in accordance with the applicable provisions of the listed codes and as indicated on the Drawings.

3.1.2 The number of wires and sizes of conduits indicated on the Drawings are 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.

3.1.3 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.

- 3.1.4 Conductors shall be continuous from outlet to outlet and no splices shall be made except within outlet or junction boxes.
- 3.1.5 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.
- 3.1.6 No cable bend shall have a radius of less than eight times its diameter.
- 3.1.7 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.
- 3.1.8 All conductors to be contained within a single conduit shall be drawn in at the same time.
- 3.1.9 A wire pulling compound shall be applied to conductors being drawn through conduit. Pulling compound shall be soap tone or other approved material.
- 3.1.10 Only cables forming part of a lift installation if any may be run in a lift shaft.
- 3.1.11 Wires and cables for feeders, sub-feeders, control, and branch circuit wiring shall be colour coded as follows:-

<u>Color</u>	<u>Phase</u>
Brown	A or 1
Brown/Orange	B or 2
Brown/Black	C or 3
Blue	Neutral
Yellow/Green	Equipment grounding

- 3.1.12 Wire and cable sizes shall be as indicated on the Drawings; however in no case shall their size be smaller than required by the listed Code.
- 3.1.13 Unless otherwise indicated, no conductor for lighting and power wires shall be smaller than 1.5mm², 2.5 mm² respectively.
- 3.1.14 All branch circuits for lighting and appliances shall be cables run inside conduits, unless otherwise indicated.
- 3.1.15 Feeders and sub-feeders shall be multi-conductor cables run exposed on walls or in trenches as shown on the Drawings.
- 3.1.16 Single cables shall be fixed directly to walls or ceilings. Where 2 or more cables are run in parallel, they shall be fixed on galvanised steel perforated trays or on other approved special cable supporting and protecting arrangement.
- 3.1.17 Cables shall be fixed to supporting structures with approved galvanised cast steel clamps at distances not exceeding 20 diameters.

3.1.18 Armoured cables used in vertical shafts shall be the steel wire armoured and not the tape type.

3.1.19 No joints or splices shall be accepted on main feeders, unless with an approved means, which shall be to the approval of local power supply authority.

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

3.2 Identification of Wires & Cables

3.2.1 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 panelboards.

3.2.2 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.

3.2.3 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.

3.2.4 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 by using identification ferrules for wires and laminated plastic/metallic tags on cables.

3.3 Cable Terminations

3.3.1 All cables terminations or joints other than sub-circuit wiring shall be carried out by using compression type connectors or lugs of size and type suitable for required application.

3.3.2 Correct type hydraulic crimping tools shall be used for each particular application. Manufacture's recommendations shall be strictly followed particularly in maintaining the recommended crimping tool pressure.

End of Section

EARTHING SYSTEM

PART 1 GENERAL

1.1 General Instructions

1.1.1 Works under this section shall be governed by Conditions of Contract and

1.2 Scope

1.2.1 Provide earthing system(s) for all Buildings as indicated on Electrical drawings, schedules and specified herein.

1.3 Codes and Standards

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

1.3.2 Any modification required by Local authorities shall be done at no extra cost.

1.3.3 The impedance of equipment (earth loop) shall comply the requirements of IEE wiring regulation.

1.3.4 The earthing resistance shall be in accordance with BS 7430 and in compliance with requirements of Local Power Authorities.

1.3.5 All earthing and bonding installation and equipment, shall comply with the requirements of the BS 7671 and BS 7430.

1.3.6 All Equipment earthing of the Electrical Works through a removable link at the Main Distribution Switchboard connecting the main earthing bus to the neutral bus. If no main switchboard is included in the works, a peripheral earth bus shall be provided in the Meters Room to which all the equipment earthing shall be bonded. The earthing bus shall in turn be bonded to the Local Authorities Low Tension Pillar neutral.

1.4 Approved Manufactures

The proposed earthing system materials and accessories shall be manufactured by one of the following manufacturers or approved equal, as listed in the "Electrical Manufacturers List".

PART 2 PRODUCTS

2.1 Materials

2.1.1 Unless otherwise specified all materials used for earthing shall be of copper or approved copper alloys, and shall be specially manufactured for the purpose.

- 2.1.2 The complete earthing system shall be electrically and mechanically continuous to provide an independent fault current return path to the earthing source.
- 2.1.3 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.
- 2.1.4 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. Otherwise earth leakage circuit breakers shall be used.
- 2.1.5 Locations where the electrode is above water table, in rock or where there is soil is chloride free. 5/8" or 3/4" diameter copper-bonded steel rod, the copper shall be 99.9% pure electrolytic molecularly bonded onto a low carbon steel core to BS 970 with a high tensile strength of at least 600 N/mm², the copper thickness shall at least 0.25 mm. the rod shall be complete with driving stud, high strength copper alloy connectors and screw in spike.
- 2.1.6 Earthing systems for sub-stations shall be in accordance with BS 7430 and the Local Electricity Authority regulations.
- 2.1.7 The earth system shall be tested in accordance with BS 7430.

2.2 Protective Conductors

- 2.2.1 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:

Current carrying conductor S (mm ²)	Earthing Wire (protective conductor) SP (mm ²)
S less than or equal to 16	S
S greater than or equal to 16 But less than or equal to 35	16
S greater than 35	0.5 S

- 2.2.2 If more than one circuit is included in a conduit, one protective conductor per neutral or per three phase circuit with no neutral shall be provided.

2.3 Earthing Pit

- 2.3.1 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.
- 2.3.2 Earth pits shall be installed at least 2 meters away from building façade.

2.4 Protective Conductors

- 2.4.1 Protective conductors shall be supplied and installed to in accordance with BS 7671.

PART 3 EXECUTION

3.1 Earthing Installation

- 3.1.1 Two separate earthing installations shall be provided. One installation shall be the System earthing and the other shall be the Authorities Service Equipment Earthing.

- 3.1.2 Where earthing terminals are brazed to equipment, the metal shall be thoroughly cleaned prior to brazing and the impaired surface repainted to prevent corrosion.

3.2 System Earthing

- 3.2.1 The System Earthing shall consist of earthing pits connected in parallel if practicable, or shall consist of 95 mm² 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.

- 3.2.2 The main earthing bus of the main switchboard(s) if any shall be connected to the system earthing by a 95 mm² bare copper cable via a 40 x 5 mm main earthing busbar fixed on the wall in an approved location.

3.3 Service Equipment Earthing

- 3.3.1 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.

- 3.3.2 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.

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

3.4 Equipment Earthing of the Electrical Works

- 3.4.1 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).

- 3.4.2 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.

- 3.4.3 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.
- 3.4.4 The cable armouring will not be accepted as equipment earthing conductor.
- 3.4.5 All socket outlets, power apparatus, lighting fixtures and switches shall be earthed.
- 3.4.6 No point on the neutral shall be connected to the earth system except as described under "System Earthing".
- 3.4.7 Additional earthing pits may be shown on the drawings at different locations. These pits shall be bonded to the earthing bus of the relevant switchboards or panelboards as applicable in order to reduce the earthing resistance. Neutral at such points shall not be bonded to the earthing system.
- 3.4.8 Shells of all water heaters shall be connected to the neutral and earthing of the corresponding circuit.
- 3.4.9 Bonding connections to gas and water pipes as required by the BS 7671 shall be made as near as practicable to the point of entry. These connections shall be made with solid copper conductors of minimum cross section in accordance with BS 7671. These bonds shall be installed as inconspicuously and nearly as possible. The connections shall be visible after installation.
- 3.4.10 Bonding conductors shall comply with BS 7671.
- 3.4.11 Tests of individual and combined LV system earthing electrodes shall be carried out and the results recorded for presentation in accordance with BS 7671.
- 3.5 Structural Steelwork Bonding
 - 3.5.1 Steelwork bonding shall be installed utilizing bolted or (thermic process) welded connections. Close coordination shall be made with other trades to ensure the timely installation of bonding conductors during the construction program. Bonding of structural steelwork shall be carried out in accordance with the BS 7671 and shall include but not be limited to the following examples:
 - 3.5.1.1 Exposed Main Structural Columns & Beams.
 - 3.5.1.2 Metallic Louvres and Grilles.
 - 3.5.1.3 Crane Runway Beams
 - 3.5.1.4 Steel Door and Frames
 - 3.5.1.5 Reinforcing Steelwork Bars and Mesh
 - 3.5.1.6 Mechanical and HVAC Plant

End of Section

CONDUITS AND FITTINGS

PART 1 GENERAL

General Instructions

Works under this section shall be governed by conditions of contract
Scope

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.

1.3 Approved Manufacturers

1.3.1 Refer to approval Electrical manufacture list at the end of Electrical specification.

PART 2 PRODUCTS

2.1 Conduits

2.1.1 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 maker's name or trade mark. Marking shall be indelible and easily legible.

2.1.2 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.

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

2.1.4 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.

2.1.5 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 of the cables are likely to be damaged while being drawn in.

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

2.1.7 Conduits and fittings shall be BS1 tested or approved equal.

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

2.3 Conduits and Fittings

2.3.1 Conduits shall be pliable smooth flame retardant conduit, it shall be made of Polyolefin (320N, Compression Force), having a maximum continuous service temperature of 60 degree C or more.

2.4 Conduits – Underground

2.4.1 Flexible conduit shall be constructed by square locked galvanised steel with a PVC outer covering.

2.5 Boxes

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

2.5.2 High Degree type boxes shall be manufactured from Noryl, a thermoplastic with a higher softening temperature. Boxes shall withstand a 15 kg. load directly suspended at 105° C for 48 hours. Boxes shall incorporate pillars with threaded brass inserts.

2.5.3 All boxes shall be provided with earth terminals.

PART 3 EXECUTION

3.1 Installation of Conduits

3.1.1. Conduits embedded in ceiling slab, in walls and underfloor shall be smooth pliable flame retardant.

3.1.2 Conduits exposed above false ceiling shall be smooth pliable flame retardant.

3.1.3 Exposed conduits other than above false ceiling shall be rigid type.

3.1.4 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.

3.1.5 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 acceptable by the Engineer.

- 3.1.6 Conduits shall be installed without causing any damage to the structural members.
- 3.1.7 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.
- 3.1.8 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.
- 3.1.9 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 Sub-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.
- 3.1.10 Conduits in slabs shall be placed parallel to the main reinforcement steel in the slab.
- 3.1.11 Top of any conduit in slabs shall be at least 2 cm below the finishes floor surface, unless otherwise indicated or authorised.
- 3.1.12 Conduits in slabs running parallel to beam axis shall not run above beams.

3.2 Exposed Conduits

- 3.2.1 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 spacer bar saddles, spaced not more than 1, 1, 0.8, 0.6 meters for 20mm, 25mm and 32mm and larger conduit sizes respectively.
- 3.2.2 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.
- 3.2.3 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.

- 3.2.4 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.
- 3.2.5 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 acceptable connectors. No running threads shall be permitted.
- 3.2.6 Conduits for TV system shall have at least 10 cm bending radius. Two bends might be necessary for the transition from floor to wall.
- 3.2.7 All exposed GI conduits shall have identification bands and labels.

3.3 Installation of Boxes

- 3.3.1 Boxes of ample capacity shall be provided at every junction of conduit system and as required by the Specifications.
- 3.3.2 All boxes shall be securely fastened.
- 3.3.3 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.
- 3.3.4 Device boxes shall be used for all wiring devices.
- 3.3.5 Junction/pull boxes shall be used only for concealed conduit work, and for conduit work above false ceiling.
- 3.3.6 Boxes for similar equipment shall be mounted at uniform height within the same or similar area. Mounting shall be as shown on the Drawings.
- 3.3.9 Device box shapes and sizes shall be determined by the type and size of wiring devices for which they serve.
- 3.3.10 Boxes fixed inside false ceiling shall be provided with mounting brackets for rigid fixing to structure members or other means of support.
- 3.3.11 All kinds of exposed pull boxes shall be painted in colour relevant to the associated exposed conduits and circuit reference shall be painted on the same.

3.4 Sleeves

- 3.4.1 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.

- 3.4.2 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 watertight sealing gland.
- 3.4.3 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.
- 3.4.4. 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.
- 3.5 Expansion Joints
- 3.5.1 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.

End of Section

CABLE TRUNKING (RACEWAY)

- | | | |
|------|---|---------|
| PART | 1 | GENERAL |
|------|---|---------|
- 1.1 General Instruction
 - 1.1.1 Works under this section shall be governed by conditions of contract.
 - 1.2 Scope
 - 1.2.1 The Contractor shall supply and install trunking for cabling as shown on the drawings and as herein specified. The system shall include, but not limited to standard rectangular trunking sections, bends, terminations, conversions, reducers, offsets, risers and all necessary parts to install a complete trunking system.
 - 1.2.2 Manufacturer's standard fittings shall be used for all connections and changes in directions. Cutting and bending trunking to form flanges and attachments will not be permitted.
 - 1.2.3 Standard lengths of trunking used shall not be less than two meters.
 - 1.2.4 Cable retaining straps shall be fitted at intervals not exceeding 1 meter.
 - 1.2.5 Where trunking passes through walls, floors, and ceilings, non combustible, non-metallic fire barriers shall be installed in the trunking.
 - 1.2.6 Contractor shall re-verify the trunking sizes indicated on the drawings and shall modify the same, if required, to allow the required wiring with a space factor of 45 per cent.
 - 1.3 Codes & Standards
 - 1.3.1 Metal trunking shall be manufactured generally in accordance with the requirements of BS 4678: Part 1. Metal thickness for body and cover material shall be at least as stipulated in Table 1 of BS 4678.
 - 1.3.2 Trunking and connectors for internal use shall be finished with class 1 protection in according with BS 4678:Part 1. Where used externally, protection shall be class 3.
 - 1.3.3 2 Inc coating shall comply BS 729 or BS 3382:Part 2. Trunking shall be bonded to earth at several point connections, as required.
 - 1.3.4 Construction of PVC trunking and its accessories shall comply with BS 4678:Part 4.
 - 1.4 Approved Manufacturers
 - 1.4.1 Refer to approval Electrical manufacture list at the end of Electrical specification.
 - 1.4.1.1 Metallic Trunking

1.4.1.2 PVC. Trunking

PART 2 PRODUCTS

2.1 Metal Trunking

2.1.1 Metal trunking shall be manufactured in accordance with the requirements of the codes and standard mentioned above. The metal thickness shall be at least as stipulated in table 1 of BS 4678.

2.1.2 Lengths of trunking shall be bonded to each other by using strip copper links not less than 12 mm wide x 1.5 mm thick and fixed with brass nuts, bolts and serrated washers. Lids shall be fixed at intervals not exceeding 1 metre by using quick release cam type fasteners. Steel screws and fasteners shall be protected against corrosion by a finish at least equivalent to zinc coating

2.1.3 Vertical trunking shall be supplied with cable support unit with insulated pins at intervals not exceeding 3 metre.

2.1.4 Horizontal trunking sizes exceeding 100 mm x 50 mm shall be supplied with cable separators with insulated pins at intervals not exceeding 2 metres.

2.1.5 All burrs rough edges caused due to any cutting or damage during erection shall be removed and the finish shall be made good. Corrosion patches if any, caused during storage and erection shall be removed and the affected area shall be treated with rust-proofing agent. Zinc rich epoxy primer of equivalent alternative shall be applied on the treated surfaces. In case of class 2 finishes this shall be followed by a coat of colour matching paint.

2.1.6 Any fixing used for securing or fitting shall not cause any long term corrosion or electrolytic action. Where brackets are used, they shall be constructed of mild steel angle or channel iron finished to the same standard as the trunking.

2.1.7 Connections to conduit, switchgear, junction boxes and distribution boards shall be made with flanged units.

2.1.8 A trunking joint shall be made where a trunking crosses an expansion joints.

2.1.9 The earth continuity links across such joints shall be of braided copper tape not less than 15 mm wide x 2 mm thick having a resistance from fixing to fixing equal to or less than the links used for standard trunking joints.

2.2 PVC Trunking

2.2.1 Trunking shall be made from high impact rigid PVC of thickness not less than 1.5 mm. Concealed trunking shall be of medium classification (IP42) and surface trunking shall be of heavy classification (IP53).

2.2.2 Lids shall be of the clip on type construction. All trunking accessories shall be of the same manufacturer. Site fabricated accessories shall not be acceptable.

- 2.2.3 Where the trunking is installed in ambient conditions higher than 25 degrees centigrade, trunking joints shall accommodate 7 mm expansion for every 6 metres of trunking run.
- 2.2.4 Protective conductor of not less than 2.5 mm² with green and yellow insulation shall be installed throughout the length of the trunking, to allow looping in and out of metallic equipment and accessories.
- 2.3 Skirting Trunking
- 2.3.1 Unless otherwise specified elsewhere, the trunking shall have three compartments one for power cables and the other for telephone and low current wires, as detailed on the Drawings.
- 2.3.2 Trunking body shall be manufactured from 1.2 mm nominal thickness zinc coated sheet steel in standard 2 meter lengths, with spot welded partition, each length supplied with one back connecting plate, one earthing strap, with plated mushrooms head steel screws and shake proof washers. The cover fixings are secured by an internal fixing bridge and external fixing strap, both of which are mobile down the length of skirting to any given position, the covers shall be cut to suit on site. Metal work shall be finished metallic silver enamel inside and outside to receive site painters finished coat.
- 2.3.3 Skirting trunking shall have enough space for standard power socket outlets and telephone or data outlets both being screened and totally enclosed by sheet metal.
- 2.3.4 Skirting trunking elbows shall be easily installed wherever necessary on site. Similarly power socket outlets and telephone outlets shall be inserted at any place on the trunking with the same ease.
- 2.4 Dado Trunking
- 2.4.1 Dado trunking shall be manufactured from a minimum of 1.6 mm galvanised mild steel with .0001 mm zinc deposit and approved finished epoxy coated. Cover shall be of minimum 1.2 mm galvanised steel.
- 2.4.2 Fittings shall be manufactured from the same steel as body and covers with epoxy coated and matching colour. Socket/switch socket plates shall be provided as one or two gangs as required. Connector blocks with four pinching screws shall be provided as required.
- 2.4.3 Dado trunking shall have provision for compartmentation when used for power, low current and telephone / data system distribution
- 2.5 Raised Floor Trunking
- 2.5.1 Raised floor trunking shall comprise of triple compartment sheet steel trunking of size and arrangement as indicated on the drawings.
- 2.5.2 Raised floor trunking shall include all necessary accessories like segregators, end caps, etc...

- 2.5.3 Trunking shall be constructed from pre-hot dipped galvanized sheet steel to BS 2989,1982 and shall have thickness of 1.6MM.
- 2.5.4 Raised floor trunking shall be so designed to be easy for replacement of cables, if required, at a later date.
- 2.5.5 Earthing studs shall provided at each end of the trunking length for proper earth continuity.
- 2.6 Service Outlet Box for Raised Floor Trunking
 - 2.6.1 Service outlet boxes for raised flooring shall be of size 250MMX250MMX80MM and shall be constructed from high pressure zinc alloy die cast material. It shall be coated with oven baked epoxy powder paint.
 - 2.6.2 The base unit of the box shall be made from electro galvanized sheet steel and shall be coated with oven baked epoxy powder paint.
 - 2.6.3 The trap cover of service box shall have 6mm recess for fixing carpet or vinyl tiles.
 - 2.6.4 The trap cover shall have suitable hinges to enable the cover open through 180 degrees to allow un-hindered access to the cables in the trunking.
 - 2.6.5 Cables emerging out of service outlet box shall be protected against damage by means of nylon cable exit gromments.
 - 2.6.6 The lifting handle for the cover and the nylon gromments shall be provided on opposite side of the trap covers
 - 2.6.7 Two earthing terminals shall be provided for additional earthing cable, whenever required.
- 2.7 Service Outlet Box for Under Floor Trunking
 - 2.7.1 Service outlet boxes and junction boxes shall be of size 250MMX250MMX90MM and shall be constructed from high pressure zinc alloy die casting base frame.
 - 2.7.2 Service/junction boxes shall be fixed on to a heavy gauge galvanized base plate.
 - 2.7.3 The design of base frame shall have whole unit in one piece without any joints/fabrication to prevent corrosion, concrete seepage into the box during casting of concrete or screeding.
 - 2.7.4 The boxes shall be constructed with provision for trunking/conduit access from all four sides. Unwanted entries during installation shall be blanked off with detachable side blanks.
 - 2.7.5 Covers of service outlet boxes shall be made of high procure zinc alloy die casting with 6mm recess to receive carpet.
 - 2.7.6 Cover shall be provided with suitable hinges designed to enable trap cover to open 180 degrees to give un-hindered access for cables in the trunking.

- 2.7.7 Covers for junction boxes shall be made of high pressure zinc alloy die-casting secured by counter sunk screws. The cover shall have 6mm recess to receive carpet where applicable.
- 2.7.8 All boxes shall be adjustable in height independently of trunking system to allow for differences in floor thickness.
- 2.7.9 Cables emerging from service boxes shall be protected against damage by means of nylon cable exit grommets.
- 2.7.10 Lifting handle and cable grommets shall be provided in opposite side of the trap cover to allow for easy access to lifting handle and to avoid damage to cable insulation.
- 2.7.11 All boxes shall be complete with weatherproof gaskets and circuit protective conductor between the covers and the boxes.

PART 3 EXECUTION

3.1 Supports

- 3.1.1 Trunking when run horizontally shall be securely supported at intervals not exceeding 1.5m, unless specially approved for supports at greater intervals, but in no case shall the distance exceed 3 m.
- 3.1.2 Trunking when run vertically shall be securely supported at intervals not exceeding 4.5 m and shall have not more than one joint between supports.

3.2 Installation

- 3.2.1 Trunking shall be securely fixed to floors walls, ceiling or multibeam trunk to the approval of the Engineer. It shall be installed such that it shall not be obstructed by other trades. Adjoining sections shall be securely fastened together to provide a rigid joint.
- 3.2.2 The sum of cross-sectional areas of all contained conductors shall not exceed 20% of the interior cross-sectional area of the trunking.
- 3.2.3 Trunking shall include all necessary cable retainers. Runs of trunking shall be parallel or perpendicular to walls and partitions.

End of Section.

CABLE TRAYS

PART 1 General

1.1 General Instructions

1.1.1 Works under this section shall governed by conditions of contract.

1.2 Scope

1.2.1 Cable trays shall be installed either indoors or outdoors or described herein or as shown on the drawings and as directed by and acceptable to the Engineer.

1.2.2. All accessories used in the cable trays system such as bends, intersections risers, reducers shall be the product of the same manufacturer as that of the cable tray. Site fabricated accessories are not acceptable.

1.3 Applicable Standards

Specification for cable trays - BSEN 10130, BSEN 10131 and BSEN 10151 as appropriate.
Specification for Hot Dip Galvanization - BS 729.

1.4 SUBMITTALS

1.4.1 Product Data: Include data indicating dimensions and finishes for each type of cable tray.

1.4.2 Shop Drawings: Detail fabrication and installation of cable tray, including plans, elevations, and sections of components and attachments to other construction elements.

Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

1.4.3 Design Calculations: Verify loading capacities for supports.

1.4.4 Coordination Drawings: Include floor plans and sections drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural

and mechanical elements.

1.4.5 Factory-certified test reports of specified products, complying with BS.

1.4.6 Field Test Reports: Indicate and interpret test results for compliance with performance

requirements specified in "Field Quality Control" Article.

1.4.7 Maintenance Data: For cable trays to include in the maintenance manuals specified in other Divisions.

1.5 COORDINATION

1.5.1 Coordinate layout and installation of cable tray with other installations.

1.5.2 Revise locations and elevations from those indicated as required to suit field conditions and as approved by Architect.

1.6 QUALITY ASSURANCE

1.6.1 Source Limitations: Obtain cable tray components through one source from a single

- manufacturer.
- 1.6.2 Listing and Labeling: Provide cable trays and accessories specified in this Section that are listed and labeled.
- 1.6.3 Comply with BS2989 for material finishes.

1.5 Approved Manufacturers

- 1.4.1 Refer to approval Electrical manufacture list at the end of Electrical specification.

PART 2 PRODUCTS

2.1 General

- 2.1.1 Cable trays shall be manufactured from cold rolled mild steel to comply with BS 5750/BSEN 10130/BSEN10131/BSEN10051as applicable. Cable trays shall have a perforated construction. All accessories used such as bends, intersections, risers, reducers, etc, used in cable tray installation shall be of the same manufacturer as that of the cable tray.

2.2 Materials

- 2.2.1 The thickness of cable tray for normal application shall comply with the following requirements:

Width of Tray	Min. thickness
Upto 305 mm	1.2 mm
Above 305 mm upto and including 600mm	1.5 mm
Above 600 mm upto and including 914mm	2.0 mm

- 2.2.2 All cable trays shall be manufactured with plain return flanges.
- 2.2.3 Unless otherwise specified, the Contractor shall be responsible for selection of the correct size of cable tray to meet the site conditions and the requirements of these specifications.
- 2.2.4 Cable tray and its accessories shall have a hot-dip galvanized finish to BS 729. Any damage caused to the tray during installation and/or storage, shall be repaired by using zinc rich epoxy primer or equal alternative, followed by a generous existing metal coating. The joining bolts, nuts and washer shall be of galvanized steel. Brass shall not be used.

PART 3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Examine substrates for compliance with requirements for installation tolerances and other conditions affecting performance of cable trays. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- 3.2.1 Install cable tray level and plumb according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.
- 3.2.2 Remove burrs and sharp edges from cable trays.
- 3.2.3 Fasten cable tray supports securely to building structure
 - a. Locate and install supports.
 - b. Design supports, including fastenings to the structure, to carry the greater of the calculated load multiplied by a safety factor of 4 or the calculated load plus 90 kg (which ever is larger).
- 3.2.4 Where necessary, the cutting line of the cable tray shall be through continuous metal parts and not through the perforations. Burrs or sharp edges shall be removed prior to installation of tray sections and accessories.
- 3.2.5 Fixing and supports shall be installed at regular intervals of 1200 mm and not more than 150 mm from all bends, tees, intersections and risers. Midspan joints between cable tray sections shall be avoided. Joints shall be positioned as close as practicable to the cable tray supports.
- 3.2.6 A minimum clear space of 25 mm shall be kept behind all installed runs of cable tray. Cables shall be installed on the trays in a single layer leaving 25 percent spare space on the tray for future use.
- 3.2.7 Cable trays shall provide direct support to the cables without cleats or saddles wherever practicable. Purpose made straps, cleats or saddles shall however be used to maintain a neat or regular disposition of cables. In vertical tray installation or where trays do not directly support the cables, load bearing cable cleats or saddles shall be employed and securely fixed to the tray. Manufacturers recommendations shall be followed in selection of cable cleats or saddles, on the basis of individual application.
- 3.2.8 Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independently of fittings. Do not carry weight of cable tray on equipment enclosure.
- 3.2.9 Install expansion connectors where cable tray crosses a building expansion joint and in cable tray runs that exceed 27 m.
- 3.2.10 Make changes in direction and elevation using standard fittings.
- 3.2.11 Make cable tray connections using standard fittings.
- 3.2.12 Locate cable tray above piping, unless accessibility to cable tray is required or unless otherwise indicated.
- 3.2.13 Seal penetrations through fire and smoke barriers according to "Fire stopping" Section.
- 3.2.14 Sleeves for Future Cables: Install capped sleeves for future cables through fire Stopping-sealed cable tray penetrations of fire and smoke barriers.
- 3.2.15 Workspace: Install cable trays with sufficient space to permit access for installing

cables.

- 3.2.16 Use separate cable trays for different systems, such as power, low voltage system (i.e. fire alarm, public address, security, ... etc.).
- 3.2.17 Use isolated cable trays against fire in the areas which are indicated in the drawings.
- 3.2.18 Use mesh cable trays for data and low current cabling.

3.3 CONNECTIONS

- 3.3.1 Ground cable trays according to manufacturer's instructions.
- 3.3.2 Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in BS EN 10088.

3.4 FIELD QUALITY CONTROL

- 3.4.1 Grounding: Test cable trays to ensure electrical continuity of bonding and grounding connections.
- 3.4.2 Anchorage: Test pullout resistance for toggle bolts and powder-driven threaded studs for each type and size of anchorage material.
 - a. Furnish equipment, including jacks, jigs, fixtures, and calibrated indicating scales, required for reliable testing.
 - b. Obtain Architect's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener.
- 3.4.3 Replace malfunctioning units.

3.5 CLEANING

- 3.5.1 On completion of cable tray installation, including fittings, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes, including chips, scratches, and abrasions.

3.6 PROTECTION

- 3.6.1 Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure cable tray is without damage or deterioration at the time of Substantial Completion.
 - a. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
 - b. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.

End of Section

TESTS & CERTIFICATES

PART 1 GENERAL

1.1 General Conditions

1.1.1 Works under this section shall be governed by Conditions of Contract.

1.2 Scope

1.2.1 After completion of the Electrical Work, the complete systems shall be tested thoroughly before commissioning.

1.2.2 Any modifications or repairs necessary on completion of the tests shall be done at the Contractor's expense.

1.2.3 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.

1.2.4 All testing equipment on Site shall be provided by the Contractor.

1.2.5 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.

1.2.6 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.

1.2.7 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.

1.2.8 Unless otherwise specified, the Contractor shall supply the electric current necessary for the tests.

1.2.9 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.

1.2.10 The Contractor shall submit Method Statement for Testing of Installation and shall submit four copies of all tests results.

1.2.11 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.

PART 2 PRODUCTS

2.1 Insulation Megger Tests

2.1.1 Tests for insulation level shall be a 500-volt Megger. A minimum of one megohm (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 megohm between the whole of the installation taken together and the grounding.

2.2 Continuity & Resistance Tests

2.2.1 A continuity test to ensure that all connections have been made properly shall be made. This can be done by the use of a bell set. Test shall also include ensuring all switches and other interrupting devices breaking the phase wire and not the neutral wire.

2.2.2 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.

2.3 Socket outlets Proper Wiring Test

2.3.1 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 and the earthing at the top.

2.4 Operational Tests

2.4.1 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.

2.4.2 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.

2.5 Insulation Resistance Tests of Motors

2.5.1 All motors shall be tested for insulation in accordance with the requirement of IEC Standard Two copies of the test data shall be submitted.

PART 3 EXECUTION

3.1 Testing of Lighting Installation

3.1.1 The Contractor shall demonstrate the proper operation of all lighting fixtures.

3.2 Tests and Reports on Fire Fighting and Alarm Systems

3.2.1 The Contractor shall perform all electrical and mechanical tests required by the equipment manufacturer's certification form. In addition, they shall measure and adjust each of the ionization detectors to the maximum stable sensitivity setting. This must be performed with the detector at its operational location and under normal operational environmental conditions in the area. Bench settings are not acceptable. All test and report costs shall be in the contract price. A checkout report shall be prepared by the installation technicians and submitted in triplicate, one copy of which will be registered with the equipment manufacturer.

3.2.2 The report shall include, but not be limited to:

- A complete list of equipment installed and wired.
- Indication that all equipment is properly installed and functions and conforms with these specifications.
- Test of individual zones as applicable.
- Serial numbers, locations by zone and model number for each installed detector.
- Voltage (sensitivity) settings for each ionization and photoelectric detector as measured in place with the HVAC system operating.
- Response time on thermostats and flame detectors (if used).
- Technician's name, certificate number and date,

3.2.3 After completion of all the tests and adjustments listed, above the Contractor shall submit the following information to the architect:

- "As-built" conduit layout diagrams including wire colour code and/or tag number.
- Complete "As built" wiring diagrams.
- Detailed catalogue data on all installed system components.
- Copy of the report.

3.2.4 Final tests and inspection shall be held in the presence of architect's representative and to their satisfaction. The Contractor shall supply personnel and required auxiliary equipment for this test without additional cost.

3.2.5 The completed smoke detection system shall be tested to insure that it is operating properly. Acceptance of the system shall also require a demonstration of the stability of the system. This shall be adequately demonstrated if the system operates for a ninety (90) day test period without any unwarranted alarm(s) occur, the Contractor shall readjust or replace the detector(s) and begin another ninety (90) day test period.

3.2.6 As required by the architect, the Contractor shall recheck the detector after each readjustment or replacement of detectors. The test shall not start until the owner has obtained beneficial use of the building under tests.

- 3.2.7 If the requirements provided in the paragraph above are not completed within one (1) year after beginning the test described therein, the Contractor shall replace the system with another acceptable manufacturer and the process repeated until acceptance of the equipment by the architect.
- 3.2.8 Before final acceptance of work, the Contractor shall deliver three copies of a composite "Operating and Shop Maintenance Manual". Each manual shall contain, but not be limited to; a statement of guarantee including date of termination and name and phone number of the person to be called in the event of equipment failure.
- 3.2.9 Individual factory issued manuals shall contain all technical information on each piece of equipment installed. In the event such manuals are not obtainable from the factory, it shall be the responsibility of the Contractor to compile and include them. Advertising brochures or operational instructions shall not be used in lieu of the required technical manuals.
- 3.2.10 The scope of work includes testing and commissioning of all the above systems in accordance with NFPA codes and other standards and regulations.
- 3.2.11 The Contractor shall be responsible for getting approvals from Civil Defense.

End of Section

MAIN DISTRIBUTION BOARDS

PART 1 GENERAL

1.1 General Instructions

- 1.1.1 Works under this section shall be governed by Conditions of Contract.

1.2 Scope

- 1.2.1 The Contractor shall supply and install the Main Distribution Board (MDB) as shown on the Drawings and as herein specified. The equipment shall include busbars, 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.
- 1.2.2 The equipment shall be suitably constructed for safe, proper and reliable operation without undue wear, corrosion, heating or other operating trouble.
- 1.2.3 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.

1.3 Quality Assurance

- 1.3.1 All components of the assembly shall be the product of a single manufacturer.
- 1.3.2 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.
- 1.3.3 Structural steel base shall be provided for securing entire assembly to floor.

1.4 Codes and Standards

- 1.4.1 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 IEC 61439, the local Power Supply Authority regulations, the IEE Wiring regulations and the documents referenced in each of these publications.
- 1.4.2 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.
- 1.4.3 Circuit breakers shall comply with IEC 947-2 (EN 60947-2) and short circuit category ICS.

- 1.4.4 Test certificate from independent laboratory to certify that the MCCB's comply with the IEC-947-2, (EN 60947-2) test sequence -2 shall be submitted when required by Engineer.

1.5 Applicable Standards

- 1.5.1 Requirements for Type Tested and Partially Type Tested Assemblies - IEC 61439.
- 1.5.2 Specification for Copper for Electrical Purposes - BS 1433 :1970.
- 1.5.3 Code of Practice for Earthing - BS 7430:1991.
- 1.5.4 Colours for Indications Lights & Pushbuttons - IEC 60043:1993
- 1.5.5 Circuit Breakers - EN 60947-2.
- 1.5.6 Circuit breakers shall comply with IEC 947-2 (EN 60947-2) and short circuit category ICS.
- 1.5.7 Test certificate from independent laboratory to certify that the MCCB's comply with the IEC-947-2, (EN 60947-2) test sequence -2 shall be submitted when required by Engineer.

1.6 Approved Manufacturers

- 1.6.1 Refer to approval Electrical manufacture list at the end of Electrical specification.

1.7 Shop Drawings

- 1.7.1 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. for review by Engineers. 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.

1.8 Testing and Commissioning

- 1.8.1 The main distribution board assembly shall be tested at factory in accordance with the requirements of IEC 61439 and the associated standards.
- 1.8.2 Work tests shall include inspection of all components, wiring and a complete electrical functioning test.
- 1.8.3 Protection relays shall be tested by primary current injection method, with currents equal to overload, short circuit and earth fault conditions.
- 1.8.4 After completion of installation of the switchgear assemblies on site, they shall be subjected to the routine tests as defined in IEC 61439.

- 1.8.5 All functional units shall be checked for correct mechanical operation.
- 1.8.6 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:
 - 1.8.6.1 Energizing of functional device circuit and equipment which have been inspected, megger tested, found satisfactory and capable of being energized with complete safety.
 - 1.8.6.2 Starting up of all electrically powered plant and equipment including those supplied and installed under other sections of the contract.
 - 1.8.6.3 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.
 - 1.8.6.4 Testing interlock options in all possible combinations and operations of control system.

PART 2 PRODUCTS

2.1 Construction of the Assembly

- 2.1.1 Unless otherwise indicated, the assembly shall be of the indoor gasketed 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 structures.
- 2.1.2 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.
- 2.1.3 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 shipping.
- 2.1.4 The assembly shall be rated for a 600 volt duty.
- 2.1.5 The assembly shall be suitably braced for the short circuit duty shown on the Drawings, at nominal operating voltage.
- 2.1.6 Approved nameplates, permanently mounted for identification of all major and control equipment shall be provided as described under "GENERAL".
- 2.1.7 The enclosure and other steel works of MDB shall pass through a four stage finishing process such as chemical spray, degreasing, iron phosphating and finally give a top coat of polyester powder electrostatically deposited and cured in a high temperature oven to give a strong molecular bonding with the steel. The final colour 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.
- 2.1.8 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.

- 2.1.9 The assembly shall consist of the required number of formed and welded sheet steel enclosures required to mount circuit protective devices and other equipment.
- 2.1.10 Bolted frames shall be provided at the rear to support and house copper busbars, cables and other accessories.
- 2.1.11 Front, side and top plates shall be steel, removable and not less than 1.5 - 2 mm thickness.
- 2.1.12 All fastenings between structural members shall be bolted, not welded to provide flexibility during installation.
- 2.1.13 Removable panels shall be provided at the front of each vertical section.
- 2.1.14 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.
- 2.1.15 A modular individual mounting arrangement (in Form of Construction) as indicated on the drawings) shall be used and the internal separations shall be carried out using rigid barriers or partitions.
- 2.1.16 Structure and buses shall be arranged to permit future sections to be added. Suitable cover plate must be provided for temporary protection.
- 2.1.17 The assembly shall be vermin and rodent proof. Protection shall be to IP41 as a minimum requirement unless otherwise indicated on the Drawings.

2.2 Busbars

- 2.2.1 Main horizontal busbar 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 shall be 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.
- 2.2.2 Each phase and neutral busbar shall be tin plated and shall consist of hard drawn, high conductivity copper of uniform rectangular cross section throughout to BS 1433.
- 2.2.3 All bus connections shall be bolted and clamp type terminals provided for cables.
- 2.2.4 All bus bars and busbar 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; "Busbars - Danger 380 volts" in 30 mm high black lettering on yellow backing round.
- 2.2.5 Neutral shall be full size, unless otherwise indicated.
- 2.2.6 No Diversity shall be used in Bus Bar dropper sizing.
- 2.2.7 Earthing bus shall be sized in accordance with the BS 7430 for prospective short circuit.
- 2.2.8 Grounding (earthing) bus shall extend through the entire length of the assembly.

- 2.2.9 Main Distribution Board that is fed directly from the transformer shall have the following additional features:
- 2.2.9.1 Neutral busbar shall be provided with a removable solid bar link for testing purposes.
- 2.2.9.2 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.
- 2.2.9.3 Any additional feature as per the Electrical Authorities requirements.
- 2.2.10 The MDB shall be type tested in accordance with IEC 61439 copy of test certificate from independent laboratory confirming that all type tests mentioned under IEC 61439 are passed, shall be submitted.

2.3 Labels

- 2.3.1 All enclosures containing functional units shall be clearly labelled with a circuit unit reference and current rating in English and Arabic. Every functional unit shall be labelled 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 on white background.
- 2.3.2 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.
- 2.3.3 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.
- 2.3.4 All terminal blocks shall be labelled relative to respective functional unit. Every control and metering device, switch, pushbutton, indicator lamp, etc..shall be labelled to indicate its purpose.
- 2.3.5 Main identification labels shall be provided on the assembly together with its rating plate.
- 2.3.6 Fixed and withdrawable portions of equipment, including fixed and plug in devices shall be labelled with both withdrawable and fixed part.

2.4 Selector Switch/Push Buttons/Indicator Lamp

- 2.4.1 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 colours in accordance with IEC 60043.
- 2.4.2 Pushbuttons for emergency stop purpose shall be of mushroom head type, with twist to release action or key reset facility as specified.

- 2.4.3 Contact blocks shall have double break silver plated contacts in NO or NC configuration rated at not less than 5A resistive at 230V, 50Hz.
- 2.4.4 Indicating lamps shall be of the flush type, 22 mm diameter, with removable coloured lenses to permit replacement of lamps from the front. Colours shall be in accordance with BS 4094.
- 2.4.5 Indicating lamps on control circuits shall be equipped with completely sealed dual wound safety isolating transformers. Lamp test facility shall be provided.
- 2.5 Circuit Breakers**
- 2.5.1 Circuit breakers shall be moulded 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.
- 2.5.2 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.
- 2.5.3 Frame shall be constructed from molded moldarta and/or glass polyester material.
- 2.5.4 The operating mechanism shall be toggle type quick-make, quick-break, trip-free, with three different positions for ON, OFF & TRIP.
- 2.5.5 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.
- 2.5.6 The trip element shall be a bi-metal for overload and an electromagnet for short circuit.
- 2.5.7 Moulded 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.
- 2.5.8 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.
- 2.5.9 Breakers shall have 400 volt duty rating, and a minimum symmetrical short circuit interrupting rating equal to 40 KA for main distribution boards associated with 100 KVA transformers.
- 2.5.10 Each breaker shall be supplied with an externally operable mechanical means to trip the circuit breaker.
- 2.5.11 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.

- 2.5.12 Where required, breakers shall be suitable for busway connection.
- 2.5.13 Main breaker shall be insulated case type provided with interchangeable trip units, current transformers, flux-transfer short trip and solid state circuiting.
- 2.5.14 The Contractor shall be responsible to submit discrimination studies for the approved circuit breakers ratings for Engineers review and approval.

2.6 Air Circuit Breakers

- 2.6.1 Air circuit breakers shall be totally withdrawable 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.
- 2.6.2 Air circuit breakers shall be equipped with solid state microprocessor based protection unit.
- 2.6.3 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.
- 2.6.4 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.
- 2.6.5 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.
- 2.6.6 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 away that the excess energy at the end of a closing cycle is used to partially recharge the closing spring.
- 2.6.7 Also the opening springs shall be automatically charged during the closing operation.
- 2.6.8 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.
- 2.6.9 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.
- 2.6.10 The arc chutes shall be of special design employing steel splitter plates. The plates shall be arranged so that the arc is rapidly de-ionised while it is contained within the chute structure and the plate spacing shall be such that back pressure is

minimised. The complete chute assembly shall be easily removed for routine inspection of the chute and contacts.

- 2.6.11 Isolating contacts shall be multi-finger spring loaded type which shall be silver plated and shall require no attention.
- 2.6.12 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
- 2.6.13 Access to live connections in the inspection position or when the breaker is completely withdrawn.
- 2.6.14 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.
- 2.6.15 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.
- 2.6.16 Breakers shall be ambient compensated type with a built in compensatory to carry rated load at 50o C.
- 2.6.17 Air circuit breakers shall conform to IEC-947-2 .
- 2.6.18 An earth terminal shall be provided at the rear of the withdrawable 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.
- 2.6.19 Short circuit performance shall comply with IEC-947-2 (EN 60947-2), including make-break tests at upto 50 KA rms and 100 KA peak with minimum recovery voltages of 550 volts.
- 2.6.20 Mechanical endurance shall ensure over 30,000 operations with only minor maintenance.
- 2.6.21 A non re-settable number of operation counter shall be provided.
- 2.6.22 Suitable cable glands shall be provided for the support of the incoming supply cables.

2.7 Current Limiter Circuit Breakers

- 2.7.1 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.
- 2.7.2 Current limiting circuit breakers shall be supplied in unit moulded case construction and shall consist of a common trip, thermal magnetic circuit breaker with an independently operating limiter section in series with each pole.

- 2.7.3 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 50o C ambient temperature.
- 2.7.4 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 hold open until interruption is complete. The unit shall not contain replaceable elements and the limiter shall automatically reset after circuit interruption.
- 2.7.5 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 unity power factor.
- 2.7.6 The current limiting circuit breaker shall have front removable lugs. Lugs shall be UL listed for copper conductors.

2.8 Branch Circuit Breakers for Chillers

- 2.8.1 Breakers protecting chillers shall also incorporate the following protections:
- Phase failure relay
 - Reverse phase relay
 - Under voltage relay
 - Overcurrent relay
- 2.8.2 All these relays shall be connected to the shunt trip circuit of the breaker.

2.9 Kilowatt-hour Metering Compartment

- 2.9.1 In main distribution boards, where kilowatthour 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.

2.10 Main Distribution Boards Schedules

2.10.1 SCHEDULE NO. 1 - COLOUR CODES FOR CABLES

Voltage	Cable Colour	Remarks
230V a.c. (single Ph. circuits)	Red, yellow, Blue	
400 V a.c. (Three Ph. circuits)	Red, yellow, Blue	

Neutral	Black	
Earth	Green/yellow	
220V/110V/24V a.c. (auxiliary circuits)	Black	
12V/24V d.c. positive	Brown	
12V/24V d.c. negative	Blue	
Instrument earth	Green/Yellow	
Analog Signal	Grey	
Thermocouples	As defined in BS 1843	

2.10.2 SCHEDULE NO. 2 - PUSHBUTTON COLOURS

Colour	Application	Remarks
Red	Stop or off Emergency stop-with mushroom head, twist to reset and with yellow color.	
Green	Start or On	
Light Blue	Reset of overload devices	

2.10.3 **SCHEDULE NO. 3 - INDICATION LAMPS**

Colour	Application	Remarks
Red	1) Main circuit breaker closed 2) Equipment tripped by protective device 3) Parameter outside safe limit	
Yellow	1) Parameter outside normal limit	
Green	1) Circuit breaker open 2) Normal function of equipment	
White	1) Supply available	
Blue	1) Specified indication as labelled	

2.10.4 SCHEDULE NO. 4 - MDB REFERENCE

No	Contract Specification Item	Tender Information	To be Completed by Tenderer	Remarks
i	No. of Phases	3	----	
ii	Rated Voltage	400 V	---- V	
iii	Rated frequency	50 Hz	---- Hz	
iv	Rated current	-----Amp	---- Amp	
v	Prospective short circuit current (min.)	----- KA	-----KA	
vi	Rated short time with stand current (RMS)	----- KA for -----seconds	----- KA ---- seconds	
vii	Rated peak withstand current	-----KA	----- KA	
viii	Type of earthing	TNC - S	-----	
ix	Main busbar dimension	-----	----- bars x (---- x ----) mm	
x	Dropper busbar dimension	-----	----- mm2	
xi	Earth bar dimension	-----	----- mm2	
xii	Main busbar arrangement	-----	Top/Bottom	
xiii	Earth bar location	-----	Top/Bottom	
xiv	Main protective device	ACB/MCCB	-----	
xv	Cable entry	Bottom/Top	-----	
xvi	Cable access	Rear	Front/Rear	
xvii	Mounting arrangement	Floor	Floor/wall	
xviii	Degree of protection	IP 41	IP -----	
xix	Dimension	H 2400 mm (max) L----- mm (max) D 1000 mm (max)	H ----- mm L ----- mm D ----- mm	
xx	Location	In doors		

PART 3 EXECUTION

(NOT USED)

End of Section.

DISTRIBUTION BOARDS

PART 1 GENERAL

1.1 General Instructions

1.1.1 Works under this section shall be governed by Conditions of Contract

1.2 Scope

1.2.1 The contractor shall supply, install, test and commission Distribution Boards and distribution board complete as herein specified and as shown on the drawings. They shall include bus assembly, cabinet and front, circuit breakers and all necessary parts to install complete distribution boards and voltmeters, ammeters and instrument transformers where required and as indicated in the schematic diagrams.

1.3 Codes and Standards

1.3.1 Distribution boards shall conform to 61439.

1.3.2 Colour shall be gray to ANSI No. 61, BS 381 C or approved equal.

1.3.3 Miniature circuit breakers shall have tripping characteristics in accordance with EN 60898 in an ambient temperature of 40 deg. C.

1.3.4 Requirements for type tested - IEC 61439

1.3.5 Specification for Colour identification- BS 381 C: 1988.

1.4 Shop Drawings

1.4.1 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. for Engineer's review. A copy of this 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 for hereinbefore shall be carried out without additional charges.

PART 2 PRODUCTS

2.1 Cabinets and Fronts

- 2.1.1 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.
- 2.1.2 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. A Circuit directory card shall provide a space of at least 0.8cm high x 7cm long or equivalent for each circuit.
- 2.1.3 The directory shall be typed to identify the load fed by each circuit.
- 2.1.4 Fronts shall be of powder coated electro galvanized sheet steel. Colour shall be grey or acceptable equal.
- 2.1.5 Joints shall be welded, galvanized and reinforced where necessary and galvanized after fabrication.

2.2 Distribution Board Bus Assembly

- 2.2.1 Bus for connections to the branch circuit breakers shall be the "Distributed Phase" or "Phase Sequence" Type.
- 2.2.2 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.
- 2.2.3 Main and neutral buses shall be minimum 98% conductivity rectangular copper bars, provided with bolted-type lugs as necessary.
- 2.2.4 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.
- 2.2.5 Necessary bussing, drilling and blank plates shall be provided for installation of future circuits when so indicated in the Schedules on the Drawings.
- 2.2.6 All screws and bolts used for making copper connections shall be equipped with lock washers. Riveted connections will not be acceptable.
- 2.2.7 Mains shall be equipped with solderless pressure indent type connectors and shall have means to prevent swiveling of connector.

- 2.2.8 Neutral busbars shall be full size and shall incorporate one neutral terminal for each single pole and neutral way.
- 2.2.9 Aluminium shall not be used for any interior panelboard parts.
- 2.2.10 Back pan or mounting on which buses and branches are mounted shall be rigid to properly support the component parts.
- 2.2.11 Reinforcing of back pan shall be by flanging or addition of angle iron.
- 2.2.12 Buses, connectors, and terminals shall be silver plated to a minimum thickness of 0.1mm.
- 2.2.13 Main Distribution Board shall be equipped with thermal magnetic type moulded case circuit breakers of frame size and trip ratings as indicated on the drawings.
- 2.2.14 The Bus bar structure and miniature circuit breaker distribution boards shall be suitably braced for a minimum short circuit duty equal to 10,000 Amps unless otherwise indicated.
- 2.2.15 Distribution Board shall have, 400 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.
- 2.2.16 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 acceptance of Engineer.
- 2.2.17 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.
- 2.3 Circuit Breakers
- 2.3.1 All plug-in type and bolt-on 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.
- 2.3.2 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.
- 2.3.3 Circuit breakers shall have minimum RMS symmetrical interrupting capacities equal to 10,000 Amps at 400 V for miniature circuit breakers and capacities equal to the values indicated in the drawings for molded case circuit breakers but shall in no case be less than the bus bar short circuit bracing of the distribution board.

2.4 Molded Case Circuit Breakers

- 2.4.1 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.
- 2.4.2 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.
- 2.4.3 Circuit breakers shall have minimum RMS symmetrical interrupting capacities at 380 V equal to the values indicated below for moulded case circuit breakers unless otherwise indicated, and shall in no case be less than the busbar short circuit bracing of the distribution board:
 - 2.4.4 25kA up to 150A frame size
35kA for 225A frame size and above.

2.5 Current Limiting Circuit Breakers

- 2.5.1 Current limiting circuit breakers shall have a maximum interrupting rating of 100 KA rms symmetrical amperes.
- 2.5.2 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.
- 2.5.3 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.
- 2.5.4 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 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.
- 2.5.5 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 unity power factor.

- 2.5.6 The current limiting circuit breaker shall have front removable lugs. Lugs shall be UL listed for copper conductors.
- 2.6 Earth Leakage Circuit Breakers
 - 2.6.1 Each leakage circuit breakers shall be current operated type providing protection against overloads, short circuit, and low level earth faults of 30 mA, 100 mA or 300 mA as applicable or as shown on the drawings.
 - 2.6.2 It shall fit in standard distribution boards.
 - 2.6.3 A push-to-test mechanism shall be provided to ensure proper operation.
 - 2.6.4 Enclosure shall be glass fibre reinforced, plastic (GRP) construction.
 - 2.6.5 Breaker shall have 6000A interrupting capacity unless otherwise indicated.
 - 2.6.6 Breaker shall in other respects be similar to miniature circuit breakers.

PART 3 EXECUTION

3.1 Distribution Board Installation

- 3.1.1 Distribution board shall be aligned, leveled and securely fastened to the building, substrata.
- 3.1.2 Connecting conduits shall not be used to support the distribution board.
- 3.1.3 All unused openings in distribution board cabinets shall be properly closed.
- 3.1.4 Distribution board interiors shall not be installed in cabinets until all conduit connections to the cabinet have been completed.
- 3.1.5 Trim shall be installed plumb and square to the enclosure finish.
- 3.1.6 Trim for flush mounted cabinets shall be installed in plaster frame, flush with finished wall.
- 3.1.7 Concealed surfaces of cabinets shall be given on site a heavy application of emulsified asphalt prior to installation.
- 3.1.8 Free standing distribution boards when installed in electrical closets, or rooms with raised floors shall be provided with galvanized steel support structures to raise the level of the panel to 10 cm above the original floor level.

3.2 Earthing

- 3.2.1 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.
- 3.2.2 Cabinets shall be provided with an earth connector welded to it.

End of Section.

MOTOR CONTROL CENTRES

PART 1 GENERAL

1.1 General Instructions

1.1 Works under this section shall be governed by Conditions of Contract.

1.2 Scope

1.2.1 The Contractor shall supply and install the motor control centre(s) as shown on the Drawings and as herein specified.

1.2.2 Busbars shall comply with IEC 61439.

1.3 Approved Manufacturers

1.3.1 Refer to approval Electrical manufacture list at the end of Electrical specification.

PART 2 PRODUCTS

2.1 Enclosure and General Requirements

2.1.1 Motor control centre shall consist of enclosed cabinet type structure with components as specified hereinafter, free standing on channel front sills with sections bolted together to make up the centre. Motor control centre shall be of Form 2 standard as per the IEC relevant regulations unless otherwise indicated.

2.1.2 Outline dimensions of motor control centre and arrangement of compartments shall be approximately as indicated on the Drawings.

2.1.3 Enclosures for the motor control centre shall be general purpose gasketed type to IP55 unless otherwise indicated on the Drawings. Self adhesive IP 55 labels shall be provided on IP 55 rated panels.

2.1.4 Incoming power feeder shall be cable entering at the top or bottom as applicable and shall terminate on main lugs or main protective device in accordance with the Drawings.

2.1.5 Ample space shall be provided for system control and operation sequence devices, etc. specified under the Mechanical Section. These devices will be supplied, installed and wired in the Motor Control Centre under the Mechanical Section.

2.1.65 Where motor control centres are controlled/monitored by Building Management System (BMS), reference shall be made to BMS narratives and specifications.

2.2 Vertical Sections

- 2.2.1 Vertical sections shall be totally enclosed, dead front and back reinforced, welded and bolted to be self supporting and free standing without need of covers and doors for alignment and rigidity. All bolted connections shall have lock washers or equivalent. The assembly shall include horizontal and vertical buses, wireways and units as herein specified. Each end shall be designed to readily allow future additions. All external welds shall be sanded smooth. Each vertical section shall be composed of fixed units.
- 2.3 Buses
- 2.3.1 The top of each section shall contain three main horizontal copper busbars, which shall run, continuously through the motor control centre from section to section. Provisions shall be made for easy additions and connections to adjacent sections. The buses shall be braced for an RMS symmetrical short circuit current of the values shown on the Drawings.
- 2.3.2 Each section shall contain four vertical busbars running the full working heights of the section and connected to the horizontal main busbars.
- 2.3.3 Wireway compartments for horizontal wiring shall be provided at the top and bottom of the control center. A vertical wiring compartment shall be designed so as to allow installation wiring to the units with the unit doors open but with the unit in place.
- 2.3.4 Earthing bus shall be sized in accordance with the BS standards, but shall not be less than half the size of the phase sections. Grounding (earthing) bus shall extend through the entire length of the assembly.
- 2.3.5 Oversize holes shall not be used for bus connections. Holes shall not be more than 1.5 mm over the nominal diameter of the bolt. Slotted holes shall be kept to a minimum. No more than one slotted hole shall be used in a connection.
- 2.3.6 All bolted connections shall be capable of being tightened from the front, and shall be silver plated to a thickness of not less than 1.5 mm.
- 2.3.7 All bolted connections shall be fastened by lockwashers, lock-nuts, or equivalent. Heavy standard size flat washers shall be used on each side of the connection, unless other means of providing wide contact pressure area are used.
- 2.3.8 All bolts and related hardware shall be heavy plated cadmium or hot-dipped galvanized steel, or equal.
- 2.3.9 Isolation barriers shall be provided between the horizontal bus and front horizontal wireways.
- 2.3.10 Barriers shall effectively protect the buses from contact with any object in, or falling from the wireways.
- 2.3.11 Vertical barriers shall be provided with readily removable solids, plates or plugs over stab contact openings to allow addition or rearrangement of units.

2.4 Unit Compartment

- 2.4.1 Each unit compartment shall be provided with an individual front door. Starters and feeder-unit doors shall be inter-locked mechanically with unit disconnect device to prevent un-intentional opening of the door while energized and unintentional application of power while door is open. Means shall be provided for releasing the interlock for intentional access to the interior at any time and intentional application of power if desired, while door is open. Padlocking arrangement shall permit locking the disconnect device with door close or open.
- 2.4.2 Components of each module shall have individual printed label identifying size, voltage, ampere rating, etc. Starter wiring diagram and overload thermal cutout device installation instruction shall be attached to each starter.

2.5 Unit Components

- 2.5.1 The starter units shall be of the combination type consisting of components as shown on the Drawings.
- 2.5.2 The motor horsepower indicated on the Drawings may not be the same as those supplied. If larger motors are supplied, components, cable and conduits of larger capacity may be necessary and if so they shall be provided.
- 2.5.3 Starter units shall be provided with 2 pilot lights for trip-ping and running conditions.

2.6 Motor Starters

- 2.6.1 Motor starters shall be furnished where indicated on the motor control center schedules.
- 2.6.2 Starters in the motor control center(s) shall be part of combination starters as shown on the Drawings.
- 2.6.3 Starters shall be as elsewhere specified under "MOTORS & STARTERS".

2.7 Breakers

- 2.7.1 Circuit breakers shall be thermal magnetic, molded case bolt-on type furnished where indicated on the Drawings. Breakers shall provide thermal inverse time-limit overload and fixed magnetic instantaneous short-circuit protection and shall be as elsewhere specified under "Main and Sub-Main Distribution Boards".
- 2.7.2 Breakers shall be ambient compensated type with a built in compensator to carry rated load at 50°C.
- 2.7.3 Earth leakage relays shall be provided where so indicated on the drawings and shall be shunt tripped with the relevant protective device.
- 2.7.4 Circuit breakers shall have frame sizes with short circuit interrupting ratings at least equal to the short circuit bracing of the motor control centre busbars.

2.8 Current Limiter Breakers

- 2.8.1 Current limiter breakers shall incorporate a slot motor, providing contact opening and arc extinguishing in less than .25 cycles. These breakers shall provide protection to all downstream circuit breakers at the available short circuit levels.
- 2.8.2 Breakers shall in other respects be similar to moulded case circuit breakers as described hereinbefore.

2.9 Terminal Blocks

- 2.9.1 Terminal blocks shall be installed and internally connected by the manufacturer, for all internal and external wire number. Each terminal point shall have a large marking area or to be equipped with two marking areas.
- 2.9.2 In addition, with each group of terminals per unit, a minimum of 20 percent unconnected extra non-load terminals, but not less than one, shall be provided for the Contractor's external connections.

2.10 Current, Potential & Control Power Transformers

- 2.10.1 Current, potential and control power transformers shall be in-stalled as indicated on the Drawings or as needed. They shall be designed for 600 volt service. They shall have adequate thermal capacity and mechanical strength to match the short circuit capacity of the motor control centre.
- 2.10.2 Potential transformers primaries and secondary's shall be protected by fuses. Primary fuses shall be current limiting.

2.11 Instruments

- 2.11.1 Instruments such as ammeters, voltmeters, etc. shall be approximately 9 cm square, semi flush mounted, and shall be accurate within one percent of full scale. Scale shall be 250 degrees and selected so that normal voltage or full-load current shall indicate at approximately 70 percent of scale reading.
- 2.11.2 Test blocks and plugs for testing all instruments and instrument transformers shall be provided.
- 2.11.3 Instruments shall generally be in accordance with the particular specifications under Sub-Section "Instruments and Metering" of these Specifications.

2.12 Selector Switches

- 2.12.1 Selector switches for use in instrument and control circuits shall be of the rotary type with a rectangular escutcheon. The operating handle shall be of the round knurled or notched type for voltage and current.

PART 3 EXECUTION

3.1 Nameplates and Indicating Lamps

- 3.1.1 Nameplates shall be provided on and in the motor control center as specified below. All nameplates shall be fixed with adhesives.

- 3.1.2 The top wiring space and each unit door shall be provided with laminated plastic nameplate engraved white on black background in English and Arabic.

- 3.1.3 All starter control wiring schematic diagrams shall be provided at the back of the unit doors.

- 3.1.4 Manufacturer's nameplate on the front of the control centre shall be provided. Manufacturer's identification on each draw out unit shall also be provided.

- 3.1.5 Indicating lamps shall be of low voltage (6V) type with built in transformer.

- 3.1.6 Lamp test facility shall be provided on one front panel, to enable verifying the status of indicating lamps.

3.2 Finish

- 3.2.1 All steel, other than some interior components which are made corrosion resistant by galvanizing or plating shall be thoroughly cleaned, treated with rust inhibiting primer and baked enamel finished in an acceptable colour.

3.3 Miscellaneous

- 3.3.1 Devices such as Hand-Off-Auto selector switches, automatic electric alternator, etc. shall be provided as specified under other sections.

- 3.3.2 If the motor control centre is for the chilled water pumps, it shall incorporate the following items:

- 3.3.2.1 Operation selector switch, three position: Manual-Off-Auto. On "manual", the pumps shall be possible to be operated individually out of the system control. On "off", no pump shall be possible to be operated. On "Auto" all duty pumps shall operate in the System when system "ON" pushbutton is pressed.

- 3.3.2.2 Standby/duty selector switch, with number of positions at least equal to the number of pumps. This switch shall select the standby pump (or duty pump in case of 2 pumps only).

3.3.2.3 System "Start-Stop" pushbutton.

3.3.2.4 Space for sequence controller as described under "General" of this subsection.

End of Section.

INSTRUMENTS AND METERING

PART 1 GENERAL

1.1 General Instructions

1.1.1 Works under this section shall be governed by Conditions of Contract.

1.2 Scope

1.2.1 Provide all instruments and metering assemblies/systems as indicated in electrical drawings and specified herein.

1.3 Codes and Standards

1.3.1 All Electrical indicating instruments shall comply with BS 89 and shall have an accuracy class index as follows:

Function	Accuracy Class Index
Switchboard Indicating Instrument	1.0
Ammeters and Voltmeters on Motor Control Panels	2.5

1.3.2 The current transformers shall comply with all relevant requirements defined in BS 3938.

1.3.3 KVARh meter shall comply with all relevant requirements of BS 5685.

1.3.4 Polyphase meters registering maximum demand in kilowatts or (MW) shall comply with BS 5685:Part 3.

1.3.5 KWH meters shall comply with British Standard BS 5685:Part 1.

1.3.6 The terminal marking shall be in accordance with BS 5472.

1.3.7 Specification for Electrical measuring instruments - BS 89 :1990.

1.3.8 Specification for Voltage Transformers - BS 7625 : 1993.

1.3.9 Specification for Current Transformer - BS 7626 : 1993.

- 1.3.10 Specification for Watthour Meters - BS EN 60521 : 1995.
- 1.3.11 Specification for Terminals - BS 5472, EN 50005.
- 1.3.12 Specification for Electricity meters - BS 5685.

PART 2 PRODUCTS

2.1 Selector Switches

2.1.1 Ammeter selector switch shall have four operating positions marked "R", "Y", "B", "N" and an "OFF" position on a 3 phase, 4 wire supply system. The selector switch shall enable to read the current in each phase and neutral in sequence.

2.1.2 On, 3 wire system, ammeter selector switch shall have these operating positions marked "R", "Y", "B" and an "OFF" position. Ammeter selector switch shall have make-before-break cutouts and shall be connected so that associated current transformers are short circuited where they are not connected to ammeters.

2.1.3 Voltmeters selector switches, operating on 3 phase, 4 wire system. Shall have six operating positions marked "R-Y", "Y-B", "B-R", "R-N", "Y-N", "B-N" and an "OFF" position. Voltmeter switches shall have "break-before-make" cutouts.

2.1.4 All labeling shall be in English and Arabic.

2.2. Current Transformers

2.2.1 Current transformers shall have an accuracy class designation according to the following table:

No.	Function	Accuracy Class Designation
i.	Tariff metering	0.5
ii.	Non Tariff metering	1.0
iii.	Switchboard indicating instruments	1.0
Iv.	Motor starter ammeters	3.0

2.2.2 Current transformers designed for measurement circuits or for protection circuits shall not be used dual purpose role serving both measuring instruments and protection gear.

- 2.2.3 All CT's shall be of the ring type. Wound primary CT's shall only be accepted where the rated primary current is so low as to make ring type CT's impracticable.
- 2.2.4 One side of the secondary of each CT shall be connected to earth at one point via a bolted removable link.
- 2.2.5 For metering circuits a front panel CT test block or a "shorteng" terminal within the panel shall be provided for test purposes.
- 2.2.6 All CT's included for use at voltage exceeding 1000 volts shall be epoxy resin encapsulated.
- 2.2.7 Dual ratio CT's shall have two separate secondary windings capable of being connected in series or in parallel to give the designed ratio.
- 2.2.8 Magnetization curves and/or type test certificate shall be provided for all CT's associated with protective devices.
- 2.2.9 Each CT shall have a rated burden 50 percent greater than the total burden of the instruments, relays, etc. which they serve.
- 2.2.10 All CT's shall have a rating plate bearing the information as stipulated in BS 3938.

2.3 Voltage Transformers

- 2.3.1 Voltage transformers shall be of the type, rating and voltage ratios as specified in the Schedules or as indicated in the drawings.
- 2.3.2 All voltage transformers shall have an accuracy class designation according to the following table:-

No.	Function	Accuracy Class Designation
i.	Metering	1.0
ii.	Switchboard indicating instruments	1.0
iii.	Motor starter ammeters	3.0

- 2.3.3 Voltage transformers shall comply with all relevant requirements of BS 3941 and shall be suitable for use in the specified service condition.
- 2.3.4 Voltage transformers designed for primary voltage less than 4000 volts shall be air insulated type with winding encapsulated in epoxy resin or other suitable synthetic material.
- 2.3.5 Each voltage transformer shall have a rated burden at least 50 percent higher than the total burden of the apparatus or instruments it serves.
- 2.3.6 The insulation resistances of each voltage transformer shall be indelibly marked on the shipping/dispatch label.
- 2.4 Meters
 - 2.4.1 All single phase and 3-phase integrating meters like watt-hour meter, Kwh meter, maximum demand meter.
 - 2.4.2 Polyphase maximum demand meters shall operate on the basis of 30 minutes demand integration period.
 - 2.4.3 Provision for transmission of data to external devices shall be made for the following:
 - 2.4.3.1 Kilowatt - hour consumption.
 - 2.4.3.2 Kilowatt - maximum demand
 - 2.4.3.3 Time reset pulse for maximum demand.
 - 2.4.4 All meters covered in the preceding clauses shall have an accuracy class designation of 2.5 or better.
 - 2.4.5 All Three phase meters shall be suitable for operation on a 4-wire system with unbalanced load.
 - 2.4.6 Phase Rotation & Accuracies
 - 2.4.6.1 Phase sequence reversal shall have negligible effect on the accuracy of the kWh meters described; Meters shall be approved by the Local Electrical Authorities and other relevant parts of this standard as indicated below:
 - 2.4.7 kWh meters Part 4 (IEC 43)
 - 2.4.8 Maximum demand meters Part 5 (IEC 211)
 - 2.4.9 House Service Case
 - 2.4.9.1 The case shall be formed from high impact black phenolic resin mouldings; base and terminal block mouldings from a single unit. The cover shall be secured to the base by three captive screws while a cord gasket of large section shall ensure a dust-tight joint. The standard terminal cover shall fit flush with the terminal block, alternatively an extended cover shall be available which shall shroud the service cables. Both cover and terminal cover screws shall have facility for sealing.

2.4.10 Meter terminal shall be loose inserts fitted from inside the meter into cavities in the terminal block; moulded barriers between terminals shall provide adequate anti-creep surfaces. Terminal shall be made of brass and shall be heavily plated to inhibit corrosion. Terminal holes shall be minimum 8mm diameter up to 50 amperes rating and 12.7 mm diameter for the 100 ampere rating. The 100 ampere rating shall be specially designed to cope with high current flow through combination of the use of copper, machine finished terminations and heavy duty plated brass inserts in the terminal block. Terminal blocks shall have connection facilities for a wide range of tariff metering. A diagram of connections shall be fixed inside the terminal cover.

2.4.11 Switchboard Case

2.4.11.1 The switchboard drawout pattern case shall be supplied for either flush or projection mounted as acceptable to Engineer. The meter main frame element shall be secured to a cradle that can be withdrawn from the case to allow the meter to be inspected or serviced. A high pressure shall be maintained between the case and cradle contacts to ensure negligible contact resistance.

2.4.12 Terminals connected to current transformer secondaries shall have shorting switches which automatically close as the cradle is withdrawn from its case.

2.4.13 A diagram of internal connections shall be fixed inside the meter case.

2.4.14 Frame and Elements

2.4.14.1 A rigid die casting of high quality silicon aluminium alloy shall form the main frame to which the meter elements shall be secured. Each element shall have a torque balance, a low load and an inductive load calibration adjuster. These shall be all linear in effect and shall be readily accessible. Protection against corrosion shall be given by electropainting the frame and elements to produce a durable synthetic resin coating.

2.4.15 Meter Coils

2.4.15.1 The voltage and current coils shall be encapsulated in polypropylene (except for 100A current coils where epoxy resin shall be used). Encapsulation shall protect the meter against high voltage surges resulting from electrical storms and system transients, in addition to rendering the coils waterproof. Voltage coils shall be machine wound in a polyurethane coated wire. Current coils shall be wound from large section copper strip designed to provide a wide load range by withstanding continuous overloads.

2.4.16 Bearings

2.4.16.1 The weight of the rotor shall be supported by a symmetrical magnetic field set up by fixed and moving high coercivity permanent magnets, leaving only small transverse forces to be contained by fixed pin and guide bearings at each end of the rotor shaft.

2.4.16.2 Guide pins shall be of polished stainless steel running in guides precision moulded from specially selected low friction material.

- 2.4.16.3 Temperature compensation for the magnets shall be provided over a temperature range of - 20 degree C to + 60 degree C.

2.4.17 Rotor System

- 2.4.17.1 The rotor disc shall be light and rigid and shall be die cast or moulded to an aluminium alloy shaft. For stroboscopic calibration 500 serrations shall cut in the edge of the disc and for testing purposes the upper surface shall have 100 and 240 division concentric circles marked in black round the periphery. Two anti-creep holes in the disc shall prevent rotation on voltage alone. A non-reverse device shall be fitted to the rotor shaft to prevent the meter from registering under reverse power flow conditions. A highly polished worm cut in the rotor shaft shall form the register drive.

2.4.18 Brake Magnet

- 2.4.18.1 A bi-polar brake magnet unit mounted in a die cast aluminium alloy housing shall be provided. Two Alcomax bar magnets shall be employed, producing a uniform field which shall be symmetrical about the centre line of the disc gap, thus minimizing the effect of disc height variations.

2.4.19 Registers

- 2.4.19.1 Three types of interchangeable register shall be possible to be fitted to polyphase meters, the final selection being left to the Engineer:
- 2.4.19.1.1 Large jumping figure cyclometer.
 - 2.4.19.1.2 Continuously driven cyclometer.
 - 2.4.19.1.3 Pointer pattern.
- 2.4.19.2 All forms of register shall have precision moulded lightweight gears which shall give strength with extremely low frictional effects. Gear wheels and pinions shall be moulded on to hard drawn and polished stainless steel shafts.
- 2.4.19.3 Mouldings shall extend along the shafts to provide end shake shoulders and low friction surfaces against the metal support plates. Register dials shall be clearly marked in the appropriate units.

2.5 Maximum Demand Indicator (Applicable to Max. Demand Meters)

- 2.5.1 The Merz pattern maximum demand indicator shall give an accurate reading of average demand over the chosen integration period. A small red pointer geared to the rotor shall drive a large black indicating pointer up scale. At the end of each period a built-in electromagnetic actuator shall be de-energised to allow the driving pointer to return to zero. The demand indicator pointer, held at its highest reading by a light ratchet spring shall be possible to be reset zero by the push button mounted in the cover. The integration period may be 5, 10, 15, 20 or 30 minutes as controlled by an external or synchronous internal time switch. An alternative to the electromagnetic actuator shall be available in the form of a self contained mechanical release to the acceptance of the Engineer.

The complete demand indicator mechanism shall be possible to be removed without disturbing the units register.

2.6 Meter Adjustments

- 2.6.1 A self locking micrometer full load adjuster screw shall be fitted to the brake magnet unit. Total range of adjustment shall be 6%.
- 2.6.2 Each element shall have a special resistor with a sliding adjuster clamp for inductive load adjustment. Total range of adjustment shall be 5% at 0.5 lagging power factor.
- 2.6.3 Adjustment for torque balance shall be made by moving two magnetic diverts across the voltage core leakage gap of each element. The self locking adjuster locking adjuster gives a total adjustment of 10% change in speed of the element.
- 2.6.4 Adjustment for low load shall be made by moving a conductive vane across the electromagnet gap using the self locking adjuster screw. Total range of adjustment shall be 20% at 5% of marked balanced load.

2.7 Attachments

- 2.7.1 The Kwh meters shall accept without increase in case size any or all of the following attachments:
 - 2.7.1.1 Non-reverse device preventing reversal of rotation with direction of power flow.
 - 2.7.1.2 Transmitting unit providing a pulse or switched output to a summator, data processing unit, etc.
 - 2.7.1.3 Two rate register with two sets of continuously driven number wheels to register units consumed during peak and off-peak periods.
 - 2.7.1.4 Maximum demand indicator Merz pattern with 30 cm long scale giving an accurate reading of average demand over a chosen integration period. Reset by self-contained or external timing device.
 - 2.7.1.5 Maximum demand alarm unit
- 2.7.2 A maximum demand indicator (4) fitted with adjustable alarm contacts to initiate an alarm or trip off non-essential load when a predetermined value is reached.

2.8 Terminals

- 2.8.1 Cable terminals shall be suitable for the specified cable sizes. Adequate space shall be provided for cable terminations.
- 2.8.2 Terminal blocks shall be made of thermosetting melamine or polyamide material with good flame resistance. Terminal blocks shall withstand a temperature rise of 90° C above the ambient temperature. Cable terminals shall have permanent label fitted to each terminal, for indication of its purpose.

- 2.8.3 Termination of standard cables shall be done by using copper or copper alloy ferrules of sizes suitable for accommodating all strands of the cable.
- 2.8.4 All auxiliary wiring except screened cables shall be connected to incoming/outgoing cables via insulated terminal blocks, screw/screw type, clipped on DIN rails. Sufficient spare space shall be allowed on the DIN rails for addition of terminal blocks in the future.
- 2.8.5 Termination of screened cables shall be done by using plugs and fixed sockets.
- 2.8.6 All terminal blocks shall be mounted at minimum 20 cms above the base of floor mounted assemblies.
- 2.9 General Requirements for Meters
 - 2.9.1 All electrical indicating instruments shall be products of a single manufacturer.
 - 2.9.2 All ammeters and voltmeters shall be the moving iron type.
 - 2.9.3 All instruments shall be flush mounted.
 - 2.9.4 The scale range of ammeters, voltmeters, wattmeters and VAR meters shall be such that under normal operating conditions, the instruments pointer shall read between 60-75% of their effective scales. The scale span of these meters shall not be less than 90 degrees.
 - 2.9.5 Ammeters for use in motor control centres shall have a maximum burden of 3 VA at the upper limit of the effective range.
 - 2.9.6 Starters shall have extended scales with maximum scale indication equal to minimum six times the upper limit of the effective scale range. The scale shape shall be such that the effective scale range is not less than two thirds of the total scale span.
 - 2.9.7 The use of resistive ammeter shunts for extending the range of ammeters will not be acceptable.
 - 2.9.8 Power factor meters shall be marked LEAD and LAG in the appropriate quadrants.
 - 2.9.9 Indicating wattmeters shall be of air cored dynamometer type 3 phase indicating meters suitable for operation on a 3 phase, 4 wire system with balanced load, unless otherwise specified.
 - 2.9.10 VAR meters shall be supplied complete with the appropriate phase shifting transformer.
 - 2.9.11 All instruments shall be equipped with external means for adjusting the zero indication.

End of Section.

WIRING DEVICES

PART 1 GENERAL

1.1 General Instructions

1.1.1 Works under this section shall be governed by Conditions of Contract

1.2 Scope

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

1.2.2 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.

1.2.3 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.

1.2.4 Samples of devices and plates shall be submitted for selection and acceptance of the Engineer.

1.3 Applicable Standards

- | | | |
|-------|---|----------------|
| 1.3.1 | Specification for ceiling roses | - BS 67: 1987. |
| 1.3.2 | Specification for 13A fused plug and socket outlets | - BS 1363:1984 |
| 1.3.3 | Specification for Aminoplastic Moulding materials | - BS 1323:1992 |
| 1.3.4 | Specification for Transformers for reduced voltage | - BS 3535:1990 |
| 1.3.5 | Specification for Lighting Switches | - BS 3676 |
| 1.3.6 | Specification for Dimmers | - BS 5548. |

1.4 Approved Manufacturers

1.4.1 Refer to approval Electrical manufacture list at the end of Electrical specification.

PART 2 PRODUCTS

2.1 General

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

2.1.2 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.

2.1.3 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.

2.1.4 Unless otherwise specified or indicated on the Drawings, plates for flush mounting devices shall be constructed of moulded material of ivory or white in colour.

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

2.2 Device Plates

2.2.1 Plates shall be rectangular or square in shape to the approval of the Engineer.

2.2.2 Plates shall be designed to match associated devices.

2.2.3 Plates for cord extension shall be provided with cord grip bushings, threaded type, of

same material and finish as of plate.

2.2.4 Unless otherwise specified or indicated on the Drawings, plates for flush mounting

devices shall be constructed of moulded material of ivory or white in colour. For devices supplied from a UPS all plates shall be red in colour

2.2.5 All emergency, UPS and any other dedicated outlet shall be clearly labelled with its

identification.

2.2.6 Fixing screws shall be chromium plated and polished. Screw heads shall be finished

to suit the plates.

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

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

2.3 Switches

2.3.1 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.

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

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

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

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

2.3.6 Switches shall be one gang or multigang, 1-way, 2-way or intermediate as indicated on the drawings and to the acceptance of the Engineer.

2.3.7 20-Amp double pole switches shall incorporate a pilot light, and shall have the words "Water Heater" engraved on it when used for that purpose.

2.3.8 32 Amp double pole switches shall be similar to MK 5105/WH1 or Crabtree 4013/3, to the acceptance of the Engineer.

2.3.9 30-Amp double pole switch shall incorporate the inscription indicating the purpose of its use.

2.4 Grid Switch Assemblies

- 2.4.1 Switch panels shall be of the gridswitch system, comprising rocker-operated grid switches and coverplates of moulded material with white finish, unless otherwise indicated.
- 2.4.2 Switch panels shall comprise 20-amp lighting switches, and other units if so indicated on the Drawings.
- 2.4.3 Switch panels shall have the words "Danger 415 volts" engraved in red in it.
- 2.4.4 Switches inside the grid switch that controls lighting fixtures supplied from an emergency power supply shall have red colour rockers.

2.5 Timer Switches

- 2.5.1 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.

2.6 Lighting Contactor Control Pushbuttons

- 2.6.1 Pushbuttons shall be double contact type with spring return action.
- 2.6.2 Body shall be made of molded plastic with clear baked acrylic protection.

2.7 Socket Outlets

- 2.7.1 Socket outlets shall be mounted with correct polarity, such that switch shall cut the hot wire.
- 2.7.2 Socket outlets shall be of the standard, 3-pin, switched, single phase, shuttered type of moulded plastic unless otherwise specified.
- 2.7.3 13-amp socket outlets shall be flat pin type, to BS 1363, single or twin as indicated.
- 2.7.4 15-amp socket shall be round pin switched type to BS 546.
- 2.7.5 30-amp sockets shall be round pin type, cover made of brass and shall be provided with corresponding plugs.

2.8 Protective Socket Cover

- 2.8.1 Weatherproof socket outlets shall be provided with protective socket covers.
- 2.8.2 Protective socket cover shall be manufactured from high impact resistant "Noryl". The cover shall be designed to fall by gravity over the socket whether a plug is inserted or not.
- 2.8.3 Cover shall be similar to Egatube "Guardian" to the acceptance of the Engineer.

2.9 Ceiling Roses

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

- 2.9.2 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 unswitched wires.
- 2.9.3 All lighting fixtures incorporated in a false ceiling shall be connected to the ceiling lighting outlet through a ceiling rose and a flexible cord.
- 2.9.4 3 Pin ceiling roses shall include plug and socket interface and shall comply BS 6972 and BS 5733.
- 2.10 Hook for Chandelier
 - 2.10.1 Hook shall be suitable for suspension of chandeliers of up to 25 kgs.
- 2.11 Fused Connection Unit
 - 2.11.1 Fused connection unit shall be surface mounting type or flush type as indicated and as applicable. The 13 Amp fused connection unit shall incorporate a double pole switch, a neon indicator and a fuse link to BS 1362 of appropriate rating. The fused connection units used for security system components shall be unswitched type.
 - 2.11.2 Outlet for fan coil units with heaters ceiling mounted shall be surface mounting type and shall comprise a 20-amp double pole switch for the fan motor and a 50-amp double pole switch for the heater.
 - 2.11.3 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.
 - 2.11.4 Outlet for fan coil units with heaters installed at low level shall be a recess mounting 25-amp twin double pole switch with two flex outlets or alternatively a 20-amp and a 50-amp two double pole switches with two flex outlets.
- 2.12 Telephone outlets
 - 2.12.1 Telephone outlets shall be cord grip type and shall consist of terminal blocks of high insulating phenolic block with non-ferrous screws and straps.
- 2.13 Door Bell Pushbuttons
 - 2.13.1 Pushbuttons shall be double contact type with spring return action.
 - 2.13.2 Body shall be made of molded plastic with clear baked acrylic protection.
 - 2.13.3 Pushbutton shall have provision for directory of names. Pushbutton shall be lighted type, similar to Legrand 40802 or acceptable equal.
- 2.14 TV Outlets
 - 2.14.1 TV outlets shall be of molded material and shall have a low attenuation (1 db) for all frequencies.

- 2.14.2 TV outlets shall be supplied with matching plugs and cord of 1.2 meters.
- 2.14.3 TV outlets shall be manufactured by the same manufacturer of the TV System and to the acceptance of the Engineer.
- 2.15 Control Stations
- 2.15.1 Control stations shall be spring type, with silver plated contacts. Contacts shall be 5 amp rated. Plate shall be constructed from aluminium gray baked enamel painted.
- 2.15.2 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.
- 2.15.3 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.
- 2.15.4 UP-STOP-DOWN momentary contact type stations shall have three pushbuttons and no pilot lights.
- 2.15.5 Pushbuttons shall be moulded from trac-resistant material and shall be provided with button shrouding ring.
- 2.15.6 Key switch shall be a cylinder lock operator type station with three positions UP-OFF-DOWN. These words shall be engraved on the station.
- 2.15.7 Stations in damp & wet locations shall be enclosed in a Feraloy box and covered with stainless steel plates.
- 2.15.8 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.
- 2.16 Cable Outlet
- 2.16.1 Cable outlet shall comprise a moulded cover plate with a side groove for 3 x 10 mm2 multicore flexible cord, a cable clamp, 3 terminals for 10 mm2 conductors.
- 2.17 Fireman's Emergency Switch
- 2.17.1 Fireman's emergency switch shall be 16 Amp double pole or four pole as applicable. It shall incorporate a neon light. Opening of cover shall not be possible when live.
- 2.17.2 It shall be protected against dust and splash of water to IP54.

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

2.18 Hand Dryer

- 2.18.1 The hand dryer should be wall mounted type, controlled by infrared proximity switch, without touch ON/OFF switch, constructed from sturdy impact resistant case of high grade ABS, where motor fan and heater elements are rated for many years of maintenance free services.
- 2.18.2 The unit should be fitted with integrated mounting plate , safety mains plug connection, safety temperature limiter, sensor controlled safety switch and thermal fusible cut-out.
- 2.18.3 The rated power should be not less than 1800w, where heating power not less than 1700w, motor power 100w and air volume not less than 38l/s.

PART 3 EXECUTION

3.1 DEVICE COORDINATION

- 3.1.1 Where items of equipment are provided under other sections of this specification or by the Owner, provide a compatible receptacle for the cap or plug and cord of the equipment.

3.2 WALL SWITCHES

- 3.2.1 Location. Set wall switches in a suitable switch box centred at the height of 125 cm from the floor, except as otherwise shown. Install switch on the strike side of the door as finally hung.
- 3.2.2 Position. Install wall switches in a uniform position so the same direction of operation will open and close the circuits throughout the job, generally up or to the left for the ON position.

3.3 SOCKET OUTLETS

- 3.3.1 Mount socket outlets vertically with the ground on top in a suitable pvc outlet box centered at the height of 40 cm from the floor or as shown on the drawings. For horizontally mounted outlets, ground should be on left. The engineer reserves the right to make any reasonable changes in outlet locations without change in the contract sum.

3.4 DEVICE PLATES

- 3.4.1 Provide device plates for each outlet of the type required for service and device involved.
- 3.4.2 Ganged Devices. Mount ganged devices under a single, one-piece, device plate.
- 3.4.3 Engraving. Engrave plates with 3mm-high black letters, if designated for engraving.

End of Section .

MISCELLANEOUS EQUIPMENT

PART 1 GENERAL

1.1 General Instructions

1.1.1 Works under this section shall be governed by Conditions of Contract

1.2 Scope

1.2.1 The Contractor shall supply and install all the miscellaneous equipment as shown on the Drawings, and as herein specified.

1.3 Approved Manufacturers

1.3.1 Refer to approval Electrical manufacture list at the end of Electrical specification.

PART 2 PRODUCTS

2.1 Disconnecting Switches

2.1.1 Switches shall be non-fusible single throw, number of poles and rating as shown on the Drawings.

2.1.2 Switches shall be quick-make, quick-break type, capable of making, carrying and interrupting specified current at its rated voltage.

2.1.3 Switches rated more than 200 amps when used with motors shall be plainly marked "Do Not Operate Under Load".

2.1.4 Switches rated 200 amps or less, when used with motors shall be motor circuit switch type, of horse-power rating equal to, or more than, that of the associated motor and having interrupting capacity at least equal to the maximum operating overload current of the motor at rated voltage.

2.1.5 Motor circuit switches shall incorporate all necessary auxiliary contacts to isolate auxiliary power supplied (if any) associated with the starter.

2.1.6 Isolating switches with no interrupting ratings shall not be used for any type and rating of motor.

2.1.7 Enclosures shall be treated with a rust-inhibiting phosphate, and finished in gray baked enamel.

End of Section.

POWER FACTOR CORRECTION CAPACITOR

PART 1 GENERAL

1.1 *General Instructions*

1.1.1 Works under this section shall be governed by Conditions of Contract

1.2 Scope

1.2.1 The contractor shall supply, install and connect a complete Power Factor Correction Capacitor Bank with control equipment for automatically controlling the connection and disconnection of capacitances in response to changes in the load power factor.

1.2.2 The bank shall be free standing individual unit or part of the switchboard as indicated on the Drawings. The bank shall provide a complete automatic regulation of the connected capacitor power at peak and off peak times.

1.2.3 The bank shall be fully assembled and internally connected. All equipment shall be suitable for continuous operation within the specified ambient conditions.

1.3 System Description

1.3.1 The capacitor banks shall comprise one cubicle for protection and control equipment and shall be manufactured as per IEC 61921.

1.3.2 The capacitors shall have permanently connected built-in discharge resistors to ensure safe discharge of the capacitors to less than 50 volts in 1 minute after switch off as per IEC 60831, Part-1 and Part-2.

1.3.3 The capacitors shall be rated for a minimum of 130% continuous current overload and 110% continuous voltage overload based on the Rated Voltage of the capacitors.

1.3.4 The set of equipment for one capacitor 'step' shall comprise an electromagnetic contactors as per IEC 60947-1 & 4-1. The contactor shall be suitable for capacitor switching duty. For current over load protection of the capacitor step, a breaker should be provided. The setting of the breaker should be set at 1.3 times the continuous current rating of the stage.

1.3.5 The cubicle shall contain busbars for the main supply cable, terminal blocks for leads for the current transformer, control lead fuses. A reactive power regulator shall be mounted on the door of the cubicle. A shunt connected series detuning reactors shall be included in the capacitor bank assembly.

1.3.6 The capacitor and reactor combination represents a series resonant circuit. The circuit should be tuned such that the series resonant frequency should be below the lowest harmonics appearing in the system.

1.3.7 The equipment ratings shall be selected to give a generous margin to withstand the high capacitor currents due to harmonics on the system voltage.

1.3.8 The equipment shall be of type tested design as per IEC 61921 (Power capacitors – Low-voltage power factor correction banks)

1.4 Applicable Standards

1.4.1 Unless specified otherwise the capacitor banks shall conform in design, material, construction and performance to the latest editions of the IEC standards, their corresponding British / European (BS EN) standards and in particular to the following publications :

- IEC 60831-1 & 2 : Shunt power capacitors of the self-healing type for A.C. systems having a rated voltage up to and including 1000 V.
- IEC 61921 : Power capacitors – Low voltage power factor correction banks.
- IEC 60076-6 : Power transformers - Part 6: Reactors
- IEC 60085-1 : Electrical insulation – Thermal evaluation and designation.
- IEC 60664 : Insulation coordination for equipment within low-voltage systems.
- IEC 60439-1 : Low-Voltage Switchgear and Controlgear Assemblies - Part 1: Type- Tested and Partially Type-Tested Assemblies.
- IEC 60947-1 : Low-voltage Switchgear and Controlgear - Part 1: General Rules
- IEC 60947-2 : Low-voltage Switchgear and Controlgear - Part 2: Circuit-Breakers.
- IEC 60947-4-1 : Low-voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-starters.
- IEC 60529: Degree of protection provided enclosures (IP code)
- IEEE 519-1992 : IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.

PART 2 PRODUCT

2.1 Power Factor Correction Capacitors

2.1.1 The capacitor units shall be dry, self-healing type with individual discharge resistors shall be protected against internal faults, over pressure, etc. and shall fully comply with and tested to the requirements of the International Electro-technical Commission Publication No IEC 60831, Part-1 and Part-2.

2.1.2 Capacitor units shall be low loss type. Losses shall be less than 0.5 watts per KVAR.

- 2.1.3 Capacitor units shall have a dielectric voltage rating of 480V 3 phase, 50 HZ.
- 2.1.4 If the ambient temperature of the room exceeds 40°C (due to failure of air conditioning systems) then the capacitor bank and its components should be derated. The capacitor units shall then be rated for 550V.
- 2.1.5 Unit of equal capacitance shall be inter-changeable.
- 2.1.6 Every capacitor shall be capable of operating for prolonged periods, without damage, at voltage 10 percent higher than the rated voltage.
- 2.1.7 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.
- 2.1.8 The temperature category of the capacitor units shall be -5/D as per the IEC Publication No. 60831, Part-1.
- 2.2 Series Reactors
- 2.2.1 The three phase series reactors shall be connected in series with each capacitor stage to prevent amplification of system harmonics and to prevent resonance. The reactor should be iron cored type with copper windings. The reactor shall comply with the IEC Publication No. 60076-6.
- 2.2.2 For applications with a sizable single phase loads generating third harmonics (150Hz), series reactors with a tuning order of 2.7 (135Hz) with a relative impedance 13.7 % should be used.
- 2.2.3 For industrial applications with 6 pulse VFD's series reactors with a tuning order of 4.3 (215Hz) with a relative impedance 5.4 % should be used.
- 2.2.4 The reactor insulation shall be Class "H" rated at 180°C to IEC 60085-1. The maximum temperature of the reactor at maximum continuous RMS amperage shall be no higher than 145°C with a 45 °C ambient.
- 2.3 Circuit Breakers
- 2.3.1 The capacitor bank shall have a suitably rated circuit breaker at the incomer. The circuit breaker shall be a three pole 'MCCB' and shall fully comply with the requirements of the IEC 60947-1 & 2.
- 2.3.2 They shall be rated for a minimum insulation voltage of 660 V and designed for 52 degrees C ambient temperature. The current rating shall be at least 1.5 times the full load current of the capacitor bank and have a mechanical endurance of a minimum 1000 operations.
- 2.3.3 It shall have a rotary front operating door mounted handle and should be interlocked with the door to ensure that the capacitor bank is de-energized when door is open.

- 2.3.4 Each stage of the capacitor bank shall have a circuit breaker of suitable rating. The setting of the breaker shall be set at 1.3 times the continuous current rating of the stage for over load protection.
- 2.4 Electromagnetic Contactor
- 2.4.1 The electromagnetic contactors shall be 660 Volts rated, of 3-pole type suitable for switching 'on' and switching 'off' operations of capacitor banks and shall comply with the requirements of the IEC 60947-1 & 4-1.
- 2.4.2 The mechanical endurance of the contactors shall not be less than 3 million operating cycles at no load. The electrical endurance at normal utilization duty for capacitor shall not be less than 200,000 operations.
- 2.4.3 The contactors shall be subjected to routine and type tests as described in IEC 60947.
- 2.5 Power Factor Regulator
- 2.5.1 The power factor regulator shall be microprocessor based and shall be programmable at site. The Power Factor Regulator programme 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 upto 60 deg. C.
- 2.5.2 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.
- 2.5.3 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.
- 2.5.4 The power factor regulator shall have means to adapt itself to network phase rotation and reversal of current transformer terminals.
- PART 3 EXECUTION
- 3.1 Calculations
- 3.1.1 Temperature rise calculations shall be submitted along with the offer to prove that the temperature rise is within the temperature tolerance levels of the capacitor bank components. The capacitor banks shall be of type tested design (IEC 61921) and temperature rise test report of the capacitor bank performed at an independent laboratory shall be submitted.
- 3.1.2 With capacitors and reactors connected in series it should be proved through submission of software simulations / calculations that the Total Demand Distortion (TDD) / Total Harmonic Distortion (THD) is within the limits as specified in IEEE Std 519-1992, standards on IEEE recommended practices and requirements for Harmonic Control in Electric Power System.

- 3.1.3 If the TDD / THD limits are exceeded even with the use of the detuned capacitor banks, then suitably rated Active Harmonic Filters shall be proposed in conjunction with the detuned capacitor banks to limit the TDD / THD below the specified limits in IEEE 519.
- 3.2 Principle of Operation
- 3.2.1 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 targetted 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 targetted one. Only one capacitor stage shall be switched at a time.
- 3.3 Enclosure
- 3.3.1 The control equipment cubicle shall be provided with suitable ventilation to limit the temperature rise with the acceptable limits of the components used. 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.
- 3.3.2 The capacitor banks enclosure shall have ingress protection minimum of IP21 as per IEC 61921.
- 3.3.3 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.
- 3.3.4 The capacitor bank comprising of capacitor units, power factor controller, series reactors, contactors, MCCB, MCB etc shall be housed in a suitable metallic enclosure having a front door with a provision for locking arrangement.
- 3.4 Tests
- 3.4.1 Routine Tests
- 3.4.1.1 All routine tests shall be carried out in accordance with IEC 61921 as per the relevant clauses mentioned against each test. Routine tests shall be carried out by the manufacturer on every low voltage power factor correction banks before delivery.
- Inspection, including checking of clearance, dimensions etc.
 - DI-electric Test.

END OF SECTION

TRANSIENT OVERVOLTAGE PROTECTION FOR ELECTRICAL AND ELECTRONIC SYSTEMS

- PART 1 GENERAL
- 1.1 General Conditions
- 1.1.1 Works under this section shall be governed by Conditions of
- 1.2 Scope
- 1.2.1 Lightning and transient overvoltage protection system shall include all required instruments, controls, etc. to protect the following equipment against the effects of transient overvoltages caused by the secondary effects of lightning or by electrical switching events.
- computers
 - uninterruptible power supplies
 - Low current systems
 - and other electronic systems
- 1.2.2 These electronic systems protection devices shall be additional to any inbuilt protection devices or arrestors provided for the individual equipment.
- 1.3 Applicable International Standards
- 1.3.1 Protectors shall conform to:
- ES 6651:1992 Protection of structures against lightning,
ES 2914:1972 Surge diverters for low voltage installations,
IEEE C62.41 Guide for surge voltages on low voltage ac power circuits.
- PART 2 PRODUCTS
- 2.1 Protection for Mains Power Distribution Systems
- 2.1.1 Transient overvoltage protectors shall be installed on all power cables entering or leaving the building, in order to protect equipment connected to the power distribution system against transient over voltages coming into the building from outside.
- 2.1.2 Protectors shall also be installed at local power distribution boards feeding vulnerable equipment, in order to protect these against transients generated downstream of the protectors in 2.1.
- 2.1.3 The protector must not interfere with or restrict the systems normal operation. It should not:-
- corrupt the normal mains power supply
 - break or shutdown the power supply during operation
 - have an excessive earth leakage current

- 2.1.4 The protector shall be rated for a peak discharge current of no less than 10kA (8/20 microsecond waveform) between any two conductors (Phase to neutral, phase to earth and neutral to earth).
- 2.1.5 The protector shall limit the transient voltage to below equipment susceptibility levels. Unless otherwise stated the peak transient 'let-through' voltage shall not exceed 600 volts, for protectors with a nominal working voltage of 230 or 240 volts, when tested in accordance with BS 6651:1992 Category B - High (6kV 1.2/50 microseconds open circuit voltage, 3kA 8/20 microseconds short circuit current).
- 2.1.6 This peak transient 'let-through' voltage shall not be exceeded for all combinations of conductors:
- phase to neutral
phase to earth
neutral to earth
- 2.1.7 The protector shall have continuous indication of its protection status. Visual status indication shall clearly show:
- full protection present
reduced protection - replacement required
no protection - failure of protector
- 2.1.8 Remote indication of status should also be possible via a volt free contact.
- 2.1.9 The status indication should warn of protection failure between all combinations of conductors, including neutral to earth.
- 2.1.10 The protector shall be supplied with detailed installation instructions. The installer must comply with the installation practice detailed by the protector manufacturer.
- 2.2 Protection for Data Communication, Signal and Telephone Lines
- 2.2.1 Transient over voltage protectors shall be installed on all data communication/signal telephone lines entering or leaving the building, in order to protect equipment connected to the line, against transient overvoltages. (Where data lines travel between buildings linking equipment in each building, transient overvoltage protectors should be installed at both ends of the line in order to protect both pieces of equipment.)

- 2.2.2 The protector must not impair the systems normal operation. It should not:
- restrict the systems bandwidth or signal frequency
 - introduce excessive in-line resistance
 - cause signal reflections or impedance mismatches (on high frequency systems).
- 2.2.3 The protector will have a low transient 'let-through' voltage for tests conducted in accordance with BS 6651:1992 Category C - High (5kV 10/700 microsecond test).
- 2.2.4 This 'let-through' performance will be provided for all combinations of conductors:
- signal line to signal line
 - signal line to screen/earth
- 2.2.5 The protector shall be rated for a peak discharge current of 10 kA.
- 2.2.6 The protector shall be supplied with detailed installation instructions. The installer must comply with the installation practice detailed by the protector manufacturer.
- 2.2.7 The protector manufacturer shall allow for the facility to mount and earth large numbers of protectors through an accessory combined mounting and earthing kit.

End of Section

LIGHTING FIXTURES

- PART 1 GENERAL
- 1.1 General Instructions
- 1.1.1. Works under this section shall be governed by Conditions of Contract
- 1.2 Scope
- 1.2.1 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.
- 1.2.2. Fixtures shall comply with all applicable requirements as herein outlined unless otherwise specified or shown on the Drawings.
- 1.2.3 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.
- 1.3 Codes and Standards
- 1.3.1 Fixtures shall be completely wired and constructed to comply with IEC Publication 598-1 598-2 and BSEN 60598-1: 1993 unless otherwise specified.
- 1.3.2 All luminaires supplied by the contractor shall be photometrically tested to BS 5225:Part 1.
- 1.3.3 Specification for Lighting Fixtures - BSEN 60598-1:1993.
- 1.3.4 Specifications for Radio Frequency Suppression - BSEN 55014:1993.
- 1.3.5 Specifications for Lighting Fixtures Photometric - BS 5225:1985.
- 1.3.6 Specifications for Electronic Starters - BS 3772 Part 1.
- 1.3.7 Specification Capacitors - BSEN 61048:1993
- BSEN 61049:1993.
- 1.3.8 Earth leakage current must be below 0.4 mA measured according to IEC-598-1.
- 1.3.9 Radio frequency interference must be in accordance with EN 55015.
- 1.3.10 Ballast must be in accordance with IEC 928 (ballast safety) and IEC 929 (ballast performance).
- 1.3.11 Total harmonic distortion must be below 10% and in accordance with EN 6000-3-2.

1.4 Approved Manufacturers

1.4.1 Lighting fixtures – refer to lighting fixtures schedule

1.5 Fixture Samples

1.5.1 Detailed catalogue cuts for all fixtures and samples of fixtures shall be submitted for review and acceptance of the Engineer before placing order for the lighting fixtures.

PART 2 PRODUCTS

2.1 Materials

2.1.1 2.1.2 2.1.3 When installed, any exposed fixture housing surface, trim frame, door frame, and lens frame shall be free of light leaks.

2.1.4 Hinged door frames shall operate smoothly without binding. Latches shall function easily by finger action without the use of tools.

B. . Ballasts shall not be mounted to removable reflectors or wireway covers unless so specified.

C. Lamp Sockets:

1.Fluorescent: Single slot entry type, requiring a one-quarter turn of the lamp after insertion.

Lampholder contacts shall be the biting edge type.

2.Compact Fluorescent: 4-pin.

3.High Intensity Discharge (HID): Porcelain.

E. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.

F.Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, aircraft cable, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

G. Metal Finishes:

1.The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion-resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match

- the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.
2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.
 3. Exterior finishes shall be as shown on the drawings.
- H. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.
- I. Light Transmitting Components for Fluorescent Fixtures:
1. Shall be 100 percent virgin acrylic.
 2. Flat lens panels shall have not less than 3 mm (1/8 inch) of average thickness.
 3. Unless otherwise specified, lenses, reflectors, diffusers, and louvers shall be retained firmly in a metal frame by clips or clamping ring in such a manner as to allow expansion and contraction without distortion or cracking.
- J. Lighting fixtures in hazardous areas shall be suitable for installation in Class and Division areas as defined in NFPA 70.
- K. Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballast integral to the fixture. Assemblies designed to retrofit incandescent fixtures are prohibited except when specifically indicated for renovation of existing fixtures.
- 2.1 Materials
- 2.1.1 Sheet Metal Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved), and parallel to each other as designed.
 - 2.1.2 Wireways and fittings shall be free of burrs and sharp edges, and shall accommodate internal and branch circuit wiring without damage to the wiring.
 - 2.1.3 Fixture, housing, frame or canopy, shall provide a suitable cover for fixture outlet box or fixture opening.
 - 2.1.4 Fixtures shall not cause a temperature exceeding 90 degree centigrade on any outside surface.
 - 2.1.5 Fixtures shall bear manufacturer's name and the factory inspection label.
 - 2.1.6 Ballasts and lamps shall be serviceable while the fixture is in its normally installed position.
 - 2.1.7 Certain fixtures may be shown in provisional position. They shall be exactly located as soon as the final layout of equipment is known.

- 2.1.8 Any plastics used in the luminaire shall be light and U.V. stable and shall be suitable for their application.
- 2.1.9 All sheet steel components shall be suitably pre-treated and electrostatically spray-painted using acrylic polyester or epoxy powder paint.
- 2.1.10 Fixtures that are used under canopy or directly exposed to weather shall be considered as being outdoor type.
- 2.1.11 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.
- 2.1.12 Cast portions of fixtures shall be not less than 1.5 mm thick.
- 2.1.13 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.
- 2.1.14 Fixtures with visible frame shall have concealed hinges and catches.
- 2.1.15 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.
- 2.1.16 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.
- 2.1.17 External fixtures shall be constructed to minimum classification of IP55 and be class II unless otherwise stated.
- 2.1.18 Fixtures with hinged diffuser doors shall be provided with spring clips or other retaining devices to prevent the diffuser from moving.
- 2.1.19 Bathroom fixtures shall be marked as being suitable for damp locations and shall be of minimum IP44 degree of protection, class-1. Lampholders of such fixtures shall be provided with a protective shield to prevent contact with the lamp cap.
- 2.1.20 Fixtures with exposed metal parts shall be provided with a means for connecting an equipment earthing conductor for such fixtures.
- 2.1.21 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.
- 2.1.22 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.
- 2.1.23 Pendent fixtures and lamp holders shall be provided with ball type aligners.

- 2.1.24 Heat generated by any lighting fixture shall not affect any part of the fitting.
- 2.1.25 Diffuser and the body of the lighting fixtures shall be guaranteed for stable colour for 5 years under the site condition.
- 2.2 Fluorescent Fixtures
 - 2.2.1 Fixtures shall be provided with white click-in type lampholders.
 - 2.2.2 Pendant 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.
 - 2.2.3 Diffusers shall be manufactured from one piece non-glued methacrylate.
 - 2.2.4 Mirror system light controlled fixtures shall comprise a metal encased aluminium mirror system with aluminium mirror strips forming a parabolic reflector. Lamps shall be screened in the longitudinal direction by means of matt-white louvre partitions unless otherwise specified on the drawings.
 - 2.2.5 Clear smooth diffusers shall be smooth from outside, finely grained from inside.
 - 2.2.6 Corrosion resistant fixtures shall comprise polyester resin fibre-glass reinforced body, dust and splash-proof.
 - 2.2.7 Damp-resistant fixtures shall comprise polyester resin fiberglass reinforced body, dust and jet-proof.
 - 2.2.8 Luminaires containing compact fluorescent lamps shall be designed to ensure the correct working conditions for the lamp.
 - 2.2.9 All compact fluorescent luminaires shall, unless otherwise stated, be supplied with low loss control gear and single pulse electronic starters.
 - 2.2.10 Explosion proof fixtures if any shall be suitable for hazardous location specially 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.
- 2.3 Finish
 - 2.3.1 All hardware shall be bonderized, cadmium-plated, given a corrosion-resistant phosphate treatment or other acceptable rust inhibiting prime coat, to provide a rustproof base before application of finish.
 - 2.3.2 Finish shall be baked enamel.
 - 2.3.3 Non-reflecting surfaces such as fixture frames and trims, shall be finished with baked enamel paint, unless otherwise specified. The colour of the paint shall be as indicated on the Drawings or as directed later by the Engineer on Site.

- 2.3.4 Light reflecting surfaces shall be finished with baked white enamel paint having a reflection factor of not less than 85%.
- 2.3.5 All parts of the reflector shall be completely covered by the finish and free from irregularities.
- 2.3.6 Unpainted surfaces shall be finished with a clear lacquer except for anodized or "Azac" surfaces.
- 2.3.7 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.
- 2.3.8 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.
- 2.4 Lamps – General
 - 2.4.1 Lamps shall be supplied and installed in all lighting fixtures listed in the Schedule of Lighting Fixtures on the Drawings.
 - 2.4.2 Lamps used for temporary lighting services shall not be used in the final lamping of fixture units.
 - 2.4.3 Lamps shall be of wattage and type as shown in the Schedule of Lighting Fixtures.
 - 2.4.4 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.
- 2.5 Lamps – Fluorescent
 - 2.5.1 Lamps shall be of the normal start energy saving type, unless otherwise indicated.
 - 2.5.2 Tubular fluorescent lamps shall be 16 mm dia. and shall have tri-phosphor coating.
 - 2.5.3 Lamps shall have bi-pin bases and a minimum approximate rated life of 24,000 hours.
 - 2.5.4 Lamps with WHITE colour rendering shall have the colour rendering features similar to 'TL'D colour 84 at 4000K and lamps with WHITE DELUXE colour rendering shall have the colour rendering features of 'TL'D colour 83 at 3000 K
 - 2.5.5 Compact fluorescent lamps shall be of the 4-pin type manufactured in accordance with BS 6982.
 - 2.5.6 Compact fluorescent lamps shall be suitable for operating as emergency lighting sources where specified.

- 2.5.7 Compact fluorescent lamps shall be suitable for operating on standard wire wound and H.F. ballasts.
- 2.5.8 Where the lamps are used horizontally, they shall be adequately supported along their length.
- 2.5.9 Lamps shall have WHITE colour rendering unless otherwise indicated.

2.6 LED LIGHT FIXTURES

- 2.6.1 LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
- 2.6.2 LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
- 2.6.3 LED drivers shall include the following features unless otherwise indicated:
- a) Minimum efficiency: 85% at full load.
 - b) Minimum Operating Ambient Temperature: -20° C. (-4° F.)
 - c) Input Voltage: 120 - 277V (±10%) at 60 Hz.
 - d) Integral short circuit, open circuit, and overload protection.
 - e) Power Factor: ≥ 0.95.
 - f) Total Harmonic Distortion: ≤ 20%.
 - g) Comply with FCC 47 CFR Part 15.
- 2.6.4 LED modules shall include the following features unless otherwise indicated:
- a) Comply with IES LM-79 and LM-80 requirements.
 - b) Minimum CRI 80 and color temperature 3000° K unless otherwise specified in
LIGHTING FIXTURE SCHEDULE.
 - c) Minimum Rated Life: 50,000 hours per IES L70.
 - d) Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.
- 2.6.5 LED Downlights:
Housing, LED driver, and LED module shall be products of the same manufacturer.
- 2.6.6 LED Troffers:
LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
- 2.6.7 Housing, LED driver, and LED module shall be products of the same manufacturer.

- 2.7 Ballasts - Fluorescent (Electronic)
- 2.7.1 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 a sheet metal housing for mechanical protection. It shall require no starter.
- 2.8 Wiring
- 2.8.1 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.
- PART 3 EXECUTION
- 3.1 Installation
- 3.1.1 Fixtures shall be installed at mounting heights as detailed on the Drawings or as instructed on Site by the Engineer.
- 3.1.2 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 review and acceptance.
- 3.1.3 Pendant 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.
- 3.1.4 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.
- 3.1.5 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.
- 3.1.6 Surface mounted fixtures longer than 60 cm shall have one additional point of support besides the outlet box fixture stud when installed individually.
- 3.1.7 Fixtures located on the exterior of the building shall be installed with non-ferrous metal screws finished to match the fixtures.
- 3.1.8 Where edison screw lampholders are used, the outer contact must be connected to the neutral conductor.

- 3.1.9 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.

End of Section

TELECOMUNICATION CABLING SYSTEM

PART 1 GENERAL

1.1. Summary

1.1.1 Provide Telecommunications in accordance with requirements of the contract documents for the communication.

1.2 Standards, Codes, Testing, Guidelines

1.2.1 EIA/TIA 568 (Electronic Industries Association/Telecommunications Industries Association) - Commercial Building Telecommunication Wiring Standard.

1.2.2 EIA/TIA 569 (Electronic Industries Association/Telecommunications Industries Association) - Commercial Building Standard for Telecommunications Pathways and spaces.

1.2.3 NETA ATS (International Electrical Testing Association) - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.2.4 NSI/TIA/EIA-607-A Grounding and Bonding.

1.2.5 BICI – TDMM Telecommunications Distribution Methods Manual – 10th Edition.

1.2.6 The contractor has the responsibility to determine and comply with the most recent release of the above listed codes and documents.

1.3 Submittals

1.3.1 Furnish submittals in accordance with general requirements and as follows:

1.3.2 Submit Shop Drawings showing planned work for the following:

1.3.3 Drawings shall indicate dimensional orientation of equipment racks, equipment cabinets, termination blocks, power receptacles and earthing busbar. Show all conduits, sleeves, slots, cable tray, access panels and cable paths.

1.3.4 Provide drawings showing typical and non-typical outlet box configurations and relative positioning of RJ45 jacks, and cable routes.

1.3.5 Drawings to show evidence of coordination with other trades.

1.3.6 Samples of test results printed using the test equipment manufacturer's software application. Sample test results shall be printed using the approved cable ID scheme. Shop Drawing/Sample test results shall be submitted for approval prior to commencement of cable testing.

1.3.7 Workstation cable termination schedules showing cable transmission and device location.

1.3.8 Submit manufacturer's product data sheets for all materials and equipment proposed for use on the project.

- 1.3.9 Submit manufacturer's product data sheets for all fire stopping materials proposed for use on the project.
- 1.3.10 Mark each product data sheet to show applicable choices and options. Where product data includes information on several products, some of which are not required, mark to indicate the applicable information.
- 1.4 Certificate of Completion:
- 1.4.1 Contractor shall submit a Certification of Completion in a form stipulated by the Owner or Owner's Representative, signed by the Contractor stating that the Work was provided in compliance with the Contract Documents and that the installation was proper for the conditions of application and use.
- 1.5 Quality Control Testing and Inspection Reports:
- 1.5.1 Provide cable test results for all cables installed under this Work, documented and formatted as described herein.
- 1.5.2 Provide Owner with Operation and Maintenance Manuals including wiring diagrams, parts lists, shop drawings and manufacturers' information on all equipment and cables provided by the Contractor. Manuals shall be provided in a high quality, 3-ring binder and completely indexed.
- 1.6 Project Closeout Record Documents:
- 1.6.1 Provide As-Built drawings in accordance with the general Condition of this Work, annotated with the appropriate installation information. As a minimum, record drawings must include: outlet symbols, outlet identification numbers, cable routes from end to end. Submitted drawings will comprise a complete set of "as installed" plans.
- 1.6.2 Outlet and cable identification shown on drawings must be coordinated with owner's standards. Identification shown on drawings must match faceplate labels, cable labels and cable test results.
- 1.6.3 As-built drawings must include dimensioned plan views and elevations of technology spaces in accordance with the general Condition of this Work, annotated with the appropriate installation information including location as a minimum, to include layout of: equipment racks, termination equipment, point to point wiring diagrams, conduit identification and cable tray comprising a complete set of "as installed" plans.
- 1.7 Warranty
- 1.7.1 Furnish a manufacturer's Performance Warranty for all ISO 11801 and EIA/TIA 568-B Category 6a cables and components covering material and labor for a minimum of twenty years from the date of acceptance of the work. Where a manufacturer's warranty is longer than twenty years, the Contractor shall offer the longer warranty. The Performance Warranty shall be issued and signed by the component manufacturer and shall list the Owner as the holder of the warranty.

PART 2 PRODUCTS

2.1 Horizontal 4-Pair shielded Twisted Pair – LSZH

2.1.1 General

- 2.1.1.1 The Cat7a Copper Cabling System should be “Next Generation” cables, utilizes a patent pending matrix tape technology in the cable, to achieve channel bandwidth performance well above industry standards.
- 2.1.1.2 The twisted-pair conductors shall be a 23 AWG construction, separated by a cross web, with all four pairs surrounded by the matrix tape and a LSZH jacket. This provides superior suppression of PSANEXT & PSAACRF, eliminating the need to field test for alien crosstalk. The innovative cable design shall provide installation flexibility, as cables can be routed in tight bundles through pathways and spaces.
- 2.1.2 Technical Information
- 2.1.2.1 Certified channel performance in a 4-connector configuration up to 100 meters. It exceeds the requirements of ANSI/TIA/EIA-568-B.2-10 Category 7a and ISO 11801 Class Ea standards, for supporting 10GBASE-T transmission over twisted-pair cabling systems.
- 2.1.2.2 Certified component performance up to 100 meters and exceeds the ANSI/TIA/EIA-568-B.2-10 Category 6a and IEC 61156-5 Category 7a standards for supporting 10GBASE-T transmission over twisted-pair cabling systems.
- 2.1.2.3 Cable Diameter 7.5mm – Smaller cable improves cable routing & management in high density installations
- 2.1.2.4 PoE Compliant – Meets IEEE 802.3af and draft requirements of IEEE 802.3at for PoE Plus. It also has an extended temperature range of 75deg.C for error-free performance in high-density cabinets and cable bundles running PoE Plus applications.
- 2.1.2.5 Conductors/Insulators– 23 AWG solid copper with Polyethylene (PE) insulation
- 2.1.2.6 Installation Tension – 25lbf (110N) maximum
- 2.1.2.7 Cable Jacket – Low Smoke Zero Halogen (LSZH)
- 2.2 Patch Cables
- 2.2.1 The Cat7a Copper Patch Cords should be “Next Generation” patch cords utilize a patent pending matrix tape technology in the cable, to achieve channel bandwidth performance well above industry standards.
- 2.2.2 They are of a stranded copper construction and now feature a smaller outside diameter (7mm) for improved patch cord management and pathway fill capacity.
- 2.2.3 Exceed requirements of ANSI/TIA/EIA-568-B.2-10 Category 7A, IEEE 802.3an-2006, and ISO 11801 Class EA channel standards
- 2.2.4 Exceed requirements of ANSI/TIA/EIA-568-B.2-10 Category 7A and IEC 61156-5 Category 7A component standards
- 2.2.5 Meet draft requirements of IEEE 802.3at for PoE Plus
- 2.2.6 Each patch cord is 100% performance tested and wired to T568B

- 2.2.7 Constructed of TX6A™ 10Gig™ 23 AWG stranded copper cable (nominal cable diameter is 7mm) and TX6A™ PLUS Modular Plugs for superior performance
- 2.2.8 Plug meets all applicable ANSI/TIA-968-A requirements and exceeds IEC 60603-7 specifications
- 2.2.9 Slender strain relief boot provides easy access in high density applications
- 2.2.10 Plug uses an integral pair manager to optimize performance and consistency by reducing untwisting of conductors within the plug
- 2.2.11 Plug performance in center of TIA/EIA component range, ensuring interoperability and 10GBASE-T Ethernet channel performance
- 2.2.12 Labels on patch cords provide identification of performance level, length, and quality control number
- 2.2.13 Patented tangle free latch prevents snags and provides easy release, saving time on frequent moves, adds, and changes
- 2.2.14 Optional Patch Cord Color Bands snap on and off individual patch cables offering endless color-coding options

2.3 Information Outlets

2.3.1 General

- 2.3.1.1 8-pin modular, Category 6a, jack module, designed to exceed ANSI/TIA/EIA-B.2-1 and IEEE 802.3an standards.
- 2.3.1.2 The Category 6a 8-position jack module shall terminate Panduit Cat6a unshielded twisted 4-pair, 23 AWG, 100 ohm cable and shall not require the use of a punchdown tool. The jack module shall use forward motion termination to optimize performance by maintaining cable pair geometry and eliminating conductor untwist – this forms a part of the four levels of noise suppression offered in the enhanced module, giving superior performance over other solutions.
- 2.3.1.3 The blue termination cap shall be color coded for T568A and T568B wiring schemes. The MINI-COM® TX6A™ 10GIG™ Jack Module must be installed as part of a complete TX6A™ 10GIG™ UTP Copper Cabling System in order to achieve 10GBASE-T Certified performance.

2.3.2 Features

- 2.3.2.1 Exceed requirements of ANSI/TIA/EIA-568-B.2-10 Category 6A, IEEE 802.3an-2006, and ISO 11801 Class EA channel standards
- 2.3.2.2 Exceed ANSI/TIA/EIA-568-B.2-10 Category 6A and IEC 61156-5 Category 6A component standards
- 2.3.2.3 Meet draft requirements of IEEE 802.3at for PoE Plus
- 2.3.2.4 Each jack is 100% tested to ensure NEXT and RL performance and is individually serialized for traceability

- 2.3.2.5 Utilize patent-pending enhanced Giga-TX™ Technology for jack terminations which optimizes performance by maintaining cable pair geometry and eliminating conductor untwist
- 2.3.2.6 Contacts plated with 50 micro inches of gold for superior performance
- 2.3.2.7 No punchdown tool required; termination tool (EGJT) ensures conductors are fully terminated by utilizing a smooth forward motion without impact on critical internal components for maximum reliability
- 2.3.2.8 Optional termination tool (TGJT) reduces termination time by 25%, ideal for high volume installations
- 2.3.2.9 Can be re-terminated a minimum of twenty times
- 2.3.2.10 Blue termination cap designates 10Gig™ Category 6A performance and provides positive strain relief; helps control cable bend radius and securely retains wires
- 2.3.2.11 Terminate 4-pair, 22 – 26 AWG, 100 ohm, solid or stranded twisted pair cable
- 2.3.2.12 Universal termination cap is color-coded for T568A and T568B wiring schemes
- 2.3.2.13 Accept 6 and 8-position modular plugs without damage
- 2.3.2.14 Can be clearly identified with optional labels and icons
- 2.3.2.15 Compatible with Mini-Com® Modular Patch Panels, Faceplates, and Surface Mount Boxes

- 2.4 Outlet Faceplate/Mounting Plate
 - 2.4.1 Provide type as shown on drawings:
 - 2.4.1.1 Single-gang mounting plate with two (2) openings containing either of the following modular jacks. The jacks should be terminated using a non-impact method (non-punchdown) to ensure the integrity and reliability of the system.
 - 6 port (up to 6 RJ45 plus blanks as needed)
 - 4 port
 - 2 port (standard location)
 - 1 port (wall phone)
 - 1 port pay phone f.
 - Blanks
 - (Consult with Owner to determine color preferences)
 - 2.4.1.2 Description: Tele/Data outlet faceplate suitable for installation in a standard NEMA electrical junction box, with straight connector outlets, capable of mounting four or six approved modular outlets, provide with blank panels as needed.

- 2.5 Equipment Racks
 - 2.5.1 The 19 in. equipment rack shall have the following minimum requirements:

- 2.5.1.1 800mm x 1044mm x (42U)
- 2.5.1.2 Locking front and rear doors
- 2.5.1.3 Adjustable front and back equipment mounting rails drilled and tapped to EIA-310-D standards
- 2.5.1.4 10 position electrical outlet strip
- 2.5.1.5 Removable side panels
- 2.5.1.6 Perforated Front & Rear Doors
- 2.5.1.7 Incorporate as standard - integral cable management including vertical channels, modular cable management finger sections, access panels top and bottom and accept a range of optional slack spools.
- 2.5.1.8 Industry standard 152mm clearance between the switch exhaust and side panel, for optimum thermal management
- 2.5.1.9 Vertical cable managers to be utilized for optimum cable management
- 2.5.1.10 Horizontal managers to be used above and below each patch panel – except where angled panels are utilized
- 2.5.1.11 Cable Ducting to be utilized above the racks to aid cable routing.
- 2.6 Power Strip/Surge Suppressor
- 2.6.2 Part Number:
 - Horizontal rack-mount power strip
 - 120V, 50/60 Hz for mounting in equipment racks.
 - NEMA 5-20P plug type, minimum 6 outlets per strip.
- 2.7 Labels
- 2.7.1 Labelling shall conform to ANSI/TIA/EIA-606(A) standards. In addition, provide the following:
 - 2.7.1.1 Label each work area outlet with permanent self-adhesive label with minimum 8mm high characters.
 - 2.7.1.2 Label each cable with permanent self-laminating label with minimum 5mm high characters, in the following locations:
 - 2.7.1.2.1 Inside receptacle box at the work areas
 - 2.7.1.2.2 Behind the communication closet patch panel.
 - 2.7.1.3 Use labels on face of data patch panels. Provide facility assignment records in a protective cover at each telecommunications closet location that is specific to the facilities terminated therein.
 - 2.7.1.4 Use colour-coded modular jacks at the patch panel & work area outlets, that conforms to ANSI/TIA/EIA-606(A) standard colour codes for termination blocks.

- 2.7.1.5 Mount termination blocks on colour-coded backboards.
- 2.7.1.6 Labels shall be machine-printed. Hand-lettered labels shall not be acceptable. Use a manufacturers approved labelling system.
- 2.7.1.7 Label cables, outlets, patch panels, and punch blocks with room number in which outlet is located, followed by a single letter suffix to indicate particular outlet within room, i.e., S2107A, S2107B. Indicate riser cables by an R then pair or cable number.
- 2.7.1.8 Mark up floor plans showing outlet locations, type, and cable marking of cables.

PART 3 EXECUTION

3.1 Installation

- 3.1.1 Cabling and equipment shall be installed in accordance with good engineering practices as established by BICSI, EIA/TIA and the NEC.
- 3.1.2 Install and proactively coordinate the Telecommunications Cabling work in cooperation with other trades installing interrelated work. Before installation, make proper provisions to avoid interference with other work. Make all repairs or changes required in the work, caused by neglect, at no additional expense to the Owner.
- 3.1.3 Perform all tests required as specified herein.
- 3.1.4 Copper telecommunication cables running parallel to electrical cables/conduits shall be separated by a minimum of 300mm.
- 3.1.5 Copper telecommunication cables, which must cross-electrical cables/conduits, shall do so only at 90-degree angles.
- 3.1.6 Ensure that all telecommunications cable pathways and supports (conduits, slots, sleeves, and horizontal and vertical cable tray) are fully installed before proceeding with cable installation. At no time shall cables be installed and left unsupported. At no times shall cables be tie-wrapped to any other supporting structure in lieu of specified cable supports. At no time shall cables be bundled even when installed within the approved cable supports.
- 3.1.7 Do not lay telecommunications cables unprotected on the floor at any time. If cables must be left on any floor, protect the cables so that they may not be walked on or have any material or equipment placed or rolled on top.
- 3.1.8 Do not exceed manufacturers published specifications related to maximum pulling tension, minimum bend radii, and maximum sidewall pressure when installing cables.
- 3.1.9 Ensure cables will not be damaged by other trades during storage, handling and installation. Any cabling which has been crushed, cut or damaged in any other way will be replaced at no additional expense to the Owner.
- 3.1.10 Keep all items protected before, during and after installation. Use dust and waterproof barrier materials as required. It shall be the Contractor's responsibility to ensure the integrity of these protective measures throughout the life of the project.

- 3.1.11 At all times during the construction, the Contractor shall protect all telecommunications equipment from damage. Equipment in the telecommunications closets shall not be installed until such time as other trades have completed their work in that area so that the equipment will not be moved or damaged.
- 3.1.12 Ensure that safe ingress and egress from all work areas are maintained during movement and installation of materials.
- 3.1.13 Clean up all debris generated by installation activities. Keep the telecommunications areas free of debris at all times.
- 3.1.14 Upon project completion, provide as-built drawings and documentation as defined herein. Craft personnel shall be qualified to perform the work activities and be knowledgeable of the following:
- Color coding of standard STP cables.
 - Bonding and earthing of equipment racks.
 - Testing conductors for electrical continuity.
 - Testing and certification of horizontal copper conductors to EIA/TIA and ISO standards and specifications.
 - Termination of shielded twisted pair cable on all specified connectors patch panels, electrical protection blocks and termination blocks.
 - BICSI installation guidelines and generally accepted industry standards and best practices, as well as manufacturer's written installation instructions.
- 3.1.15 Connectors and Faceplates
- 3.1.15.1 Data Outlet
- 3.1.15.1.1 Provide 8-pin modular connectors and an accompanying faceplate and/or mounting plate at the appropriate outlet location as shown on the Drawings. Install single or double-gang faceplates in drywall, wall box and floor box locations as required. Install faceplates level and align to adjacent outlet faceplates. Coordinate the colour of the connectors as stated herein, and be consistent throughout. Coordinate the colour of the wall plate with the Architects.
- 3.1.15.2 Wall Mounted Phone
- 3.1.15.2.1 Provide an 8-pin modular connector and supporting faceplate capable of supporting a wall mount telephone at the appropriate outlet location as shown on the Drawings.
- 3.1.16 Ladder Rack/Cable Tray
- 3.1.16.1 Telecommunications rooms:
- 3.1.16.1.1 Provide cable tray in the IT rooms as shown on the Drawings. Mount cable trays overhead in all spaces. Follow manufacturer installation instructions and best practices at all times. Provide heavy-duty butt-splice-kits where cable tray lengths require the joining of two sections. Provide threaded-rod-ceiling-kits, spaced 4 feet on center, and/or end-foot-kits to support the cable tray overhead. Ground the cable tray to the nearest earthing busbar located within the respective equipment room. Ensure each section is electrically bonded to ground either through mechanical

connection or bonding strap. Coordinate exact dimensions with architectural plans and provide shop drawings for approval prior to installation.

- 3.1.16.1.2 Provide wall mounted supporting tray for cables passing vertically through equipment rooms.

3.1.17 Identification

- 3.1.17.1 Provide on all termination blocks installed under this Work, machine generated designation strips with the cable ID and pair number, in uppercase lettering. The scheme must be consistent with owner's standards and must match exactly with identification scheme used on the as-built drawings and the cable test results.

- 3.1.17.2 Provide on workstation faceplates installed under this Work, machine generated labeling adhesive label strip. The scheme must be consistent with owner's standards and must match exactly with identification used on the as-built drawings and the cable test results.

- 3.1.17.3 Provide on all telecommunications cables installed under this work a machine-generated label with the cable ID, in black uppercase lettering on a permanent adhesive, white label stock, covered with a permanent water resistant sealer. Labels shall be placed on both ends of the cable and no more than 6" (150mm) from the point at which the cable is broken out into individual copper pairs or strands from the connector or termination block. The scheme must be consistent with owner's standards and must match exactly with identification used on the as-built drawings.

- 3.2.22.4 If at any time during the project, the label becomes marred or illegible, the Contractor shall immediately replace it with a duplicate pre-printed label.

- 3.2.22.5 All cable IDs shall be both physically and visually accessible upon completion of the project.

- 3.2.22.5 Hand lettered label stock will not be accepted for final installation. Hand lettered stock is only acceptable for use with temporary labelling required during construction phases.

3.2 Field Quality Control

- 3.2.1 Inspection and Testing: Testing the cabling system prior to system cut-over and hand-off to the Owner.

3.2.1.1 STP Horizontal and Backbone Cable Testing

- 3.2.1.1.1 Provide End-to-end testing of each cable per Category-7a EIA/TIA 568-B.1, PERMANENT LINK test, for: Attenuation, NEXT, PSNEXT, Return Loss, ELFEXT, and PSELFEXT data that indicate the worst case result, the frequency at which it occurs, the limit at that point, and the margin. These tests shall be performed in a swept frequency manner from 1 MHz to 500MHz for Category-7a cables using a swept frequency interval that is consistent with TIA and ISO requirements. Information shall be provided for all pairs or pair combinations and in both directions.

- 3.2.1.1.2 Any individual test that fails the relevant performance specification shall be marked as FAIL. In addition to the above requirements provide the following:

- Length (in meters), ACR, propagation delay, and delay skew results.

- Cable manufacturer, cable model number/type.
 - Tester manufacturer, model, serial number, hardware version, and software version.
 - Circuit ID number and project name.
 - "Autotest" specification used.
 - Overall pass/fail indication.
 - Operator's name
 - Date of test
- 3.2.1.1.3 Cable test results files shall be provided on CD and/or printed copy if requested. Groups of test results and folder names shall be structured in an organized and unambiguous format. Provide a table contents file in word or excel format for each test result disk. Individual test results shall be named to match exactly with physical labeling and as-built drawings.
- 3.2.2 After the installation is complete, in addition to any other required testing as described herein, and at such times as the Owner and/or Engineer directs, the Contractor shall be present while the Owner conducts an operating test for approval. The installation shall be demonstrated to be in accordance with the requirements of this specification. Any defects revealed shall be corrected promptly at the Contractor's expense and the tests performed again.
- 3.2.3 The Contractor shall provide all testing as described in the Construction Documents. The Contractor shall provide materials, equipment, and labor for testing verification as requested by the Owner or Engineer.
- 3.2.4 Copies of test reports shall be provided to the Owner and Owner's Representatives as described.
- 3.2.5 If, upon verification testing of published test results, multiple errors, omissions, failures, discrepancies and/or deviations are encountered; the Owner or Engineer reserves the right to have the Work completely retested by an independent testing agency. The Owner and Engineer will incur no expense in the cost of retesting. The full cost of retesting shall be borne by the Contractor and shall be deducted from the balance of fees retained. Upon completion of the retesting of the Work, the Engineer will direct the Contractor to replace or repair the Work as required by the independent test results. Repair or replacement work shall be completed at no additional cost to the Owner or Engineer. This clause shall in no way reduce or diminish the rights of the Owner to complete the Work under other remedies within these Construction Contract Documents.

End of Section

LIGHTING CONTROL SYSTEM

PART 1 GENERAL

1.1 General Instruction

- 1.1.1 Works under this section shall be governed by conditions of contract.

1.2 Scope

- 1.2.1 The contractor shall supply, install and connect the low voltage programmable lighting control system complete including lighting control panels, relays (switching modules), Low voltage switches, conduits, wiring, control bus...etc. complete as shown on the drawings and as specified herein to cover building control requirements such as lighting control (On/Off and dimming), shutter & blinds control (Open/Close) temperature control and load management based on one or more applications such as, time, daylight & brightness, manual switches, temperature...etc.
- 1.2.2 A two-wire bus cable shall link in parallel all sensors (push buttons, brightness sensors, timers, etc.) and actuators (on/off controllers, dimming controllers, shutter controllers...etc.) to each other.
- 1.2.3 The system shall be decentralized stand-alone system, capable of being integrated with the Building Management System (BMS) by providing the required interface so as to monitor and control the required circuits from the BMS workstation. BMS supplier shall provide necessary interface module (gateway) to connect the lighting controls.
- 1.2.4 The entire system shall consist of bus lines each consisting of up to 64 devices. Two consecutive lines shall be connected to each other via line couplers that act as network filters and also provide communication between devices in different lines.
- 1.2.5 In the event of failure of a device in one line, only the control functions controlled by that device shall be affected and all other devices shall continue to operate as normal.

1.3 System Features

- 1.3.1 The Interface module with the BMS system shall be able to exchange data and commands from and to the lighting control system to achieve control and monitoring of the lighting system from the BMS PC. The BMS supplier shall provide interface module with BMS.
- 1.3.2 The lighting control system shall provide ON / OFF control of light fittings (Fluorescent, Incandescent, Neon and LED...etc.) for all the lighting circuits controlled by the system.
- 1.3.3 The system shall permit the user to turn ON / OFF individual loads and group of loads, and to set pre-determined lighting patterns via switches, time clocks, building automation system and other automated control devices.

- 1.3.4 System programming shall be implemented via a PC or Notebook located anywhere in the system and having access level passwords. Any device in the system shall be accessible for programming from the PC location without the need to manipulate the device locally.
- 1.3.5 The bus cable shall be laid in the building in the form of a linear, star or tree structure similar to the power mains. Systems requiring fixed wiring configurations shall not be acceptable.
- 1.3.6 Each device in the system shall be addressable via a software programmable physical address. Any device in the system shall communicate with any other device via software programmable group addresses (telegrams). Each device will respond to only those group addresses for which they are programmed to do so.
- 1.3.7 There shall be an EEPROM storing the physical address, group addresses & other software parameters for every device, thus making it intelligent. No centralized processors or centralized memory storage devices shall be permitted.
- 1.3.8 Each of the devices shall have a built-in push button along with a LED. The LED shall lit in the event the push button is pressed and if there is power to the device, thus depicting that the device is communicating in the system.
- 1.3.9 In the event of power failure or bus wiring failure each of the system devices (switching modules and dimming controllers...etc.) shall be programmed to attain a fail-safe position (controlled circuits to become "On", "Off" or "As it is, Last status")
- 1.3.10 The system shall have the capability to control relays via switches equipped with IR receivers as and when required.
- 1.3.11 3-gang and 5- gang switches equipped with infrared receivers shall transmit commands to the system upon receiving a signal from a hand held infrared transmitter (IR remote control). The same switches will be connected to the system via the two-wire bus cable.
- 1.3.12 Each switch button shall feature two status LED's; green indicating ON and red indicating OFF with a possibility to reverse them via software.
- 1.3.13 The system shall incorporate a diagnostic module that shall scan the system for any faults in the bus wiring and display an alarm LED in the event of faults in the wiring.
- 1.3.14 The system shall be expandable and flexible, i.e. new components could be added to the system by attending them to the two-wire communication bus and setting their physical address and parameters by the programming software.

1.4 Codes and Standards

- 1.4.1 All devices in the system shall comply with one of the international standards listed below and shall be manufactured in accordance with EMC guidelines and the low voltage guidelines where not in contradiction with Local Power Authorities requirements:
- CE Standards
 - British Standards BS
 - Underwriters Laboratories UL
 - National Fire Protection Association NFPA

PART 2 PRODUCTS

2.1 Lighting control modules (Intelligent Contactors)

- 2.1.1 Lighting control modules for On/Off switching shall be DIN rail mounted consisting of either four (4) or eight (8) individually programmable integral relays (contactors). The output states of each of these relays shall be displayed on the front. Each of these relays shall be latch-on type with manual operation (override) possible even without power to the system.
- 2.1.2 The relay control modules shall receive its operating power supply from the same bus cable without any other power supply. It should not operate on any 220/240 V AC supply to avoid possible fire hazards.
- 2.1.3 Each of these contactors shall be rated 16 A/AC together with an inrush current carrying capacity of 500 A suitable for switching loads with high switch-on peaks. The contactors shall also have a capacitive load rating of at least 200 microfarads.
- 2.1.4 Additional contactors shall not be used to control any of the lighting circuits.
- 2.1.5 Each of the lighting control modules shall have its own individual address and shall be capable of being programmed from a PC located anywhere in the system for the purpose of changing parameters without the need to access the module locally.
- 2.1.6 The control modules shall be capable of being programmed with different applications to suit site requirements for e.g. staircase lighting function that switches 'Off' the relays after a preprogrammed time from the time it has switched 'On'. The application for which a relay has been programmed shall apply irrespective of the signal from which it is controlled.
- 2.1.7 Each of the relays shall be capable of being programmed with its own 'On' and 'Off' delays that shall be applicable irrespective of the signal from which the relays are controlled.
- 2.1.8 In the event of power failure or bus wiring failure or control module failure, each of the relays shall attain a pre-programmed fail-safe position ('On', 'Off' or 'As it is, Last status') at the time of commissioning.
- 2.1.9 Lighting control modules (Relays controllers) shall be installed in a dedicated Lighting Control Panel (LCP).

2.2 System Power Supply

- 2.2.1 The power supply module feeding power to the network shall consist of a built in back-up power to compensate short voltage interruptions of up to 200 ms. This back-up power shall enable the system to put all actuators in a fail-safe position (either on or off or as it is) in the event of power failure.
- 2.2.2 The choke-integrated power supply shall be suitable for DIN rail mounting. This power supply shall produce and monitor the supply voltage for the bus. Power Supply rating shall be 45 VA and shall have a 30 Volts DC output and 220 Volts AC Input.

2.3 Switches

- 2.3.1 The low voltage system switches shall have indication for 'On' and 'Off' status with 'Red' and 'Green' colors with a possibility to reverse them via software. In the case of circuits switched in parallel from multiple signals, the switch 'LED' shall display the true status of the circuit based on the latest signal sent to the particular circuit. It shall be possible to control any circuit in the system from any of the switch channels to ensure all channels are available for entire control of the system.
- 2.3.2 Each switch shall be addressable and shall communicate with other system devices through a two-wire bus cable.
- 2.3.3 Switches shall be in 1,2 or 4 buttons arrangements per switch plate. Switch plate covers shall be of the screw-less design in white matt color to the approval of Engineer.
- 2.3.4 The assignment of discrete intensity level for lighting groups shall be either by use of the Manual Dimmer Control Plate, Infrared Transmitter or a Hand held programming Console or PC.

2.4 Time Controller

- 2.4.1 A Controller device shall consist of at least 100 timer channels (groups) in the form of lighting scenarios and shall control circuits (such as switching lighting on/off, dimming lights up/down, open/close shutters...etc.) on a particular network group (line) to have local standalone operation. It shall be possible to send signals from one controller channel in one network to circuits in another network if programmed to do so. This is to ensure that all timer channels are available for control of all circuits in the system.
- 2.4.2 Each controller shall be capable of being programmed locally with timer programs for any of the 100 channels combined together, without the need to connect a PC.
- 2.4.3 Each of the channels shall have a manual operation function to over-ride the channel to 'On' or 'Off' irrespective of the time programs.
- 2.4.4 The controller shall have a built-in EEPROM to ensure that the timer programs and control groups are retained even in the event of power failure. This controller device shall ensure uninterrupted stand-alone operation of the system at all times. Whether a BMS is connected to with the lighting control system or not.

2.5 Light sensors (Twilight Switches)

- 2.5.1 A light value switch capable of switching up to three lighting groups and other loads shall be used where each individual channel has a separate switching set point. The brightness range of the set points shall be adjustable from 2 to 2000 lux or 20 to 20000 lux as agreed with the consultant/client at the time of commissioning. A light sensor shall be connected to the switch to detect daylight.
- 2.5.2 It shall be possible to over ride the circuits controlled (based on brightness) via timer channels of the TP controller.

2.6 Lighting control Panels (LCP)

- 2.6.1 The LCP shall house the system devices and the related control equipment depending on the no. of circuits being controlled. This is to ensure the power wiring between the DB's and the control modules inside the LCPs is kept to a minimum. The LCPs shall be surface mounted IP65 polycarbonate enclosures together with built-in DIN-rails for easy installation of the control equipment.

2.7 Software

- 2.7.1 The programming shall be implemented via a PC or notebook computer located anywhere in the system and having access level passwords. Programming via local system switches or with no password security shall not be acceptable. Any device in the system shall be accessed for programming from the PC location without having to manipulate the device locally.

2.8 Addressing/programming Mechanisms.

- 2.8.1 Each device in the system shall be addressable via a software programmable physical address. Any device in the system shall communicate with any other device via software programmable group addresses (telegrams).
- 2.8.2 Each device shall respond to only those group addresses for which they are programmed to do so.
- 2.8.3 There shall be an EEPROM storing the physical address, group addresses & other software parameters for every device, thus making it intelligent. No centralized processors or centralized memory storage devices shall be permitted.
- 2.8.4 Individual addresses, timing functions, group and pattern numbers shall be interred into the system by means of a PC or notebook located anywhere in the system.
- 2.8.5 Changes in individual, pattern or group control of the relays and dimmers shall be accomplished without rewiring or other hardware changes.

PART 3 EXECUTION

3.1 Equipment Installation and Documentation

- 3.1.1 **Installation:** The Lighting Control System shall be installed and wired completely as shown on the plans by the sub-Contractor, who shall make all necessary wiring connections to external devices and equipment.
- 3.1.2 **Documentation:** Accurate "as built" drawings shall be furnished by the contractor to aid the owner in programming. These should indicate the load controlled by each relay and the identification number for that relay. They should also identify the physical location of each switch connected to an input and the identification number of that input. Three sets of space plans or reflected ceiling plans shall be furnished by the contractor indicating which fixtures are controlled by each relay.

3.2 Service and Support.

- 3.2.1 **Startup:** After the system has been installed, the documentation delivered to the owner and the telephone lines are operational the Contractor shall secure the services of a factory trained representative of the manufacturer to verify correct operation of all system components. The Contractor shall guarantee all material and workmanship involving the system after startup.

3.2.2 **Factory support:** Factory support shall be made available free of charge during the warranty period and to answer programming and application questions.

3.2.3 The manufacturer, or his representative, shall have a remote terminal capable of programming the controller and auditor to support the Employer's personnel during this period.

3.2.4 The Employer's system shall include a modem (EMODEM-2 or equal), necessary cabling and telephone extension to support this telecommunications operation.

3.3 Control System Concept

3.3.1 The programmable lighting and control system shall consist of two levels of control –

- Central BMS PC based graphics software for time based control and manual override by the operator. The software shall consist of graphics based overview of the entire building, floors and going up to the individual rooms. It shall have the necessary timer modules to control the circuits in the form of various groups. It shall be possible to pre-program the time channels in advance with special holiday programs, weekly programs, etc.
- In the event the PC is not operational or is switched Off, a second level of standalone operation shall also be possible via local controller modules capable of being programmed with switching times locally without the need to connect a PC. A 100-channel controller capable of being programmed with multiple time schedules / lighting scenarios shall be provided for the lighting and control system.

3.3.2 Alternatively the controller shall be provided for each network group of 64 devices as and when required to ensure this standalone operation. This shall ensure that the system remains operational at all times in the auto mode.

3.3.3 All other circuits which are controlled based on applications such as occupancy sensors, daylight, local switches...etc. shall at all times be working in the standalone 'Auto' mode with monitoring and override control possible from the central BMS PC Workstation.

3.4 Lighting Control Concept

3.4.1 All lights controlled by the system shall be controlled such that unnecessary lights shall be switched OFF based on applications such as occupancy, time schedules, override switches, etc. Also lights redundant due to sufficient daylight shall be switched OFF based on light sensor and time schedules.

- All lighting in floor corridors/lifts lobbies in basements, ground floor, parking floors, and typical floors shall be switched on-off based on pre-programmed time schedules as decided at the time of commissioning. Time controller shall be as specified under Clause 2.4.
- All lighting in car park areas in basements, ground floor and upper parking floors shall be switched on-off based on pre-programmed time schedules and twilight switches as decided at the time of commissioning.
- However, driveway lights shall be on 24 hours. Time controller and twilight switches shall be as specified under Clause 2.4 and 2.5 herein above.

- All external/elevation lighting in ground floor, typical floors and roof levels shall be switched On-Off based on pre-programmed time schedules and twilight switches as decided at the time of commissioning. Time control and twilight switches shall be as specified under Clause 2.4 and 2.5.

3.4.2 One override switch shall be provided/located adjacent to every LCP for maintenance purpose. This switch shall control On-Off all lighting circuits connected to LCP.

3.5 Submittals

3.5.1 Within 30 days of the award of the contract, the equipment supplier shall provide the engineer with 6 copies of submittals for approval. Submittals shall consist of the following:

3.5.2 Bill of materials: Submit in bill of materials form an itemized list of all materials supplied to meet the specification.

3.5.3 Riser Diagram: a one-line diagram of the system configuration.

3.5.4 Wiring Diagrams / Data Sheets: Data sheets and typical drawings and wiring diagrams of all system components.

3.5.5 Samples of switches and all other room devices.

3.5.6 Copy of installation Instruction sheet for each product.

3.5.7 Copy of Specification sheet for each product.

3.6 Installation

3.6.1 All wiring shall be in accordance with the National Electrical Code (NEC) and conform to all local codes.

3.6.2 The contractor is responsible for assuring that the conduit size and wire quantity, size and type are suitable for system supplied. The contractor shall review the proper installation of each type of device with the equipment supplier.

3.7 Validation

3.7.1 The control system contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operations submitted.

3.7.2 Witnessed validation demonstration shall consist of:

3.7.2.1 Demonstrate group and pattern switching

3.7.2.2 Demonstrate timer and delay functions

3.7.2.3 Demonstrate scheduling function

3.7.2.4 Demonstrate manual override commands

3.7.2.5 Display and demonstrate system man/machine interface functionality.

3.8 Manuals

3.8.1 The contractor shall provide complete system documentation at acceptance including:

3.8.2 As-built drawings of project

3.8.3 Equipment supplier submittals

3.8.4 System operation manual

3.9 Training

3.9.1 All training shall be by the control system supplier and shall utilize specified manuals and as-built documentation.

3.9.2 Operator training shall include two twelve-hour sessions encompassing:

3.9.3 Sequence of Operation review

3.9.4 Use of all specified MMI functions

3.9.5 One training session shall be conducted at system completion, and the other shall be conducted forty five days after system completion.

3.10 Spare Parts

3.10.1 Include the following spare parts with the contract to be handed over to the employer at the end of the construction period:

3.10.2 5% spares of all relays.

3.10.3 5% spares of all switches

3.10.4 5% spares of light sensors

3.11 Warranty

3.11.1 All components, system software, parts and assemblies supplied shall be guaranteed against defects in materials and workmanship for one year from date of commissioning and final acceptance of the project.

3.11.2 Labour to troubleshoot, repair, reprogram, or replace system components shall be furnished by the contractor at no charge to the owner during the warranty period.

3.11.3 All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.

End of Section .

UNINTERRUPTED POWER SUPPLY (UPS)

PART 1 GENERAL

1.1 General Instructions

1.1.1 Works under this section shall be governed by conditions of contract.

1.2 Scope

1.2.1 The Contractor shall supply, install, connect, commission and test the Uninterrupted Power Supply systems including but not limited to UPS unit, long life Sealed Lead Acid batteries, battery racks, battery charger, static bypass switch, terminal tapping, isolation transformer, circuit breakers, etc. complete as herein specified.

1.3 Codes and Standards

Design & manufacture	: ISO 9001, ISO 14001, IEC 60146
Construction and safety	: IEC 60950, EN 50091-1, IEC 62040-1
Protection	: IEC 60521
EMC	: IEC 62040-2, EN 50091-2 level B
Certification	: TUV, CE
Performance and topologies	: IEC 62040-3, EN 50091-3

1.4 Approved Manufacturers

1.4.1 For uninterrupted power supply system, Refer to approval Electrical manufacture list at the end of Electrical specification.

1.4.2 For sealed Lead Acid Maintenance Free Batteries, Refer to approval Electrical manufacture list at the end of Electrical specification.

1.5 System Operation

1.5.1 The UPS shall be designed to operate as an on-line double conversion system in the following modes:

1.5.1.1 Normal

1.5.1.2 The UPS shall deliver power to critical loads without interruption. The rectifier/charger shall draw alternating current (AC) from the mains and shall convert it into direct current (DC) for the inverter. The inverter shall convert it back into clean AC current for the load. The rectifier/charger shall also charge the battery.

1.5.2 Mains Power failure

1.5.2.1 In the event of a mains failure, the critical loads shall be supported by the inverter with power from the battery.

1.5.3 Recharge Cycle

- 1.5.3.1 When mains power has been re-instated, the rectifier/charger gains shall support the load via the inverter and shall recharge the battery.
- 1.5.4 Static bypass mode
- 1.5.4.1 The static switch shall transfer the load to the bypass line without interrupting power to the critical loads. If the inverter needs to be shut down the loads shall be transferred back to the inverter by turning the inverter on.
- 1.5.5 Maintenance bypass/ Test mode
- 1.5.5.1 A manual bypass switch shall be used to isolate the charger/rectifier inverter output and the static bypass for maintenance purposes. Isolation shall be achieved without load interruption.
- 1.5.6 Eco Mode
- 1.5.6.1 Under normal conditions, the load shall be supplied by Mains 2 via the static bypass. If the mains goes out of tolerance, the load shall be automatically transferred to the inverter.

1.6 Electrical Characteristics

- | | | | |
|--------|--|---|---|
| 1.6.1 | Power rating | : | Refer to relevant drawings and Schematics. |
| 1.6.2 | Active power | : | Refer to relevant drawings and Schematics. |
| 1.6.3 | Normal AC input | : | 400V $\pm 10\%$ (adjustable $\pm 15\%$) |
| 1.6.4 | Frequency | : | 50 Hz $\pm 10\%$ |
| 1.6.5 | Current Distortion
are not acceptable | : | THDI <4% with THM active filter.LC passive filters |
| 1.6.6 | Power factor | : | upto 0.95 with THM active filter |
| 1.6.7 | Bypass AC input | : | 400V $\pm 10\%$ three phase + neutral |
| 1.6.8 | Frequency | : | 50 Hz $\pm 1\%$ |
| 1.6.9 | UPS Output | : | 400 V $\pm 1\%$ three phase + neutral |
| 1.6.10 | Frequency | : | 50 Hz $\pm 0.05\text{Hz}$ |
| 1.6.11 | Voltage distortion | : | <1.5% ph/ph, <2% ph/N for linear loads
<2% ph/ph, <3% ph/N for non-linear loads |
| 1.6.12 | Transient Response | : | +/- 2% for 0 to 100% & 100 to 0% load steps |
| 1.6.13 | Permissible overload | : | 150% for one minute and 125% for ten minutes |
| 1.6.14 | Parallel Operation | : | For redundancy or power upgradation facility
should be available to parallel 4 units with
a common bypass switch/breaker. |

1.6.15	Battery back up	:	Refer to relevant BOQ and Schematics.
1.6.16	Battery type	:	Sealed lead acid maintenance free, 10 year life
1.6.17	Efficiency		
1.6.17.1	Double conversion mode	:	upto 93.5%
1.6.17.1	Eco Mode	:	upto 97%
1.6.18	Noise level	:	65dBA
1.6.19	Storage temperature :		
1.6.19.1	UPSs with batteries	:	-25°C +45°C dry heat
1.6.19.2.	Operating temperature	:	0°C to +35°C
1.6.19.3	Humidity	:	95% without condensation at ambient temperature.

1.7 Degree of Protection

1.7.1 The degree of protection of UPS cubicles shall be IP20 or higher.

1.8 Other Features

1.8.1	Cold start	:	This function shall make it possible to start the UPS even when Mains 1 is absent. The power shall be supplied by the battery for a period determined by the battery charge level and the power required by the load. However, the battery discharge time can never exceed three times the rated back up time plus two hours.
1.8.2	Media contacts board	:	This board shall provide 12 isolated relay contacts (250V, 1A) that may be used to activate indicating lights or buzzers to inform the user of the operation status of the UPS and the battery.
1.8.3	Event Log	:	This display PC board shall store up to 400 events (alarms, UPS status information, etc.) It shall also provide statistical information on a number of UPS parameters (battery back up time, number of transfers to battery power, number of transfers to the static bypass, current limiting, operating time on the inverter and on Mains 2). This information may be accessed locally on the standard display or on a remote terminal via the JBUS protocol.
1.8.4	Solution Pac Software	:	Shall be installed on computer-network management platforms & shall be used to manage electrical power for an entire company: <ul style="list-style-type: none"> - UPS programming - display of mains voltage and frequency - display of the battery status, charge level and remaining back up time - logging of events occurring on the mains supply, etc

In the event of incidents on the mains supply, it shall be possible to program the system to send warning messages to a pager or a PC via electronic mail.

1.9 Transfer Tests

- 1.9.1 With a nominated test load connected to the UPS output stage, monitor the output voltage and frequency, utilising transient recording instrument, while carrying out the following sequence of tests. The necessary load basics for conducting following tests shall be arranged by the Sub Contractor.
 - 1.9.1.1 Automatic transfer of the load to and from the bypass circuit, should be via, isolation transformer.
 - 1.9.1.2 Manually transfer the load to and from the bypass circuit..
 - 1.9.1.3 For multi-module system, bring each module line. Check each module shows the load.
 - 1.9.1.4 With an appropriate load connected, remove the modules off-line one at a time until system 'overload' is indicated and the load transfers to bypass.
 - 1.9.1.5 With an appropriate load connected to the UPS output stage, verify that the load transfers to bypass when a system undervoltage is simulated.
 - 1.9.1.6 Simulate a 'transfer to UPS' failure and verify that the appropriate indicator lamp is illuminated.

1.10 Commissioning

- 1.10.1 Verify correct voltages and phase rotation at the supply point.
- 1.10.2 Verify correct voltages and phase rotation at input of rectifier/charger.
- 1.10.3 Verify correct link voltage and waveform after the smoothing stage.
- 1.10.4 Verify DC link walk-in with the inverter stage switched on.
- 1.10.5 Check AC waveforms and inverter output voltages after smoothing stage.
- 1.10.6 Verify that the internal noise and vibration levels specified in Clause 1.7 of Section 210548 are achieved.

1.11 Warranty

- 1.11.1 The Contractor / supplier shall warrant that:
 - 1.11.1.1 The supplied equipment shall be free from defects and shall perform as to comply with these specifications and shall undertake to repair and/or replace at his own cost and expense, such items and equipment supplied by him, which are not in accordance with specifications or otherwise defective, within 15 days after a written notice from company is issued.
 - 1.11.1.2 This warranty shall be valid for twenty four (24) calendar months from the date of successful commissioning of the supplied equipment.

1.12 Testing

- 1.12.1 After completion of UPS system installation by the sub contractor, a comprehensive site testing shall be done to confirm/check the following, prior to operation. All tests shall be witnessed by Engineer/Employer's representative.
- 1.12.1.1 All system components are delivered to site undamaged.
- 1.12.1.2 The system is complete with all components as specified and described in the schedules.
- 1.12.1.3 Installation of system is carried out in compliance with the specifications and the drawings.
- 1.12.1.4 The system performs in accordance with the specifications both in normal and standby power supply conditions.
- 1.12.1.5 Check tightness of all internal power connections including batteries.
- 1.12.1.6 Check correct operation and sealing of doors and covers.
- 1.12.1.7 Check all clearances between live parts and enclosure metal works.
- 1.12.1.8 Check the proper operation and ambient conditions of the Local air conditioning system.

PART 2 PRODUCTS

2.1 Rectifier/Charger

- 2.1.1 A solid state rectifier, fully microprocessor controlled, shall convert the AC power from the mains into regulated DC power. A temperature sensor shall be used to control temperature compensation. The power shall be filtered to supply the inverter and charge the battery. The rectifier/charger shall be sized to support the inverter at full rated load and simultaneously charge the battery to 95% of its full capacity over a period equal to ten times the battery back up duration. The rectifier/charger shall be of modular construction to facilitate maintenance.

2.2 Input Anti Harmonic Active THM Filter & Protection

- 2.2.1 The input of the rectifier/charger shall be protected by fuses.
- 2.2.2 Input current shall be limited to 125% for the nominal input current.
- 2.2.3 Stand alone active filter of appropriate rating to be installed in shut configuration in the input of the UPS to reduce the input current harmonics to less than 4% at full load and improve the input power factor to 0.95. The active filter will employ latest state of the art DSP processors and a LCD display for operator interface. Offered Active Filters should comply to the Specifications attached for Active Filters.

2.3 Battery Bank

- 2.3.1 The battery shall provide backup time for full load as indicated in BOQ.

2.4 Inverter

2.4.1 Operation:

2.4.1.1 The inverter shall be made of three inverter legs with IGBT transistors and pulse width modulation (PWM). The built-in output transformer shall be of the delta/zig/zag type.

2.4.2 Output voltage and frequency
400V, 50 Hz

2.4.3 Thermal overloads

2.4.3.1 The inverter overload capability shall depend on the current drawn, in order protect various components from excessive temperature rise.

- 2 hours from 1.05 In to 1.1 In
- 30 mins from 1.1 to 1.15 In
- 10 mins from 1.15 In to 1.25 In (For p.f. =0.8)
- 3 mins from 1.25 In to 1.35 In
- 1 min from 1.35 In to 1.65 In

2.4.4 Steady state regulation

2.4.4.1 $\pm 1\%$ voltage for the RMS values of the phase to neutral and phase to phase voltages.

2.4.5 Synchronization range

2.4.5.1 From 0.25 - 2 Hz in 0.25 Hz steps . May be personalised.

2.4.6 Transient conditions

2.4.6.1 Operation with battery power : $\pm 2\%$ for 100% load steps
2.4.6.2 Operation without battery power $+2\%/-4\%$ for 100% load
2.4.6.3 Return to the $\pm 1\%$ voltage range in less than 20 ms.

2.4.7 Non-linear loads

2.4.7.1 All phase conductors shall be sized for the rated current.
2.4.7.2 The neutral conductor shall be sized for 1.5 times the rated current.
2.4.7.3 Load Crest factor upto 3
2.4.7.4 Output voltage (ph-ph) distortion=2% maximum
2.4.7.5 Output voltage (ph-N) distortion=3% maximum

2.4.8 Mains 2 (AC input to bypass)

2.4.8.1 Mains 2 tolerances/transfer conditions

2.4.8.1.1 The inverter shall transfer the load to the mains 2 supply without interruption provided the following conditions prevail :

- voltage within the $U_n - 10\%$ to $U_n + 10\%$

- frequency within the personalized tolerance range
- phase shift between inverter and Mains 2 voltages less than 3 degrees

2.4.8.2 Overload capability of the static switch :

2.4.8.2.1 Thermal overloads : 1.25 In : for 10 mins > 1.35 In for 1 min

2.5 Maintenance Bypass

2.5.1 On -line single UPS units, parallel redundant UPSs or UPSs in Eco mode shall be equipped with a maintenance bypass which may be used to transfer the load directly to Mains 2 . This is carried out using three switches. Step by step help shall be provided on the front panel of the UPS when the doors are open. Prior to transferring the load to the maintenance bypass the inverter must be shut down.

2.5.2 In parallel UPS configurations for capacity, the isolation switches shall be located in the external bypass panel.

2.6 Static Bypass

2.6.1 The static bypass shall be sized for continuous operation under the following conditions :

2.6.1.1 Transfer without interruption of power to the load

2.6.1.2 The static bypass must enable automatic transfer to the Mains 2 supply without interruption of power to the load, following detection by the control electronics of one of the following conditions:

- load on inverter greater than the rated output
- battery discharged to the end of its back up time, Mains 2 within tolerances.
- inverter malfunction.

2.6.2 Manual transfer:

2.6.2.1 It is possible to carry out a manual transfer from the UPS control panel.

Overloads:

2.6.2.2 The static switch has the following overload characteristics :

- >135% of rated inverter output can be sustained for 1 minute
- 125% of rated inverter output can be sustained for 10 mins.

2.6.3 Microprocessor based control functions

2.6.3.1 The UPS controls circuits shall be microprocessor based. All operations and parameters shall be managed by internal software thus eliminating the need for manual settings and potentiometers. Self-test and diagnostics circuits shall be used to detect and isolate a fault, right down to the PC-board itself or the connections. All individual circuits on the PC-board and all connections can be checked.

2.7 Control and Indication Panel

- 2.7.1 The UPS shall be equipped with a control panel comprising system-status indications that may be used to control, monitor and display various system functions and parameters. The graphic display may be set to display data in English, French, etc.

2.8 Monitoring System Parameters

2.8.1 Parameters displayed (RMS)

- input voltage (phase-to-phase;
- input current per phase;
- bypass input voltage (phase to phase & phase to neutral);
- bypass input frequency;
- inverter output voltage (phase to phase & phase to neutral);
- inverter output current per phase;
- input, output current & bypass frequency;
- percentage load at the inverter output;
- inverter output power factor
- inverter output in kVA and kW;
- DC voltage
- load crest factor.
- battery current (charge/discharge);
- battery back up time and remaining service life;
- temperature in the battery cubicle

2.9 Mimic Panel

2.9.1 Five LEDs shall indicate the status of the following elements:

- rectifier/charger
- battery;
- static switch
- inverter
- load

2.10 Buzzer Reset Button

- 2.10.1 This button shall be used to stop the buzzer. However, a new malfunction will activate the buzzer again.

2.11 Full Shutdown/Emergency Power Off

- 2.11.1 Full shutdown or emergency power off button shall be provided to activate the following :

- 2.11.1.1 Shutdown of the inverter
- 2.11.1.2 Opening of the static switch on the bypass
- 2.11.1.3 Opening of the battery circuit breaker;
- 2.11.1.4 Opening of an isolated relay contact on the Media contacts board

2.11.2 It shall be possible to activate the "full shutdown" function externally via a relay contact.

2.12 Spare Parts

2.12.1 The Contractor shall furnish lists of recommended spare parts by the manufacturer for 3 years (over and above the one year defect liability period) duly priced with his Tender.

2.12.2 The Employer/Engineer reserves the right to accept or reject the same either in full or in part and the contractor shall supply the spare parts as per the final approved list, at the time of handing over/ taking over of the Project.

2.12.3 Spare parts shall be packed in suitable containers or boxes bearing labels, clearly designating the contents and the particular of equipment for which they are intended.

2.12.4 The Contractor shall properly store and protect the spare parts until the completion of the works and deliver the same to the Employer's stores.

2.13 UPS System Schedules (To be filled by the Tenderer)

2.13.1 Schedule No. 1 UPS System Reference:

	Normal Operation	Standby Operation	Remarks
Supply Authority	MEW	Battery	
Number of phases	3	3	
Phase sequence	RYB	RYB	
Line voltage	400 V	400 V	
Phase voltage	230 V	230 V	
Frequency	50 Hz	50 Hz	
Voltage tolerances	± 10%	± 10%	
Frequency tolerances	± 1%	± 1%	
Total Harmonic Distortion (THD) in voltage	± 45%	± 45%	
Supply neutral arrangement	TNC-S	TNC-S	
3 Phase symmetrical short circuit level at UPS input	32 KA	----- KA	

2.13.2 Schedule No. 2 (Electrical Requirements)

1	Load Description I) No. of phases ii) KVA rating iii) Power factor iv) Crest factor v) Max. load step/surge current duration vi) Operation	3 ---- KVA Not less than 0.9 ----- :1 ---- amps for ----- sec. Parallel operation
2.	Nominal voltage	----- V, ----- phase
3.	Voltage phase balance at stated Load	----- % in accordance with IEC 146: part 4.
4	Nominal frequency	50 Hz.
5.	Load current THD levels	4.5%
6.	Battery autonomy period	30 minutes
7.	Type of batteries	Sealed Lead Acid, long life (10 year min.)
8.	Output Voltage	---- V, ----- phase
9.	Output Frequency	50 Hz \pm 0.5%
10.	Operating temperature	- 5° C to 35° C
11	Noise Level	Less than or equal to 65 dBA (ISO 3746)

2.13.3 Schedule No. 3

Instrumentation for each UPS System

2.13.3.1 Input supply

1. AC voltmeter with 7 position selector switch (Ph-Ph, Ph-neutral selector and off selection) :
2. AC ammeter - 3 Nos.(one for each phase) :
3. Frequency meter :
4. Kilowatt meter (indicating total power) :
5. Battery voltmeter :
6. Battery ammeter (for charge/discharge indication) :

2.13.3.2 Output Supply

1. AC voltmeter with 7 position selector switch (Ph-Ph, Ph-neutral selector and off selection) :
2. AC ammeter - 3 Nos.(one for each phase) :
3. Frequency meter :
4. Kilowatt meter (indicating total power) :

PART 3 EXECUTION

(NOT USED)

End of Section.

GENERATOR ASSEMBLIES

PART 1 GENERAL

1.1 General Instructions

Works under this section shall be governed by Conditions of Contract.

1.2 Scope

- 1.2.1 The Contractor shall supply, install, connect and commission standby diesel generating set with all necessary switchgears, Engine control panels and protective devices, ,and all necessary accessories for supply of electric power to emergency services indicated on the drawings and/or as described in these specifications.
- 1.2.2 The supply, installation, connection, commissioning and testing of the generator sets shall be in accordance with BS 5514, BS 4999 and BS 5000, the IEE wiring regulations and the associated drawings.
- 1.2.3 The design and installation shall include air inlet and outlet attenuation, louvers, filters, and accousting linings for generator room, as required, to provide a satisfactory generator installation.
- 1.2.4 All equipment supplied under this scope shall be new and shall have, in addition to normal manufacturers' warranty, an assurance of continued availability of spare parts for minimum period of 10 years.
- 1.2.5 The manufacturer of the generator set shall be of international repute.

1.3 Alternative Offer

- 1.3.1 If the contractor has some reservations as to the successful operation of the equipment by following the drawings and/or specifications, an alternate bid shall be submitted together with the requested bid highlighting such changes and justifying the reasons thereof, as may be necessary for successful operation of the plant.
- 1.3.2 The general arrangement shown on the drawings and/or as described in the specifications shall be substantially maintained.
- 1.3.3 The absence of any such alternative bid, shall qualify the bidder's acceptance of the drawings and or specifications.
- 1.3.3.1 It shall be assumed that by submission of the bid, the contractor shall accept the responsibility for the successful operation of the equipment and its various parts.

1.4 Applicable Standards

General Requirements for Rotating Electrical Machines	:	BS 4999.
Reciprocating Internal Combustion Engines Performance	:	BS 5514.
Fuel Oil Consumption	:	BS 5514 Part 1:1987.
Speed Governing	:	BS 5514 Part 4:1984.
Torsional Vibrations	:	BS 5514 Part 5:1984.
Overspeed Protection	:	BS 5514 Part 6 :1992.
Fuel Oils for Non Marine Use	:	BS 2869.
Code of Practice for Safety of Machinery	:	BS 5304.
Radio Frequency Interference suppression	:	BSEN 55014 and BS 1597.

PART 2 PRODUCTS

2.1 Equipment

The equipment shall include but not be limited to the items described in these specifications.

The design of the sets shall permit the easy replacement of all items subject to wear.

Electrical equipment included in the emergency plant installation shall comply with the relevant clauses of these specifications, unless otherwise indicated.

2.1.1 Engine

- A. The engine shall be diesel, water cooled multi-cylinder unit constructed to BS 5514 or ISO 3046. All auxiliaries necessary for operation, including turbo charging and charge air cooling equipment shall be supplied as applicable.
- B. The rating of the engine shall be capable of continuous operation as defined in BS 5514. The rating shall include both full and 110% full load for 1 hour operation.
- C. Fuel injection shall be enclosed in-line direct fuel injection type with diaphragm type fuel lift pumps. Full flow filters with replaceable elements shall be fitted and 24V fuel solenoid shall be provided.
- D. The engine shall be suitable for operation by using fuel oil to BS 2869, DIN 51 601 or as recommended by the manufacturer.
- E. The construction of the engine shall facilitate on site maintenance and repairs including access to and removal of pistons and connecting rods. The engine and A.C. generator shall be mounted on a common, rigid bed plate supported on spring type antivibration mountings Means for lifting and moving the set into position shall be provided.

- F. The engine speed governing system shall be in accordance with BS 5514: part 4 to meet the specified values of tolerances. Means for manual adjustments of engine speed in a range of ± 5 percent from the rated speed under all specified load conditions shall be provided at the control panel.
- G. An engine over speed protection device shall be provided in accordance with BS 5514: part 6 (ISO 4046/6).
- H. The engine lubrication system shall include a large capacity oil sump within the baseplate of the plant. The sump shall be fitted with gear type oil pump with full flow or filters on the suction and delivery sides. A bypass pressure relief valve shall be fitted in the pump delivery. Drip trays shall be fitted to collect any spillage of oil and collecting drained oil.
- I. The lubrication system shall provide a continuous, automatic lubrication to all moving parts (without any manual intervention). The system shall also include oil cooler, crankcase breather pipe, manual lubrication facility for priming, sump drain pipe to facilitate oil drainage from the side of the skid and a dipstick.
- J. The engine coolant shall be circulated by a gear driven centrifugal pump mounted on the engine. A thermostatically controlled valve shall be provided in the cooling system to assist rapid heating of water temperature during the starting of the engine and to provide temperature control when engine is running.
- K. An electric immersion heater connected to mains supply shall be fitted to maintain the engine jacket water temperature to assist quick starting of the engine in cold environment i.e. when the ambient temperature is below 100C. The cooling system shall be closed loop type with set mounted or remote radiator with integral fan. The radiator fan shall be either directly driven from the engine or driven by an electric motor connected to generator electrical supply. The radiator fan shall be sized to accommodate the pressure drops in duct works, louvers and attenuators used in the installation of the emergency plant.
- L. The cooling system shall include all pipe works, valves, sensors, heaters, etc, to provide satisfactory operation of the diesel generator set under the specified loading and ambient conditions.
- M. Care must be taken to see that the surface to which the generator is bolted is aligned in all direction so as to avoid bearing trouble.
- N. Engine mounted radiators shall be connected to radiator exhaust louvers, by means of a fire retardant flexible cowl connection as necessary and as applicable.

2.1.2 Starting System

- a. The engine starting system shall be capable of starting and running the engine at rated cranking speed required for satisfactory ignition.
- b. Engine shall be started by means of battery operated starter motors, mounted on the engine flywheel housing.

- c. Where two starter motors are used for starting, each motor shall be capable of providing the required starting duty at the lowest specified ambient temperature.
- d. The starter motors shall be disengaged from the engine, when the engine fires or when the starting sequence is de-energized.
- e. Starter batteries shall be sealed maintenance free, lead acid type and shall have a capacity required for the above starting operation and to initiate three starting cycles.
- f. Batteries shall be located close to the engine with the leads between the batteries and the engine duly protected against physical damage.
- g. The batteries shall be easily accessible for maintenance and inspection.
- h. Constant voltage type battery charger with monitoring instrumentation shall be provided for charging the starter batteries. The battery charger shall be automatically disconnected during the engine starting.

2.1.3 Alternator

- A. The alternator shall be brushless, salient pole and with revolving field and self regulating alternator.
- B. The alternator shall be continuously rated in accordance with BS 5000: part 99, and shall be capable of providing 110% output for 1 hour in any 12 hour duty period.
- C. The generator shall be self cooled by means of an integral shaft mounted fan over the ambient air temperature range specified.
- D. Contractor should take care that the air entering the alternator is not preheated by passing over any hot body such as the engine or its exhaust system.
- E. The alternator shall be of fabricated steel construction with ball and roller bearing, dynamically balanced and with rotating field salient pole construction with heavy damper windings.
- F. The machine shall have an A.C exciter and liberally rated silicon diode assembly with a built-in excitation system and automatic voltage regulator (AVR). It shall be screen protected, drip proof and with a large terminal box.
- G. Positive voltage build up shall be ensured by the permanent magnets in the exciter field.
- H. Constant output voltage control shall be achieved by a transistorised voltage regulator which adjusts the exciter field current to compensate for all normal variations.
- I. AVR components shall be contained within an enclosure mounted on the alternator. The enclosure shall be isolated from any vibration forces transmitted from the generator.

- J. Insulation to windings of the alternator shall be rated Class H as a minimum standard. All windings shall be fully impregnated for tropical climates, with high quality oil resistant varnish.
- K. Radio interference suppression of the alternator/regulator shall comply with the requirements of BSEN 55014 and BS 1597.
- L. The voltage regulation limits shall be within $\pm \frac{1}{2}$ percent under all conditions of load, power factor and temperature variations from cold to hot.
- M. Voltage drift shall be negligible. Total harmonic content in the line voltage waveform shall be in the range of 3 percent

2.1.4 Generator Set Mounting

- A. The generator set shall be vibration isolated from structure on spring type anti vibration mountings. There shall be no rigid connections between the generator set and the structure.
- B. The spring type vibration isolators shall preferably be constructed from suitably treated and finished steel or steel alloys. They shall be equipped with rubber, neoprene or glass fibre acoustic pads to prevent transmission of high frequencies.
- C. Spring type isolators shall have auxiliary dampers or adjustable snubber type restraints to prevent excessive movements as the machine speed passes through resonant frequency of the mounting system.

2.1.5 Coupling System

- A. The coupling system shall be of unit construction which forms the engine and generator into one unit of exceptional strength and ensures perfect alignment.
- B. The alternator end shield and the engine flywheel housing faces shall be fully machined with spigots concentric to their shafts.
- C. The machined flanges mounted on the alternator shall be connected to the flywheel housing flange by steel bolts.
- D. A flexible rubber block coupling shall be fitted between the engine and alternator to provide the drive and absorb the transmission of shock loads. The torsional flexibility shall be designed to match the torsional characteristics of the system to prevent resonant conditions.

2.1.6 Engine Control Panel and Protective Devices

- a. The engine control panel should be environmentally sealed, Solid state micro processor-based modules for engine control, A/C metering and shall include an oil pressure gauge, coolant temperature gauge, battery charge rate ammeter, run/stop/ remote selector switch, level gauges for the bulk fuel tank and engine monitoring system.

- b. The panel shall incorporate all receiving auxiliary contacts for connections of wiring to a remote start/stop control and a remote annunciator panel as described hereinafter.
- c. The control shall be mounted on the generator set.
- d. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.
- e. The control shall be UL508 listed, CSA282-M1989 certified, and meet IEC8528 part 4.
- f. All switches, lamps and meters shall be oil-tight and dust-tight, and the enclosure door shall be gasketed.
- g. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.
- h. The controls shall meet or exceed the requirements of Mil-Std 461C part 9, and IEC Std 801.2, 801.3., and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
- i. The entire control shall be tested and meet the requirements of IEEE587 for voltage surge resistance.
- j. The generator set mounted control shall include the following features and functions:
 - i. Three position control switch labeled RUN/OFF/AUTO.
 - ii. In the RUN position the generator set shall start, and accelerate to rated speed and voltage.
 - iii. In the OFF position the generator set shall immediately stop, bypassing all time delays.
 - iv. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

- v. Red “mushroom-head” push-button EMERGENCY STOP switch.
- vi. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.
- vii. Push-button RESET switch.
- viii. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
- ix. Push-button PANEL LAMP switch.
- x. Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power.
 - 1. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
- xi. Generator Set AC Output Metering:
- xii. The generator set shall be provided with a metering set including the following features and functions:
- xiii. 2.5-inch, 90 degree scale analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter.
- xiv. These meters shall be provided with a phase select switch and an indicating lamp for upper and lower scale on the meters.
- xv. Ammeter and KW meter scales shall be color coded in the following fashion: readings from 0-90% of generator set standby rating: green; readings from 90-100% of standby rating: amber; readings in excess of 100%: red.
- xvi. Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor.
- xvii. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.

2.1.7 Engine monitoring system

- A. Engine monitoring system shall be provided with individual fault lamps/Display for alarms & shutdown listed below.
- B. A lamp test switch shall be provided to indicate status of various indicating lamps.
- C. The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing alarm and shutdown conditions.
- D. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions.
- E. The generator set control shall indicate the existence of the following alarm and shutdown conditions on a digital display panel:
 - low oil pressure (alarm)
 - low oil pressure (shutdown)
 - oil pressure sender failure (alarm)
 - low coolant temperature (alarm)
 - high coolant temperature (alarm)
 - high coolant temperature (shutdown)
 - engine temperature sender failure (alarm)
 - low coolant level (alarm or shutdown—selectable)
 - fail to crank (shutdown)
 - overcrank (shutdown)
 - overspeed (shutdown)
 - low DC voltage (alarm)
 - high DC voltage (alarm)
 - weak battery (alarm)
 - high AC voltage (shutdown)
 - low AC voltage (shutdown)
 - under frequency (shutdown)
 - over current (warning)
 - over current (shutdown)
 - short circuit (shutdown)
 - over load (alarm)
 - emergency stop (shutdown)
- F. Provisions shall be made for indication of two customer-specified alarm or shutdown conditions.
- G. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions.

- H. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.
- I. The generating set shall include a complete engine start/stop control to start the engine on closing the relevant contact and to stop the engine on opening the contact. A cranking limiter shall be provided to open the starting circuit in approximately 45 to 90 sec if the engine is not started within that time.

2.1.8 Engine Status Monitoring:

- A. The following information shall be available from a digital status panel on the generator set control:
 - engine oil pressure (psi or kPA)
 - engine coolant temperature (degrees F or C) Both left and right bank temperature shall be indicated on V-block engines.
 - engine oil temperature (degrees F or C)
 - engine speed (rpm)
 - exhaust temperature (optional)
 - number of hours of operation (hours)
 - number of start attempts
 - battery voltage (DC volts)
- B. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

2.1.9 Exhaust System

- A. Exhaust system shall include a residential silencer including flexible exhaust fitting, properly sized and installed according to the manufacturer's recommendation.
- B. Silencer shall be mounted so that its weight is not supported by the engine.
- C. Exhaust pipe shall have sufficient size to ensure that exhaust back pressure does not exceed the maximum limitations specified by the generator set manufacturer.
- D. The muffler and indoor exhaust piping shall be lagged to maintain a surface temperature not to exceed 650C.
- E. The insulation shall be installed so that it does not interfere with the functioning of the flexible exhaust fittings.
- F. Flexible gastight connection pieces shall be provided in the exhaust pipe line to allow for thermal expansion and to prevent vibration being transmitted from the engine.

- G. A clearance hole shall be allowed where exhaust pipe passes through to avoid overheating of the surrounding wall.

2.1.10 Base Frame Construction

- A. The combined engine-generator unit shall be bolted to a separate sub-frame which will be attached to a main frame through RESILIENT MOUNTINGS so providing complete protection from engine vibration for the control gear, radiator and other set mounted components. Mountings under the set will not be considered.
- B. The generator shall be mounted on spring type restrained vibration isolators having a static deflection of 50 mm under load conditions.
- C. Air inlet and exhaust attenuators shall be fitted in builders work to reduce the transmitted noise to specified levels. The generator room shall have appropriate acoustic treatments having a minimum sound transmission loss of 45dB STG.
- D. Base frame shall have four lifting points.

2.1.11 Daily Fuel Tank and Fuel Lift Pump

- A. A daily fuel tank with sufficient fuel capacity for at least 8 hours duty on full load shall be provided, in a suitable location in the room. A dial type fuel gauge, fuel filter inlet and outlet connections, drain plug and all feed and return fuel pipe shall be fitted to the tank complete with hose for filling purposes.
- B. An electrical or manual fuel lift pump shall be supplied and installed near the daily fuel tank to lift fuel automatically or manually from the bulk storage tank (if available) to the daily storage tank. Necessary float switches to operate lift pump shall be provided.

2.2 Automatic Transfer Switch (ATS) System

2.2.1 General

- A. The Contractor shall supply, install and connect automatic transfer and bypass isolation switch(es) system with number of poles, rating, voltage and withstand ratings as shown on the drawings and as herein specified.
- B. The system shall be the product of one manufacturer and shall consists of an automatic transfer switch and a two way by-pass isolation switch.
- C. The neutral conductors shall be switched in the automatic transfer switch (ATS) The automatic transfer switch shall be provided with fully-rated overlapping neutral transfer contacts.
- D. The neutrals of the normal and emergency power sources shall be connected together only during the transfer and retransfer operation and remain connected together until power source contacts close on the source to which transfer or retransfer is being made. The overlapping neutral transfer contacts shall not overlap for a time duration greater than 100 milli seconds.
- E. The automatic transfer switch shall be housed in an enclosure having a minimum ingress protection of IP42.

2.2.2 Mechanically held transfer switch

- A. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a single-solenoid mechanism, momentarily energized to minimize power consumption and heat generation.
- B. The switch shall be positively locked and unaffected by voltage variations or momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life. The switch shall be mechanically interlocked to ensure only one of two possible positions - Normal or Emergency.
- C. All main contacts shall be of silver composition.
- D. ATS utilizing components of moulded case circuit breakers or contactors could be considered with price justification and to the approval of Local Power Authorities and acceptance of Engineer.
- E. The inspection of all contacts, linkages and moving parts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at any point throughout the entire travel to properly inspect and service the contacts when required.

2.2.3 By-pass - Isolation Switch

- A. The isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from both source and load power conductors. All main contacts shall be manually driven.
- B. Power interconnections shall be silver-plated copper busbar. Separate bypass and isolation handles shall be utilized to provide clear distinction between the two functions.
- C. The by-pass handle shall provide three operating modes; by pass to normal, automatic and by pass to emergency.
- D. When the by-pass switch is at the automatic mode the by pass contacts shall be all open so they will not be subjected to fault currents.
- E. The isolation handle shall provide three operating modes; closed, test and open.
- F. The test mode shall permit testing of the entire emergency power system including the automatic transfer switch without any interruption to the load.
- G. The open mode shall completely isolate the automatic transfer switch from all source and load power conductors.
- H. When the isolation switch is in the test or open mode, the bypass switch shall function as a manual transfer switch allowing transfer and retransfer of the load between the two available sources without the feedback of load regenerated voltage to the transfer switch.
- I. Transfer and retransfer operation shall comply with paragraph 42.7 of UL1008.

2.2.4 Microprocessor control module

- A. The control module shall direct the operation of the transfer switch. The module's sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance and inherent digital communications capability.
- B. The control module shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the control module to be disconnected from the transfer switch for routine maintenance.
- C. The control module shall be completely enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance.
- D. Sensing and control logic shall be provided on plug-in printed circuit boards for maximum reliability. Interfacing relays shall be industrial control grade plug-in type with dust covers.
- E. All relays shall be identical to minimize the number of unique parts.
- F. The control panel shall meet or exceed the voltage surge withstand capacity in accordance with IEEE relevant standards, and the impulse withstand voltage test in accordance with the proposed NEMA standard ICS 1-109.

2.2.5 Operation of the Set

- A. The diesel generating set shall be used as "Mains failure" set with automatic start up after a pre-set time during a power failure. Start-up signal for the generator shall be initiated in the event of;
- B. Complete main failure in one or all phases of main supply.
- C. Drop or increase in main voltage (adjustable from $\pm 2.5\%$ to $\pm 10\%$).
- D. Unbalance in main phase voltage of $\pm 2.5\%$.
- E. The generator set shall be capable of supplying various emergency and essential electric loads as a single unit.
- F. The generator set shall be suitable for operation under local climatic conditions, as specified.
- G. The emergency generating set shall be designed so that it can take a sudden load of its rated output and stabilize its speed and voltage in less than 5 seconds. It shall be capable of carrying full load within 2 minutes after having been first loaded.
- H. Should the engine fail to start in 25 seconds following a power interruption, the emergency plant shall come to rest for 10 seconds. Two further attempts shall be automatically performed with intermediate period of rest.
- I. It shall be possible to operate the generator set manually for testing and normal operation purposes.
- J. After the restoration of normal power to above 90% of its rated value for an adjustable period of time (setting 2 to 60 minutes) the change over switch shall automatically revert to its normal operation. The emergency plant shall stop only after a cool down time (setting for 1 to 30 minutes).
- K. Control modules shall be single phase for single phase power sources and three phase for three phase power sources. A selector switch shall be included in the three phase control modules to enable temporary operation on single phase power sources.
- L. The voltage of each phase of the normal source shall be monitored, with pick-up adjustable from 85 to 100% and drop out adjustable from 75 to 98% of pick-up setting both in increments of 1%, and shall be fully field-adjustable without the use of any tools, meters or power supplies. Repetitive accuracy of settings shall be $\pm 2\%$ or better over an operating temperature range of -20°C to $+70^{\circ}\text{C}$. Settings at factory shall be 90% for pick-up and 85% for dropout.
- M. Single phase voltage sensing of the emergency source shall be provided with a pick-up adjustable from 85 to 100% and frequency sensing with pick-up adjustable from 90 to 100%. Both voltage and frequency settings shall be fully field adjustable in 1% steps increment. Repetitive accuracy of settings shall be minimum $\pm 2\%$ at an operating temperature range of -20°C to $+70^{\circ}\text{C}$.
- N. The control module shall include four time delays that are fully field adjustable:

- O. Time delay adjustable from 0 to 6 seconds to override momentary normal source outages to delay all transfer switch and engine starting signals. Transfer to emergency time delay adjustable from 0 to 5 minutes.
- P. Retransfer to normal time delay adjustable from 0 to 30 minutes. This time delay is automatically by passed if emergency source fails and normal source is acceptable.
- Q. Unloaded running time delay for emergency engine generator cool down, adjustable from 0 to 60 minutes.
- R. 10 AMPs rated contacts, 32 V DC shall be provided for low voltage engine start signal when the normal source fails. The start signal shall prevent dry cranking of the generator by requiring the generator to reach proper output, and to run from the duration of the cool down setting regardless of whether the normal sources restores before the load is transferred.
- S. A momentary type test switch shall provided to simulate a normal source failure.
- T. Terminals for remote contacts operation shall be provided.
- U. A visual position indicator shall be provided to indicate by- pass isolation switch position.
- V. Pilot lights shall indicate availability of power sources and automatic transfer switch position.
- W. An instruction plate shall be provided.
- X. Auxiliary contracts shall be provided to signal the actual availability of the normal and emergency sources.
- Y. Operators manual shall be furnished with each ATS providing installation and operating instructions.
- Z. The Automatic transfer switch shall comply with UL 1008, NFPA70, NFPA99, NFPA110, IEEE, NEMA and IES relevant standards.
- AA. Proper factory test with a test certificate of all parameters of the ATS shall be provided prior to installation.

2.2.6 Finish

All sheet steel used shall be zinc coated for rust protection.

Sets shall be painted with an etching primer and finished with a high gloss grey paint grade 632 to BS 381C, or approved equal.

2.3 Alarm Annunciator

- A. Annunciator shall be constructed of sturdy sheet steel enclosure having a removable front panel and adapter ring.
- B. Annunciator shall be a flush mounting unit. The face of the front panel shall incorporate nine lamps, an audible alarm, a toggle switch marked NORMAL and OFF, and a lamp test push-button switch. The printed circuits internal wiring, terminal block and battery voltage sensors shall be accessible on removing the front panel.

C. Following indications, alarms and lockouts shall be included in the control panel:-

Indication Lamp Identification Label	Indication Lamp Colour	Function
- Mains available	R.Y.B	Indication
- Mains on load	Green	Indication
- Set on stand-by	Green	Indication
- Set on manual	Amber	warning lamp
-	Mains failed	Red Alarm
- Set on load	Green	Indication
- Control switch off	Red	Alarm
- Control switch manual	Amber	warning /Alarm
- Set failed to start	Red (Flashing)	Alarm/Lockout
Generator overload relay tripped	Red	Alarm
- Earth fault relay tripped	Red	Alarm/Lockout
- Circuit breaker open	Green	Indication
- Circuit breaker closed	Amber	Indication
- Circuit breaker tripped	Red	Indication
- High engine temperature	Amber	warning /Light

Additionally following indication lamp shall be provided to show the status of the generator set:-

- Low oil pressure
- Excessive coolant temperature
- Engine over speed
- Low fuel supply
- Low battery voltage
- High battery voltage
- Low jacket water temperature

Annunciator panel shall operate on DC source taken from the batteries of the generator it-self.

The indication lamps shall be twin long life LED type.

In all cases, the re-set of lock out shall be done manually. Lamps shall continue to light until the fault is reset.

Lamp test facility shall be provided to check the status of lamps.

Alarm and lockout system shall not operate during normal shut down operation.

2.4 Schedule of Requirements

SCHEDULE NO. 1

Generator set reference:

Type of generating set operation : Prime/standby

Load data

nominal voltage

nominal current

Frequency

Steady state voltage tolerance

Maximum load step change

Duration of load step change

Voltage dip

Frequency tolerance

Location of site

Altitude

Air temperature range

Relative humidity range

2.13.1.16 Concrete foundation : isolated/non-isolated.

SCHEDULE NO. 2

Engine and Alternator Details (to be filled by the Sub-Contractor).

2.5	Generator set reference	:
	Manufacturer and type No.	:
	Rated power/efficiency	:
	Rated voltage	:
	Rated current	:
	Rated frequency	:
	Power factor	:
	Overload capacity	:
	Method of engine starting	:
	Type of cooling	:
	Type of governor and Class (BS 5514:Part 4)	:
	Type of fuel	:
	Fuel consumption at full load	:
	Exhaust system details	:
	Sound annunciator details	:
	Alternator Details	:
	Degree of Protection	:
	Method of cooling	:
	Insulation class	:
	Maximum temperature rise	:
	Rated ambient temperature	:
	Method of excitation	:
	Bearing Types	:

2.6 Safety

All external electrical and mechanical connections shall be with flexible end connections to allow free movements of the diesel generator set on resilient mountings. All exposed mounting parts shall be fully guarded to prevent contact by personnel. Guards shall comply with BS 5304, and shall be removable for maintenance purposes.

A permanently fixed warning notice with 6 mm white lettering on a red background shall be fixed to the set in a prominent position.

The warning shall be as follows: "THE GENERATING SET IS UNDER AUTOMATIC CONTROL AND MAY START AT ANY TIME WITHOUT WARNING"

PART 3 EXECUTION

3.1 Generator Earthing

- A. Generator shall have its neutral solidly connected to the system earth through the transfer switch. No local system earthing means shall be used as it would create a multiple earthing of the neutral which may cause stray currents. Alternatively the Sub-Sub-Contractor may use a local earthing of the neutral if he uses an overlapping neutral transfer contact in the automatic transfer switch.
- B. Generator frame shall be connected to the equipment earthing system through a separate equipment earth conductor. Additionally a local earth electrode might be required if generator is appreciably remote from the main electrical room. Neutral and frame of generator shall not be bonded except in the case of local neutral earthing as mentioned above.
- C. The generator set earthing shall be separate from the general earthing of the building.

3.2 Quality Assurance

Manufacturers

The generating set manufacturer shall preferably be the actual manufacturer of either the alternator or the generator and shall be responsible for the assembly.

The generator set manufacturer shall have a reliable local representative of good repute, keeping adequate stocks of spare parts and providing efficient after sales services.

3.3 Tests on Site

Tests and inspection procedures shall be formulated to check the performance requirements and characteristics of the diesel generating sets.

Visual Inspection

All equipment which form part of the diesel generating plant shall be visually inspected for damage and checked against the manufacturer catalogues/drawings and schedule, for the following:-

- Type of generating set
- Serial number
- Engine details
- Alternator, exciter and AVR details
- Rated speed

- Rated voltage
- Number of phases
- Rated frequency
- Rated KVA at continuous rating
- Rated KW at continuous rating
- Rated KVA at service rating
- Rated KW at service rating
- Ancillary equipment

Preliminary Inspection Check

Preliminary inspection check shall include the following:

- Alignment of engine/alternator assembly on bed plate.
- Installation of vibration isolators

Preliminary Running Test

Preliminary running test to check the following:

- Engine start and stop control
- Engine oil pressure
- Generator voltage and frequency including phase sequence
- Control and protection devices
- Leaks in oil, water and exhaust
- Excessive vibration
- Adjustments of meters and potentiometer related to generated output parameters.

Load Tests

The set shall be run continuously for 8 hours test run at rated load followed by 110 percent of rated load for a period of one hour.

Every 15 minutes for the first hour and every hour thereafter, the following parameters shall be recorded:-

- All electrical output parameters associated with main alternator.
- Parameters of charging alternator
- Measurements of all engine parameters
- Lubricating oil consumption
- Cooling air medium flow
- Alternator cooling air inlet and outlet temperatures.

Transient Load Switching

Resistive load shall be applied and switched "ON" and "OFF" in STEPS, with the diesel generator running at rated speed and generating rated voltage.

Transient recordings of maximum, minimum and nominal voltage and frequency levels together with the response times shall be obtained.

Insulation Test

Remove all external wiring between the plant and load bank/ test panels.

Isolate sensitive electronic equipment in alternator and control panel as per manufacturers recommendation.

Open any neutral earthing links.

Using 1000V megger check the insulation resistance:-

Between the load terminals and plant structure

Between the generator terminals.

Reconnect electronic equipment and neutral earth links.

Functional Test

The operation of interlocks and interconnections with all external equipment and controls to be connected on site, shall be simulated as part of these tests.

Controls, Alarms and Protection

Local controls, alarms and shutdown functions associated with the generator set installation shall be simulated and demonstrated on site. These tests shall include, but not limited to the following:

High coolant temperature test

Overspeed test

Low oil pressure test

Overcrank test to look after failure to start the engine after five consecutive attempts.

Noise and vibration test: Shall be undertaken to ensure that the internal noise and vibration levels specified in Clause 1.7 of Section 210548 are achieved.

3.4 Product Data

- A. The Contractor shall furnish certified performance data and curves as a part of his proposal and a description of his quality control program.
- B. The Manufacturer shall ascertain that his equipment withstands the starting KW and KVA requirements of the connected load as shown on the Drawings.
- C. The Contractor shall furnish an outline drawing showing principal dimensions, space requirements, and location of connections of the equipment quoted, mainly for starting, cooling, fuel and lubricating system and ventilation requirements.

- D. The Contractor shall provide a basic tool kit, engine maintenance handbook, spare parts manual and generating set instruction handbook.
- E. The Contractor shall itemise all sight flow indications, temperature sensing devices, and pressure gauges and indications which will be furnished for local indication of critical items as recommended. If these indicators are standard with the equipment, it shall be so indicated.
- F. The Contractor shall furnish complete information, catalogues, with schematic and detailed diagrams showing all equipment furnished and shall include the control system which will describe the operation, manufacturing and type of all instruments and control items.
- G. All literature and catalogues shall be in English.

3.5 Shop Drawings

- A. The Contractor shall submit for review and acceptance the shop drawings for the Generator set including all necessary civil work details, such as trenches, concrete bases, etc., generator starting characteristics and manufacturers approval for the generator's correct selection as to connected load, derating factors, etc., wiring diagrams and description of operation.
- B. A copy of these shop drawings shall also be sent to the local power authorities for approval (if needed).
- C. Any modifications to the drawings required by the Engineer or the Local Power Authorities to allow the equipment to comply with the codes, standards and specifications called for herein shall be carried out with no extra cost.

3.6 Spare Parts

- A. The Contractor shall furnish assurance of availability of recommended spare parts for 2 years and 4 years operation (over and above the one year defect liability period achieving a total of 3 years and 5 years of extended operating maintenance) duly priced with his Tender.
- B. The Employer/Engineer reserves the right to accept or reject the same either in full or in part and the contractor shall supply the spare parts as per the final accepted list, at the time of handing over/ taking over of the Project.
- C. Spare parts shall be packed in suitable containers or boxes bearing labels, clearly designating the contents and the particular of equipment for which they are intended.
- D. The Contractor shall properly store and protect the spare parts until the completion of the works and deliver the same to the Client's stores.

3.7 Warranty

- A. The Contractor shall provide the generator supplier's warranty, warranting that the equipment supplied under this specification will be new, of best quality, free from defects in design, material, workmanship and suitable for the specified operating conditions.
- B. Any defects or inadequacies discovered in the equipment during first eighteen months from date of delivery and twelve months from the date of erection/installation of equipment, whichever shall expire first, shall be made good to the satisfaction of the Engineer at the Contractor's cost.
- C. Any equipment repaired, replaced or modified shall be subject to a defect free warranty for a further period of Twenty four months from the date of repair, replacement or modification.

End of Section.

End of electrical specifications

INTEGRATED ANALOGUE ADDRESSABLE FIRE DETECTION,

AND VOICE EVACUATION SYSTEM

PART 1 GENERAL

1.1 General Instruction

1.1.1 Works under this section shall be governed by conditions of contract. **1.2 Scope**

1.2.1 The contractor shall supply, install, test, connect and commission a high quality fast-acting electronic Analogue addressable type fire detection and alarm with truly integrated Voice Evacuation and Emergency Telephone Systems.

1.2.2 The fire detection with integrated voice alarm system shall comprise of main fire alarm control panels, optical smoke/heat sensor, heat sensor, manual call points, electronic sounders with optional pre-recorded speech facility, fire alarm mimic panels, interface units, distributed amplifiers and audio control units.

1.2.3 All the outstations like the optical/heat sensors, heat sensors, duct and beam sensors, electronic pre-recorded voice alarm speakers, sounders, manual call points, fire alarm mimic panels, spur off (tee breaker) units and distributed amplifier units shall be provided with short circuit isolators.

1.2.4 The fire alarm mimic panels, master fire alarm control panel and the graphics terminal shall be sited as shown on the drawings. All loop cabling, other components and accessories deemed necessary for a safe, reliable and satisfactory system shall be included in the system.

1.2.5 Prior to placing order for any equipment, the contractor shall submit comprehensive document comprising working drawings, catalogues and descriptive literature of components, maintenance manuals etc for engineer's study and approval.

1.2.6 The contractor shall be required to train and instruct client's personnel in the correct use, operation and supervision of the system, preferably prior to the handing over of the project.

1.2.7 The contractor shall ensure that all system components offered shall be manufactured by one manufacturer who shall also be on the local civil defence authority's list of approved manufacturers.

1.2.8 The Contractor shall be responsible for all submittals of complete design information to Local Civil Defense Authority and for obtaining all necessary approval certificates prior to the commencement of the installation and upon completion.

1.2.9 In order to ensure whole site integration capability, the fire and voice alarm system will be awarded to a single specialist manufacturer who will be responsible for the design, global operation, management and interfacing of the system.

- 1.2.10 The system shall be fully programmed to accommodate fire alarm and voice communication zones as indicated on the drawings and schematics. The system shall be configured to allow on site modifications with the minimum disruption using the PC based software to facilitate future changes or alterations to the building.

1.3 System Description

- 1.3.1 The fire detection and alarm system shall be designed to facilitate accurate identification of the source of heat / smoke / fire in their early stages to minimise occurrences of false alarms due to faulty equipment, electrical transients, system faults etc.
- 1.3.2 The fire alarm control panels shall make final decision on whether a fire or fault exists by comparing the plotted patterns from a fire sensor against known fire and fault patterns held in it's memory. System shall be true Analogue with the ability to print the output from a fire sensor over a period of time.
- 1.3.3 All system components and devices shall be connected to two-wire loop circuits with short circuit isolation means either built-in each component or group isolation. Removal or disconnection of any component from the loop shall not affect the functioning and performance of other component and the system.
- 1.3.4 System shall facilitate the latest addressing technique i.e. all the devices on the loops of the FACP shall be allocated addresses automatically from the panel at the time of system power up on a numerically lowest unused value basis (algorithms) and also given an address during commissioning, the value of which shall be stored in non-volatile memory, within the electronics module of the outstation. This value shall be read during loop allocation and provided it is valid shall be used to setup the outstations primary address.
- 1.3.4.1 The Fire Alarm System component addressing shall be such that:-
- 1.3.4.1.1 If the devices are inserted or removed all the existing devices shall keep the same address.
- 1.3.4.1.2 The panel shall allocate the address in strict sequential order when the loop is powered up to speed up commissioning. It shall be not possible for two devices to have the same address.
- 1.3.5 Facilities shall be provided to constantly monitor and check the following circuits and fault conditions:
- 1.3.5.1 the power supply to the loop /s;
- 1.3.5.2 for open-circuit, short-circuit, earth fault and any other fault condition in the loop wiring;
- 1.3.5.3 for communication failure and errors in all cards and loops;
- 1.3.5.4 for faults in keyboard and printer circuits;

- 1.3.5.5 monitoring of all devices status every 1.3 minutes to create a table of each 1 analogue channel for event analysis.
- 1.3.6 All devices i.e., Audio Control Units, Distributed Amplifier Units, Optical/Heat Sensor, Heat Sensor, Duct and Beam Sensors, Fire Alarm Interface Units, Electronic Sounders with/without optional pre-recorded speech facility, Manual Call Points, etc. shall be installed on the same loop.
- 1.3.7 All devices shall be assigned a maximum of 32 character alphanumeric label. In case of fire, fault or warning, the label of device sensing threshold shall appear on visual display unit of the panel.
- 1.3.8 Any correction in label/programming shall have to be carried out from the built-in keyboard of FACP. Use of separate PC or tools for on-site labelling/programming shall not be acceptable.
- 1.3.9 Any event i.e. Fire, fault or warning shall be recorded with time, date and place of occurrence in the memory of FACP. These events can either be displayed on VDU or printed, as required.
- 1.3.10 Provision shall be done at the fire alarm control panels to silence the loop powered alarm sounders and the speaker circuits but the visual indication shall remain until the system is reset.
- 1.3.11 It shall be possible to change the sensitivity of analogue sensors from fire alarm control panel only.
- 1.3.12 The sensitivity shall be varied automatically, if required, by time zoning feature whereby it allows sensors to be programmed to respond at different sensitivities relative to any time of day, and any day of week.
- 1.3.13 The main fire alarm control panel shall be located as shown on the schematics and the floor drawings.
- 1.3.14 There shall be a seamless software interface between the fire detection and voice alarm system.
- 1.3.15 The voice alarm system shall comprise of voice command centres (units with facility to control the audio) and distributed amplifiers as shown in the schematics.
- 1.3.16 All distributed amplifier unit components and devices shall be connected to two-wire loop circuits with each component adhering to NFPA Class A Style 7 standards of wiring. Removal or disconnection of any component from the loop or short circuits on the loop, shall not affect the functioning and performance of other components on the same loop and on the system.
- 1.3.17 Facility to introduce / change delay periods in operating speaker circuits, shall be possible to be programmed from FACP without the need to change any hardware. All the programming related to voice alarm speaker circuits shall be restricted to the FACP. Introduction of separate programming for operation of speaker circuits, into the voice command units shall not be acceptable.
- 1.3.18 The distributed amplifier rack units shall house the amplifiers and the speaker circuits shall be wired as shown in the schematics. The distributed amplifier racks shall be mounted close to the broadcast zone they are to serve so that the loudspeaker wiring

is minimised. Each of these units shall house the power supply, battery backup and full monitoring facilities. These units shall be modular in construction allowing for a high degree of flexibility so that the performance can be closely matched to the requirements. This unit shall meet the Voice Alarm Standards as hitherto mentioned in NFPA 72 and BS 5839 Part 8.

- 1.3.19 The voice Command Unit for audio controls shall be designed to complement the fire alarm control panel. It shall provide manual access to the voice alarm section of the system. The voice command centre shall be an integral part of the fire alarm control panel unit. Housing both these units in one rack to justify the above shall not be acceptable. If in case this unit has to be independent of the FACP then the interlinking between the FACP and the Voice Alarm Command Unit shall adhere to NFPA Class A Style 7 standards. Silencing and sounding and the programming of the phased evacuation of the speaker circuits shall all be done from the fire alarm control panel only. Controls on the voice command unit shall be available for upto 64 broadcast zones of the voice alarm. Standard configurations shall allow for recorded Alert and Evacuate messages as well as an emergency microphone to be operated in each area. In addition upto four other recorded messages shall be stored in this unit.
- 1.3.20 The distributed amplifier rack units shall also be wired to the detection loops of the fire alarm control panels only. This shall be in addition to the audio cable interlinking the voice command centre for audio controls the distributed amplifier racks.
- 1.3.21 The integrated Fire alarm and Voice alarm system shall cover the corridor areas and loop powered loop signalled pre recorded electronic voice sounders connected to the fire alarm system.
- 1.3.22 The Distributed Amplifier Rack Units shall include amplifiers for local areas. These units shall be capable of complete standalone operation for the areas it is assigned should the network/interface connections fail
- 1.3.23 In the event of a catastrophic failure occurring on any individual component within the Distributed Amplifier Rack Unit, pre-recorded emergency alarm message shall still be available at the voice command audio control unit.
- 1.3.24 The voice alarm system shall be capable of broadcasting pre-recorded emergency alarm messages and live speech in the event of fire detection system activating.
- 1.3.25 The systems shall be capable of broadcasting upto four different pre-recorded messages to different zones or group of zones simultaneously.
- 1.3.26 Evacuate signal shall relate to a general evacuation message and the alert message shall corresponds to standby instructions.
- 1.3.27 In addition a FIRE DRILL and an ALL CLEAR message shall be incorporated into the operation.
- 1.3.28 A fireman's microphone shall be fitted to the Voice Command Centre units. These shall allow direct voice instructions to be transmitted to a single zone, selected zones or all zones.
- 1.3.29 When a fireman microphone is operated, this shall override any automatic voice alarm signal being transmitted to the selected zone. The Alert and Evacuate pre-recorded messages will be maintained in other zones while live voice fire announcements are being broadcast to selected loudspeaker zones.

1.4 Codes and Standards

- 1.4.1 The voice alarm system wiring shall conform NFPA class – A, style 7.
- 1.4.2 Loop cabling and fire alarm components and accessories shall comply NFPA 72, and BS 5839, Part 8.
- 1.4.3 Smoke sensors shall be LPCB approved and shall conform BS 5445, Part 7.
- 1.4.4 Heat sensors shall be LPCB approved and shall conform BS 5444, Part 5.
- 1.4.5 Audio control unit shall meet the requirements of BS 5839, Part 1 and BS 7443.
- 1.4.6 Fire alarm system cables shall conform BS 7629 and BS 6387.

1.5 Approved Manufacturers

- 1.5.1 Refer to approval Electrical manufacture list at the end of Electrical specification.

1.6 System Operation

- 1.6.1 In the event of a fire being reported from the smoke/heat Detectors, activation of manual call points or sprinkler operation the sequence of alarm operation shall be as follows:
 - 1.6.1.1 If a fire condition is reported from any sensor this shall cause a fire signal to be reported at the control panel and the loop powered pre-recorded voice alarm sounder within that room shall alarm the occupant. The system then shall incorporate a delay for up to 3 minutes maximum and if the alarm is not acknowledged in this time period, the evacuation message should be broadcast through the speakers automatically to the affected zone/floor plus the adjacent zone/floor above and below (to be decided at the time of commissioning). The zones/floors other than the affected and its adjacent zones/ floors above and below shall be on alert condition and then after a further delay of 3 sec shall go onto evacuate condition.
 - 1.6.1.2 If a Manual Break Glass Unit is activated or a sprinkler flow switch is operated, then the evacuation shall be transmitted immediately to the affected zone/floor plus the adjacent zones/the floor above and the floor below. The signal to the other floors shall be as previously described.
 - 1.6.1.3 In each of the above cases, upon initiation of an evacuation signal all the electronic sounders in areas such as plant rooms and emergency staircase shall operate immediately. The signals shall not discriminate with zones/floors.
 - 1.6.1.4 Activation of the fire alarm system shall directly initiate some or all of the following to be agreed as a part of the overall engineering policy.
 - 1.6.1.4.1 Signal to all elevator machine rooms indicating fire status (to control lifts)
 - 1.6.1.4.2 Release doors normally locked by magnetic devices.
 - 1.6.1.4.3 Release doors normally held open by magnetic devices
 - 1.6.1.4.4 Shutdown mechanical equipment ventilation plant

- 1.6.1.4.5 Shutdown general exhaust fans
 - 1.6.1.4.6 Start up smoke extract fans
 - 1.6.1.4.7 Start up exhaust make up fans
 - 1.6.1.4.8 Start up stair vestibule pressurisation fans
 - 1.6.1.4.9 Automatically operate fire dampers
 - 1.6.1.4.10 Initiate alert signals in all panels
- 1.6.2 Sprinkler valves, flow switches and other monitored valves shall be directly supervised by the fire alarm systems to other systems within the building. These shall include but not limited to the following (please refer the schematics for any such supervision)
- 1 Building automation system
 - 2 Staff pager system
 - 3 Emergency lighting system
 - 4 Security system

PART 2 PRODUCTS

2.1 Main Fire Alarm Control Panel (FACP)

- 2.1.1 The panel shall be computer controlled using analogue technique to detect smoke / heat/ fire conditions. The panel shall be complete with, but not limited to, the following elements: The number of FACPs shall be as shown in the drawings. All the FACPs are to be peer to peer networked to provide global fire and fault conditions at all FACPs.
- 2.1.1 Visual display unit capable of displaying 16 lines 40 characters backlit display (white on blue).
- 2.1.2 Built-in 40 character thermal printer operating when the access door is open There shall also be an option to enable the printer when the door is closed.
- 2.1.3 Keyboard shall be built-in the control panel such that the Labelling of devices can be done from this keyboard. Any correction in label, if required, shall be done by this keyboard.
- 2.1.4 Integral sealed lead acid battery and charger with 24 hour back up to power the system shall be provided to the event of main supply failure.
- 2.1.5 Essential controls shall include, minimum; sound alarms, silence alarms and reset fire. These shall be enabled by a keyswitch.
- 2.1.6 Cancel fault buzzer
- 2.1.7 Fire, fault, warning and power on lamps.

2.1.8 Simple menu driven function keys with password protection shall allow users to an extensive range of software based features such as:-

2.1.8.1 Last 100 fire events

2.1.8.2 Last 255 system events

2.1.8.3 Current fault and warning logs.

2.1.8.4 Analysis of analogue sensor information

2.1.8.5 Interrogation of sensor cleanliness

2.1.8.6 Loop map connections

2.1.8.7 Enable/ disable sensors, zones, sounders, interface unit channels.

2.1.8.8 Fire plan configuration menus

2.1.8.9 Outstation label changes

2.1.8.10 Address allocation

2.1.8.11 Status of outstation

2.1.8.12 Status of all cards

2.1.8.13 Printer on, off, line feed and test facilities.

2.1.8.14 Address allocation including SAFE addressing.

2.1.9 All control buttons and keyboard shall be enclosed behind a lockable cover.

2.1.10 The system shall include RS 232/ RS 485 Serial Port communication option.

2.1.11 Control panel shall have minimum of 2 loops of 24V, 400mA, max rating per circuit.

2.1.12 Control panel have a secure networking facility to indicate a remote zone and remote zone text across the network.

In addition to the above, all other necessary controls, elements and accessories shall be included to provide a complete and efficient panel conforming to the requirements of BS 5839: part 4: 1988.

2.2 Multi Sensors

2.2.1 These shall be of addressable optical / heat type. The optical element shall monitor for visible smoke from slow smouldering fires. Smoke sensing design shall comply to BS 5445: part 7 and shall be LPCB approved.

2.2.2 All smoke sensors shall comprise of three components:-

- 2.2.2.1 Termination Plate, Electronics Module and a replaceable sensor chamber. The termination plate shall incorporate the terminals for wiring only and shall not contain any electronic parts. The electronic module shall plug onto the termination plate as a second fix item. It shall have microprocessors and other electronic components and circuitry suitable for an Analogue addressable system. The sensing chamber shall fit on the electronic module as a third fix item.
- 2.2.2.2 This design shall allow sensing element alone to be replaced, should it become dirty due to a build up of dust from the surrounding atmosphere. When removed, the panel shall display a fault condition with a message "Sensor chamber Removed" with a relevant label/address. The sensor chamber shall also have 360 degree viewing LED indicator.

Sensors mounted in the false ceilings shall be provided with semi flush mounting kits.

2.3 Heat Sensors

- 2.3.1 These shall comply with the requirements of BS 5445: Part 5: 1977 and shall be LPCB approved. They shall be complete with the other elements described for smoke sensors above, for an analogue addressable sensing device. The heat sensors in the restaurants /kitchens shall be IP55 rated..
- 2.3.2 Sensors mounted in the false ceilings shall be provided with a semi flush mounting kits.

2.4 Beam Sensors

- 2.4.1 The Beam Sensors shall be loop addressed, loop powered, loop signalled with short circuit isolator and shall detect fire by obscuration of an optical beam by smoke. It shall utilise a transmitter and receiver unit and be suitable for ranges of up to 100 meters. It shall be used in areas as indicated in the drawings.
- 2.4.2 A method of automatic gain control shall be employed to minimise the effects o a build up of dust and dirt on the lens.
- 2.4.3 LEDs shall be provided integral with the transmitter/receiver units to assist in the alignment set-up.
- 2.4.4 The Beam sensors shall be LPCB approved and to BS 5839 Part 5.
- 2.4.5 The degree of protection of beam sensors shall be IP40.

2.5 Duct Sensors

- 2.5.1 Duct Sensors shall be addressable, loop powered, loop signalled. They shall comprise of a sampling unit with probes extending into a straight section of the mechanical ventilation ductwork. The duct sensor shall comprise of Optical Smoke/Heat Sensing devices.

2.6 Manual Call Points

- 2.6.1 These shall comply with the requirements of BS 5839: part 2: 1983, and shall be complete with all-electronic components and circuitry for a safe addressable device. Polycarbonate cover type option shall also be provided if required. The manual call point shall have an inbuilt microprocessor to ensure a response time of less than 1 second. The unit shall incorporate a key operation facility for testing purposes and a specially designed film fitted over the glass to prevent fragmentation when broken. It

shall incorporate an integral LED to activate upon breaking the glass/testing the unit with a special key.

2.7 Voice Alarm Sounders

2.7.1 All Voice Alarm sounders shall be loop powered and loop signalled connecting all devices e.g.: sensors, sounders, manual call points, repeat panels, interface units in the same 2 wire loop. The alarm sounders shall incorporate sound, speech and strobe effects all in one range of alarm devices. This range should offer variants from IP 31 to IP65 depending on Client's requirements.

2.7.2 The sounder shall consume less power thus enabling to have more sounders in the same loop.

2.7.3 All sounders shall have the option of integral strobe that is completely loop powered. The strobe option shall be equivalent to a standard 3w xenon strobe and shall use 1/20 of the power. The strobe element of the sounders shall be fully monitored for circuit failures.

2.7.4 For commissioning purposes the system shall have an option to use the Handy Link IR remote control to tune individual sounders and adjust the sound remotely using password access at the control panels, for better system integrity.

2.7.5 Voice and Tone mode can be freely mixed within the same sounder. All messages and strobe signals shall be synchronised across the same control panel.

2.7.6 Voice alarm sounder shall have a backward compatible version of the system sounder for replacement to the existing system without the need to upgrade the system software. Standard voice should be as follows:

2.7.6.1 Alert message (female voice)

"An incident has been reported in the building, please wait for further Instructions"

2.7.6.2 Alarm message 1(female voice)

"Attention please, This is an emergency. Please leave the building immediately by the nearest available exit "

2.7.6.3 Alarm message 2 (male voice)

"This is the fire alarm". Please leave the building immediately by the nearest available exit. Wait for further instructions"

2.7.6.4 Test message (female voice)

"This is a test message, Please ignore and no action is required"

2.8 Interface Units

2.8.1 Interface units shall give / accept contacts from other services required to be interfaced with fire alarm system. Such as Interfacing with AHU'S, BMS, Elevators, Pressurisation Fans etc. All inputs and outputs are to be fully monitored for cable

faults. The Power Supply units if required, with the interfaces shall also be monitored for any faults.

2.9 Graphics Terminal

2.9.1 The graphic visual display shall pictorially represent Fire, Fault and Emergency events on a Visual display Unit (VDU). This facility shall be to provide the operator with the additional visual information over and above textual messages. All system events ie fire, fault and warning shall be automatically printed onto the graphic printer. Operation of the graphics terminal shall normally be by selection of the appropriate pages guided by a navigation system. It shall automatically track the relevant initiating device for the first occurrence of each type of the event. The graphics terminal shall provide the following:

2.9.1.1 Events display/status bar giving a clear and concise view of the current events on the fire alarm system.

2.9.1.2 Ability to control and change the following

- Disable actions
- Labels
- Auxiliary text

2.9.1.3 User Action buttons

2.9.1.4 Historic data of all the system events

2.9.1.5 Access levels/passwords to target specific levels of access to specific users

2.9.1.6 Graphical representation (if required) of the site allowing the exact location of the fire alarm events, eg, fires, faults etc.

2.9.1.7 Panel remote buzzer cancellation

2.9.1.8 Event acknowledgement

2.9.1.9 Clock synchronisation with panels with local adjustment facility

2.9.1.10 Touch screen support

2.9.2 The terminal shall assign a number of different graphic pages to each fire event – from a site overview of building layout, through a floor layout and breaking the site into increasing levels of detail. Number of graphic pages required shall be finally determined by the Client/Engineer.

2.9.3 The system shall operate on the Microsoft Windows platform. The platform specification required is an IBM PC compatible with the following minimum specifications.

2.9.3.1 Dual core processor

2.9.3.2 3.5 GHZ speed.

- 2.9.3.3 4 GB RAM
- 2.9.3.4 500 GB Hard Disk
- 2.9.3.5 Minimum 17 inch LCD colour monitor
- 2.9.3.6 Two serial ports and two parallel ports
- 2.9.3.7 Real time clock
- 2.9.3.8 DVD Writer
- 2.9.3.9 Microsoft mouse

- 2.9.4 The combined text and graphics package shall be provided on the same supervisor. The graphics supervisor shall be provided in the Main control room located in Ground Floor and the security control room in Second floor.

2.10 Audio Control Unit

- 2.10.1 The Audio Control Unit (ACU) shall be a mains and battery backed unit and shall be installed next to the Graphic supervisors located at Main Security control room in Ground Floor. (please refer the schematic for the locations). These units shall be connected to the loops of the FACP's and the voice alarm audio loops. and shall initiate the broadcast of live speech in the designated public areas using manual controls. The use of these units shall be primarily for broadcast of fire messages and other optional auxiliary messages which are site and application specific.
- 2.10.2 The Audio Control Units shall be to BS5839 Part 1 and BS7443. The units shall have either grey or brown cover with black back box.
- 2.10.3 There shall be an audible indication by an integral buzzer to announce a local ACU fault.
- 2.10.4 The user controls on the unit shall be keyswitch enabled to allow authorised use of system controls.
- 2.10.5 The Audio loop shall connect the ACUs to all the Distributed Amplifier Units (DAUs) as shown on th schematics. The audio loop shall carry the messages and data from the master ACU to the distributed amplifier units in the system. The messages it carries shall be from the microphone or from the auxiliary message stores.
- 2.10.6 The message from ACU to distributed amplifier units shall be from the microphone or from the auxiliary message stores.
- 2.10.7 The integral microphone with Press to talk button shall be located behind the enable controls door. It shall be possible to loop connect 10 external all call microphones for fire announcements.
- 2.10.8 The ACUs shall be capable of storing 4 auxiliary messages (as mentioned below) that can be initiated at ACU for broadcast on the secure fire alarm network with each message of 45 second duration.
- 2.10.8.1 Test

- 2.10.8.2 All Clear
- 2.10.8.3 To call all faithful for prayer.
- 2.10.9 The ACUs shall be IP 40 rated.

2.11 Distributed Amplifier Unit

- 2.11.1 The Distributed Amplifier Unit shall be mains powered and battery backed. The unit shall be normally installed near its loudspeaker circuit area. They shall amplify audio signal for broadcast to its zones of loudspeakers. The audio signal shall be either live or pre-recorded messages. The live speech shall be from the microphone and the pre-recorded messages from the digital stores which shall be local on the Alert and Evacuate Store Modules in the DAU.
- 2.11.2 Each DAU zone shall consist of a maximum of 8 loudspeaker circuits with each channel powered from separate amplifier module, to secure the broadcast of messages.
- 2.11.3 The amplification of audio shall be by means of amplifier modules installed in the DAUs. There shall be a number of modules available with various power ratings to meet the loudspeaker requirements. Their frequency bandwidth shall be in the range of 150Hz to 20Khz.
- 2.11.4 The DAU shall meet the requirements of BS5839 Part 1,4 and 8. Each of the DAUs shall be given a label by the Fire Alarm Control Panel to identify its location in the system. The label shall be automatically displayed along with the DAU events.
- 2.11.5 The DAU shall facilitate optional local live speech. The global speech shall be broadcasted from the ACU microphones via the Audio loop to all the DAU and its loudspeaker circuits in the system.
- 2.11.6 The DAU shall be IP 40 rated.
- 2.11.7 All the DAUs shall be provided with built-in short circuit isolators. Any open or short circuit fault on any of its speaker circuits shall not affect in any way the functioning of the other speaker circuits.

2.12 Audio Amplifiers

- 2.12.1 The audio amplifiers shall be fitted in the DAU.
- 2.12.2 All amplifier modules of the voice alarm system shall be supervised with any failure initiating an audible and visual indications.
- 2.12.3 Each speaker circuit shall be provided with a dedicated amplifier and shall consist of a minimum of 2 speaker circuits (one zone). A single amplifier catering to all the speaker circuits shall not be acceptable.
- 2.12.4 The amplifier modules shall have the following specifications:-
 - 2.12.4.1 Power Output:50, 100 or 250 watt rms to meet the load demand
 - 2.12.4.2 Output voltage:100V
 - 2.12.4.3 Input: Balanced via 3 pin XLR

- 2.12.4.4 Impedance: 20 kilo-ohms
- 2.12.4.5 Frequency response: 150Hz-20000Hz
- 2.12.4.6 Total Harmonic distortion: <0.4% @ full power
- 2.12.4.7 Sensitivity (full output): 0dBm (775mW) @ 1Khz
- 2.12.8.8 Signal to noise ratio: >80dB
- 2.12.5 Messages & Alarm Warning Signals
 - 2.12.5.1 A dedicated digital message storage and playback unit shall provide upto 4 discrete pre-recorded message alarms. The message unit shall be fully solid state, with no moving parts.
 - 2.12.5.2 The messages shall be recorded into non-volatile electronic memories using real (not synthesised) speech. The recordings shall be made with a clear (preferably professional) speaker using professional recording equipment in a recording studio or a room with a controlled acoustic environment (noise <25dB[A], reverberation time <0.5s from 400Hz - 10kHz).
 - 2.12.5.3 Message storage shall allow for a minimum of 60 seconds for each message. Each message shall be independently stored and programmed. Each message channel shall be provided with an onboard alarm tone generator which shall automatically establish an essential alarm signal in accordance with BS 5839.
 - 2.12.5.4 The digital message storage unit shall have separate electronically generated alarm tones, one for each of the four voice messages.
 - 2.12.5.5 The tone shall not be recorded on the non-volatile memory, thereby removing the possibility of common mode failure.
 - 2.12.5.6 The text of each message to be recorded shall be agreed with the engineer prior to application, however for tender purposes assume the following:-
 - 2.12.5.6.1 Alert
 - 2.12.5.6.2 Evacuate
 - 2.12.5.6.3 System Test And All Clear
 - 2.12.5.7 the alert message shall be 5s of an approved attention drawing alert signal as specified in BS 5839, followed by the words attention please. attention please. we are investigating an alarm condition. it may be necessary to evacuate the building, please listen for further announcements. the complete message (signal and words) shall be continuously repeated with intervening time intervals of 30s.
 - 2.12.5.8 the evacuate message shall be 5s of an approved attention drawing evacuate signal as specified in BS 5839, followed by the words: attention please. attention please. this is an emergency. please leave the building by the nearest available exit. do not use the lifts. the complete message (signal and words) shall be immediately and continuously repeated with no intervening time intervals.

- 2.12.5.9 the test message shall be fire warning system test. this is a test of the fire warning system. this is a functional test for system operation, loudspeaker coverage, signal level and speech intelligibility.
- 2.12.5.10 Fourth message shall be as per the Clients requirements.
- 2.12.5.11 the alert and test message shall use a female voice, the evacuate message a male voice, both unaccented. all messages are to be in arabic and english.
- 2.12.5.12 Prior to installation of the equipment, the Contractor shall provide, on a standard compact cassette, a copy of each recorded message for review by the Local Civil Defence and the Engineer.
- 2.12.5.13 Messages shall start from the beginning within 0.25s of activation.
- 2.12.5.14 There shall be no user controls on the unit, other than to start and stop the test messages.
- 2.12.5.15 A message run indicating LED (preferably green) shall be provided for each message channel.
- 2.12.5.16 Erasure of any message shall not be possible without the connection of external components.
- 2.12.5.17 The message unit shall provide the following minimum performance:-
- .1 frequency response 200Hz - 5.5kHz +/- 2dB
 - .2 S/N >60dB at rated output
 - .3 distortion <1% @ 1kHz at rated output
- 2.12.5.18 The unit shall have automatic self surveillance

2.13 Equipment Rack

- 2.13.1 The equipment shall be housed in a standard rack of suitable height, with Plexiglas door and lock. Ventilation panels of 1 U height shall be provided between each item of equipment.
- 2.13.2 Details of the proposed equipment shall be forwarded to the engineer's approval, complete with performance specifications, dimensions, construction and finish.
- 2.13.3 The system shall include man / machine interface terminal facility, which shall allow live speech broadcasts to be addressed to selected areas of the site. The unit shall also allow initiation of stored messages and alarm signals.

2.14 Speakers

- 2.14..1 Loudspeakers shall be high quality, capable of transmitting an alarm tone, as well as voice communication.
- 2.14..2 Loudspeakers enclosures shall be of metal construction, complete with fire dome of steel or equivalent fire protection performance. Fire domes shall not have significant degradation of the loudspeaker frequency response.
- 2.14..3 All loudspeakers shall be complete with 100v line matching transformers and with adjustable tapping ranging from 100%, 50%, 25% and 12% full power.

- 2.14.4 The maximum input voltage of the loudspeaker shall be 100V rms.
- 2.14.5 Outdoor speakers shall be terminated through weatherproof type plugs and sockets provided with a push-on cap and cap retaining ring.
- 2.14.6 The sensitivity of loudspeakers shall be measured at a distance of 1 meter with a random noise signal of 1W.
- 2.14.7 All speakers shall be provided with thermal fuses with suitably rated connections on the primary of the transformer.

2.15 Voice Alarm Speakers – (Ceiling Mounted)

- 2.15.1 The Voice Evacuation Ceiling speakers shall be 4" Mylar cone.
- 2.15.2 The rear of the speaker shall be completely sealed protecting the cone during and after installation.
- 2.15.3 Speakers shall have an In - Out screw terminals for wiring.
- 2.15.4 The Speaker baffles shall be round, steel with white finish.
- 2.15.5 Speakers shall be provided for use with 70V systems.
- 2.15.6 Speakers shall provide power taps at 1/4w, 1/2w, 1w, and 2w.
- 2.15.7 Speakers shall provide UL listed 90 dBA sound output at 2w.
- 2.15.8 Speaker frequency shall be from 250 Hz to 13000 Hz

2.16 Voice Alarm Speakers – (Wall Mounted)

- 2.16.1 The speakers shall be with a 4" Mylar cone.
- 2.16.2 The rear of the speaker shall be completely sealed protecting the cone during and after installation.
- 2.16.3 Speakers shall have an In - Out screw terminals for wiring.
- 2.16.4 Speaker housings shall be red in staircase areas and white if used in the ground floor or typical floors as indicated on the drawings.
- 2.16.5 Speakers shall be provided for use with 70V systems.
- 2.16.6 Speakers shall provide power taps at 1/4w, 1/2w, 1w, and 2w.
- 2.16.7 Speakers shall provide UL listed 90 dBA sound output at 2w.

2.17 Fire Telephone System

- 2.17.1 A telephone control system shall be housed in the master fire control panel in the BMS 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 calls. The LCD will display call-in information in full language, without the need for individual LED's and switches per

telephone station The user shall connect a call by pressing the 'connect' switch. Systems require individual Switch/LED to establish communication with remote fire telephone may be acceptable subject to engineer approval.

- 2.17.2 The telephone circuits shall be annunciate and cause an audible alarm whenever a call is placed to the control centre from a remote telephone location.
- 2.17.3 The master telephone control module shall provide processing of all two-way communication functions. This module shall include a sound alert for call and trouble signalling, trouble silence switch with ring back, a trouble indication and supervising monitor circuit.
- 2.17.4 A Red master telephone handset with flexible-coiled 5-foot cord shall be provided and recessed within a protective enclosure at the Main Control Panel.
- 2.17.5 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 conversation between all phones of the system.
- 2.17.6 Provide one circuit per each remote fire telephone.

2.18 Fire Telephone Jacks

- 2.18.1 Remote firemen's telephone jacks shall be flush mounted.
- 2.18.2 Fire Tel. Jacks shall be connected into separate circuit for each Jack.
- 2.18.3 Jacks shall be with the inscription "FIRE FIGHTER TELEPHONE".
- 2.18.4 Provide one fire telephone handset enclosure at BMS room with 5 handset

2.19 Battery /Charger Console

- 2.19.1 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.
- 2.19.2 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.
- 2.19.3 The front panel shall include a DC voltmeter, a DC ammeter, indicator lights for float and high-rate charge modes, a push-button permitting manual initiation of the timed high-rate charge mode.
- 2.19.4 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.

- 2.19.5 Access to the charger compartment shall be by a lift-off top cover, held in place with screws.
- 2.19.6 The unit shall be ventilated through louvers
- 2.19.7 The cabinet shall be made of sheet steel finished in baked gray enamel.
- 2.19.8 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.

2.20 Repeater Panel

- 2.20.1 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.
- 2.20.2 The communication with fire alarm panel shall be by means of microprocessor based data communication system.

PART 3 EXECUTION

3.1 Wiring

- 3.1.1 All cables associated with Fire Alarm installation shall be fire resistant 2 core 1.5 sq mm screened type. Cables shall comply with BS 7629 : 1993 and BS 6387.
- 3.1.2 The cable for use on the Fire Alarm loop, Audio loop and the loudspeaker circuit shall be of the following type and specification. (typically 1 km per circuit. The audio loop may exceed 1 km).
 - 3.1.2.1 The cable shall be to BS 6387 having typically no more than 2 cores.
 - 3.1.2.2 The cable shall have maximum of 0.5 micro-farad intercore capacitance.
 - 3.1.2.3 The cable shall have maximum of 13 ohms per core.
 - 3.1.2.4 Maximum size of the cable shall be 1.5 sq.mm cross section.
 - 3.1.2.5 The cable shall have with an inherent or thorough metal conduit screen for earth continuity in order to produce electrical protection and screening.
 - 3.1.2.6 The cable shall have protection from heat and mechanical damage.
 - 3.1.2.7 The cable screen shall be capable of being earthed at each system device (outstation)
- 3.1.3 The network cable (to interconnect the main fire alarm control panels) shall be of 3 core 1.5 sq mm Beldon 9729 or equivalent.
- 3.1.4 Multi core cables having more than 2 cores shall not be allowed for loop wiring.

3.2 Inspection and Verification

- 3.2.1 Upon completion, arrange for the manufacturer to make a complete inspection and adjustment of the system including all components, to ensure that:

- 3.2.1.1 The system complies with the contract documents, the manufacturer's recommendations, and the applicable codes and standards
- 3.2.1.2 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.
- 3.2.2 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.
- 3.2.3 Submit the following to the Engineer:
 - 3.2.3.1 Certificate of verification confirming that inspection has been completed and listing the conditions on which the inspection and verification are based
 - 3.2.3.2 Test report on all equipment checked during verification, including panels, annunciators, bells, manual stations and automatic detectors

3.3 Testing and Commissioning

3.3.1 Preliminary Tests

- 3.3.1.1 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.

3.3.2 Acceptance Test

- 3.3.2.1 Provide the service of competent, factory-trained engineer or technician authorised 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.
- 3.3.3 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.
- 3.3.4 Submit seven (3) copies of the approval certificate and verification report to the Engineer after completion. Insert one (1) copy in the operation and maintenance manuals
- 3.3.5 Demonstrate complete system to Civil Defence for their approval and certification.

End of Section.

Distribution Rack switch and Rack Cabinet

1- Distributed Rack Switches

1.1 The distributed switch is to meet the following minimum specification:

- Port Auto-configuration
- Auto-sensing 10/100/1000 ports
- Telnet and console access
- Spanning Tree Protocol (IEEE 802.1D):
- IEEE 802.1w Rapid Convergence Spanning Tree Protocol:
- IEEE 802.1s Multiple Spanning Tree:
- Layer 2 switching (VLAN support)
- Layer 3 routing
- Security - Port security
- Quality of Service (QoS) - Traffic prioritization (IEEE 802.1p):
- Class of Service (CoS)
- Support PoE for all ports

1.2 Performance

- 1000 Mb Latency < 13.3 μ s (LIFO)
- Throughput up to 9.6 Gbps

1.3 Connectors and cabling

- 100BASE-TX ports: RJ-45 connectors
- 1000BASE-T ports: RJ-45 connectors
- 100BASE-FX ports: LC connectors,
- 1000BASE-SX, - LC fiber connectors, 50/125 micron multimode fiber-optic cabling

1.4 Power Supplies

- Dual redundant hot swappable power supply

2. Equipment Rack

The construction of the cabinet shall be comprised of a top and bottom tubular frame connected by two vertical aluminum extrusion posts. The cabinet frame can be clad with steel, glass or acrylic doors, and steel side panel as required.

The footprint of the cabinet shall be 800 x 800 mm (or larger when required) The cabinet shall be for use in an indoor environment and shall comply with IEC 529 IP20. The cabinet shall have a load capacity of 900 kg when fully populated with active equipment.

2.1 Cabinet Framework

- Tube Frames: 25 x 25 x 2.5 mm wall thickness corner welded steel tube
- Fascias: 1.2 mm Steel CR4 Zinc Coated
- Central Posts: Extruded Aluminum with Density 2.97 kg/m
- Corner Moldings: Nylon 66.

2.2 Doors and Panels

- Side Panels: 1.2 mm Steel CR4
- Rear Doors: 1.5 mm Steel CR4
- Front Door Styles: 1.5 mm Steel CR4
- Door Glass: 4 mm toughened BS6206 1981 – grey tint– exposed edges arrised
- Locking System: 90° turn locking handle with two point espan locking
- Top Panels: 1.2 mm Steel CR4

- Hinge Moldings: Nylon 66.

2.3 Material

Top Frames, Top Panels, Side Panels and doors:

Mixed Metal Iron Phosphate Pretreatment, NCS 1502Y Light Grey – Structured Epoxy Polyester Powder DFT 50 µm 19” and ETSI Mount: Angles, Top Panel Fixing Channels, Lock Rods: 8 µm thick Zinc Plate, Clear Trivalent Chromium Passive (ZNX) RoHS Compliant.

END OF SECTION

UNITED NATIONS DEVELOPMENT PROGRAMME



Tender And Contract

Documents

GENERAL SPECIFICATIONS – MECH WORKS

VOL 3 OF 4



GENERAL MECHANICAL REQUIREMENTS FOR PLUMBING

PART 1 GENERAL

1.1 General Requirements

1.1.1 The work shall be governed by general conditions of contract.

1.1.2 It is the Contractors responsibility to be fully aware of and comply with all of the requirements of the above documents, and further assure that all Subcontractors are equally informed.

1.2 Application

1.2.1 This section applies to sanitary and domestic water use.

1.3 Scope of Works

1.3.1 The works covered under this contract include the supply, installation, testing, adjusting and putting into operation systems, components of systems, and individual items of equipment, and work related thereto, in accordance with the project Tender Documents. Products not mentioned but obviously necessary for the completion of those Works shall be provided.

1.3.2 Unless specifically mentioned otherwise, the following electrical works and materials for the Mechanical equipment shall be supplied and installed of the specification but in all respect to the requirements of the electrical specifications.

1.3.2.1 All control panels including door lock disconnected switches, push buttons, starters, contractors, circuit breakers, time delays, selector switches, relays, transformers, timers, controllers, pilot lights, set points, alarms and all other electrical equipment which are necessary for the satisfactory operation, control and protection of all plant supplied under this section of the specifications.

1.3.2.2 Whenever a number of starters controllers, instruments, indicating lights and the like occur or are shown on the Mechanical and/or electrical Drawings, they shall be arranged in a central position in a neat, easily cleaned, factory-built panel, or motor control center assembly. The assembly shall include isolators and all necessary fuses, bus bars, starters, instruments, relays, push-buttons, indicating lights and the like. Components shall be mounted in a logical order based on the sequence of operation.

1.3.2.3 All control equipment including sensors, detectors, actuators, controllers, pressure level and flow switches, annunciation alarms, remote control stations and all such equipment needed for the proper system operation.

1.3.2.4 All control wiring for the above mentioned equipment.

1.3.2.5 Final connection, between disconnect switches, power outlets, flex outlet and mechanical equipment.

- 1.3.2.6 Power cables between submersible pumps and control panel.
- 1.3.3 The following electrical works and materials for the mechanical equipment shall be supplied and installed under the electrical part of this contract.
- 1.3.3.1 All power supply up to and including the following:
- Disconnect switches when specified to be installed separate from the control panel.
 - Flex outlet for electric water heater.
- 1.3.3.2 Power supply upto control panels when specified with an integral disconnect switch.
- 1.3.3.3 Power supply to disconnect switches when the switches are built-in the equipment.
- 1.3.3.4 Empty conduits with pull wires for all cables and wires classified under the mechanical scope of works.
- 1.3.3.5 Control outlet boxes for all control equipment classified under the mechanical scope of works.
- 1.3.3.6 Power cables and conduits or fixing arrangement between water pumps, and their control panel.

1.4 Quality Assurance

- 1.4.1 The manufacturer's of all materials and equipment must have at least ten years of experience in the design and manufacture of their products.

1.5 Related Work Specified Elsewhere

1.6 Engineer's Drawings

- 1.6.1 The Drawings are based on design and include general layouts and typical details of various systems to be installed. The Contractor shall make the installations in a workmanlike manner to conform to the structure, to avoid obstructions, to preserve head room, and to keep openings and passage ways clear without additional instruction and without additional cost to the owner.

1.7 Shop Drawings and Data to be Submitted for Approval

- 1.7.1 The Contractor shall submit Shop Drawings showing the exact routing and locations of all the piping, equipment, etc., all in their respective locations and according to the dimensions of the approved manufacturer. Shop Drawings scale shall be 1/10, 1/20, 1/50 and 1/100 as applicable and as approved by the Engineer.
- 1.7.2 The Contractor shall submit catalog cuts and brochures of products with reference to proper paragraph in specifications. All submittals shall be binded in one Booklet.
- 1.7.3 The Contractor shall submit adequate Engineering data on each piece of equipment together with all characteristic curves, capacity selection charts and all data for testing and balancing of the systems. In addition the Contractor shall submit manufacturer's printed installation instructions.
- 1.7.4 The Contractor shall submit at the beginning of the project a schedule of submittals for materials and shop drawings to the approval of the Engineer.

1.8 Approved Materials

- 1.8.1 All materials shall be furnished in accordance with the requirements of the Specifications.
- 1.8.2 The naming of manufacturers in the Specifications shall be strictly adhered to in all circumstances.
- 1.8.3 Substitution of materials other than those named shall not be submitted.
- 1.8.4 Materials shall be delivered in unbroken packages bearing the brand and maker's name, and shall be stored on platforms and properly covered to protect them from moisture, heat and dust.
- 1.8.5 All materials shall be supplied from the main factories in the country of origin of the manufacturer. Any deviation from this, like supplying equipment assembled in another different country under a license or another name is not accepted unless approved by the Engineer.

1.9 Instruction Period

- 1.9.1 The Contractor shall be responsible for the training and familiarization of the Employer's Maintenance Staff for a period of at least six weeks on all equipment and plants he has supplied or installed.

1.10 Instruction Manual and As-built Drawings

- 1.10.1 The Contractor shall furnish and submit to the Engineer in electronic and hard copy triplicate bound, A4 size, Instruction Manuals containing the following material.
- 1.10.2 Brief description of each system and its service and basic operation features.
- 1.10.3 Manufacturer's mechanical equipment parts list of all functional components of the systems listed on the Drawings, control diagrams and wiring diagrams of controllers. List shall give system No., unit no., Manufacturer's Model No., and Manufacture's Drawing no. Parts list shall include manufacturer's recommended spare parts for one year operation.
- 1.10.4 Chart of the tag numbers, location and function of each valve.
- 1.10.5 Maintenance instructions for each type of equipment.
- 1.10.6 Possible breakdowns and repairs for each type of equipment.
- 1.10.7 List of nearest local suppliers for all equipment.
- 1.10.8 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.
- 1.10.9 Complete, as installed, color coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.
- 1.10.10 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.
- 1.10.11 All items shall be available at least four weeks prior to the substantial completion date.

1.11 Abbreviations

- 1.11.1 The following abbreviations have been mentioned in the specifications.

AGA	American Gas Association.
ANSI	American National Standard Institute.
ASA	Acoustical Society of America, American Standards Association.
ASME	American Society of Mechanical Engineers.

ASTM	American Society for Testing and Materials.
AWWA	American Water Works Association.
BSI	British Standards Institution.
NPC	National Plumbing Code.
UPC	Uniform Plumbing Code.
UL	Under Writers Laboratories.

1.12 Workmanship

- 1.12.1 All workmanship required to accomplish the work mentioned in Mechanical specification or shown on related Drawings, shall conform to the highest standards, and as required by the Engineer.
- 1.1.2.2 The Engineer will be the sole judge of the standards required.

PART 2 PRODUCTS

(NOT USED)

PART 3 EXECUTION

3.1 Cleaning and Adjusting

- 3.1.1 All apparatus shall be thoroughly cleaned before being placed in operation. Finished surfaces shall be restored if damaged and entire installation shall be delivered in perfect condition, subject to the approval of the Engineer. Systems shall be adjusted and balanced to operate as shown in the Drawings and herein specified.

3.2 Tests

- 3.2.1 All piping and equipment shall be tested as specified under the corresponding Specifications and to meet local and specified requirements. Provide anemometers, thermometers, gauges, voltmeters, ammeters, and similar instruments, not part of the permanent installation, but required to record the performance of the equipment and systems. Labor, materials, power, etc., required for testing, shall be furnished by the Contractor, unless otherwise indicated under the particular section of the Specifications.
- 3.2.2 Tests shall be performed in the presence of representatives of the Engineer and such other parties that have legal jurisdiction and all results shall be recorded.
- 3.2.3 In general, pressure tests shall be applied to piping systems only before connection of fixtures, equipment and appliances. In no case shall any piping, fixtures, equipment or appliances be subjected to pressures exceeding the ratings as prescribed by the manufacturers of fixtures, equipment and appliances, or accepted engineering standards for piping and fittings.
- 3.2.4 All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Engineer and authorities having jurisdiction, and at no additional cost to the Employer.
- 3.2.5 Any damages resulting from tests shall be repaired and/or damaged materials replaced, all to the satisfaction of the Engineer, and at no additional cost to the Employer.
- 3.2.6 The duration of tests shall be as determined by all parties having jurisdiction, but in no case less than the time prescribed in each division of the Specifications.

3.2.7 The following tests should be furnished for but limited to the following:

- a) Noise and vibration isolation test
- b) Insulation test
- c) Sanitary drainage test
- d) Pump tests
- e) Noise and vibration measurement
- f) Water heaters
- g) Area storm drainage
- h) Domestic water supply test
- j) Steam /Condensate pipe test

3.3 Coordination of Trades

3.2.9 The Contractor shall coordinate the work to ensure orderly, timely installations of the work of applicable trades within the various spaces indicated.

3.4 Access Doors

3.4.1 Access doors shall provide ready access to concealed control valves, traps, cleanouts, motors and other items requiring operation, adjustment, or maintenance.

3.5 Permits

3.5.1 The Contractor shall obtain and pay for all necessary permits, inspections and tests, for the proper installation of his work, as may be required by the various administrative authorities having jurisdiction.

3.5.2 Certificates of inspections, tests etc., with the proper approval certified thereon, shall be secured by the Contractor and these documents shall be delivered to the Engineer before the work in question will be accepted.

3.6 Openings in Exterior Walls

3.6.1 Openings in exterior walls, particularly at or below grade shall be kept properly plugged and caulked at all times, (except when being worked on) to preclude the possibility of flooding due to storms or other causes. After completion of work, openings shall be permanently sealed and caulked in the manner herein specified.

FACILITY SANITARY SEWERAGE

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and its requirements.

1.1 Sanitary Drainage

1.1.1 The Sanitary Drainage Systems consist of sanitary drainage, fixtures, fittings, piping and equipment as hereinafter specified and as shown on the Drawings. The sanitary drains shall be carried to appropriate manholes shown on the Drawings.

1.1.2 Pipe installations shall not be concealed within the building structure until satisfactory completion of the inspection and testing procedure.

1.1.3 Traps shall conform to BS 5572 and all relevant British Standards.

1.1.4 Plastic traps shall be to BS 3943 and of 'P' type unless otherwise specified.

1.1.5 For sinks, showers, baths, bidets and bowl urinals, traps shall be a two piece tubular trap, and bottle trap for lavatory basin.

1.1.6 Floor drains subject to evaporation shall have a water seal of 125mm.

1.1.7 All floor drains shall be set 3 mm. below the normal finished floor, with a gradual pitch extending away from the drain, unless otherwise noted on Architectural Drawings.

1.2 Site Drainage

1.2.1 The Site Drainage shall consist of site sanitary drainage complete with piping, manholes, submersible pumps, keep and all ancillaries as deemed necessary and as shown on the Drawings.

1.3 Reference Standard

1.3.1 All work under this section shall conform to the requirements of the National Plumbing Code Handbook and Uniform Plumbing Code, unless otherwise specified hereinafter.

1.4 Codes and Standards

1.4.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall conform to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
National Plumbing Code	NPC		-
Uniform Plumbing Code	UPC		-
British Standards	BS	BS497	Specification for manhole covers, road gully gratings and frames for drainage purposes

BS4164 Specification for coal-tar-based hot-applied coating materials for protecting iron and steel, including a suitable primer.

BS8005 Part 1 Guide to new sewerage construction.

1.5 Related Works Specified Elsewhere

1.5.1 The works specified in the following divisions, sections and sub-contains the following:

- General Mechanical Requirements for Plumbing.
- Plumbing Insulation
- Facility Potable Water Storage Tanks
- Facility Storm Drainage
- Plumbing Fixtures

PART 2 PRODUCTS

2.1 Gully Traps (PVC)

2.1.1 Each gully trap shall be of heavy duty UPVC construction and of the P or S-trap type.

2.1.2 Gully trap shall have either cast iron open grating cover or solid recessed cover with cast iron frame as shown on the Drawings and/or as need be.

2.2 PVC Floor Drains with Stainless Steel Cover

2.2.1 Supply and install wherever shown on the Drawings floor drains of sizes and shapes as indicated on the Drawings.

2.2.2 Each floor drain shall be of the UPVC construction with 70 mm water seal.

2.2.3 Drain shall have stainless steel AISI 304 removable square tile with circular grid strainer and stainless steel cover. The open area of the strainer shall be at least two-thirds of the cross-section area of the drain line to which it connects.

2.2.4 Stainless steel covers shall have minimum 15 years warranty.

2.2.5 Tile shall fit, as practical as possible, one floor tile of the space.

2.2.6 Drain shall be fitted with 1" (25mm) access plug for cleaning purposes.

2.2.7 This floor drain is applicable to bathrooms, toilets, kitchens and pantries.

2.2.8 Floor drain in Domestic Washing Machine Room shall be sealed type.

2.3 Flower Bed Drains

2.3.1 Each drain shall be of uPVC with trapped sump and flat type chrome plated brass or heavy duty stainless steel strainer.

2.3.2 Flower bed drains shall be supplied complete with stainless steel mesh enclosing the strainer and surrounded by gravels as detailed on drawings.

2.4 Cleanouts

- 2.4.1 Each cleanout shall be of the same material and dimensions as the pipe to be cleaned, and shall be placed at ceiling level, in walls, or slabs, as need be, for ease of operation.
- 2.4.2 Floor pipe cleanouts on PVC pipes shall have stainless steel cover.

2.5 PVC Roof Vent Caps

- 2.5.1 Supply and install vent caps on all vent stacks at the highest level of the stack and wherever shown on the Drawings.
- 2.5.2 Each vent cap shall be of UPVC with open slots all around cowl and shall be cemented onto the stack vent pipe at least 150 cm above roof level.

2.6 PVC Floor Drains

- 2.6.1 Supply and install wherever shown on the Drawings floor drains of sizes and shapes as indicated on the Drawings.
- 2.6.2 Each floor drain shall be of the UPVC construction with 70 mm water seal.
- 2.6.3 Drain shall have white polypropylene removable square tile with circular grid strainer. The open area of the strainer shall be at least two-thirds of the cross section area of the drain line to which it connects.
- 2.6.4 Drain shall be fitted with 1" (25mm) access plug for cleaning purposes.
- 2.6.5 This drain shall be applicable to shafts.

PART 3 EXECUTION

3.1 Internal Drainage Installation Requirements

- 3.1.1 All horizontal soil and waste piping shall be installed with a slope of not less than one percent (1%) unless otherwise specified and/or noted on the Drawings.
- 3.1.2 All horizontal soil and waste piping shall be installed with a slope of not less than one percent (1%) unless otherwise specified and/or noted on the Drawings.
- 3.1.3 All plumbing fixtures shall be individually trapped and vented. Rough in and install fixtures at height as recommended by manufacturer unless otherwise indicated. Sinks directly connected to grease traps shall not be trapped.
- 3.1.4 Vent piping shall not be trapped and shall be graded to drip back to waste or soil line.
- 3.1.5 Changes in direction of piping shall be generally made with long radius fittings.
- 3.1.6 Floor drains subject to evaporation shall have a water seal of 125mm.
- 3.1.7 Floor drains shall be clamped to flashing or to water proofing membrane. Clamping collars shall be supplied with drains only where flashing is required.
- 3.1.8 All floor drains shall be set 3 mm. below the normal finished floor, with a gradual pitch extending away from the drain, unless otherwise noted on Architectural Drawings.
- 3.1.9 All pipes and fittings shall be kept clean, with the exposed ends of in-completed or unconnected work to be plugged.
- 3.1.10 Cleanouts shall be placed at all changes in directions, at bends, at ends of soil, waste, sewer and as shown on drawings with a maximum spacing of 15 m. on straight runs inside building.
- 3.1.11 All pipes running under building or under streets shall be encased in concrete of minimum 100 mm thickness.
- 3.1.12 All work done under this section shall be in accordance with the National Plumbing Code Handbook and Uniform Plumbing Code unless otherwise specified.

3.2 External Drainage Installation Requirements

- 3.2 Connections to manholes shall be watertight after installation.
- 3.2.1 All piping shall conform accurately to the lines and grades shown on the Drawings.
- 3.2.2 Any connections for existing systems shall be made with a minimum amount of disturbance to the existing lines.
- 3.2.3 Any existing pipe lines or structures which are damaged while making connections shall be replaced or reconstructed to the satisfaction of the Engineer without cost to the Employer.
- 3.2.4 All piping shall be examined for defects. Any defective piece discovered after installation and test shall be removed and replaced by the Contractor at no expense to the Employer.
- 3.2.5 System shall be inspected and joints approved before any backfilling is placed over pipes.
- 3.2.6 All pipe and fittings shall be kept clean until final acceptance of work. The exposed ends of all in-completed lines shall be closed with wooden plugs adequately secured at all times when pipe laying is not actually in progress.

3.2.7 All piping shall be installed on a good foundation and adequate means taken to prevent settlement.

3.2.8 Precautions shall be taken to protect incomplete work from flooding due to storms or other causes. All pipe lines or structures not stable against uplift during construction shall be thoroughly braced or otherwise protected.

3.3 Manholes Installation Requirements

3.3.1 Manholes shall have the minimum inside dimensions shown on the Drawings.

3.3.2 Manhole walls shall be of poured-in-place reinforced concrete. Top section must be cast such as to suit elevation and accommodate size of manhole frame and cover.

3.3.3 Manhole floor shall be of reinforced concrete and inverts stream lined with cement and mortar into a semi-circular path with sanitary turns and have their corners filled and sloped towards the water path to prevent any settlements of solids as detailed on the Drawings.

3.3.4 Concrete foundation matts for manholes shall be constructed in accordance with details as shown on the Drawings.

3.3.5 All pipes or castings to be embedded in the manhole walls shall be accurately set, and if so required, headers shall be laid round the casting so embedded.

3.3.6 All work must be carried out in a manner to ensure watertight work, and any leaks shall be caulked, repaired, or the entire work shall be removed and rebuilt. Attention is particularly called to the necessity of keeping the water level below all parts of the foundation and walls until the cement has obtained adequate setting.

3.4 Frames, Covers & Gratings

3.4.1 The Contractor shall furnish and set level and to the proper grade, frame and cover or frame and grating of the form and dimensions shown on the Drawings. The concrete masonry shall be neatly and accurately brought to the dimensions of the base of the frame. The frames shall be thoroughly embedded in mortar. All covers and frames shall be to BS 497 Part 1.

3.4.2 All castings for frames, covers, and gratings shall be of tough gray iron, complying with BS 2789:1973 (Updated 1985). All castings shall be made accurately to dimensions and shall be machined to provide even bearing surfaces. Covers and gratings must fit the frames in any position and if found to rattle under traffic, shall be replaced. Filing to obtain tight covers will not be permitted. No plugging, burning-in or filling will be allowed. All castings shall be carefully coated inside and out with coal tar based material complying with the requirements specified in BS 4164. Coating surfaces shall be clean, dry and free from rust before applying the coatings.

3.4.3 Covers of manholes located inside buildings shall be of double seal and those located outside shall be of single seal.

3.5 Excavation and Backfilling for Pipe Laying

3.5.1 The laying of pipe underground will require trimming and grading of trench bottoms for pipes and will require backfilling with approved materials and tamping around all pipes to center line of pipes as the pipe laying progresses to provide protection and stability for the piping. Pipe laying work shall be conducted so that trenching operations are not advanced too far ahead of pipe laying operations resulting in excessive lengths of open trenches.

3.5.2 The pipe shall not be laid in water or when the trench or weather conditions are unsuitable for such work.

- 3.5.3 The Contractor shall trim the bottom of all trenches to receive pipes and shall provide grade finish by hand methods. The bottoms of all trenches shall be rounded so that, in so far as practical at least one-third of the circumference of the pipe will rest firmly on 200 mm. of undisturbed sand at proper line and grade. Bell holes, where required, shall be dug to ensure pipe resting for its entire length upon the bottom of the trench. Trenches shall not be excavated below grade by machine.
- 3.5.4 After pipes have been tested and approved, trenches shall be backfilled with approved materials carefully deposited in layers not to exceed 150 mm. in thickness on both sides, and thoroughly and carefully tamped. Backfilling and tamping in layers of 150 mm. shall be continued until a depth of 300 mm. has been placed over the pipe. Backfill around the pipes to a depth of 150 mm. shall be clean sand. No backfill shall be placed in a manner such as to cause injury to the pipe. Where pipe crossings occur, the lower pipe shall be laid first and the backfill thoroughly compacted to the level of laying the higher pipe. Backfill materials under such conditions shall be earth, approved gravel or concrete as directed.
- 3.5.5 Care should be taken to provide adequate cover before using power compactors or heavy rollers.
- 3.5.6. All pipes running under roads and all pipes with a cover of less than one meter, should be protected by laying concrete or precast concrete slab over the bedding.
- 3.6 Drainage Testing**
- 3.6.1 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 immediately and to the satisfaction of the Engineer.
- 3.6.2 The Contractor shall perform, at his own expense, any tests or inspections required by local authorities. The Engineer shall witness the tests.
- 3.6.3 All joints shall be inspected and an inspection of the line as a whole shall show pipes to be true to line and grade with full circles visible at all manholes.
- 3.7 Fixtures Testing**
- 3.7.1 When the roughing-in work is completed and before connection of fixtures, the entire system shall be subjected to thorough flushing and then to a water test by plugging up all openings and filling all of the lines as per tests sections. Any defects shall be corrected, at the expense of the Contractor.
- 3.7.2 After all fixtures are connected, the entire system shall be subjected to a smoke test. For PVC piping the correct grade of cartridge should be selected so that it is not harmful to the pipe-work or joint materials or an air test shall be performed in accordance with BS 8005 Part 1.
- 3.7.2 Tests shall be performed in the presence of the parties having jurisdiction and the Engineer, and all results shall be recorded.

SANITARY WASTE AND VENT PIPING

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and its requirements.

1.1 Introduction

1.1.1 Works of this Section shall be governed by Conditions of Contract and requirements.

1.1.2 This section describes basic materials and requirements for Pipework services installations for building.

1.2 Related Works Specified Elsewhere

1.2.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

- General Mechanical Requirements for Plumbing.
- Plumbing Insulation
- Facility Sanitary Sewerage
- Facility Storm Drainage
- Plumbing Fixtures

1.3 Storage of UPVC Pipes

1.3.1 UPVC pipe and fittings shall be stored under cover at all times. Sun light shall not be permitted to come into contact with the PVC materials at any time, except during installation in trench. The pipes shall be stored on flat level ground free from large or sharp edged stones or objects, and shall be stacked to a maximum height of 1.5 m. (or as recommended by the manufacturer) with sockets at alternate ends, and in such a manner as to prevent sagging or bending.

1.4 Pipe Identification

1.4.1 All pipes shall be indelibly marked at intervals of not greater than 3m. The marking shall show the manufacturer's identification, the standard name and number, and the nominal size and class. Adhesive labels alone shall not suffice. All pipes complying with British Standards shall be kite marked.

1.5 Codes and Standards

1.5.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
American Water Works Association	AWWA	C601-68 C501-67 M45	FIBERGLASS PIPE DESIGN MANUAL
American Society for Testing and Materials	ASTM	ASTM A53-88a	Specification for pipe, steel, black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
		ASTM A307	Specification for Carbon Steel Bolts and Studs. 60,000psi tensile strength
		ASTM D1785	Specification for poly (vinyl chloride) (PVC) plastic pipe, schedules 40, 80, and 120.
		ASTM D3517M	Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermo-setting – Resin) Pressure Pipe.
American Standard Association	ASA	ASA 40.1	-
		ASA B16.22	-
		ASA B1618	-
		ASA B9.1	-
British Standards	BS	ASA B35.5	-
		BS 4514	Specification for unplasticized PVC soil and venting pipes, fittings and accessories.
		BS 5255	Specification for thermoplastics waste pipe and fittings.
		BS 5254	Specification for polypropylene waste pipe and fittings (external diameter 34.6 mm, 41.0 mm and 54.1 mm.)
		BS 3505	Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water.
		BS 4346 Part 1	Joints and fittings for use with unplasticized PVC pressure pipes. Injection moulded unplasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply.
		BS 4346 Part 2	Mechanic joints and fittings, principally of unplasticized PVC.
		BS 4660	Specification for unplasticized polyvinyl chloride (PVC-U) pipes and plastics fittings of nominal

			sizes 110 and 160 for below ground gravity drainage and sewerage.
		BS 5481	Specification for unplasticized PVC pipe and fittings for gravity sewers.
		BS 1387	Specification for screwed and socketed steel tubes and tubulars and for plain and steel tube suitable for welding or for screwing to BS21 pipe threads.
		BS 3601	Specification for carbon steel pipes and tubes with specified room temperature properties for pressure pipes.
		BS 21	Specification for pipe threads for tubes and fittings where pressure tight joints are made on the threads.
Deutsches Institute for Normung	DIN	DIN 19534	-
American National Standards Institute	ANSI	ANSI B18.2.2	
		ANSI B31.1	
		ANSI A21,10,11	-

PART 2 PRODUCTS

2.1 UPVC Pipes TYPE 1

- 2.1.1 Polyvinyl chloride pipes (PVC) shall be of the unplasticized rigid type and of high density and complete homogeneity material
- 2.1.2 UPVC Pipes -Type 1 shall comply with BS EN 1329-1 : 2000 specification for pipes, fittings and the system.
- 2.1.3 UPVC Pipes - Type 1 piping systems shall be used in the field of :
 - 2.1.3.1 Soil and waste discharge systems (low and high temperature) inside buildings (marked with "B").
 - 2.1.3.2 Soil and waste discharge systems for both inside buildings and buried in ground within the building structure (marked with "BD").
 - 2.1.3.3 Ventilation pipe work.
- 2.1.4 UPVC Pipes Type 1 piping system sockets and spigots shall be either for solvent cement joints or ring seal joints.

2.2 UPVC Pipes - Type 3

- 2.2.1 Polyvinyl chloride pipes (PVC) shall be of the un-plasticized rigid type and of high density and complete homogeneity material.

- 2.2.2 UPVC Pipes - Type 3 shall comply with BS EN 1401-1 : 1998 specifications for pipes, fittings and the system.
- 2.2.3 UPVC Pipes - Type 3 shall be used in the field of non-pressure under ground drainage and sewerage:
- 2.2.3.1 Outside the building structure (marked "U") and
- 2.2.3.2 Both buried in ground within the building structure and outside the building (marked "D").

PART 3 EXECUTION

3.1 Arrangement and Alignment of Pipes

- 3.1.1 Install piping in a neat, workmanlike manner and the various lines shall be parallel to building walls wherever possible.
- 3.1.2 Install pipe groups for plumbing parallel with pipes of other trades.
- 3.1.3 Space pipe supports, arrange reducers and Pitch piping to allow air to be vented to system high points and to allow the system to be drained at the low points. However, where obstructions exist, automatic air vents shall be installed at all air pocket points and ½" (15 mm) drain gate valves shall be supplied and installed at all low points and riser legs.

3.2 Special Requirement for PVC Pipe Installation

- 3.2.1 Before installation, the pipe shall be inspected for defects. Defective, damaged or unsound pipe will be rejected. Deflections from a straight line or grade, between the center lines extended, of any 2 connecting pipes made necessary by vertical curves or horizontal curves or offsets, shall not exceed 12500/D mm. per linear meter of pipe, where D represents the nominal internal diameter of the pipe expressed in millimeters. If the alignment requires deflections in excess of these limitations, special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth. Except where necessary in making connections with other lines, pipe shall be laid with the bells facing in the direction of laying.
- 3.2.2 Pipes in trenches-Place each length of pipe with a uniformly distributed bearing for the bottom 0.3 of the pipe on the sand fill in the trench. Excavate recesses to accommodate pipe bells, sleeves, glands or other fittings. Take up and re-lay any pipe that has the grade or joint disturbed after laying. Clean the interior of the pipe of all foreign material before lowering into the trench, and keep clean during laying operations by means of plugs or other acceptable methods.
- 3.2.3 Plumbing vents exposed to sun light shall be protected by waterbase synthetic latex paints.
- 3.2.4 Thermal Expansions
- 3.2.4.1 When drainage and vent stacks exceed six (6) meters in height, approved expansion joints, restraint fittings and offsets shall be placed on vertical risers and horizontal branches as follows:
- 3.2.5 Expansion joints are recommended at alternate floors in all vertical stacks.
- 3.2.6 Expansion joints shall be placed in horizontal branches containing two or more vertical risers and exceeding ten (10) meters in length immediately upstream of vertical riser whenever possible.

- 3.2.7 .An expansion joint, shall be placed below the connection point of a waste pipe to the stack, if this connection is exposed below floor slab, and above the connection point if this connection is above floor slab.
- 3.2.8 No expansion joints shall be required in building drain below grade.
- 3.2.10 Approved expansion fittings that utilize rubber-o-rings in a recessed groove may be used to compensate for thermal expansion. The ring slides along the pipe when expansion or contraction occurs. Expansion joints shall be installed by solvent cementing techniques.

3.3 General Requirements for Piping Installation

- 3.3.1 Make all changes in size and direction of piping with standard fittings.
- 3.3.2 Make all branch connections with tees.
- 3.3.3 Use eccentric reducing fittings or eccentric reducing couplings where required by the contract documents or where required to prevent pocketing of liquid or non-condensable.
- 3.3.4 Pipe bending shall not be resorted to except in extreme cases and only after the written approval of the Engineer.
- 3.3.5 Piping shall be designed with Loops to take the thermal expansion. Wherever this is not possible for physical reasons, expansion joints with guides shall be used.
- 3.3.6 Installation of pipes shall be complete with all cutting, patching and making good of walls, slabs, partitions, etc., due to fixing, supporting and anchoring of pipes.
- 3.3.7 Pipes and fittings shall both be manufactured according to one single standard unit of measurement in metric.

3.4 Pipe Sleeves

- 3.4.1 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un-insulated lines or of the insulation for insulated pipes.
- 3.4.2 Install sleeves through interior walls and partitions flush with finished surfaces; sleeves through outside walls to project 15mm. on each side of the finished wall; and floor sleeves to project 25mm. above finished floors.
- 3.4.3 Set sleeves in place before pouring concrete or securely fasten and grout in with cement.
- 3.4.4 Sleeve construction:
 - . Interior Partitions - galvanized sheet iron.
 - . Interior & Exterior Masonry Walls and Floors-galvanized steel pipe.
- 3.4.5 Fill the space between outside of pipe or insulation and the inside of the sleeve or framed opening with fibrous asbestos in interior walls and floors and pack with oakum, seal with watertight mastic or asphalt in exterior walls.

3.5 Cleaning of Piping Systems

- 3.5.1 Plug all opening ends of piping, valves and equipment except when actual work is being performed to minimize accumulation of dirt and debris.
- 3.5.2 After installation is complete, place temporary screens at connections to all equipment and at automatic control valves where permanent strainers are not provided.

- 3.5.3 Prior to the performance of tests, flush out all piping that is to receive a hydrostatic test with clean water.
- 3.5.4 Remove dirt and debris collected at screens, strainers and other points from the system.
- 3.5.5 The Contractor shall disinfect water piping before it is placed in service. The Contractor shall furnish all equipment and materials necessary to do the work of disinfecting and shall perform the work in accordance with the procedure outlined in AWWA Standard for Disinfecting Water Mains Designation C 601-68. The dosage shall be such as to produce a chlorine residual for not less than 10 ppm after a contact period of not less than 24 hours. After treatment, the piping shall be flushed with clean water until the residual chlorine content does not exceed 0.2 ppm.
- 3.5.6 During the disinfecting period, care shall be exercised to prevent contamination of water in steel main.

3.6 Material Tests and Identification

- 3.6.1 In addition to the tests required for specific piping systems, the manufacturer shall test all materials as specified prior to delivery.
- 3.6.2 Check all materials for defects. Identify all materials with factory applied permanent stampings or markings designating their conformance to specified requirements.

3.7 Testing

3.7.1 Drainage and Sewer Pipes

- 3.7.1.1 Drains and sewers should generally be subjected to an internal pressure test of 1.2 m head of water above the crown of the pipe at the high end but not more than 6 m at the low end. Inspection and tests should be made during the installation and as the work proceeds, to ensure the pipework is properly secured and clear of obstructing debris and superfluous matter.
- 3.7.1.2 The final test of the completed drainage and vent system shall be made by filling all traps with water and then introducing into the entire system a pungent, thick smoke produced by one or more smoke machines. When the smoke appears at stack openings on the roof, the stack openings shall be closed and a pressure equivalent to a 1-inch water column (248.8 Pa) shall be held for a test period of not less than 15 minutes.

FACILITY STORM DRAINAGE

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and its requirements.

1.1 Storm Drainage

1.1.1 Storm water shall be drained by means of roof drains and leaders and free discharged around the building at convenient locations shown on the Drawings.

1.2 Reference Standard

1.2.1 All work under this section shall conform to the requirements of the National Plumbing Code Handbook and Uniform Plumbing Code, unless otherwise specified hereinafter.

1.3 Codes and Standards

1.3.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall conform to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
National Plumbing Code	NPC	-	-
Uniform Plumbing Code	UPC	-	-
British Standards	BS	BS497	Specification for manhole covers, road gully gratings and frames for drainage purposes
		BS4164	Specification for coal-tar-based hot-applied coating materials for protecting iron and steel, including a suitable primer.
		BS8005 Part 1	Guide to new sewerage construction.

1.4 Related Works Specified Elsewhere

1.4.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

- General Mechanical Requirements for Plumbing.
- Facility Sanitary Sewerage
- Sump Pumps
- Plumbing Equipment

PART 2 PRODUCTS

2.1 UPVC Pipes Type 1

- 2.1.1 Polyvinyl chloride pipes (PVC) shall be of the unplasticized rigid type and of high density and complete homogeneity material
- 2.1.2 UPVC Pipes -Type 1 shall comply with BS EN 1329-1 : 2000 specification for pipes, fittings and the system.
- 2.1.3 UPVC Pipes - Type 1 piping systems shall be used in the field of :
 - 2.1.3.1 Ventilation pipe work.
 - 2.1.3.2 Rainwater pipework within the building structure.
- 2.1.4 UPVC Pipes Type 1 piping system sockets and spigots shall be either for solvent cement joints or ring seal joints.

2.2 UPVC Pipes - Type 3

- 2.2.1 Polyvinyl chloride pipes (PVC) shall be of the un-plasticized rigid type and of high density and complete homogeneity material.
- 2.2.2 UPVC Pipes - Type 3 shall comply with BS EN 1401-1 : 1998 specifications for pipes, fittings and the system.
- 2.2.3 UPVC Pipes - Type 3 shall be used in the field of non-pressure under ground storm.
 - 2.2.3.1 Outside the building structure (marked "U") and
 - 2.2.3.2 Both buried in ground within the building structure and outside the building (marked "D").

2.3 Cleanouts

- 2.3.1 Each cleanout shall be of the same material and dimensions as the pipe to be cleaned, and shall be placed at ceiling level, in walls, or slabs, as need be, for ease of operation.
- 2.3.2 Floor pipe cleanouts on PVC pipes shall have stainless steel cover.

PART 3 EXECUTION

3.1 Internal Storm Water Installation Requirements

- 3.1.1 All storm drainage piping above grade shall have a slope of two percent (2%) where possible the minimum acceptable is one percent (1%).
- 3.1.2 Changes in direction of piping shall be generally made with long radius fittings.
- 3.1.3 All pipes and fittings shall be kept clean, with the exposed ends of in-completed or unconnected work to be plugged.
- 3.1.4 Cleanouts shall be placed at all changes in directions, at bends, at ends of pipes and as shown on drawings with a maximum spacing of 15 m. on straight runs inside building.
- 3.1.5 All pipes running under building or under streets shall be encased in concrete of minimum 100 mm thickness.
- 3.1.6 All work done under this section shall be in accordance with the National Plumbing Code Handbook and Uniform Plumbing Code unless otherwise specified.

3.2 Testing

- 3.2.1 If an inspection of the completed part thereof shows any structures, pipes or joints which are defective, the defective work shall be replaced or repaired immediately and to the satisfaction of the Engineer.
- 3.2.2 The Contractor shall perform, at his own expense, any tests or inspections required by local authorities. The Engineer shall witness the tests.
- 3.2.3 All joints shall be inspected and an inspection of the line as a whole shall show pipes to be true to line and grade with full circles visible at all manholes.

SANITARY FIXTURES

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and its requirements.

1.1 Scope of Work

- 1.1.1 The Sanitary Fixtures along with accessories, pipe fittings shall be installed and put in operation as hereinafter specified and as shown on drawings.
- 1.1.2 All fixtures and trimmings, insofar as practicable, shall be of one manufacture.
- 1.1.3 Ample application of petroleum jelly shall be made to all surfaces of exposed chrome plated piping, valves and fittings immediately after installation.
- 1.1.4 All fixtures shall be set straight and true.
- 1.1.5 Concealed brackets, hangers and plates shall have a shop coat of paint.
- 1.1.6 All exposed piping and trim shall be chrome plated and fully protected during installation. Strap or padded wrenches shall be used on chrome plated pipe fittings and valves.
- 1.1.7 Contractor shall comply with authorities requirements for GreenBuilding (if applicable) and shall consider the following flow rates:-
 - 1.1.7.1 Maximum flow rate for shower = 1.5 gpm (Not Applicable In Our Case)
 - 1.1.7.2 Maximum flow rate for Lavatory = 0.5 gpm
 - 1.1.7.3 Maximum flow rate for all toilets = 1.1 gallon per flush
 - 1.1.7.4 All Toilets shall be dual flush.
 - 1.1.7.5 All ablutions taps shall be self closing type.

1.2 Related Works Specified Elsewhere

- 1.2.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.
 - General Mechanical Requirements for Plumbing
 - Plumbing Piping and Pumps
 - Plumbing Equipment

PART 2 PRODUCTS

2.1 Sanitary Fixtures

- 2.1.1 Sanitary fixtures shall be complete with all required trimming, including mixers, waste plugs, traps, supplies, stop valves, escutcheons, casings and all necessary hangers, plates, brackets, anchors and supports.
- 2.1.2 Vitreous china fixtures shall be of first quality with smooth glazed surfaces, free from warp, cracks, checks, discolorations or other imperfections.
- 2.1.3 Enamelled cast iron fixtures shall be of acid-resisting type.
- 2.1.4 In the selection of sanitary fixtures and their accessories, model numbers of certain manufacturers catalogues are given to describe the type, shape and quality of the items

requested and do 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.

- 2.1.5 All fixtures and fittings types and models shall be as detailed in the schedule of fixtures, indicated on the Drawings.

2.2 Accessories

- 2.2.1 Accessories shall be provided in the locations indicated on Architectural Drawings and fixed at heights indicated therein or as directed by the Engineer. The Accessories shall be from approved manufacturers.

PART 3 EXECUTION

3.1 Exposed Piping and Trim in Toilet Areas

- 3.1.1 All piping, valves and fittings exposed to view shall be screwed, polished, chrome plated brass. Plating shall be accomplished after threading.

3.2 Fixture Setting

- 3.2.1 Fixtures shall be set in a neat, finished and uniform manner making the connections to all fixtures at right angles to the wall, unless otherwise directed by the Engineer. Roughing for this work must be accurately laid out so as to conform to finished wall material. Fixtures are not to be set until so directed by the Engineer.

- 3.2.2 The location and disposition of all items shall be as indicated on the relevant drawings.

3.3 Cleaning

- 3.3.1 On a daily basis as the Works of this Section proceed, remove and dispose of all debris resulting from the Works of this Section.
- 3.3.2 Leave work areas of the Works of this Section broom clean at the end of each work day.

DOMESTIC WATER PIPING AND FITTINGS

PART 1 GENERAL

1.1 Introduction

1.1.1 Works of this Section shall be governed by Conditions of Contract.

1.1.2 This section describes basic materials and requirements for Pipework services installations for building.

1.2 Related Works Specified Elsewhere

1.2.1 The works specified contains the following:

- General Mechanical Requirements for Plumbing
- Plumbing Insulation
- Plumbing Piping and Pumps
- Plumbing Equipment
- Plumbing Fixtures
- Pool and Fountain Plumbing System
- Gas and Vacuum Systems For Laboratory & Healthcare Facilities

1.3 Storage of UPVC Pipes

1.3.1 PVC pipe and fittings shall be stored under cover at all times. Sun light shall not be permitted to come into contact with the PVC materials at any time, except during installation in trench. The pipes shall be stored on flat level ground free from large or sharp edged stones or objects, and shall be stacked to a maximum height of 1.5 m. (or as recommended by the manufacturer) with sockets at alternate ends, and in such a manner as to prevent sagging or bending.

1.4 Pipe Identification

1.4.1 All pipes shall be indelibly marked at intervals of not greater than 3m. The marking shall show the manufacturer's identification, the standard name and number, and the nominal size and class. Adhesive labels alone shall not suffice. All pipes complying with British Standards shall be kitemarked.

1.5 Arrangement and Alignment

1.5.1 Install piping in a neat, workmanlike manner and the various lines shall be parallel to building walls wherever possible.

1.5.2 Install pipe groups for plumbing parallel with pipes of other trades.

1.5.3 Space pipe supports, arrange reducers and Pitch piping to allow air to be vented to system high points and to allow the system to be drained at the low points. However, where obstructions exist, automatic air vents shall be installed at all air pocket points and 1/2" (15 mm) drain gate valves shall be supplied and installed at all low points and riser legs.

1.6 Storage

- 1.6.1 PVC pipe and fittings shall be stored under cover at all times. Sun light shall not be permitted to come into contact with the PVC materials at any time, except during installation in trench. The pipes shall be stored on flat level ground free from large or sharp edged stones or objects, and shall be stacked to a maximum height of 1.5 m. (or as recommended by the manufacturer) with sockets at alternate ends, and in such a manner as to prevent sagging or bending.

1.7 Codes and Standards

- 1.7.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

<u>Reference Code</u>	<u>Abbreviation</u>	<u>Applicable Standard</u>	<u>Title of Standard</u>
American Water Works Association	AWWA	C601-68 C501-67 M45	FIBERGLASS PIPE DESIGN MANUAL
American Society for Testing and Materials	ASTM	ASTM C425	Specification for compression joint for vitrified clay pipe and fittings.
		ASTM A53-88a	Specification for pipe, steel, black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
		ASTM B88	Specification for seamless copper water pipe.
		ASTM B280-88	Specification for seamless copper tube for A/C and refrigeration field service.
		ASTM A307	Specification for Carbon Steel Bolts and Studs. 60,000psi tensile strength
		ASTM D1785	Specification for poly (vinyl chloride) (PVC) plastic pipe, schedules 40, 80, and 120.
		ASTM D3517M	Specification for "Fiberglass" (Glass – Fiber-Reinforced Thermosetting – Resin) Pressure Pipe.
American Standard Association	ASA	ASA 40.1	-
		ASA B16.22	-
		ASA B1618	-

		ASA B9.1	-
		ASA B35.5	-
British Standards	BS	BS 4514	Specification for unplasticized PVC soil and venting pipes, fittings and accessories.
		BS 5255	Specification for thermoplastics waste pipe and fittings.
		BS 5254	Specification for polypropylene waste pipe and fittings (external diameter 34.6 mm, 41.0 mm and 54.1 mm.)
		BS 3505	Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water.
		BS 4346 Part 1	Joints and fittings for use with unplasticized PVC pressure pipes. Injection moulded unplasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply.
		BS 4346 Part 2	Mechanic joints and fittings, principally of unplasticized PVC.
		BS 4660	Specification for unplasticized polyvinyl chloride (PVC-U) pipes and plastics fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage.
		BS 5480	Specification for Glass Reinforced Plastic (GRP) Pipes, Joints and Fittings for use of Water Supply or Sewerage.
		BS 5481	Specification for unplasticized PVC pipe and fittings for gravity sewers.
		BS 1387	Specification for screwed and socketed steel tubes and tubulars and for plain and steel tube suitable for welding or for screwing to BS21 pipe threads.
		BS 2871	Specification for copper and copper alloys, tubes.
		BS 864 Part 2	Specification for capillary and compression fittings for copper tubes.
		BS 3601	Specification for carbon steel pipes and tubes with specified room temperature properties for pressure pipes.
		BS 21	Specification for pipe threads for tubes and fittings where pressure tight joints are made on the threads.
American Society for Heating,	ASHRAE	-	-

Deutsches Institute for Normung	DIN	DIN 19534	-
American National Standards Institute	ANSI	ANSI B18.2.2 ANSI B31.1 ANSI A21,10,11	-

PART 2 PRODUCTS

2.1 UPVC Pipes - Type 2

- 2.1.1 UPVC pipes-Type 2 (Un-plasticized Polyvinyl Chloride) pipes shall be to BS 3505 latest edition Class E 15 Bar (1500 Kpa) working pressure at 68° F (20° C) fluid temperature and 103° F (40° C) ambient temperature or ASTM specification D 1785 Schedule 40 for inside the buildings, and as per ASTM specification D1785 schedule 80 for the risers.
- 2.1.2 The pipe shall be homogenous throughout and free from visible cracks, holes, foreign inclusions or other defects. The pipe shall be as uniform as commercially practicable in color, opacity, density and other physical properties.
- 2.1.3 All fittings and accessories shall be of same material and quality as the pipe and jointing up to 2 ½" diameter shall be of the spigot and socket cemented type where solvent cement is applied to both parts all in compliance with B.S. 4346: Part I: 1969 joints and fittings for use with un-plasticized PVC pressure pipes, Part I : Injection moulded PVC PVC fittings for solvent welding for use with pressure pipes. After pushing the pipe into the socket, the joint shall be allowed to set for at least 10 hr.
- 2.1.4 Jointing for all pipes buried underground outside buildings and for all pipes above 3" diameter shall be of the rubber ring integral socket type to BS 4346 Part 2.
- 2.1.5 Expansion joints with guides as recommended by manufacturer shall be installed on long run solvent cemented pipes every 30 meters of length, and wherever shown in the specification.
- 2.1.6 Bending PVC pipes is only allowed in non-critical application at room temperature and after the approval of the Engineer.
- 2.1.7 Before bending, the pipe should be heated at the section to be bent to a temperature of about 275-300° F (135-150° C).
- 2.1.8 The bore should be supported by packing with sand or by insertion of thick rubber pipe, the heating being carried out in a hot air oven or by immersion in hot oil or glycerine. Overheating should be avoided, and the pipe should not be held at the bending temperature too long.

2.2 Cross Linked Polyethylene Pipes (XLPE)

- 2.2.1 XLPE piping system shall be basically consist of the following components:
 - 2.2.1.1 Cross linked polyethylene pipe pulled in coloured (red for hot water blue for cold water application) corrugated conduits of polyethylene material.
 - 2.2.1.2 Ring main line fittings and valves of bronze or DZR brass construction.

2.2.2 Pipes

- 2.2.2.1 The inner pipe shall be made of cross linked polyethylene which can withstand up to 95 degree C fluid temperature inside it at a maximum pressure of 10 bars. Pipes shall be able to withstand short time temperature loading up to 110 degree C at a maximum pressure of 10 bars.
- 2.2.2.2 All pipes shall be stamped at equal intervals with clear marks showing clearly the name of the manufacturer along with the pressure and temperature ratings, pipe diameter and wall thickness, pipe standard DIN 16892/93 and the country of origin of manufacturer.
- 2.2.2.3 All pipes shall be laid so that they can be easily replaced, whenever necessary by fast and easy pulling from the conduits.
- 2.2.2.4 Pipes shall satisfy the requirement for drinking water installation and approved by a recognized health organization DVGW or equivalent whenever specifically intended for potable application.

2.2.3 Conduits

- 2.2.3.1 The conduits shall be made of temperature stabilized high density polyethylene and shall be capable of retaining its form up to 105 degree C. Conduits shall have different colour for different application.

2.2.4 Fittings & Accessories

- 2.2.4.1 One single line XLPE pipe in one single conduit will supply water to one fixture only from a main ring above false ceiling.
- 2.2.4.2 Ring feed line shall have an isolating valve of bronze construction. Each pipe at its termination above false ceiling shall be labeled with a tag indicating the fixture it is supplying.
- 2.2.4.3 Pipes to be connected to the different fittings via a special wall box of reinforced plastic fitted with bronze or DZR brass elbow suitable for ½" or ¾" threaded connection as required. The box should be suitably designed in order to enable the replacement of existing pipes in the event of their damage (puncturing).
- 2.2.4.4 All valves, wallbox, elbows, tees, bends should be of bronze or DZR brass connections to be of a cone grip unions type allowing full flow capacity, minimum pressure loss, easily detachable with torque clearly defined for a fool proof installation.
- 2.2.4.5 Contractor to use proper tools for assembly as recommended by manufacturer, i.e. assembly pliers, Ratchet torque wrench, cutters, etc.
- 2.2.4.6 Distribution ring shall be located above the false ceiling as indicated on the drawings.

2.3 **Polypropylene Pipes (PP-R)**

- 2.3.1 Polypropylene Copolymer Random (PP-R) pipes shall be manufactured according to DIN 8077/8078, fittings shall be manufactured according to DIN 16962.
- 2.3.2 Pipes and fittings shall be jointed using electro-fusion welding process. Welding shall be made as recommended by the manufacturer. Threaded fittings shall be used to connect to other piping systems, fixtures, etc., fitting with metal insert shall be sealed with Teflon tape.

- 2.3.3 PP-R piping system shall be installed with special pre-caution for thermal expansion especially for exposed installation.
- 2.3.4 Thermal expansion shall be compensated by use of proper elbows, fittings, as recommended by the manufacturer.
- 2.3.5 PP-R pipes shall not be installed or stored under direct UV light. Pipes in shafts and roof shall be of multi-layer PP-R aluminium consisting of main pipe PP-R coated with aluminium foil and covered with PP-R film treated to resist long time exposure to UV light. Pipes on roof shall be insulated and cladded.
- 2.3.6 Pipe bending shall be generally avoided, in extreme cases pipes may be bent by heating with hot air without direct flames. The minimum bending radius shall be 8 times the pipe diameter.
- 2.3.7 PP-R pipes and fittings shall be certified for potable water use by a recognized European Standard, DVGW or approved equivalent.
- 2.3.8 Pressure rating of pipes and fittings shall be PN 25. Pipes shall be suitable for working pressure of 10 bars at a working temperature of 60 degree C.

2.4 Flanged Pipe Joints

- 2.4.1 All flanged joints shall be made up with compressed ring type asbestos gaskets. Gaskets shall be 1.5 mm. thick.
- 2.4.2 Bolts for flanges shall be of low carbon steel with hexagonal heads and hard pressed steel hexagon nuts. Bolts shall be to ASTM specifications A 307 or SAE grade 2, with tensile strength of 64000 psi (441.3 Mpa) minimum.
- 2.4.3 All bolt holes shall be spot faced.

2.5 Joints between Dissimilar Materials

- 2.5.1 Screwed Pipe to Cast Iron Pipe
- 2.5.2 Joints between wrought-iron, steel, brass or copper pipe and cast iron pipe shall be made with cast iron spigots screwed to the steel pipe and caulked to the cast iron pipe.
- 2.5.3 Copper Tubing to Screwed Pipe Joints
- 2.5.4 Joints shall be made by the use of brass converter fittings. The joint between the copper pipe and the fitting shall be properly soldered, and the connection between the threaded pipe and the fitting shall be made with a standard pipe size screw joint.

2.6 Joints Between Dissimilar Metals (Dielectric isolators)

- 2.6.1 Make joints between ferrous and non-ferrous screwed piping and equipment by using Teflon or nylon isolating materials in the form of screwed unions.
- 2.6.2 Make joints between ferrous and non-ferrous flanged piping and equipment with insulating gaskets and "Teflon sleeves and washers between flanges, bolts and nuts.
- 2.6.3 The entire insulating joint including the dielectric material shall be suitable to withstand the temperature, pressure and other operating characteristics for the service for which they are used.

2.7 Fire Stop Collar

- 2.7.1 Supply and install factory manufactured fire stop collar for all the plastic pipes penetrating fire rated walls and floors. The Collar should be of heavy gauge galvanized metal to house the intumescent insert. The intumescent shall provide a minimum of 15 times the free expansion and shall contain no water soluble expansion ingredients and approved to be used in combination with the smoke sealant from the same manufacturer. The collar should be UL classified and FM systems approved to the requirements of ASTM E814 (UL 1479).
- 2.7.2 The fire sealant should be of non hardening compound, non water soluble ingredients, capable of expanding a minimum of 5 times when subjected to 230 degree F to 100°F. The sealant should be UL classified and FM system approved to the requirements of ASTM E814 (UL 1479).

2.8 Hose Bibs

- 2.8.1 Hose bibs shall be finished ¾" (20 mm) chrome plated brass, compression type with chrome plated handle and standard ¾" (20 mm) male hose connection or otherwise indicated on the Drawings.

2.9 Vacuum Breaker

- 2.9.1 Where indicated or otherwise required, vacuum breakers shall be installed and set at least 100 mm above the floor level of equipment or fixture rims to prevent contamination of water supply.

2.10 Shock Arrestor (Water Hammer)

- 2.10.1 Shock arrestor shall be mechanical pneumatic type, stainless steel construction with hermetically sealed bellows and threaded connection.
- 2.10.2 Arrestors shall be located adjacent to all quick closing valves, solenoid valves, where required and as indicated on Drawings.
- 2.10.3 Proper sizes shall be determined by the individual application.

2.11 Water Meter

- 2.11.1 Water meters, all bronze construction type, shall be supplied and installed by the Contractor. The water meter shall be a disk positive displacement type and shall be furnished with a straight reading dial and shall have a rated maximum delivery of not less than twice the flowing GPM (l/s).

2.12 Water Pressure Reducing Valves

- 2.12.1 Each valve shall be constructed of bronze body, with stainless steel spring and shaft and nylon diaphragm.
- 2.12.2 The spring shall be designed to provide the pressure reduction indicated on the Drawings.
- 2.12.3 The valve shall be designed for a work pressure of 250 psi and shall be threaded or flanged ended as the pipe connecting to it.

- 2.12.4 The valve shall be of the self contained type without any control lines with all internal parts being accessible by removing spring chamber and without dismantling the valve itself.
- 2.12.5 The valve shall be designed to operate smoothly and quietly without chattering or any water hammer problems.

2.13 Pipe Expansion Joints

- 2.13.1 Supply and install expansion joints wherever pipes cross structural expansion joints, wherever required to prevent undue stresses caused by thermal expansion of the pipes and wherever expansion cannot be accommodated by natural offsets and changes of direction.
- 2.13.2 Expansion joints shall be of the packless-bellow type with flanged or welded ends as suitable for the pipe application.
- 2.13.3 Bellows shall be of stainless steel and suitable for a pressure of 125 psi (860 Kpa) or the design working pressure, whichever is greater. Expansion joints shall be provided with guides to prevent any unnecessary misalignment of the pipe. Guides and anchor arrangements shall be per the recommendations of the expansion joints manufacturers and as shown on the drawings.

PART 3 EXECUTION

3.1 Arrangement and Alignment of Pipes

- 3.1.1 Install piping in a neat, workmanlike manner and the various lines shall be parallel to building walls wherever possible.
- 3.1.2 Install pipe groups for plumbing parallel with pipes of other trades.
- 3.1.3 Space pipe supports, arrange reducers and Pitch piping to allow air to be vented to system high points and to allow the system to be drained at the low points. However, where obstructions exist, automatic air vents shall be installed at all air pocket points and ½" (15 mm) drain gate valves shall be supplied and installed at all low points and riser legs.

3.2 Special Requirement for PVC Pipe Installation

- 3.2.1 Before installation, the pipe shall be inspected for defects. Defective, damaged or unsound pipe will be rejected. Deflections from a straight line or grade, between the center lines extended, of any 2 connecting pipes made necessary by vertical curves or horizontal curves or offsets, shall not exceed 12500/D mm. per linear meter of pipe, where D represents the nominal internal diameter of the pipe expressed in millimeters. If the alignment requires deflections in excess of these limitations, special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth. Except where necessary in making connections with other lines, pipe shall be laid with the bells facing in the direction of laying.
- 3.2.2 Pipes in trenches-Place each length of pipe with a uniformly distributed bearing for the bottom 0.3 of the pipe on the sand fill in the trench. Excavate recesses to accommodate pipe bells, sleeves, glands or other fittings. Take up and re-lay any pipe that has the grade or joint disturbed after laying. Clean the interior of the pipe of all foreign material before lowering into the trench, and keep clean during laying operations by means of plugs or other acceptable methods.
- 3.2.3 Plumbing vents exposed to sun light shall be protected by waterbase synthetic latex paints.

3.3 General Requirements for Piping Installation

- 3.3.1 Make all changes in size and direction of piping with standard fittings.
- 3.3.2 Make all branch connections with tees.
- 3.3.3 Use eccentric reducing fittings or eccentric reducing couplings where required by the contract documents or where required to prevent pocketing of liquid or non-condensable.
- 3.3.4 Pipe bending shall not be resorted to except in extreme cases and only after the written approval of the Engineer.
- 3.3.5 Piping shall be designed with Loops to take the thermal expansion. Wherever this is not possible for physical reasons, expansion joints with guides shall be used.
- 3.3.6 Installation of pipes shall be complete with all cutting, patching and making good of walls, slabs, partitions, etc., due to fixing, supporting and anchoring of pipes.
- 3.3.7 Automatic air vents shall be installed at all air pocket locations, and/or at the highest points in the lines.
- 3.3.8 Pipes and fittings shall both be manufactured according to one single standard unit of measurement either both English or both metric.

3.4 Connection to Equipment and Control Valves

- 3.4.1 Provide flanges or unions at all final connections to equipment and control valves to facilitate dismantling. Arrange connections so that the equipment being served may be removed without disturbing the piping.
- 3.4.2 Install all supply piping, pumps and other equipment including gate valves and strainers therein, at line size with the reduction in size being made only at the outlet piping from the control valve at the full size of the tapping in the equipment served.

3.5 Pipe Sleeves

- 3.5.1 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un-insulated lines or of the insulation for insulated pipes.
- 3.5.2 Install sleeves through interior walls and partitions flush with finished surfaces; sleeves through outside walls to project 15mm. on each side of the finished wall; and floor sleeves to project 25mm. above finished floors.
- 3.5.3 Set sleeves in place before pouring concrete or securely fasten and grout in with cement.
- 3.5.4 Sleeve construction:
 - . Interior Partitions - galvanized sheet iron.
 - . Interior & Exterior Masonry Walls and Floors-galvanized steel pipe.
- 3.5.5 Fill the space between outside of pipe or insulation and the inside of the sleeve or framed opening with fibrous asbestos in interior walls and floors and pack with oakum, seal with watertight mastic or asphalt in exterior walls.

3.6 Cleaning of Piping Systems

- 3.6.1 Plug all opening ends of piping, valves and equipment except when actual work is being performed to minimize accumulation of dirt and debris.
- 3.6.2 After installation is complete, place temporary screens at connections to all equipment and at automatic control valves where permanent strainers are not provided.
- 3.6.3 Prior to the performance of tests, flush out all piping that is to receive a hydrostatic test with clean water.
- 3.6.4 Remove dirt and debris collected at screens, strainers and other points from the system.
- 3.6.5 The Contractor shall disinfect water piping before it is placed in service. The Contractor shall furnish all equipment and materials necessary to do the work of disinfecting and shall perform the work in accordance with the procedure outlined in AWWA Standard for Disinfecting Water Mains Designation C 601-68. The dosage shall be such as to produce a chlorine residual for not less than 10 ppm after a contact period of not less than 24 hours. After treatment, the piping shall be flushed with clean water until the residual chlorine content does not exceed 0.2 ppm.
- 3.6.6 During the disinfecting period, care shall be exercised to prevent contamination of water in steel main.

3.7 Material Tests and Identification

- 3.7.1 In addition to the tests required for specific piping systems, the manufacturer shall test all materials as specified prior to delivery.
- 3.7.2 Check all materials for defects. Identify all materials with factory applied permanent stampings or markings designating their conformance to specified requirements.

3.8 Testing

3.8.1 Water Pipes

- 3.8.1.1 Test all domestic water piping system, including valves, fittings and joints under a pressure equal to 100 psig (690 Kpa) or 1 ½ times the working pressure, whichever is greater.
- 3.8.1.2 Blank off or remove all elements such as traps, instruments, automatic valves, diaphragm valve, relief valves, pumps or any other equipment which may be damage by test pressure. Open, but do not back seat, all valves.
- 3.8.1.3 Fill the system with water and vent the system at high points to remove air. Maintain the required test pressure for sufficient length of time to enable complete inspection to be made of all joints and connections and for a minimum of six hours, unless specified otherwise.
- 3.8.1.4 Repair all leaks or defects uncovered by the tests and retest the system.
- 3.8.1.5 After test have been completed, drain the system and blow out and clean it of all dust and/ or foreign matters. Clean all strainers, valves and fittings of all dirt, fillings and debris.

3.9 Installation of Unions and Flanges

- 3.9.1 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 15 metres of pipe run.

- 3.9.2 Unions shall be used on all screwed pipes and shall be of the same quality and service. Flanges, suitable for welding, shall be used on all welded pipes, and shall be all steel construction to ASTM or BS Standards.
- 3.9.3 Threaded flanges shall be used on all 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 BS Standards.

GENERAL DUTY VALVES FOR PLUMBING

PART 1 GENERAL

1.1 General Requirements

- 1.1.1 Valves shall be installed only in vertical or horizontal positions unless otherwise required by the Drawings.
- 1.1.2 All valves shall be installed in accessible locations to facilitate easy removal for maintenance.
- 1.1.3 Valves shall be full-line size.
- 1.1.4 All threaded end valves shall be installed with unions to facilitate the removal of the valve from the pipeline.
- 1.1.5 Gate valves shall be installed on both sides of every piece of equipment for all pipe-system connections, and where shown on the Drawings.

1.2 Related Works Specified Elsewhere

- 1.2.1 The works specified in the following divisions, contains the following:
 - General Mechanical Requirements for Plumbing
 - Plumbing Insulation
 - Plumbing Piping and Pumps
 - Facility Water Distribution
 - Facility Potable Water Storage Tanks
 - Domestic Water Softeners
 - Facility Storm Drainage
 - Compressed Air System (Non Medical)
 - Plumbing Equipment
 - Fuel Fired Domestic Water Heater
 - Domestic Water Heat Exchanger
 - Plumbing Fixtures
 - Pool and Fountain Plumbing System
 - Gas and Vacuum Systems For Laboratory & Healthcare Facilities

1.3 Valves Pressure Rating

- 1.3.1 Unless specified otherwise all valves, strainers, flexible connections, etc. shall be selected for pressure rating at least 1.5 times the operating pressure.
- 1.3.2 Contractor shall submit a schedule of all valves, strainers, etc., showing the required pressure rating for each fitting and shall indicate its location and service.

1.4 Quality Assurance and Control

- 1.4.1 All valves shall be kite marked to the applicable B.S. standard.
- 1.4.2 All valves shall be full line size.
- 1.4.3 All valves in steam lines shall be suitable for steam application.

PART 2 PRODUCTS

2.1 Gate Valves

2.1.1 Gate valves shall be all bronze with, non rising stem, flanged ends, bolted bonnet and bronze wedge disc faces and seats.

2.1.2 One gate valve shall be supplied and installed:

- a- At the supply and return from each equipment.
- b- At the discharge and suction of each pump.
- c- In general at all points shown on the Drawings and/or specified.

2.1.3 Copper alloy gate valves shall conform to BS 5154.

2.2 Check Valves (Spring Loaded Type)

2.2.1 Check valves shall be of the non-slam spring loaded, globe type with the capability to absorb and dampen the shock wave from the piping system water hammer. Check valves 2" (50 mm) and smaller, shall be all bronze, screwed ends. Valves 2½" (65 mm) and larger, shall be cast iron, flanged ends.

2.2.2 One check valve shall be installed:

- a- At the discharge of each pump.
- b- At all points shown on the Drawings and/or where specified.

2.2.3. Copper alloy check valves shall conform to BS 5154.

2.3 Float Valves

2.3.1 Float valves 2" (50 mm) and smaller shall be all bronze, screwed ends, float operated. Valves 2 ½" (65 mm) and larger shall be cast iron body, flanged ends, float operated. Float shall be all copper and mounted at the end of a brass or copper rod, which actuates valve operation.

2.3.2 Copper floats shall conform to BS 1968.

2.4 Automatic Air Vents

2.4.1 Supply and install all automatic air vents as shown on the Drawings and wherever specified in this book of specifications.

2.4.2 Automatic air vents of the spherical float type shall be installed at all high points in the piping. Vents shall have cast iron housing and bolted cover with gasket. Float shall be constructed of stainless steel. Vents shall be suitable for a maximum operating pressure of 150 psi (1030 Kpa). A ½" (15 mm) lock shield valve shall be directly installed ahead of each automatic air vent, and a ½" (15 mm) drain line shall be provided to discharge at a convenient point.

2.5 Backflow Presenters

2.5.1 This type of valve shall be used on domestic water systems, wherever applicable.

2.5.2 Valve shall combine the double check valve protection effect together with an air gap venting to the atmosphere, working on the reduced pressure principle.

2.5.3 Valve shall be suitable for 125 psi (860 Kpa) steam and 200 psi (1380 Kpa).

2.6 Pipe Expansion Joints

2.6.1 Expansion joints shall be provided wherever pipes cross structural expansion joints and wherever required to prevent undue stresses caused by thermal expansion of the pipes.

2.6.2 Expansion joints shall be of the packless-bellow type with flanged or welded ends as suitable for the pipe application.

2.6.3 Bellows shall be of stainless steel and suitable for a pressure of 125 psi (860 Kpa) or the design working pressure, whichever is greater. Expansion joints shall be provided with guides to prevent any unnecessary misalignment of the pipe. Guides and anchor arrangements shall be per the recommendations of the expansion joints manufacturers.

2.7 Water Pressure Reducing Valves

2.7.1 Supply and install wherever shown on the Drawings and as specified here-in-after water pressure reducing valves of the direct operated type.

2.7.2 Each valve shall be constructed of cast iron body, with stainless steel spring and shaft and nylon diaphragm.

2.7.3 The spring shall be designed to provide the pressure reduction indicated on the Drawings.

2.7.4 The valve shall be designed for a work pressure of 1720 KPa and shall be threaded or flanged ended as the pipe connecting to it.

2.7.5 The valve shall be of the self contained type without any control lines with all internal parts being accessible by removing spring chamber and without dismantling the valve itself.

2.7.6 The valve shall be designed to operate smoothly and quietly without chattering or any water hammer problems.

2.8 Strainers

2.8.1 Water strainer shall be supplied and installed at the suction connection of all pumps, and ahead of all automatic flow control valves.

2.8.2 Strainers shall be Y-pattern type with bronze body, screwed cover, brass basket and screwed ends.

2.8.3 Basket shall have 1/32" (0.8 mm.) perforations for water service.

2.9 Flexible Connectors

2.9.1 Flexible Connectors shall be easy flexing, long cyclic life connectors, to protect mechanical equipment by relieving piping stresses, caused by piping misalignment, sagging pipe hangers, and thermal expansion.

2.10 Double Regulating Valves

2.10.1 Supply and install wherever shown on the drawing and wherever specified double regulating valves.

2.10.2 Valves shall be of the screwed in bonnet type of bronze construction. Stem should be rising type of brass construction. Seat shall be brass with regulating disk. Valve shall be complete with double regulating device and BS 21 taper threads (ISO R7).

2.10.3 Temperature and pressure ratings shall be in accordance with BS 5160.

PART 3 EXECUTION

3.1 Installation of Valves

- 3.1.1 Valves shall be installed only in vertical or horizontal positions unless otherwise required by the Drawings.
- 3.1.2 All valves shall be installed in accessible locations to facilitate easy removal for maintenance.
- 3.1.3 Valves shall be full-line size.
- 3.1.4 All valves shall be installed with unions to facilitate the removal of the valve from the pipeline.
- 3.1.6 Gate valves shall be installed on both sides of every piece of equipment for all pipe-system connections, and where shown on the Drawings.

HANGERS AND SUPPORTS FOR PLUMBING PIPING

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and its requirements.

1.1 Hangers and Supports, Anchors and Guides - General

- 1.1.1 Support, anchor and guide all piping to preclude failure or deformation. Construct and install hangers, supports, anchors, guides and accessories to the approval of the Engineer. Do not use wire, tape or metal bands. Supports shall be designed to support weight of pipe, weight of fluid and weight of pipe insulation.
- 1.1.2 Fasten piping securely to the structure without overstressing any portion of the supports or the structure itself. Secure pipe support, anchors and guides to concrete by means of inserts or if greater load carrying capacity is required by means of steel fishplates embedded in the concrete.
- 1.1.3 Arrange hanger to prevent transmission of vibration from piping to building and supports.
- 1.1.4 Un-insulated copper or brass pipe and/or tubing shall be isolated from ferrous hangers or supports
- 1.1.5 Support piping and tubing at intervals indicated in the schedule hereinafter and at all changes in direction. Maximum deflection shall not exceed 3 mm.
- 1.1.6 Clearance for application of specified Vapour sealed insulation without cutting pipeline covering or fitting covering in installation of pipe hangers and fittings shall be provided.
- 1.1.7 Furnish pipe hangers and supports complete with rods, bolts, lock nuts, swivels, couplings, brackets and all other components and accessories, to allow installation to freely expand and contract.
- 1.1.8 Provide trapeze hangers where several pipes can be installed parallel and at the same level. Trapeze shall be of steel channel sized to support load and drilled for rod hanger at each end. Provision should be made to keep the lines in their relative position to each other by the use of either clamps or clips.
- 1.1.9 For hanger rods on piping use size 3/8" (10 mm).
- 1.1.10 Provide additional steel members required for hanging piping systems in areas with special conditions, or where vertical or horizontal structural steel supports are required other than those provided in the structure.
- 1.1.11 Provide lateral bracing for supporting rods over 450mm. long braced at every fourth hanger with diagonal bracing attached to slab or beam.
- 1.1.12 Floor supports - provide for supporting horizontal piping from floors with cast-iron rests, with pipe nipples to suit. Fasten to floor. Where provision for expansion is required, provide pipe roll stands, without vertical adjustment. Provide concrete or steel pipe piers, fasten stands to piers.
- 1.1.13 Wall supports - provide for supporting horizontal piping from wall with steel J-Hook for pipe located close to wall.

1.1.15 Hangers on PVC pipes shall be of design which does not clamp the pipe tightly but permits axial movement.

1.1.17 Support but do not rigidly restrain PVC pipes at end of branches and at change of direction or elevation. Vertical piping shall be maintained in the straight alignment. Support trap arms in excess of 900mm in length as close as possible to the trap.

1.2 Horizontal Piping Support Schedule

1.2.1 Steel and PVC Pipes

- . ¾" and 1" (20 and 25 mm) steel pipe-----2.5 meter
- . 1 ¼"-2" (32 and 50 mm) steel pipe-----3.0 meter
- . 2 ½"-4" (65 and 100 mm) steel pipe -----4.0 meter
- . 5"-6" (125 and 150 mm) steel pipe-----5.0 meter
- . 2 ½" (65 mm) and smaller PVC pipe-----1.2 meter
- . 3" (80 mm) and over PVC pipe-----1.8 meter

1.2.2. Vertical spacing of PVC pipes shall be twice as those of horizontal spacing.

1.2.3 Vertical spacing of other pipes - at every floor level.

DRINKING-WATER STORAGE TANKS

PART 1 GENERAL

1.1 Related Documents

- 1.1.1 Drawings and general provisions of the Contract, including Conditions of Contract and Specification Sections, apply to this Section.

1.2 Summary

- 1.2.1 This Section includes potable-water storage tanks and related specialties and accessories for indoor installations.

1.3 Delivery and Storage

- 1.3.1 Handle and store water storage tank systems, components, and parts to prevent distortions and other damage that could affect their structural, mechanical, or electrical integrity. Replace damaged items that cannot be restored to original condition.
- 1.3.2 Store items subject to deterioration by exposure to elements, in a well-drained location, protected from weather, and accessible for inspection and handling.
- 1.3.3 Deliver paint in unopened containers with unbroken seals and labels showing designated name, specification number, color, directions for use, manufacturer, and date of manufacture, legible and intact at time of use.

1.4 Submittals

- 1.4.1 Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories. Indicate dimensions, wall thicknesses, insulation, finishes and coatings, required clearances, methods of assembly of components, and piping connections.
- 1.4.2 Manufacturer Seismic Qualification Certification: Submit certification that indicated fibre glass, potable-water storage tanks, accessories, and components will withstand seismic forces defined in "Mechanical Vibration and Seismic Controls."
- 1.4.2.1 Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- 1.4.2.1.1 The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
- 1.4.2.1.2 The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- 1.4.2.2 Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- 1.4.2.3 Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 1.4.3 Manufacturer Certificates: For shop inspection and data reports as required by ASME Boiler and Pressure Vessel Code. Confirm successful pressure and leak testing.

- 1.4.4 Manufacturer Certificates: Confirm successful pressure and leak testing.
- 1.4.5 Field Test Reports: Indicate and interpret test results for compliance with performance requirements specified in "Field Quality Control" Article.
- 1.4.6 Water Samples and Reports: Specified in "Cleaning" Article.

1.5 Quality Assurance

- 1.5.1 ASME Compliance for Plastic Tanks: Fabricate and stamp plastic, pressure water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels."
- 1.5.2 NSF Compliance: NSF 14, "Plastics Piping Components and Related Materials," and NSF 61, "Drinking Water System Components--Health Effects." Include appropriate NSF marking.

PART 2 PRODUCTS

2.1 Performance Requirements

- 2.1.1 Pressure Rating of Pressure-Type Water Tanks: At least 860 kPa (125 psig), unless otherwise indicated.
- 2.1.2 Pressure Rating of Specialties and Accessories for Pressure Systems: At least 860 kPa (125 psig), unless otherwise indicated.
- 2.1.3 Pressure Rating of Piping for Pressure Systems: At least 860 kPa (125 psig), unless otherwise indicated.
- 2.1.4 Pressure Rating of Other Tanks and Piping Components: At least equal to system operating pressure.

2.2 Accessories

- 2.2.1 Overflow: The overflow for the tank shall consist of an overflow weir and outside drop pipe, adequately supported. The overflow pipe shall be PVC and shall terminate 300 to 600 mm above grade and shall be fitted with a flapper valve or screen to prevent ingress of birds and insects.
- 2.2.2 Vent: Vent shall be tank manufacturer's standard type, factory supplied, mushroom vent with stainless bird screen. The free area of the vent shall be sized 50 percent in excess of the pump-in rate.
- 2.2.3 Float Valves: The float valves shall be full bore, equilibrium ball type, designed to close tight against maximum pressure when half submerged, with renewable, synthetic rubber, valve disc and balancing piston bucket. Float valves to be all bronze construction including levers and arms, with Stainless Steel float and suitable for 1034 kPa cold water working pressure.
- 2.2.4 Drain Valve: Bronze /Cast Iron non-rising stem with indicator, for minimum working pressure of 1034 kPa, clear waterway equal to full nominal diameter, hand wheel operated, and open by turning counterclockwise.

PART 3 EXECUTION

3.1 Connections

- 3.1.1 Install piping adjacent to water storage tanks to allow service and maintenance.
- 3.1.2 Connect water piping to water storage tanks with unions or flanges and with shutoff valves. Connect tank drains with shutoff valves and discharge over closest floor drains.
- 3.1.3.2 Valves DN50 (NPS 2) and Smaller: Gate or ball. (Bronze)
- 3.1.3.4 Drain Valves: DN20 (NPS 3/4) gate or ball valve. Include outlet with, or nipple in outlet with, ASME B1.20.7, 3/4-11.5NH thread for garden-hose service, threaded cap, and chain.

3.2 Field Quality Control

- 3.2.1 Pressure Testing: Hydrostatically test ASME code, water storage tanks to ensure structural integrity and freedom from leaks. Fill tanks with water, vent air, pressurize to 1-1/2 times tank pressure rating, disconnect test equipment, hold pressure for 30 minutes with no drop in pressure, and check for leaks. Replace tanks that fail test with new tanks and repeat until test is satisfactory.
- 3.2.2 Pressure Testing: Hydrostatically test non-ASME code, pressure water storage tanks to ensure structural integrity and freedom from leaks at pressure of 345 kPa (50 psig) above system operating pressure, but not less than 1035 kPa (150 psig). Fill tanks with water, vent air, pressurize tanks, disconnect test equipment, hold pressure for two hours with no drop in pressure, and check for leaks. Repair or replace tanks that fail test with new tanks and repeat until test is satisfactory.
- 3.2.3 Nonpressure Testing: Fill nonpressure water storage tanks to water operating level to ensure structural integrity and freedom from leaks. Hold water level for two hours with no drop in water level.
- 3.2.4 Repair leaks and defects with new materials and retest system until results are satisfactory.
- 3.2.5 Prepare written reports for specified tests.

3.3 Cleaning

- 3.3.1 Clean and disinfect water storage tanks.
- 3.3.2 Use purging and disinfecting procedure prescribed by Engineer or, if method is not prescribed, use procedure described in AWWA C652 or as described below:
 - 3.3.2.1 Purge water storage tanks with potable water.
 - 3.3.2.2 Disinfect tanks by one of the following methods:
 - 3.3.2.2.1 Fill tanks with water/chlorine solution containing at least 50 mg/L (50 ppm) of chlorine. Isolate tanks and allow to stand for 24 hours.
 - 3.3.2.2.2 Fill tanks with water/chlorine solution containing at least 200 mg/L (200 ppm) of chlorine. Isolate tanks and allow to stand for three hours.

- 3.3.2.3 Flush tanks, after required standing time, with clean, potable water until chlorine is not present in water coming from tank.
- 3.3.2.4 Submit water samples in sterile bottles to Engineer. Repeat procedure if biological examination shows evidence of contamination.
- 3.3.3 Prepare written reports for purging and disinfecting activities.

3.4 Commissioning

- 3.4.1 Perform the following final checks before filling:
 - 3.4.1.1 Verify that tests of tanks are complete.
 - 3.4.1.2 Verify that tests of piping systems are complete.
 - 3.4.1.3 Check piping connections for leaks.
 - 3.4.1.4 Verify that pressure relief valves have correct setting.
 - 3.4.1.5 Test operation of tank accessories and devices.
 - 3.4.1.6 Manually operate relief valves.
 - 3.4.1.7 Adjust pressure settings.
 - 3.4.1.8 Manually operate vacuum relief valves.
 - 3.4.1.9 Adjust vacuum settings.
 - 3.4.1.10 Check for proper seismic restraints.
- 3.4.2 Filling Procedures: Follow manufacturer's written procedures. Fill tanks with water to operating level.

DOMESTIC WATER HEATERS

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and its requirements.

1.1 Introduction

- 1.1.1 This section includes all water heating installations as part of the domestic water distribution system inside the building

1.2 Scope of Work

- 1.2.1 The contractor shall be responsible to complete above works based on CONSULTANT'S approval of submitted samples, documents etc as per specifications and applicable standards

1.3 Related Works Specified Elsewhere

- 1.3.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

- General Mechanical Requirements for Plumbing.
 - Plumbing Insulation
 - Plumbing Piping and Pumps
 - Plumbing Equipment

1.4 Codes and Standards

- 1.4.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the above codes, standards and regulations.

PART 2 PRODUCTS

2.1 Electric WaterHeaters

Electric water heaters are required to supply hot water to sanitary fixtures and shall be designed and rated in accordance with current British Standards.

Electric heater units shall be of the immersed type; heating elements made of nickel-plated copper about 8 watt/cm² density, with thermostat hot water trap and cold water inlet baffle.

The units shall be made of heavy gauge steel lined with improved glass or copper, with magnesium alloy or nickel chrome alloy anode and stainless steel dip tube.

The units shall be provided with 50mm fiberglass insulation and enameled steel jacket, temperature and pressure relief valves, non return valve and drain valve.

Each electric water heater shall be fitted with 2 No Y2 " diameter valve for inlet and outlet water.

Water heaters will be of the wall-mounted type with wall-hanging brackets, which permit the water heaters of different makes without need for making holes in walls.

The top and bottom covers should be made of synthetic material and shape in order to permit easy cleaning of the appliance and has an up-to-date design.

The particular construction should permit rust proof installation in project location.

The outlet hot water temperature should be of 90°C in winter.

2.2 Spare Parts

- 2.2.1 The Contractor shall provide as part of his contract a list of spare parts for all the equipment supplied sufficient for three years of operation all in accordance with the recommendations of the manufacturers of the equipment.

2.3 Guarantee and Warranted Period

- 2.3.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.
- 2.3.2 All guarantee shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.
- 2.3.3 The Contractor shall guarantee every piece of equipment from any manufacturing or installation defects for a period of one year, starting from the date of issue of the substantial completion certificate.

FIRE PROTECTION SPECIALITIES

PART 1 GENERAL

1.1 Approvals

- 1.1.1 No items shall be installed in breach of any of the existing local Fire Department regulations. In all access, however, installation shall comply with National Fire Codes (NFPA latest editions), or indicated otherwise.

1.2 Requirements

- 1.2.1 Supply and install wherever shown on the drawings all materials specified as per the capacities and ratings indicated on the drawings.

1.3 Codes and Standards

- 1.3.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

<u>Reference Code</u>	<u>Abbreviation</u>	<u>Applicable Standard</u>	<u>Title of Standard</u>
1. Underwriters Laboratories	UL	-	-
2. National Fire Protection Association	NFPA	-	-

PART 2 PRODUCT

2.1 Portable Fire Extinguishers

- 2.1.1 Extinguisher shall be from ISO 9001, LPCB certified manufacturer rechargeable CO2 type as shown on drawings.
- 2.1.2 CO2 extinguishers shall be seamless extruded of high grade steel light construction to BS 5423 and approved by F.O.C. or equivalent and to have a rating of 55B. Extinguishers shall have permanent leak proof shut-off safety disc, non metallic horn, flexible hose and wall hooks.

PART 3 EXECUTION

3.1 Maintenance Schedules

- 3.1.1 Maintenance schedules shall be provided with each type of extinguisher. The schedules shall be in protective covers and shall detail all aspects of maintenance of extinguishers including details of weight checks, pressure test, discharge tests, internal and external visual checks, time periods for checks and action to be taken on finding a fault. The schedules will also contain full details for repairing, recharging and resetting extinguisher contents and re-ordering instructions.

FIRE SUPPRESSION PIPING

PART 1 GENERAL

- 1.1 General Requirements
- 1.2 Tests
- 1.3 Related Work Specified Elsewhere
- 1.4 Codes and Standards

PART 2 PRODUCTS

- 2.1 Fire Suppression Pipe

PART 3 EXECUTION

- 3.1 Installation
- 3.2 Cleaning of Piping Systems
- 3.3 Approved List of Manufacturers

FIRE SUPPRESSION PIPING

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and its requirements.

1.1 General Requirements

- 1.1.1 Pipe bending shall not be resorted to except in extreme cases and only after the written approval of the Engineer.
- 1.1.2 Piping shall be designed with Loops to take the thermal expansion. Wherever this is not possible for physical reasons, expansion joints with guides shall be used.
- 1.1.3 Installation of pipes shall be complete with all cutting, patching and making good of walls, slabs, partitions, etc., due to fixing, supporting and anchoring of pipes.
- 1.1.4 Automatic air vents shall be installed at all air pocket locations, and/or at the highest points in the lines.
- 1.1.5 Pipes and fittings shall both be manufactured according to one single standard unit of measurement, either both English or both metric.
- 1.1.6 Provision shall be made for flushing the system.
- 1.1.7 All piping shall be installed so that the system may be thoroughly drained.
- 1.1.8 The piping shall be pitched in the direction of drainage.
- 1.1.9 Drain valves shall be provided where necessary, where shown on the Drawings and at all sectional valves to help draining the major part of the system. On all risers 4" (100mm) or larger, drain valve shall be 2" (50 mm) size, on 2½" (65 mm) and 3" (80mm) risers, 1¼" (32 mm) valves shall be used and on small risers, ¾" (20mm) drain valves shall be provided.
- 1.1.10 No direct interconnections shall be made between sewers and fire drain systems.
- 1.1.11 Fire piping shall not be used, in any way, for domestic water supply purposes.
- 1.1.12 All valves shall be located where readily accessible.
- 1.1.13 Provision shall be made for test connections and valves.
- 1.1.14 Control power transformer as applicable to limit control voltage to 24 VDC maximum.

1.2 Tests

- 1.2.1 The system shall be subjected to a hydrostatic pressure test, to the satisfaction and in the presence of the Engineer. Pressure shall not be less than 300 psi (2070 Kpa) or at 50 psi. (345 Kpa) in excess of the maximum static pressure when the maximum static pressure is in excess of 150 psi (1030 Kpa) and the test shall be maintained for two hours.
- 1.2.2 If leaks develop during the test, the contractor shall make all necessary repairs and shall retest the system at no additional cost to the Employer.

1.3 Related Work Specified Elsewhere

- 1.3.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

Section 10 44 00 - Fire Protection Specialists
 Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
 Section 21 05 23 - General Duty Valves for Fire Suppression Piping
 Section 21 05 29 - Hangers and Supports for Fire Suppression Piping
 Section 21 05 48 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
 Section 21 05 53 - Identification for Fire Suppression System
 Section 21 12 00 - Fire Suppression Stand Pipes
 Section 21 13 00 - Fire Suppression Sprinkler Systems
 Section 21 20 00 - Fire Extinguishing Systems
 Section 21 30 00 - Fire Pumps
 Section 21 40 00 - Fire Suppression Water Storage

1.4 Codes and Standards

1.4.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall conform to the applicable portions of the latest editions of the following codes, standards and regulations.

<u>Reference Code</u>	<u>Abbreviation</u>	<u>Applicable Standard</u>	<u>Title of Standard</u>
3. Underwriters Laboratories	UL	-	-
4. British Standards	BS	BS3169 BS5839 Part 1	Specification for first aid reel hoses for fire fighting purposes Fire detection and alarm systems for buildings. Code of practice for system design installation and servicing.
5. National Electrical Manufacturers Association	NEMA	MIG Part 14	
6. National Electrical Code	NEC	-	-
7. National Fire Protection Association	NFPA	14	Combined Stand Pipe & Hose System with Sprinklers
8. American Water Works Association	AWWA	-	-

PART 2 PRODUCTS

2.1 Fire Suppression Pipe

- 2.1.1 Pipes above ground shall be of the ERW type galvanized steel pipes to B.S. 1387 "medium weight" or ASTM A 53-88a Sch. 40. All pipe fittings elbows, tees, crosses, unions, reducers, etc. shall be of the same quality and weight as the pipes.
- 2.1.2 Pipe fittings 2" (50 mm) and smaller shall be suitable for threaded connections, 2½" (65 mm) and larger shall be flanged / grooved fittings.
- 2.1.3 Unions and grooved fittings, flanges shall be installed at all valves inlets or outlets, on all pipe branches and in general, every 15 metres of pipe run.
- 2.1.4 Unions shall be used on all screwed pipes and shall be of the same quality and service. Grooved fittings shall be used on all pipes above 2½" and shall be all steel construction to ASTM or BS Standards.
- 2.1.5 Contractor shall rectify any damage to the pipes from the processes of grooving to the satisfaction of the Engineer.
- 2.1.6 Pipes under ground shall be HDPE to ISO 4427, PE 100 resin all fittings shall be electrofusion and butt fusion types.

PART 3 EXECUTION

3.1 Pipe Installation

- 3.1.1 Piping shall be pitched to permit complete draining of the system.
- 3.1.2 Fire standpipe shall not be used in any way to provide water for other purposes.
- 3.1.3 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un-insulated lines or of the insulation for insulated pipes.
- 3.1.4 Install sleeves through interior walls and partitions flush with finished surfaces; sleeves through outside walls to project 15mm. on each side of the finished wall; and floor sleeves to project 25mm. above finished floors.
- 3.1.5 Set sleeves in place before pouring concrete or securely fasten and grout in with cement.

3.2 Cleaning of Piping Systems

- 3.2.1 Plug all opening ends of piping, valves and equipment except when actual work is being performed to minimize accumulation of dirt and debris.
- 3.2.2 Prior to the performance of tests, flush out all piping that is to receive a hydrostatic test with clean water.
- 3.2.3 Remove dirt and debris collected at screens, strainers and other points from the system.

WET PIPE SPRINKLER SYSTEM

PART 1 GENERAL

- 1.1 General Requirements
- 1.2 Tests
- 1.3 Signs
- 1.4 Related Work Specified Elsewhere
- 1.5 Codes and Standards

PART 2 PRODUCTS

- 2.1 Fire Suppression Pipe
- 2.2 Sprinkler Head-Upright
- 2.3 Concealed Automatic Sprinkler
- 2.4 Recessed Extended Coverage Horizontal Sidewall Sprinkler.
- 2.5 Sprinkler Alarm Test Station
- 2.6 Sprinkler Zone Control Valve
- 2.7 Pre-Action Riser Assembly and Related Accessories

PART 3 EXECUTION

- 3.1 Pipe Sleeves
- 3.2 Cleaning of Piping Systems
- 3.3 Approved List of Manufacturers

WET PIPE SPRINKLER SYSTEM

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and its requirements.

1.1 General Requirements

- 1.1.1 Pipe bending shall not be resorted to except in extreme cases and only after the written approval of the Engineer.
- 1.1.2 Piping shall be designed with Loops to take the thermal expansion. Wherever this is not possible for physical reasons, expansion joints with guides shall be used.
- 1.1.3 Installation of pipes shall be complete with all cutting, patching and making good of walls, slabs, partitions, etc., due to fixing, supporting and anchoring of pipes.
- 1.1.4 Automatic air vents shall be installed at all air pocket locations, and/or at the highest points in the lines.
- 1.1.5 Pipes and fittings shall both be manufactured according to one single standard unit of measurement, either both English or both metric.
- 1.1.6 Sprinkler installations shall comply fully with the requirements of NFPA section 13 and/or the rules of the loss prevention council / BS 5306 Part 2 latest edition.
- 1.1.7 Provision shall be made for flushing the system.
- 1.1.8 All piping shall be installed so that the system may be thoroughly drained.
- 1.1.9 The piping shall be pitched in the direction of drainage.
- 1.1.10 Drain valves shall be provided where necessary, where shown on the Drawings and at all sectional valves to help draining the major part of the system. On all risers 4" (100mm) or larger, drain valve shall be 2" (50 mm) size, on 2½" (65 mm) and 3" (80mm) risers, 1¼" (32 mm) valves shall be used and on small risers, ¾" (20mm) drain valves shall be provided.
- 1.1.11 No direct interconnections shall be made between sewers and sprinkler drain systems.
- 1.1.12 Sprinkler piping shall not be used, in any way, for domestic water supply purposes.
- 1.1.13 All valves controlling the water supply shall be located where readily accessible.
- 1.1.14 Provision shall be made for test connections and valves.
- 1.1.15 Control power transformer as applicable to limit control voltage to 24 VDC maximum.
- 1.1.16 Protection areas and maximum spacing (Standard spray upright / pendant sprinkler) for light hazard is 18 square meter and for Ordinary hazard is 12.0 square meter as per NFPA 13 and this shall be subject to authorities having jurisdiction
- 1.1.17 Protection areas and maximum spacing (Side Wall Sprinklers) for light hazard is 18.2 square meter, 9.29 square meter for Ordinary hazard and for external coverage light hazard is as per NFPA 13 Table 8.8.2.1.2 and Local Authorities having jurisdiction.

1.2 Tests

- 1.2.1 The system shall be subjected to a hydrostatic pressure test, to the satisfaction and in the presence of the Engineer. Pressure shall not be less than 300 psi (2070 Kpa) or at 50 psi. (345 Kpa) in excess of the maximum static pressure when the maximum static pressure is in excess of 150 psi (1030 Kpa) and the test shall be maintained for two hours.
- 1.2.2 If leaks develop during the test, the contractor shall make all necessary repairs and shall retest the system at no additional cost to the Employer.

1.3 Signs

- 1.3.1 Provide at sprinkler test valve a metal sign 100 x 200 mm size with white letters on red background, reading "SPRINKLER TEST VALVE". Letters shall not be less than 50 mm in height.

1.4 Related Work Specified Elsewhere

- 1.4.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

Section 10 44 00 - Fire Protection Specialists
Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
Section 21 05 23 - General Duty Valves for Fire Suppression Piping
Section 21 05 29 - Hangers and Supports for Fire Suppression Piping
Section 21 05 48 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
Section 21 05 53 - Identification for Fire Suppression System
Section 21 12 00 - Fire Suppression Stand Pipes
Section 21 13 00 - Fire Suppression Sprinkler Systems
Section 21 20 00 - Fire Extinguishing Systems
Section 21 30 00 - Fire Pumps
Section 21 40 00 - Fire Suppression Water Storage

1.5 Codes and Standards

Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall conform to the applicable portions of the latest editions of the following codes, standards and regulations.

<u>Reference Code</u>	<u>Abbreviation</u>	<u>Applicable Standard</u>	<u>Title of Standard</u>
9. Underwriters Laboratories	UL	-	-
10. British Standards	BS	BS3169 BS5839 Part 1	Specification for first aid reel hoses for fire fighting purposes Fire detection and alarm systems for buildings. Code of practice for system design installation and servicing.
11. National Electrical Manufacturers Association	NEMA	MIG Part 14	
12. National	NEC	-	-

Electrical Code

13. National Fire Protection Association	NFPA	14	Combined Stand Pipe & Hose System with Sprinklers
14. American Water Works Association	AWWA	-	-

PART 2 PRODUCTS

2.1 Fire Suppression Pipe

- 2.1.1 Pipes above ground shall be of the ERW type galvanized steel pipes to B.S. 1387 "medium weight" or ASTM A 53-88a Sch. 40. All pipe fittings elbows, tees, crosses, unions, reducers, etc. shall be of the same quality and weight as the pipes.
- 2.1.2 Pipe fittings 2" (50 mm) and smaller shall be suitable for threaded connections, 2½" (65 mm) and larger shall be flanged / grooved fittings.
- 2.1.3 Unions and grooved fittings, flanges shall be installed at all valves inlets or outlets, on all pipe branches and in general, every 15 metres of pipe run.
- 2.1.4 Unions shall be used on all screwed pipes and shall be of the same quality and service. Grooved fittings shall be used on all pipes above 2½" and shall be all steel construction to ASTM or BS Standards.
- 2.1.5 Contractor shall rectify any damage to the pipes from the processes of grooving to the satisfaction of the Engineer.
- 2.1.6 Pipes under ground shall be HDPE to ISO 4427, PE 100 resin all fittings shall be electrofusion and butt fusion types.

2.2 Sprinkler Head-Upright

- 2.2.1 Sprinkler heads shall be bronze or brass construction, spray type 135o F (57o C) rating, with thermosensitive glass bulb. Head located in finished areas shall be chrome-plated.
- 2.2.2 Not less than 12 spare sprinkler heads shall be provided together with sprinkler head wrenches, all supported on steel clip in a suitable steel cabinet with hinged door and latch. Cabinets shall be finished in red enamel with white letters on door reading: "SPARE SPRINKLER PARTS". Cabinets shall be wall hung and in compliance with all authorities having jurisdiction. Location of cabinet shall be as directed by the Engineer.
- 2.2.3 All sprinklers shall have a normal orifice 15 mm and rated for ordinary hazard.
- 2.2.4 Sprinklers shall be rated for a working pressure of 175 PSI (1207 Kpa).
- 2.2.5 This type of sprinklers shall be installed in car parking and areas where false ceiling is not provided.

2.3 Concealed Automatic Sprinkler

- 2.3.1 The sprinkler head shall be of the quick response concealed type of brass string a 3 mm. diameter glass bulb of 135 o F rating. The sprinkler frame shall have drop-down deflector. The assembly shall be recessed into the ceiling and concealed by a flat cover plate.
- 2.3.2 This type of sprinkler shall be installed in all floors.
- 2.3.3 Spare sprinkler heads with wrenches and cabinets to be provided as described above.

2.4 Recessed Extended Coverage Horizontal Sidewall Sprinkler

- 2.4.1 The sprinkler head shall be of the quick response horizontal side wall chrome plated recessed type with deflector and 3 mm frangible glass bulb. The glass bulb of the fast thermal response shall consist of a controlled amount of special fluid hermetically sealed inside a precisely manufactured glass capsule.
- 2.4.2 Spare sprinkler heads with wrenches and cabinets to be provided as described above.

2.5 Sprinkler Alarm Test Station

2.5.1 Sprinkler alarm check valve with trim

- 2.5.1.1 This valve is a part of sprinkler alarm test station and serves a dual purpose of preventing reverse flow of water (non-return) and provides a hydraulic fire alarm independent of electric power supply.
- 2.5.1.2 Valve shall be UL listed and FM approved for a working pressure of 175 PSI (1207 Kpa). Valve shall have a ductile/cast iron body with internal pins, sprinkler and nuts of stainless steel and brass seat. The valve clipper shall be of Teflon coated steel with EPDM rubber clapper having stainless steel rubber faced retainer. The clapper assembly shall be hinged to access cover for quick removal and easy servicing. Valve shall be available in flanges, grooved or combined connection versions. Valve shall have necessary tappings for pressure gauges, alarm devices, drains, etc., Valve shall be suitable for horizontal or vertical installation.
- 2.5.1.3 The alarm valve shall be complete with external by-pass trim to minimize clapper movement and prevent false alarm. Trim shall include drain and test valve, retard chamber for variable pressure systems, pressure gauges at inlet/outlet, strainer, electric pressure switch, restricted drain orifice, water motor alarm and alarm motor stop valve.
- 2.5.1.4 When water flows through the Alarm valve, the water will raise the clack disk, and flows to the system with a small amount passing thru a special groove to the alarm motor and gong and initiating the alarm.
- 2.5.1.5 The clack will remain in the raised position until there is no flow of water thru the control valve then the stop valve will be closed.
- 2.5.1.6 When sprinklers are in operation during a fire, the alarm gong may be shut off by closing alarm motor stop valve.
- 2.5.1.7 An electrical pressure switch connected in the flow of the alarm gong shall also initiate an electric alarm in the main fire control panel.
- 2.5.1.8 The drain and test valve is to drain the sprinkler installation of water after a fire has been extinguished and before replacing the sprinklers that have operated. It is also used to test the running pressure of the water supplies.

2.5.2 Water motor alarm and gong

2.5.2.1 Water motor alarm and gong shall comprise a weather proof, hydraulically driven mechanical bell that automatically sounds a continuous alarm when the sprinkler system activates. It shall be installed not higher than 5 or 6 meters above the valve and it shall be tested at least once a week.

2.5.3 Isolating Valves (OS & Y Resilient Wedge Gate Valves)

2.5.3.1 The valve shall be provided upstream and down stream of sprinkler control station and shall be located in such a place to be always readily visible and accessible to authorized persons. Valves shall be secured open by a padlocked or riveted strap.

2.5.3.2 The valve shall conform to the latest revision of A.W.W.A Resilient Seated Gate Valve Standard C-509 and be UL listed/ FM approved.

2.5.3.3 All internal parts shall be accessible without removing the body from the line.

2.5.3.4 The wedge shall be cast iron, complete encapsulated with resilient material. The resilient sealing material shall be permanently bonded to the cast iron wedge with a rubber tearing bond to meet ASTM D429.

2.5.3.5 NRS stems shall be cast bronze with integral collars in compliance with A.W.W.A. OS & Y stems shall be bronze. The NRS stuffing box shall have two O-Ring seals above the thrust collar. These rings shall be filed replaced without removing the valve from service.

2.5.3.6 There shall be low friction thrust bearings above and below the stem collar. The stem nut shall be independent of the wedge and of solid bronze. The waterway in the seat areas shall be smooth, unobstructed, free of cavities and for valves 4" (100mm) and larger at least 0.19" (4.8mm) greater in diameter than the nominal valve size.

2.5.3.7 The body and bonnet shall be coated both interior and exterior with a fusion bonded heat cured thermo setting material meeting all the application and performance requirements of A.W.W.A. C-550.

2.5.3.8 The gasket seal between two surfaces shall employ the use of composition ring type gaskets retained to prevent the possibility of blow out.

2.5.3.9 Each valve shall be hydrostatically tested to the requirements of both A.W.W.A. and UL/FM.

2.6 **Sprinkler Zone Control Valve**

2.6.1 Butterfly Valve (indicating type)

2.6.1.1 Butterfly valve shall be of the flangeless type, lug or wafer style, it shall be rated 1380 KPa bi-directional, with a 1380 KPa dead end service rating. The body material shall be shock resistant ductile iron with extended neck. There should be no exposed fasteners in the waterway to pin the disc to the stem. The liner shall be molded in or captive boot design. Top and bottom stem bushings of dissimilar material are required with a positive retention mechanism for the stem.

2.6.1.2 Butterfly valve shall be gear operated and shall be secured open with a padlock. It shall be provided with supervisory tamper switch to give signal to BMS (if specified) and to the fire alarm station.

2.6.2 Waterflow Alarm Switch

2.6.2.1 The water flow alarm devices consist of a vane type waterflow switch for use on wet sprinkler systems, it shall be UL listed and FM approved. The unit shall contain two single pole, double throw, snap action switches and adjustable, instantly recycling pneumatic retard that delays actuation of electrical switches to reduce possibility of false alarms.

2.6.2.2 The unit shall be enclosed in a die-cast housing, the cover shall be held in place with two tamper resistant screws.

2.6.2.3 Unit shall be installed on sprinkler branch line to detect water flow exceeding 38 Litres downstream of the device. When activated, the snap action switches shall operate a local electrical alarm bell (under electrical specification) and indicate signal to fire alarm panel and BMS.

2.6.3 Combined Drain and Test Valve

2.6.3.1 Drain and test valve shall have a body of brass, bronze filled Teflon seal, stainless steel stem, and zinc plated steel handle, it shall include an orifice plate signed for a flow of one sprinkler and a sight glass. Test and drain valve shall be tested once a week and it shall be connected to a separate drain riser.

2.7 Pre-Action Riser Assembly and Related Accessories

2.7.1 General Description

2.7.1.1 When one electrical thermal detector senses the presence of fire, the electrical releasing control panel activates fire alarm devices and latches the solenoid releasing valve in the open position. The solenoid valve, when closed, is preserving supply water pressure in the inlet of the Deluge Riser Assembly. Actuating the solenoid valve releases that water pressure, allowing water flow into the sprinkler system in readiness for the subsequent operation of a sprinkler.

2.7.1.2 To fully operate the system, two electrical detectors shall activate and a sprinkler shall open. During the early stages of a fire, smoke or heat activates the first detector which causes the control panel to produce a local alarm and an alarm at the main fire alarm panel. Electrical relays inside the releasing control panel can be used to shut down air moving equipment when the panel goes into the "first alarm" condition. Subsequent activation of a second, nearby or adjacent, detector shall cause the panel to energize the solenoid valve open and release water into the sprinkler piping. Water flowing into the sprinkler piping will simultaneously produce water pressure that causes the transfer of contacts in the pressure switch mounted in the Riser Assembly. The flow of water into the sprinkler piping effectively converts the dry system into a wet pipe system. In the event the fire subsequently produces sufficient heat to operate a sprinkler head, water will flow from that sprinkler, controlling or suppressing the fire.

2.7.1.3 The solenoid valve is a supervisory valve and its circuit is supervised.

2.7.1.4 Pre-action riser assembly shall consist of the following:

- Manual Emergency Releasing Station Valve
- Supervised Isolating Valve
- Solenoid Valve
- Water Flow Alarm Pressure Switch
- Alarm Test Valve
- Automatic Drain Valve

2.7.1.5 The system shall be complete with the following:

- Control Panel
- Electric Emergency Station

- Fire Alarm Bell & Trouble Alarm Bell

2.7.1.6 Open Sprinklers (Spray Nozzle)

2.7.1.6.1 Sprinkler head shall be bronze or brass construction chrome plated pendant recessed type with chrome escutcheon.

2.7.1.6.2 Sprinklers shall be of non-automatic fixed pattern and solid cone discharge type.

PART 3 EXECUTION

3.1 Pipe Sleeves

3.1.1 Piping shall be pitched to permit complete draining of the system.

3.1.2 Fire standpipe shall not be used in any way to provide water for other purposes.

3.1.3 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un-insulated lines or of the insulation for insulated pipes.

3.1.4 Install sleeves through interior walls and partitions flush with finished surfaces; sleeves through outside walls to project 15mm. on each side of the finished wall; and floor sleeves to project 25mm. above finished floors.

3.1.5 Set sleeves in place before pouring concrete or securely fasten and grout in with cement.

3.2 Cleaning of Piping Systems

3.2.1 Plug all opening ends of piping, valves and equipment except when actual work is being performed to minimize accumulation of dirt and debris.

3.2.2 Prior to the performance of tests, flush out all piping that is to receive a hydrostatic test with clean water.

3.2.3 Remove dirt and debris collected at screens, strainers and other points from the system.

FIRE PUMPS

PART 1 GENERAL

- 1.1 General Requirements
- 1.2 Related Works Specified Elsewhere
- 1.3 Codes and Standards

PART 2 PRODUCTS

- 2.1 Fire Fighting Set (Wet Riser and Sprinkler-NFPA Regulations)
- 2.2 Description of Operation

PART 3 EXECUTION

- 3.1 Installation of Pumps
- 3.2 Pump Settings
- 3.3 Pumps Testing
- 3.4 Spare Parts
- 3.5 Special Tools
- 3.6 Operation and Maintenance Manuals
- 3.7 Guarantee And Warranted Period
- 3.8 Approved List of Manufacturers

FIRE PUMPS

PART 1 GENERAL

1.1 General Requirements

- 1.1.1 The Contractor shall be responsible to confirm the total dynamic head of the fire pumps and seek the approval of the fire department or persons having jurisdiction and the approval of the Engineer before ordering the pumps.

1.2 Related Works Specified Elsewhere

- 1.2.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

- Section 10 44 00 - Fire Protection Specialists
- Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
- Section 21 05 23 - General Duty Valves for Fire Suppression Piping
- Section 21 05 29 - Hangers and Supports for Fire Suppression Piping
- Section 21 05 48 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
- Section 21 05 53 - Identification for Fire Suppression System
- Section 21 11 00 - Fire Suppression Piping
- Section 21 12 00 - Fire Suppression Stand Pipes
- Section 21 13 00 - Fire Suppression Sprinkler Systems
- Section 21 20 00 - Fire Extinguishing Systems
- Section 21 40 00 - Fire Suppression Water Storage

1.3 Codes and Standards

- 1.3.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall conform to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
Underwriters Laboratories British Standards	UL	- BS5839 Part 1	- Fire detection and alarm systems for buildings. Code of practice for system design installation and servicing.
National Electrical Manufacturers Association	NEMA	MIG Part 14	
National Electrical Code	NEC	-	-
National Fire Protection Association	NFPA	-	-

PART 2 PRODUCTS

2.1 Fire Fighting Set (Wet Riser and Sprinkler-NFPA Regulations)

2.1.1 General Requirements

2.1.1.1 Supply and install wherever shown on drawings Fire Fighting Pumps (one duty and one stand-by) of capacities as indicated on drawings. If the Fire Fighting Pumps are not driven by diesel engine, they shall additionally be connected to the stand-by generator power.

2.1.1.2 All components of the fire fighting set shall be UL listed/FM approved for fire fighting application.

2.1.1.3 Each pump shall be of the centrifugal type.

2.1.1.4 Each pump shall be specially tested for fire service application and meet all requirements of NFPA 20.

2.1.1.5 Pumps shall furnish not less than 150% of rated capacity at a total head not less than 65% of total rated head. The shut off head for pumps shall not exceed 40% of rated head.

2.1.1.6 Pump and driver shall be mounted on an extra heavy cast iron drip rim ring base.

2.1.1.7 Pumps shall be of the bronze fitted construction with cast iron casing, and renewable bronze casing-wearing rings. Impeller shall be of the enclosed type cast bronze, dynamically balanced and keyed to shaft with stainless steel keys.

2.1.1.8 Pump shaft shall be carbon steel with stainless steel shaft sleeves.

2.1.1.9 Pumps shall be complete with the following:

2.1.1.9.1 Eccentric tapered suction reducer and concentric tapered discharge increaser.

2.1.1.9.2 Concrete foundation blocks isolation pads.

2.1.1.9.3 Casing automatic relief valve at casing discharge set to open higher than design discharge pressure and lower than shut-off discharge pressure to prevent overheating when pump operates at shut-off with no discharge.

2.1.1.9.4 Open drip cone to collect and drain water dripping from the casing relief valve.

2.1.1.9.5 A flow water measuring device to test the pump capacity of water flow of not less than 175% of pump rated capacity.

2.1.2 Electric Control Panel

2.1.2.1 Electric control panel shall be completely assembled, tested and wired at the supplier's workshop before shipping and shall be marked "Fire Pump Controller". All components of the controller shall be in strict compliance with Chapter 7 of Section 20 of NFPA and with no contradiction to Local Civil Defence Authority.

2.1.2.2 The controller shall be of the manual and automatic control type and shall be complete with the following:

- 2.1.2.2.1 Externally operable disconnect switches.
- 2.1.2.2.2 Circuit breakers and starters.
- 2.1.2.2.3 Pressure switch.
- 2.1.2.2.4 Pilot lights to indicate circuit breaker closed and power available, pump operating or off.
- 2.1.2.2.5 Ammeter test link and voltmeter test studs.
- 2.1.2.2.6 Two position selector switch marked "Auto-Manual".
- 2.1.2.2.7 Low level float switch, in the fire storage reservoir to be interconnected with the control panel to prevent pumps from starting and initiate an alarm in case water level drops to the level of the float switch.
- 2.1.2.2.7 An automatic warning of power failure to the motor starting switch shall be given visually and audibly at the guard control room. Power for this warning system shall be taken from a separately switched sub-circuit to that feeding the motor.
- 2.1.3 Electrical Driven Pump
 - 2.1.3.1 Electrically driven pump shall be coupled to a totally enclosed fan cooled motor through a flexible coupling.
 - 2.1.3.2 Motor shall comply with the provisions of the National Electrical Code and with the Requirements of the Electrical specifications.
 - 2.1.3.3 Motor shall be rated for continuous duty and shall not be used to voltages exceeding 110 percent of rated voltage.
 - 2.1.3.4 Motor shall be of such capacity that at rated voltage and rated frequency, the full load ampere rating will not be exceeded under any conditions of pump load.
 - 2.1.3.5 Motor shall be derated according to NEMA Standard MGI part 14 for altitudes.
 - 2.1.3.6 Motor shall be provided with watertight conduit boxes.
- 2.1.5 Jockey Fire Pump
 - 2.1.5.1 Supply and install wherever shown on the Drawings and of capacities indicated there upon a jockey fire pump.
 - 2.1.5.2 Pump shall be of the vertical multistage type with a cast iron casing and stainless steel stages and impeller.
 - 2.1.5.3 Pump shall be self-venting.
 - 2.1.5.4 The impeller shall be hydraulically self-centering and no external adjustment shall be necessary
 - 2.1.5.5 The shaft shall be of stainless steel construction and the bearings shall be grease lubricated ball type.
 - 2.1.5.6 The pump shall be supplied complete with:
 - 2.1.5.7 Electric motor of totally enclosed type, flexibly coupled to the pump. Motor shall be sized to prevent overloading at the highest operating head specified.
 - 2.1.5.8 Jockey pump controller factory wired and tested in one unit to (IEC) or NEMA Standards.

- 2.1.5.9 Controller shall include hand-off-auto switch, a fusible 3-pole disconnect switch, magnetic motor contactor and thermal overload relays with external reset. The controller shall be furnished in a sturdy, wall-mounted enclosure with hinged door. A pressure switch installed in the piping system and set for approximately 0.35 bars greater than the pressure switch for the main fire pump when pressure in the system drops below the preset level.
- 2.1.5.10 Controller shall include a minimum-run timer, to insure a 3 minutes minimum pump operation, to prevent the jockey pump from frequent operations and shall include volt free contacts for connection to BMS.

2.2 Description of Operation

- 2.2.1 The low level water reservoir shall be used for fire fighting purposes.
- 2.2.2 The network is always wet and under pressure, where a jockey fire pump is used to pressurize the system and to operate whenever water leakage in the system occurs.
- 2.2.3 Whenever a fire valve is opened or a sprinkler head is actuated automatically, water under pressure from the network will flow automatically and the jockey pump runs automatically for a preset time, after which it stops, and one of the fire pumps starts automatically if the following two conditions are satisfied simultaneously.
- a) The flow switch, in the main fire water stream senses the flow, and
 - b) The contacts of the pressure switch, in the suction line of the pump, are closed.
- 2.2.4 The operation of the fire pumps will ring two alarm bells one in the pump room and the other in the main control panel located wherever shown on drawings.
- 2.2.5 A flow switch is installed in the main supply line to each zone; when this switch senses any flow it should give a visual and audible alarm in the main fire control panel. In addition the signal should be linked with the fire alarm system (supplied under Electric Section). So that an alarm shall be initiated in that particular zone.
- 2.2.6 If the first pump fails to start, the stand-by pump shall start automatically. When all the fire valves are closed, the flow switch shall automatically stop the operating fire pump.

PART 3 EXECUTION

3.1 Installation of Pumps

- 3.1.1 Pumps shall be mounted on bases with isolating pads as specified in the specification.
- 3.1.2 Pumps and motors shall be aligned and levelled throughout the length and width, and wherever necessary, suitable shims shall be provided to facilitate pipe connections and levelling.
- 3.1.3 Pumps shall be secured to bases with proper size anchor bolts.
- 3.1.4 Drains for packing glands and base shall be piped to nearest drain outlet.
- 3.1.5 Where corrosion can occur, appropriate corrosion-resistant materials and assembly methods must be used including isolation of dissimilar metals against galvanic interaction.
- 3.1.6 Provide casing connections for vents, drains, suction and discharge pressure gauges.
- 3.1.7 Balance impellers and all other moving components statically and dynamically.

- 3.1.8 Grout base plates completely to provide a rigid non-deflecting support.
- 3.1.9 Install packing rings with alternate layers staggered 90 degrees. Tighten packing for seal while permitting prescribed amount of leakage.
- 3.1.10 Install and align mechanical seals in accordance with the manufacturer's recommendations.
- 3.1.11 Each pump shall be provided with pressure gauges at suction and discharge sides.
- 3.1.12 Coupling guards shall be provided to all pumps.

3.2 Pump Settings

- 3.2.1 All pumps and motors shall be properly set, levelled, and aligned on bases and foundation pads in strict accordance with the manufacturer's instruction and their recommended tolerances. This shall be done before any piping or electrical connections are made.
- 3.2.2 After all connections have been made, and just prior to putting each pump into operation, it shall be checked again for levels and alignment.
- 3.2.3 All necessary adjustments shall be made to assure that the thrust is balanced, that shaft rotates freely when turned by hand and that pump is quiet in operation.

3.3 Pumps Testing

- 3.3.1 Pumping equipment shall be tested for operating characteristics, and duration of test shall be set by the Engineer. Apparent defective equipment shall be repaired or replaced and adjustment made to the equipment as may be necessary, all to the satisfaction of the Engineer.
- 3.3.2 Before shipment, the manufacturer shall test all components hydraulically at 150% of rated working pressure for ability to withstand maximum design pressure and for tightness.
- 3.3.3 Upon completion of the installation, test all equipment under field operating conditions to demonstrate capability of the equipment to meet specified requirements. Compile and certify the following data.
 - a. Water flow, GPM (l/s) at rated head.
 - b. Shut-off head.
 - c. Operating Kilowatts from measured voltage, amperes and power factor.

3.4 Spare Parts

- 3.4.1 The Contractor shall provide as part of his contract a list of spare parts for all the equipment supplied sufficient for three years of operation all in accordance with the recommendations of the manufacturers of the equipment.

3.5 Special Tools

- 3.5.1 A complete set of special tools, oil and grease for all the plant and equipment supplied, adequate for 12 months operation shall be supplied by the Contractor at the completion date of the project.

3.6 Operation and Maintenance Manuals

- 3.6.1 The Contractor shall furnish and submit to the Engineer in triplicate bound, A4 size, Instruction Manuals containing the following material:-
- 3.6.1.1 Brief description of each system and its service and basic operation features.
- 3.6.1.2 Manufacturer's mechanical equipment parts list of all functional components of the systems listed on the Drawings, control diagrams and wiring diagrams of controllers. List shall give system No., unit no., Manufacturer's Model No., and Manufacture's Drawing no. Parts list shall include manufacturer's recommended spare parts for one year operation.
- 3.6.1.3 Maintenance instructions for each type of equipment.
- 3.6.1.4 Possible breakdowns and repairs for each type of equipment.
- 3.6.1.5 List of nearest local suppliers for all equipment.
- 3.6.1.6 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.
- 3.6.1.7 Complete, as installed, color coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.
- 3.6.1.8 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfilment of the specified requirements.
- 3.6.1.9 All items shall be available at least four weeks prior to the substantial completion date.

3.7 Guarantee And Warranted Period

- 3.7.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.
- 3.7.2 All guarantee shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.
- 3.7.3 The Contractor shall guarantee every piece of equipment from any manufacturing or installation defects for a period of one year, starting from the date of issue of the substantial completion certificate.

FIRE SUPPRESSION VALVE AND HOSE CABINET

PART 1 GENERAL

- 1.1 General Requirements
- 1.2 Related Work Specified Elsewhere
- 1.3 Codes and Standards

PART 2 PRODUCTS

- 2.1 Fire Hose Cabinet
- 2.2 Fire Hose Cabinet (Exposed Cabinet Type)
- 2.3 Hose Cabinet Equipment and Accessories
- 2.4 Fire Hose Landing Valve

PART 3 EXECUTION

- 3.1 Pipe Installation
- 3.2 Cleaning of Piping Systems
- 3.3 Approved List of Manufacturers

FIRE SUPPRESSION VALVE AND HOSE CABINET

PART 1 GENERAL

1.1 General Requirements

- 1.1.1 To be read and governed by general Conditions of Contract and its Sections.
- 1.1.2 The Contractor shall be responsible to confirm and seek the approval of the fire department or persons having jurisdiction and the approval of the Engineer before ordering the materials.
- 1.1.3 Pipe bending shall not be resorted to except in extreme cases and only after the written approval of the Engineer.
- 1.1.4 Automatic air vents shall be installed at all air pocket locations, and/or at the highest points in the lines.
- 1.1.5 Pipes and fittings shall both be manufactured according to one single standard unit of measurement, either both English or both metric.
- 1.1.6 Provision shall be made for flushing the system.
- 1.1.7 Drain valves shall be provided where necessary, where shown on the Drawings and at all sectional valves to help draining the major part of the system. On all risers 4" (100mm) or larger, drain valve shall be 2" (50 mm) size, on 2½" (65 mm) and 3" (80mm) risers, 1¼" (32 mm) valves shall be used and on small risers, ¾" (20mm) drain valves shall be provided.
- 1.1.8 Fire fighting piping shall not be used, in any way, for domestic water supply purposes.
- 1.1.9 All valves controlling the water supply shall be located where readily accessible.

1.2 Related Work Specified Elsewhere

- 1.2.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.
- 1.5.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

- Section 10 44 00 - Fire Protection Specialists
- Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
- Section 21 05 23 - General Duty Valves for Fire Suppression Piping
- Section 21 05 29 - Hangers and Supports for Fire Suppression Piping
- Section 21 05 48 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
- Section 21 05 53 - Identification for Fire Suppression System
- Section 21 11 00 - Fire Suppression Piping
- Section 21 12 00 - Fire Suppression Stand Pipes
- Section 21 13 00 - Fire Suppression Sprinkler Systems

- Section 21 20 00 - Fire Extinguishing Systems
- Section 21 30 00 - Fire Pumps
- Section 21 40 00 - Fire Suppression Water Storage

1.3 Codes and Standards

- 1.3.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall conform to the applicable portions of the latest editions of the following codes, standards and regulations.

<u>Reference Code</u>	<u>Abbreviation</u>	<u>Applicable Standard</u>	<u>Title of Standard</u>
15. Underwriters Laboratories	UL	-	-
16. British Standards	BS	BS3169 BS5839 Part 1	Specification for first aid reel hoses for fire fighting purposes Fire detection and alarm systems for buildings. Code of practice for system design installation and servicing.
17. National Electrical Manufacturers Association	NEMA	MIG Part 14	
18. National Electrical Code	NEC	-	-
19. National Fire Protection Association	NFPA	14	Combined Stand Pipe & Hose System with Sprinklers
20. American Water Works Association	AWWA	-	-

PART 2 PRODUCTS

2.1 Fire Hose Cabinet

- 2.1.1 Cabinets are as detailed on Architectural drawings.

2.2 Fire Hose Cabinet (Exposed Cabinet Type)

- 2.2.1 Supply and install Fire Hose Cabinets wherever shown on drawings and to the details indicated on the drawings.
- 2.2.2 Cabinet shall be constructed of steel 16 – Gauge for “Trim, 18 – Gauge for “Tub” and 20 – Gauge for “Door”. Cabinet size shall be in accordance with the details shown on drawings. Cabinet door shall be flush, pull handle and tension latches and shall be equipped with full length plan hinges on the right or the left as conditions requires.
- 2.2.3 Cabinets shall receive an approved shop coat of paint inside and outside.

2.3 Hose Cabinet Equipment and Accessories

- 2.3.1 Each Fire Hose Cabinet shall include the following:-

- 2.3.1.1 Fire hose diameter 1" (25 mm), 100ft.(30 m.) long, light weight made of red rubber with a working pressure of 150 psi. (1030 Kpa).
- 2.3.1.2 Hose shall comply with BS 3169 Type A.
- 2.3.1.3 Hose reel of the swinging type, up-to 180 degrees full swing complete with guide arm.
- 2.3.1.4 Chromium plated diameter 1" (25 mm) fog nozzle capable of complete shut off, straight stream or any degree of solid conical fog.
- 2.3.1.5 Diameter 1" (25 mm) pressure reducing valve and gate valve with die cast non-ferrous alloy housing with machined water way.
- 2.3.1.6 Fire hose: 2 ½" (65 mm) dia. 100 ft. (30 m) long, light weight made of single jacket cotton rubber lined and shall carry UL Listing, with polished chrome plated brass couplings. Hose shall be in the cabinet with no permanent connection at the riser.
- 2.3.1.7 Hose rack of the swinging type up-to 180 deg. Full swing complete with guide arm. Rack shall be steel backed red enamel.
- 2.3.1.8 Chrome – plated. All purpose nozzle 2 ½" (65 mm) dia. with adjustable spray head and capable of complete shut-off, straight steam or any degree of solid conical fog.
- 2.3.1.9 2 ½" (65 mm) dia. bronze angle hose landing valve with quick press-type compiling adaptor cap and chain.
- 2.3.1.10 6 kgs. Dry chemical fire extinguisher with spray hose and nozzle.
- 2.3.1.11 5 kgs. CO2 fire extinguishers with spray hose and nozzle.

2.4 Fire Hose Landing Valve

- 2.4.1 Fire hose landing valve shall be in accordance with B.S. The valves shall be angle type, 300 psi (2070 Kpa) with built-in pressure reducing and globe valve with polished, chrome-plated brass body and trim, red cast iron wheel handle, bronze stem, renewable composition disc, FLANGED 2 ½" (65 mm) inlet and quick coupling outlet with polished brass chrome plated cap and chain.
- 2.4.2 For valves with integral pressure reducing valve, the pressure regulator shall be spring loaded with springs made of zinc plated steel and chamber of chrome plated bronze. The regulator shall have stainless steel adjusting and lock screw and ball, bronze piston and Nitrile rubber low pressure seal.

PART 3 EXECUTION

3.1 Pipe Installation

- 3.1.1 Piping shall be pitched to permit complete draining of the system.
- 3.1.2 Fire standpipe shall not be used in any way to provide water for other purposes.
- 3.1.3 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un-insulated lines or of the insulation for insulated pipes.
- 3.1.4 Install sleeves through interior walls and partitions flush with finished surfaces; sleeves through outside walls to project 15mm. on each side of the finished wall; and floor sleeves to project 25mm. above finished floors.

3.1.5 Set sleeves in place before pouring concrete or securely fasten and grout in with cement.

3.2 Cleaning of Piping Systems

3.2.1 Plug all opening ends of piping, valves and equipment except when actual work is being performed to minimize accumulation of dirt and debris.

3.2.2 Prior to the performance of tests, flush out all piping that is to receive a hydrostatic test with clean water.

3.2.3 Remove dirt and debris collected at screens, strainers and other points from the system.

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 General Requirements

1.1.1 The work of this Section shall be governed by General Conditions of Contract.

1.1.2 It is the Contractors responsibility to be fully aware of and comply with all of the requirements of the above listed documents, and further assure that all Subcontractors are equally informed.

1.2 Application

1.2.1 This section applies to and is part of all previous sections.

1.3 Scope of Works

1.3.1 The works covered under this contract include supply, installation, testing, adjusting and putting into operation systems, components of systems, and individual items of equipment, and work related thereto, in accordance with the project Tender Documents. Products not mentioned but obviously necessary for the completion of those works shall be provided such as, but are not limited to the following:

- Requirements of fire dampers wherever duct crossing fire wall.
- System air balancing and associated requirements to do the balancing
- System water balancing and associated requirements to do the balancing.
- Insulation of valves and valve boxes.
- Maintaining the noise levels as specified
- Steel platforms (fly over) above services in plant rooms and roof.

1.3.2 Unless specifically mentioned otherwise, the following electrical works and materials for the Mechanical equipment shall be supplied and installed in all respect to the requirements of the Electrical Specifications.

- a) All control panels including doorlock disconnected switches, push buttons, starters, contractors, circuit breakers, time delays, selector switches, relays, transformers, timers, controllers, pilot lights, setpoints, alarms and all other electrical equipment which are necessary for the satisfactory operation, control and protection of all plant supplied under this section of the specifications.
- b) Whenever a number of starters controllers, instruments, indicating lights and the like occur or are shown on the Mechanical and/or electrical Drawings, they shall be arranged in a central position in a neat, easily cleaned, factory-built panel, or motor control center assembly. The assembly shall include isolators and all necessary fuses, busbars, starters, instruments, relays, push-buttons, indicating lights and the like. Components shall be mounted in a logical order based on the sequence of operation.
- c) All control equipment including thermostats, sensors, detectors, actuators, controllers, pressure level and flow switches, annunciation alarms, remote control stations and all such equipment needed for the proper system operation.
- d) All control wiring for the above mentioned equipment.

- e) Final connection, between disconnect switches, power outlets, flex outlet and mechanical equipment.
- f) The following electrical works and materials for the mechanical equipment shall be supplied and installed under the electrical part of this contract.
 - i- All power supply upto and including the following:
 - . Power outlets for indoor split units.
 - . Disconnect switches when specified to be installed separate from the control panel.
 - . Flex outlet for exhaust fans.
 - ii- Power supply upto control panels when specified with an integral disconnect switch.
 - iii- Power supply to disconnect switches when the switches are built-in the equipment.
 - iv- Empty conduits with pull wires for all cables and wires classified under the mechanical scope of works.
 - v- Control outlet boxes for all control equipment classified under the mechanical scope of works.
 - vi- Power cables and conduits or fixing arrangement between heat pumps units or VRF units and their control panel.
 - vii- Power cables and conduits from central control panel to the various equipment controlled from the same panel, such as exhaust fans, supply air fans, etc..

1.4 Quality Assurance

- 1.4.1 The manufacturer's of all materials and equipment must have at least ten years of experience in the design and manufacture of their products.

1.5 Related Work Specified Elsewhere

- 1.5.1 In addition to the mentioned above, the works shown herein after shall be applicable along with the requirements of the related divisions and sections.

1.6 Engineer's Drawings

- 1.6.1 The Drawings are based on design and include general layouts and typical details of various systems to be installed. The Contractor shall make the installations in a workmanlike manner to conform to the structure, to avoid obstructions, to preserve head room, and to keep openings and passage ways clear without additional instruction and without additional cost to the owner.

1.7 Shop Drawings and Data to be submitted for Approval

- 1.7.1 The Contractor shall submit Shop Drawings showing the exact routing and locations of all the piping, ducting, equipment, etc., all in their respective locations and according to the dimensions of the approved manufacturer. Shop Drawings scale shall be 1/10, 1/20, 1/50 and 1/100 as applicable and as approved by the Engineer.
- 1.7.2 The Contractor shall submit catalog cuts and brochures of products with reference to proper paragraph in specifications. All submittals shall be binded in one Booklet.

1.7.3 The Contractor shall submit adequate Engineering data on each piece of equipment together with all characteristic curves, capacity selection charts and all data for testing and balancing of the systems. In addition the Contractor shall submit manufacturer's printed installation instructions.

1.7.4 The Contractor shall submit at the beginning of the project a schedule of submittals for materials and shop drawings to the approval of the Engineer.

1.8 Approved Materials

1.8.1 All materials shall be furnished in accordance with the requirements of the Specifications.

1.8.2 The naming of manufacturers in the Specifications shall be strictly adhered to in all circumstances.

1.8.3 Substitution of materials other than those named shall not be submitted.

1.8.4 Materials shall be delivered in unbroken packages bearing the brand and maker's name, and shall be stored on platforms and properly covered to protect them from moisture, heat and dust.

1.8.5 All materials shall be supplied from the main factories in the country of origin of the manufacturer. Any deviation from this, like supplying equipment assembled in another different country under a license or another name is not accepted unless approved by the Engineer.

1.9 Instruction Period

1.9.1 The Contractor shall be responsible for the training and familiarization of the Employer's maintenance staff for a period of at least six weeks on all equipment and plants he has supplied or installed.

1.10 Machinery Guards

1.10.1 All moving parts of machinery shall be protected by strong guards to adequately protect all personnel working on or in the vicinity of equipment.

1.10.2 Wherever possible, moving parts should be protected by guards supplied by the equipment manufacturer. All guards must be strongly attached to equipment and should be designed to be easily removed for access, servicing, adjustment and maintenance.

1.11 Instruction Manual and As-built Drawings

1.11.1 The Contractor shall furnish and submit to the Engineer in electronic and hard copy triplicate bound, A4 size, Instruction Manuals containing the following material:

1.11.2 Brief description of each system and its service and basic operation features.

1.11.3 Manufacturer's mechanical equipment parts list of all functional components of the systems listed on the Drawings, control diagrams and wiring diagrams of controllers. List shall give system No., unit no., Manufacturer's Model No., and Manufacturer's Drawing no. Parts list shall include manufacturer's recommended spare parts for one year operation.

1.11.4 Chart of the tag numbers, location and function of each valve.

1.11.5 Maintenance instructions for each type of equipment.

1.11.6 Possible breakdowns and repairs for each type of equipment.

- 1.11.7 List of nearest local suppliers for all equipment.
- 1.11.8 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.
- 1.11.9 Complete, as installed, color coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.
- 1.11.10 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.
- 1.11.11 All items shall be available at least four weeks prior to the substantial completion date.

1.12 Abbreviations

- 1.12.1 The following abbreviations have been mentioned in the specifications.
 - 1.12.1.1 AMCA - Air Moving and Conditioning Associations.
 - 1.12.1.2 ANSI - American National Standard Institute.
 - 1.12.1.3 ARI - Air Conditioning and Refrigeration Institute.
 - 1.12.1.4 ASA - Acoustical Society of America, American Standards Association.
 - 1.12.1.5 ASHRAE - American Society of Heating Refrigeration and Air Conditioning Engineers.
 - 1.12.1.6 ASME - American Society of Mechanical Engineers.
 - 1.12.1.7 ASTM - American Society for Testing and Materials.
 - 1.12.1.8 BSI - British Standards Institution.
 - 1.12.1.9 SMACNA - Sheet Metal and Air Conditioning Contractors National Association
 - 1.12.1.10 UL - Under Writers Laboratories.
 - 1.12.1.11 BTU - British Thermal Units.

1.13 Workmanship

- 1.13.1 All workmanship required to accomplish the work mentioned in Mechanical specification or shown on related Drawings, shall conform to the highest standards, and as required by the Engineer.
- 1.13.2 The Engineer will be the sole judge of the standards required.

PART 2 EXECUTION

2.1 Cleaning and Adjusting

- 2.1.1 All apparatus shall be thoroughly cleaned before being placed in operation. Finished surfaces shall be restored if damaged and entire installation shall be delivered in perfect condition, subject to the approval of the Engineer. Systems shall be adjusted and balanced to operate as shown in the Drawings and herein specified.

2.2 Tests

- 2.2.1 All piping and equipment shall be tested as specified under the corresponding section of the Specifications and to meet local and specified requirements. Provide anemometers, thermometers, gauges, voltmeters, ammeters, and similar instruments, not part of the permanent installation, but required to record the performance of the equipment and systems. Labor, materials, power, etc., required for testing, shall be furnished by the Contractor, unless otherwise indicated under the particular section of the Specifications.

- 2.2.2 Tests shall be performed in the presence of representatives of the Engineer and such other parties that have legal jurisdiction and all results shall be recorded.
- 2.2.3 In general, pressure tests shall be applied to piping systems only before connection of fixtures, equipment and appliances. In no case shall any piping, fixtures, equipment or appliances be subjected to pressures exceeding the ratings as prescribed by the manufacturers of fixtures, equipment and appliances, or accepted engineering standards for piping and fittings.
- 2.2.4 All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Engineer and authorities having jurisdiction, and at no additional cost to the Employer.
- 2.2.5 Any damages resulting from tests shall be repaired and/or damaged materials replaced, all to the satisfaction of the Engineer, and at no additional cost to the Employer.
- 2.2.6 The duration of tests shall be as determined by all parties having jurisdiction, but in no case less than the time prescribed in each division of the Specifications.
- 2.2.7 The following tests should be furnished for but limited to the following:
- a. Vibration isolation test
 - b. Sound attenuator test
 - c. Insulation test
 - e. Refrigeration pipes test.
 - f. Pump tests
 - g. Heat pumps/VRF tests
 - h. Air and water balancing
 - i. Exhaust systems tests
 - j. Noise and vibration measurement
 - k. Room condition tests
 - m. Controls and building management test
- 2.3 Coordination of Trades**
- 2.3.1 The Contractor shall coordinate the work to ensure orderly, timely installations of the work of applicable trades within the various spaces indicated.
- 2.4 Access Doors**
- 2.4.1 Access doors shall provide ready access to concealed control valves, traps, cleanouts, motors, fire dampers, and other items requiring operation, adjustment, or maintenance.
- 2.4.2 Doors and frames shall be of 12-gauge galvanized steel with invisible hinges, and cam lock fastenings. For plaster walls or ceiling, frames shall have a 50 mm. wide lath plaster bond. For masonry walls, the frame shall be set flush with masonry with provisions in the jamb for anchoring. Doors shall be solid flush steel with grey metal primer. Location of access doors shall be coordinated with and shall have the approval of the Engineer before the mechanical work is installed.
- 2.5 Permits**
- 2.5.1 The Contractor shall obtain and pay for all necessary permits, inspections and tests, for the proper installation of his work, as may be required by the various administrative authorities having jurisdiction.
- 2.5.2 Certificates of inspections, tests etc., with the proper approval certified thereon, shall be secured by the Contractor and these documents shall be delivered to the Engineer before the work in question will be accepted.

2.6 Openings in Exterior Walls

- 2.6.1 Openings in exterior walls, particularly at or below grade shall be kept properly plugged and caulked at all times, (except when being worked on) to preclude the possibility of flooding due to storms or other causes. After completion of work, openings shall be permanently sealed and caulked in the manner herein specified.

DX SPLIT AIR CONDITIONING UNITS & VRF SYSTEM

PART 1 GENERAL

1.01 SCOPE OF SECTION

A. This technical specification establishes the quality of materials and workmanship to be used in the supply and installation of the packaged and Split air conditioning units VRF system.

1.02 WORK INCLUDED

A. Provision of all labor, materials and the performance of all operations in connection with the supply and installation of the packaged and room air condition as specified herein and shown on the drawings.

B. Coordination: The Contractor shall be responsible for proper coordination of the work of all trades.

1.03 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of packaged and room air conditioning equipment and fittings whose products have been in satisfactory use in similar service for not less than 10 years.

B. Installer: Firms regularly engaged in the installation of packaged and room air conditioning equipment of a similar quality and scope as this project for at least 5 years.

1.04 APPLICABLE CODES AND STANDARDS

- A. The room air conditioners shall comply fully with the latest relevant International and British Standards in all respects.
- B. The following are the most commonly used standards associated with ducted split air conditioners, however the Contractor shall ensure that all applicable standards are complied with, whether listed here or not.

BS:3456 Part 2	- Room Air Conditioners
Section 2.34 BS: 2852	- Testing for Rating of Room Air Condition
BS: 5491	- Testing Unit Air Conditioners Above 7Kw Capacity
NEC Article 44	- Air Conditioning and Refrigerating Equipment.
ISO R859	- Testing and Rating Room Air Conditioners Consolidated Consultants
15780-2 ARI 210	- Unitary Air Conditioning Equipment
ARI 270	- Sound Rating of Outdoor Unitary Equipment
ARI 360	- Commercial Industrial Air Conditioning Equipment.

1.05 SUBMITTALS

Products: Submit full manufacturers data for every item.

1.06 WARRANTY

A. Provide 12 months warranty in accordance with contract conditions.

PART 2 PRODUCTS

2.01 CEILING MOUNTED DX SPLIT SYSTEM AIR CONDITIONERS

- A. Direct Expansion (DX) split system air conditioning units shall be installed as indicated on the drawings and shall be complete with all required refrigerant piping, temperature controls and all other necessary ancillary items.
- B. The units shall deliver the design cooling capacity at the external ambient specified. The units shall be suitable for continuous operation with external ambient temperature at 40°C.
- C. Controls shall be factory wired and completely enclosed within the unit. All operating controls shall be located in a single area. Adjustable thermostats shall automatically cycle the compressor to maintain space conditions and the sensing element shall extend across the complete face of the cooling coil.
- D. Condensate removal shall be by means of gravity drainage.
- E. Evaporator and condenser coils shall be of copper tube construction with aluminum fins and additional anti corrosion coating suitable for salty spray atmosphere.
- F. Compressor motor shall be 2 poles, permanent split capacitor type protected against both thermal and electrical overload.
- G. Filters shall be washable type easily accessible and shall cover the full unit area of recirculated air. Air filters may be nylon fiber, glass fiber cellular plastics material and shall have a minimum efficiency of 80% when tested in accordance with BS 2831 Test Dust No. 3.
- H. Refrigerant stop valves which incorporate a spindle gland shall be serviceable with the valves "in situ". Consolidated Consultants 15780-3
- I. Gas line insulation shall be carried out using 19 mm thickness of a cell, foamed plastic, tubular pipe insulation. Tape all joints to form a good vapour seal, then wrap with glass cloth and paint with two coats of approved vapour seal.
- J. The evaporator/fan coil section shall be ceiling, wall or floor standing and complete with concealed control panel and finishes as indicated on the drawings.
- K. The control panel shall have at least the following functions:
 - 1. On/Off/Cool Control
 - 2. Low/High cooling control
 - 3. Adjustable Thermostat
 - 4. Air discharge direction control On/Off

2.02 VARIABLE REFRIGERANT FLOW SYSTEM AIR CONDITIONERS

- A. VRF split system air conditioning units shall be installed as indicated on the drawings and shall be complete with all required refrigerant piping, temperature controls and all other necessary ancillary items.
- B. Outdoor Unit shall be of Modular design to enable the units to be joined together in rows. shall have specially profiled aluminum vanes, achromatized and plastic coated for surface protection against corrosive air, acid rain and saline air.
- C. Outdoor Unit shall have specially profiled aluminum vanes, achromatized and plastic coated for surface protection against corrosive air, acid rain and saline air. Each module should contain an inverter compressor in order to modulate capacity according to the demand of the indoor units.
- D. Each module shall be operable independently of the total combination in case of a failure of a module or compressor. rugged, integral unit module with baseframe and sturdy feet.
- E. Weatherproof, galvanized steel plate, primed and powder coated for outdoor or indoor installation.
- F. Electric load limiting: electrical peak load limiting function. Sequence start: automatic run-time compensation between compressors.
- G. Self-diagnosis function: for outdoor and indoor units over the data bus with operator access via the local manual operating panel and/or via the computerized diagnosis tool, providing presentation and storage of all process parameters for effective system maintenance, including a maintenance protocol print out.
- H. Backup function: If a compressor failure occurs in a single module system the remaining compressor shall ensure a 50% system capacity. This function shall be activated at the

outdoor unit. Auto Restart: Built in auto restart capability to ensure automatic system start after power failure. Consolidated Consultants 15780-4

- I. The outdoor units shall be CE marked.
- J. Expansion Valve: Electronic injection valve, controlled by the Micro-processor system controller.
- K. Defrost: Short, direct defrost function by reversing the circulation flow.
Connection ratio: From 50% up to 130%
- M. Piping Limitations: Max.: actual maximum distance between outdoor and indoor units 150 m (175m equivalent). Height difference between outdoor and indoor: 50m
Total Pipe length = 300 meter.
- N. Compressor shall be Scroll type compressor with only one moving component (scroll); optimized for R410A refrigerant in a hermetically sealed, pressurized gascooled, sound insulated casing with integrated drive motor.
- O. All compressors shall be fitted within the unit on anti-noise mountings. To prevent a lack of oil occurring, a dynamic oil balancing system shall be fitted to the inlet side and a large surface area oil separator is installed on the outlet side. In addition, an automatic oil return cycle for the whole system network shall be periodically activated by the MICRO-PROCESSOR system controller.
- P. The compressor, the electrical and thermal motor protection and the oil sump heating shall all be controlled by the MICRO-PROCESSOR system controller.
- Q. Cooling circuit Optimized for the use of R 410 A refrigerant & shall comprise refrigerant collector, filter and oil separator.
- R. Four-way changeover valve for switching between cooling/heating and dynamic defrost circuit by reversing the circulation flow.
- S. Optimum level of fill for the evaporator and overheating control for the heating mode by way of an electronic injection valve, controlled by the Micro-processor system controller.
- T. Condenser Fans shall be low noise, slow running, propeller fans with characteristic curve optimized for partial load for large volume of air at low noise level. Fan shall be fitted with swirl optimized, protective grille, for vertical air discharge & suitable for External Static pressure > 60 Pa.
- U. Indoor Unit shall be provided with long-life washable filter. The unit shall be vibration free. The coil shall be made of HI-X Cu piping with profiled aluminum fins and shall be designed for counter. Also it shall be provided with electronic expansion valve with stepping motor.
- V. All Ducted Fan coil units shall be provided with the following : False ceiling duct connection unit, Microprocessor temperature control & Radial fan, vibration-free and quiet running. Protected by a thermal contact. Consolidated Consultants 15780-5
- W. The units shall deliver the design cooling capacity at the external ambient specified.
- X.. Controls shall be factory wired and completely enclosed within the unit. All operating controls shall be located in a single area. Adjustable thermostat shall automatically cycle the compressor to maintain space conditions and the sensing element shall extend across the complete face of the cooling coil.
- Y. Condensate removal shall be by means of gravity drainage.
- Z. Unit electrical power shall be 380 volts 3 phase 50 hertz. The unit shall be capable of operating within line voltage limits of +3% to -4.6%.
- Aa. Backup function: If a compressor failure occurs in a single module system the remaining compressor shall ensure a 50% system capacity. This function shall be activated at the outdoor unit.

- Bb. Each module should contain an inverter compressor in order to modulate capacity according to the demand of the indoor units.
- Cc. Sequence start: automatic run-time compensation between compressors.
- Dd. Evaporator and condenser coils shall be of copper tube construction with aluminum fins and additional anti corrosion coating suitable for salty spray atmosphere.
- Ee. Compressor motor shall be 2 poles, permanent split capacitor type protected against both thermal and electrical overload.
- Ff. Filters shall be washable type easily accessible and shall cover the full unit area of recirculated air. Air filters may be nylon fiber, glass fiber cellular plastics material and shall have a minimum efficiency of 80% when tested in accordance with BS 2831 Test Dust No. 3.
- Gg. Refrigerant stop valves which incorporate a spindle gland shall be serviceable with the valves "in situ".
- Hh. Gas line insulation shall be carried out using minimum 10 mm thickness of a cell, foamed plastic, tubular pipe insulation. Tape all joints to form a good vapour seal, then wrap with glass cloth and paint with two coats of approved vapour seal.
- Ii. The evaporator/fan coil section shall be ceiling, wall or floor standing and complete with concealed control panel and finishes as indicated on the drawings.
- Jj. All Ducted Fan coil units shall be provided with the following more than 150 Pa external static pressure.
- Kk. Individual control for each indoor unit shall be synchronized with the outdoor unit.
- Ll. The control panel shall have at least the following functions:
 1. On/Off/Heating/Cooling Control Consolidated Consultants 15780-6
 2. Low/High heating and cooling control
 3. Adjustable Thermostat
 5. Air discharge direction control On/Off
- Mm. Energy metering system shall be provided for VRF system to measure and give readable digital data and to be connected to BMS and billing system to measure the power consumption of each office or other application in the buildings.

PART 3 EXECUTION

3.01 PRODUCT STORAGE AND HANDLING

- A. All products shall be delivered in manufacturer's original protective packaging.
- B. All products shall be inspected at time of delivery for damage and for compliance with Specifications.
- C. All products that are found to be damaged, or not in accordance with the Specifications shall immediately be repaired or removed from the site and replaced. Repairs shall not be undertaken before Engineer's review of the Contractor's proposed action.
- D. All products shall be handled and stored as recommended by manufacturer to prevent damage and deterioration.
- E. The Contractor shall supply handling equipment such as lifting beams, reinforced canvas slings, protective paddings, struts, cradles, etc., required to handle products without damaging hardware or linings and coatings.

3.02 INSTALLATION

- A. All units mounted externally shall have a raised concrete base with a minimum height of 100mm above surrounding surfaces. The base shall be sloped to provide natural drainage and ensure that ponding does not occur under the unit.
- B. Each unit of whichever type shall be complete with a local electrical disconnect switch.
- C. The units shall be of the sizes, capacities, duties and types indicated on the drawings and shall be installed in strict accordance with the manufacturers requirements.
- D. Each outdoor unit shall be installed on a vibration isolation base as per relevant specification section.

HVAC FANS

PART 1 GENERAL

1.1 Scope of Work

- 1.1.1 The works covered under this Section shall include all the supply, installation, testing and delivery in good operating conditions of a complete Ventilating system as described, shown detailed or implied in the tender documents of the project.
- 1.1.2 The Contractor shall provide all the necessary components and accessories as well as manpower, scaffolding, painting, testing facilities, etc... at his own expense to execute a complete operable system.
- 1.1.3 The Contractor shall program his work such that it will not interfere with other trades and to suit site requirements.

1.2 Related Works Specified Elsewhere

- 1.2.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.
- Common Works Results for HVAC
 - HVAC Insulation
 - Instrumentation And Controls for HVAC
 - HVAC Piping and Pumps
 - HVAC Air Distribution
 - HVAC Cleaning Devices
 - Central HVAC Equipment
 - Decentralized HVAC Equipment
 - Integrated Automation

1.3 Codes and Standards

- 1.3.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

<u>Reference Code</u>	<u>Abbreviation</u>	<u>Applicable Standard</u>	<u>Title of Standard</u>
American Society of Heating Refrigerating and Air Conditioning Engineers.	ASHRAE	-	-
National Electrical Manufacturers Association	NEMA	-	-
National Electrical Code	NEC	---	-
Air Moving and Conditioning Associations	AMCA	-	-
National Fire	NFPA	NFPA 90A	Standard for Air Conditioning and

Protection Association			Ventilation Systems
Underwriters Laboratories	UL	UL181	-
American Standards for testing and Materials	ASTM	ATSM A525-75	Specification for general requirements for steel sheet, zinc-coated (galvanized) by the hot-dip process.

1.4 General Requirements for Ventilating Fans

- 1.4.1 The fan motors and starters shall be in accordance with the Electrical division of these specifications.
- 1.4.2 Test and rate all fans in accordance with the standards of the AMCA. All fans must bear the AMCA certified rating seal.
- 1.4.3 Make appropriate allowance for the effects on fan performance of all installation conditions including plenum enclosures and inlet and discharge arrangements so that actual installed fan performance equals that specified.
- 1.4.4 Balance all fan wheels and all other moving components statically and dynamically. Where coating is specified and it affects the balance of the fan wheel, perform balancing after the coating has been applied.
- 1.4.5 Drill all fan shafts on the center line to receive a tachometer.
- 1.4.6 Belt driven fans shall be connected to the driving motor by means of an approved V-belt drive, with adjustable sheaves, unless otherwise designated. V-belt drives shall be designed for 50% overload capacity and the motors for such drives shall be equipped with adjustable bases or slide rails.
- 1.4.7 Bearings shall be self-aligning, grease lubricated, ball-bearing type, and shall be complete with grease fittings, extended for easy access where necessary.
- 1.4.8 Weather proof hoods should be provided for all motors and drives exposed to weather to the approval of the Engineer.
- 1.4.9 Back draft dampers, gravity type, shall be installed on the fan discharge of all fans discharging directly to the atmosphere except the kitchen hood fan.
- 1.4.10 Fans scheduled for the exhaust of kitchen equipment hoods and high temperature exhaust systems shall include an up blast arrangement on the discharge with complete grease drainage and insulated heat shield to protect motor and drive, all designed for high temperature services.
- 1.4.11 Fans are to operate steadily without pulsation at design conditions. Centrifugal fan characteristic curves must be such that the fan operating point falls below the point of no flow static pressure, to the right of the point corresponding to that of maximum mechanical efficiency, and a 15% increase in static pressure over that specified results in not more than a 15% reduction in cfm and does not affect the stability of fan operation. If necessary accomplish the foregoing by modifying the width of the wheel and/or by providing inlet vanes to change the characteristic curve.
- 1.4.12 Performance curves shall be submitted for each fan for approval.

PART 2 PRODUCTS

2.1 Centrifugal In-Line Fan (Smoke/Fume Fans)

2.1.1 Fan shall be of the centrifugal in-line type steel construction and shall be complete with:

- a- Electric motor mounted outside the air stream.
- b- Metallic fixing frame and supports.
- c- Dust proof, non fused disconnect switch under motor casing.
- d- Belt drive and belt guard.
- e- Vibration isolators.
- f- All aluminium centrifugal backward inclined blades impeller with non overloading horse power characteristic.
- g- Flexible duct connection at each end.
- h- Fans used for smoke exhaust shall have all welded housing with motors and all parts rated for the high temperature anticipated by the smoke, but not less than 572°F (300°C).
- j- Electric meter shall be of variable speeds if shown in capacity schedule.

2.1.2 Fans shall be supplied complete with minimum IP55 sheet steel control panel. The panel shall include but shall not be limited to the following:-

- a- Door interlocked disconnect switch.
- b- Duty alternator (where needed)
- c- Circuit breaker.
- d- Motor starters
- e- On/Off/Auto with pilot light
- f- Control power transformer
- g- Control wiring
- h- Volt free contacts for connection to BMS
- i- Single phasing protection

2.1.3 Fans shall be coated at the factory with anti corrosion coating as recommended by the manufacturer.

2.2 Centrifugal In-Line Fan (Up to 500 Cfm)

2.2.1 Fan shall be constructed of steel with epoxy finish highly resistant against atmospheric agents. Fan shall have back inclined impeller fixed and balanced directly on the motor. Electrical connections shall be enclosed in a plastic box with IP54 protection. All fans exhausting air from the dryer shall be rated for 60 degree C air temperature.

2.3 Centrifugal Single Inlet Fans (Staircase / Lift Well Pressurization)

2.3.1 Pressurization fan shall be of the centrifugal single inlet backward curved blades type with two-piece housing where wheel, shaft and inlet pan assembly installed in lower housing section. Average life of fan bearing shall not be less than 200,000 hours. Fan shall be complete with:

- a) Electric motor mounted on one chassis with the fan.
- b) Reinforced heavy gauge fan casing.
- c) Metallic fixing frame and supports.
- d) Dust proof, non-fused disconnect switch.
- e) Pulleys, belt drive and belt guard.
- f) Spring vibration isolators.

- g) Heavy flanges on both sections of housing for assembly. Flanged joints shall be gasketed for air tightness.
- h) Galvanized steel mesh screen.
- i) Non-return damper
- j) Fans shall be supplied complete with minimum IP55 sheet steel Control Panel (CP) as indicated in Electrical Drawings. The panel shall include but shall not be limited to the following:-

- Door interlocked disconnect switch
- Duty alternator (where needed)
- Circuit breaker
- Motor starters
- On/Off/Auto with pilot light
- Control power transformer
- Control wiring
- Volt free contacts for connection to BMS
- Single phasing protection.

2.3.2 Fans shall be coated at the factory with anti corrosion coating as recommended by the manufacturer, for outdoor use in high temperature and humid atmosphere.

2.3.3 Fans shall be interlocked with fire alarm panel to be activated in case of fire in any particular zone.

2.4 Centrifugal In-Line Fan (Not for Smoke)

2.4.1 Fan shall be of the centrifugal in-line type all aluminium construction and shall be complete with:

2.4.1.1 Electric motor mounted outside the air stream, when air temperature inside the duct is above 200 °F (93 °C), otherwise inside air stream.

2.4.1.2 Metallic fixing frame and supports.

2.4.1.3 Dust proof, non fused disconnect switch under motor casing.

2.4.1.4 Belt drive and belt guard or as stated in Capacity Schedule.

2.4.1.5 Vibration isolators.

2.4.1.6 Aluminium air foil blades impeller with non overloading horse power characteristic.

2.4.1.7 Flexible duct connection at each end.

2.5 Fresh Air Fans

2.5.1 Fan shall be of the centrifugal double inlet width, backward curved blades type with non-overloading design wheel diameters and outlets areas shall be in accordance with the standard sizes adopted by the AMCA for non-overloading fans. Inlets shall be fully stream lined and housing shall be suitably braced to prevent vibration or pulsation.

2.5.2 Fan shall be supplied complete with:

2.5.2.1 Electric motor mounted on one chassis with the fan.

2.5.2.2 Reinforced heavy gauge fan casing.

- 2.5.2.3 Metallic fixing frame and supports.
- 2.5.2.4 Pulleys, belt drive and belt guard (of expanded metal with tachometer hole).
- 2.5.2.5 Vibration isolators.
- 2.5.2.6 Fan wheels with die formed backward curved blades designed for maximum efficiency and quiet operations. Wheels shall be statically and dynamically balanced.
- 2.5.2.7 Heavy flanges on both sides of housing. Flanged joints shall be gasketed for air tightness.
- 2.5.2.8 Fan inertia should be checked against motor capability. If fan inertia is found larger, then a centrifugal or plate clutching service should be used to enable the fan to be brought up to speed without damaging the motor.
- 2.5.2.9 Motorized damper at fan outlet to open and close with fan on/off operation.

2.6 Spare Parts

- 2.6.1 The Contractor shall provide as part of his contract a list of spare parts for all the equipment supplied sufficient for three years of operation all in accordance with the recommendations of the manufacturers of the equipment.

2.7 Special Tools

- 2.7.1 A complete set of special tools, oil and grease for all the plant and equipment supplied, adequate for 12 months operation shall be supplied by the Contractor at the completion date of the project.

2.8 Operation and Maintenance Manuals

- 2.8.1 The Contractor shall furnish and submit to the Engineer in triplicate bound, A4 size, Instruction Manuals containing the following material:-
 - 2.8.1.1 Brief description of each system and its service and basic operation features.
 - 2.8.1.2 Manufacturer's mechanical equipment parts list of all functional components of the systems listed on the Drawings, control diagrams and wiring diagrams of controllers. List shall give system No., unit no., Manufacturer's Model No., and Manufacture's Drawing no. Parts list shall include manufacturer's recommended spare parts for one year operation.
 - 2.8.1.3 Maintenance instructions for each type of equipment.
 - 2.8.1.4 Possible breakdowns and repairs for each type of equipment.
 - 2.8.1.5 List of nearest local suppliers for all equipment.
 - 2.8.1.6 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.
 - 2.8.1.7 Complete, as installed, colour coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.

2.8.1.8 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.

2.8.1.9 All items shall be available at least four weeks prior to the substantial completion date.

2.9 Guarantee and Warranted Period

2.9.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.

2.9.2 All guarantees shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.

2.9.3 The Contractor shall guarantee every piece of equipment from any manufacturing or installation defects for a period of one year, starting from the date of issue of the substantial completion certificate.

HVAC DUCTS AND CASING

PART 1 GENERAL

1.1 Introduction

1.1.1 This section includes the design, supply, installation testing and commissioning of complete ductwork system for air conditioning fresh air, exhaust and ventilation systems.

1.2 Scope of Work

1.2.1 The contractor shall be responsible for submitting complete above works based on design consultant's approval of submitted samples, documents etc as per specifications and applicable standards.

1.3 Related Works Specified Elsewhere

1.3.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

- Common Works Results for HVAC
- HVAC Insulation
- Instrumentation and Controls for HVAC
- HVAC Piping and Pumps
- HVAC Air Distribution
- HVAC Cleaning Devices
- Central HVAC Equipment
- Decentralized HVAC Equipment
- Integrated Automation

1.4 Reference Standards

HVAC DW 144	Sheet Metal Ductwork
NFPA 90A	Standard for the installation of air conditioning and ventilating systems
SMACNA	Sheet Metal and air conditioning contractors national association
ASHRAE	American society of heating, refrigeration and air conditioning.
UL 181	Underwriters laboratories
ASTM A653-99	Specification for steel sheet, Zinc-coated (Galvanized) by the Hot-Dip process.

1.5 Ductwork Design Criteria

1.5.1 All rectangular ducts shall be of the low pressure rating and all circular round ducts shall be of the high pressure rating.

1.5.2 Galvanized sheet steel shall be fabricated, erected and installed in accordance with NFPA 90A and "SMACNA" sheet metal manuals.

1.5.3 All rectangular metal ducts shall be sealed in accordance with ASHRAE Standard 90 and SMACNA low pressure duct construction standards. All high pressure ducts shall be air tight.

1.5.4 Kitchen exhaust ducts shall be constructed and installed in conformance with NFPA 96 and must: Be constructed from carbon steel (for concealed ducts) with a minimum thickness of 1.4 mm and from stainless steel (for exposed ducts) with a minimum thickness of 1.1 mm.

1.5.5 Stair case or lift well pressurization duct shall be fire rated.

- 1.5.6 Ducts that meant to be used for smoke exhaust shall be fire rated unless:-
- 1.5.7 It doesn't cross any other fire / smoke zones, i.e. its route within the same fire / smoke zone which it serves.
- 1.5.8 It is contained solely in a fire rated shaft and no other services included in the same shaft.
- 1.5.9 All return air ducts inlets shall be fitted with stainless steel wire mesh.

PART 2 PRODUCTS

2.1 Ductwork

- 2.1.1 Galvanized sheet steel ducts shall be of G90 coating designation within ASTM A653-99, standard specification for 'steel sheet zinc coated by the hot dip process'. The weight of coating on both sides of duct shall be 0.9 oz/ft² (275g/m²) as a minimum check limit triple spot test.
- 2.1.2 The ducts' gauges, thickness, type and method or jointing shall be as detailed and tabulated on the Drawings and/or in compliance with ASHRAE Standards and Handbooks.
- 2.1.3 Stainless steel ducts shall be of 316 for all Toxic exhaust air in accordance with ASTM Standards and Specifications.

2.2 Duct Hangers and Support

- 2.2.1 Supply and install steel work necessary for the support of the ductwork. Hangers shall be spaced not more than 3000 mm. apart, and at changes of direction. Types and construction of hangers shall be as detailed on the Drawings and in compliance with SMACNA recommendations.

2.3 Flexible Ducts

- 2.3.1 Ducts shall be all metal constructed of heavy gauge corrugated aluminium with water tight continuous lock seams.
- 2.3.2 Ducts shall be UL 181 Class O non-combustible and complying to NFPA 90A & 90B, or tested to BS 476 (parts 6, 7 & 20) class 1 flame spread and meets the requirements of CP 413 section A2.2.3.
- 2.3.3 For air conditioning flexible ducts shall have 25mm thick fiber glass insulation and sheathed in durable polymer vapour barrier.

2.4 Fire Rated Ductwork

- 2.4.1 2 hours fire resisting ductwork shall be installed where indicated on the drawings or mentioned in Specifications or required by Local Authorities.
- 2.4.2 Provide complete 2 hours fire rated fire resistive enclosures for smoke and pressurization systems where ductwork is located outside fire rated shaft.
- 2.4.3 Fire resisting duct and smoke duct shall be manufactured erected and tested in accordance to BS 476 Part 24 ISO 6944.
- 2.4.4 Fire resisting duct shall prove by test that its cross section area is maintained above 75% when subject to full fire temperature.

- 2.4.5 Fire resisting duct shall be constructed and protected to insure maintaining the stability, integrity insulation supports, fixing throughout the required period.
- 2.4.6 Fire resistance filling (fire stopping material) shall seal the clearances between fire resisting duct and wall to insure the stability and integrity of the system.
- 2.4.7 Fire resisting duct shall be connected to fans by fire rated flexible connectors. Flexible connectors shall be made of glass fabric coated on both sides with flame retardant silver grey polyurethane rubber tested to BS476 Part 20.
- 2.4.8 All drop rods and exposed bearers shall be insulated in accordance to manufacturers instructions to assure its fire resistance.

PART 3 EXECUTIONS

3.1 Duct Construction

- 3.1.1 All ducts shall be constructed and erected so as to be rigid and free from sway, drumming and movement. Duct work shall be true to sizes indicated on Drawings, straight and smooth on the inside with neatly finished joints. Whenever internal acoustic lining is indicated on the Drawings, the duct sizes have to be increased to accommodate the lining.
- 3.1.2 Ductwork joints shall be square with all sharp edges removed.
- 3.1.3 The ducts shall be routed with a minimum of directional changes and abrupt transitions.
- 3.1.4 Adequate space shall be provided around ducts to assure proper support and to allow the installation of the specified insulation.
- 3.1.5 All connections between ductwork, including flexible connections, fittings and equipment, shall be made with gradually tapered transition fittings.
- 3.1.6 Whenever a flexible duct is used to correct misalignment between the supply duct and the diffuser ceiling location, the misalignment (or offset) shall not exceed one-eighth (1/8) the length of the collar (or diffuser diameter). Flexible duct length shall not exceed 30 cm.
- 3.1.7 Changes in section of ductwork shall be effected by tapering in ducts with as long a taper as possible. All branches shall be taken off at not more than 45 degree angle from the axis of the main duct unless otherwise approved by the Engineer.
- 3.1.8 The ducts shall be securely anchored to the building in an approved manner.
- 3.1.9 The ducts shall be installed as to be completely free from vibration under all conditions of operation.
- 3.1.10 The ducts and hangers shall be installed straight, plumb and level.
- 3.1.11 Wherever ducts pass thru walls or floors, a sleeve of galvanized mild steel sheet shall be provided and the space between the pre-insulated duct and the sleeve shall be caulked with lead wool and finished on each face with a mastic fill.
- 3.1.12 Flexible ducts should be kept as short as possible (maximum 30 cm) and fully extended.
- 3.1.13 All slip joints shall be made in the direction of flow.
- 3.1.14 All elbows shall have a centre line radius equal to at least 1.5 times the width of the duct, otherwise turning vanes shall be installed in the elbows.

- 3.1.15 Adjustable splitters and hinged volume dampers shall be provided at every duct junction on both supply and exhaust ductwork for adjusting air volumes.
- 3.1.16 Where splitters and dampers are installed above suspended ceiling, flush-mounted controlling devices shall be used.
- 3.1.17 Connection to diffusers, grilles and registers shall be made absolutely airtight.
- 3.1.18 Equalizing grids or turning vanes shall be installed ahead of an air outlet whenever poor approach conditions, from the main duct to the outlet, exist.
- 3.1.19 In critical low noise level projects, poor approach conditions are not allowed.
- 3.1.20 Where the duct is pierced for any reason, sealing compound shall be used.
- 3.1.21 All joints and fittings concealed in vertical duct shafts shall be welded.

3.2 Protection and Cleaning

- 3.2.1 During construction, cover all open ends of ductwork with one layer of canvas.
- 3.2.2 Remove all foreign materials and clean the duct inside and outside.
- 3.2.3 Clean ducts before operating fans and filters. Never operate fans unless filters are installed.
- 3.2.4 Operate the fans and thoroughly blow out the interior surfaces of the duct work.
- 3.2.5 After tests, wash cleanable filters and replace renewable media.

3.3 Access Openings in Insulated Ducts

- 3.3.1 Where ducts require to be thermally insulated the door frame shall be extended beyond the face of the duct by a measurement equal to the thickness of the insulation and as arranged so that the insulation can be 'dressed' into the frame. Doors or covers shall be suitably insulated and provisions made to ensure that the seal is continuous across the whole opening. The extent of the opening shall be clearly visible or otherwise indicated. Where it is impossible to vapour seal an access opening, provision shall be made for collecting and draining condensation.

AIR DUCTS ACCESSORIES

PART 1 GENERAL

1.1 Introduction

- 1.1.1 This section includes the design, supply, installation testing and commissioning of all materials for the complete installation of air distribution specialties and duct accessories for the air distribution system..

1.2 Scope of Work

- 1.2.1 The contractor shall be responsible for submitting complete above works based on design consultant's approval of submitted samples, documents etc as per specifications and applicable standards.

1.3 Related Works Specified Elsewhere

- 1.3.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

- Common Works Results for HVAC
- HVAC Insulation
- Instrumentation And Controls for HVAC
- HVAC Piping and Pumps
- HVAC Air Distribution
- HVAC Cleaning Devices
- Central HVAC Equipment
- Decentralized HVAC Equipment
- Integrated Automation

1.4 Reference Standards

UL 555	Standard for fire Dampers and ceiling dampers
NFPA 90A	Standard for the installation of air conditioning and ventilating systems.
ASTM – A525	Specification for general requirements for steel sheet, zinc-coated (galvanized), by the Hot-dip process.
BS 5588-Part 9	Code of Practice for air-conditioning and ventilation duct work

1.5 Fire Dampers – General Requirements

- 1.5.1 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.
- 1.5.2 Assemblies shall be complete with damper blades, fusible links, linkage and stops.
- 1.5.3 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.
- 1.5.4 Dampers and frames shall have suitable peep holes.
- 1.5.5 Fire damper installation shall guarantee the fire wall integrity.

1.6 Noise Attenuation

- 1.6.1 The Contractor shall supply and fix acoustic insulation and noise attenuator units where necessary and as shown on drawings and/or required by the Specialist study to reduce the air borne noise transmission through the distribution duct system, so that the specified noise criteria levels are satisfied.

PART 2 PRODUCTS

2.1 Volume Control Dampers

- 2.1.1 Volume control dampers shall be complete with locking levers and quadrants, indicating their position.
- 2.1.2 Volume dampers shall be provided whether shown/or not on drawings in main ducts, in all branch ducts supplying three (3) or more air outlets, in all fresh air intakes etc to achieve proper system balancing.
- 2.1.3 Volume control 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.
- 2.1.4 Upon completion of the ductwork, dampers shall be adjusted and set to deliver the amounts of air indicated on the Drawings.

2.2 Gravity Dampers

- 2.2.1 Gravity dampers shall consist of:
- a- Galvanized sheet steel frame.
 - b- Aluminum blades.
 - c- Stainless steel bearing shafts and brass bearings.
 - d- Neoprene seal to withstand 120 °C. air temperature.
 - e- Aluminum blade travel stop.
- 2.2.2 All blades shall be coupled together by means of an aluminum bar.

2.3 Flexible Connections

- 2.3.1 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. The fabric shall have a flame spread rating of not over 25 and a smoke developed rating of not higher than 50.
- 2.3.2 Flexible connections shall connect ducts across structural expansion joints.
- 2.3.3 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.
- 2.3.4 Neoprene laminated fabric, with neoprene facing on interior surface, shall be used for ducts handling other than clean dry air.
- 2.3.5 Flexible duct connection used for air conditioning, air handling units shall have vinyl coated fabric insulated with 1" (25 mm) fiberglass insulation of 0.75 lbs/ft3 (12 Kg/m3)

minimum density, designed to NFPA-90 or BS 5588 part 9 Standards. The connector should be pre-assembled metal to fabric.

- 2.3.6 The connector shall be 24 gauge galvanized zinc to ASTM-A525 G 60.

2.4 Belt Guards

- 2.4.1 Guards shall be provided for all belt-driven units.

- 2.4.2 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.

- 2.4.3 The entire assembly shall be rigidly supported.

- 2.4.4 Provision shall be made for accessibility of all points drilled to receive tachometer.

- 2.4.5 Provide coupling guards on direct-connected units.

- 2.4.6 Guards shall be designed for easy removal for service and shall comply with Underwriters' Safety Requirements.

2.5 Pressure Relief Damper (Operating Theaters)

- 2.5.1 This shall be a counter balanced back draft damper designed for gravity relief at relatively low pressure differentials.

- 2.5.2 Adjustable counter balance weights shall enable the damper to operate in the range of -08 inch (20 Pa) water gauge.

- 2.5.3 Frame and blades shall be made of extruded aluminum, extruded vinyl edge seals.

- 2.5.4 Bearing shall be of PTFE or dust ball bearing pressed units frame.

- 2.5.5 Linkage shall be of aluminum tie bar.

- 2.5.6 Counter balance shall be fabricated from zinc plated bar on blades (except top blade) adjustable for final "on the job" setting.

PART 3 EXECUTION

3.1 Access Openings

3.1.1 General

3.1.1.1 Access doors shall be provided for volume damper quadrants installed in concealed spaces, for control valves, for fire dampers or as specified hereinafter.

3.1.1.2 All access openings shall be rigidly framed and made air-tight. Covers shall be simply and speedily removed and re-fixed. Multiple set screws or self-tapping screws will not be acceptable as a method of fixing. Access doors and other openings in ductwork shall be provided for the purposes given below. The number, size and locations shall be as indicated on the Drawings or as necessary to ensure adequate access to equipment and plant.

3.1.2 Access for Personnel

3.1.2.1 Access doors shall not be larger than 1350mm. high by 500mm. wide, unless essential for equipment handling. Doors shall open against the air pressure. Duct openings and the access doors shall be adequately reinforced to prevent distortion. Suitable sealing gaskets shall be provided together with sufficient clamping type latches to ensure air-tight and water-tight sealing between the door and the duct. All personnel access openings shall have latch handles on both the inside and outside of the door.

3.1.3 Access for Maintenance, Cleaning and Inspection

3.1.3.1 Inspection openings shall generally not be larger than 300mm high by 400mm. wide unless essential for access to equipment, in which case the size shall be agreed before manufacture. The opening in the duct shall be adequately stiffened and the door cover sufficiently rigid to prevent distortion. Approved sealing gaskets and suitable fastenings shall be provided to ensure air-tight sealing.

3.1.4 Test Holes for Test Equipment and Instruments

3.1.4.1 Test holes shall be provided wherever instructed by the engineer, and in all main ducts and branch ducts to correctly establish design air flows and to check the performance of fans and regulating dampers. All holes shall be 25mm. dia. and suitably strengthened. Cover plates shall be screw-fixed to the duct and sealed.

3.1.5 Access Openings in Insulated Ducts

3.1.5.1 Where ducts require to be thermally insulated the door frame shall be extended beyond the face of the duct by a measurement equal to the thickness of the insulation and as arranged so that the insulation can be 'dressed' into the frame. Doors or covers shall be suitably insulated and provisions made to ensure that the seal is continuous across the whole opening. The extent of the opening shall be clearly visible or otherwise indicated. Where it is impossible to vapour seal an access opening, provision shall be made for collecting and draining condensation.

HANGERS AND SUPPORTS FOR HVAC PIPING

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract.

1.1 Hangers and Supports, Anchors and Guides - General

- 1.1.1 Support, anchor and guide all piping to preclude failure or deformation. Construct and install hangers, supports, anchors, guides and accessories to the approval of the Engineer. Do not use wire, tape or metal bands. Supports shall be designed to support weight of pipe, weight of fluid and weight of pipe insulation.
- 1.1.2 Fasten piping securely to the structure without overstressing any portion of the supports or the structure itself. Secure pipe supports, anchors and guides to concrete by means of inserts or if greater load carrying capacity is required by means of steel fishplates embedded in the concrete.
- 1.1.3 Arrange hanger to prevent transmission of vibration from piping to building and supports.
- 1.1.4 Un-insulated copper or brass pipe and/or tubing shall be isolated from ferrous hangers or supports
- 1.1.5 Support piping and tubing at intervals indicated in the schedule hereinafter and at all changes in direction. Maximum deflection shall not exceed 3 mm.
- 1.1.6 Clearance for application of specified Vapour sealed insulation without cutting pipeline covering or fitting covering in installation of pipe hangers and fittings shall be provided.
- 1.1.7 Furnish pipe hangers and supports complete with rods, bolts, lock nuts, swivels, couplings, brackets and all other components and accessories, to allow installation to freely expand and contract.
- 1.1.8 Hangers shall be formed steel clevis type, unless otherwise specified, with adjustable attachment to hanger rod. For copper or brass pipe, use plastic sheathed hangers. Pipe hangers shall fit over vapour sealed insulated piping.
- 1.1.9 Where pipe exceeds maximum loading recommended for clevis type hanger, provide steel pipe clamps.
- 1.1.10 Provide trapeze hangers where several pipes can be installed parallel and at the same level. Trapeze shall be of steel channel sized to support load and drilled for rod hanger at each end. Provision should be made to keep the lines in their relative position to each other by the use of either clamps or clips.
- 1.1.11 For hanger rods on piping 3/8" (10 mm) thru 2" (50 mm) inclusive use 3/8" (10 mm) rods, and for piping 2 1/2" (65 mm) thru 5" (125 mm) use 5/8" (16 mm) rods, and for piping 6" (150 mm) thru 12" (300 mm) use 7/8" (22 mm) rods.
- 1.1.12 Provide additional steel members required for hanging piping systems in areas with special conditions, or where vertical or horizontal structural steel supports are required other than those provided in the structure.

- 1.1.13 Provide lateral bracing for supporting rods over 450mm. long braced at every fourth hanger with diagonal bracing attached to slab or beam.
- 1.1.14 Floor supports - provide for supporting horizontal piping from floors with cast-iron rests, with pipe nipples to suit. Fasten to floor. Where provision for expansion is required, provide pipe roll stands, without vertical adjustment. Provide concrete or steel pipe piers, fasten stands to piers.
- 1.1.15 Wall supports - provide for supporting horizontal piping from wall with steel J-Hook for pipe located close to wall and not larger than 3" (80 mm) pipe. For greater loads, up to 1500 lbs (680 Kg) maximum loading provide welded steel bracket.
- 1.1.16 Pipe-covering (insulation) protection saddles.
- 1.1.17 Provide hanger shields to protect vapor sealed pipe insulation within mechanical equipment rooms at each support point by a 360 degree insert of high density, 100 psi, waterproofed calcium silicate encased in a 120 ° sheet metal shield. Insert thickness shall be same as insulation. Shield length shall equal nominal pipe diameter, minimum but shall not be shorter than 100mm. and need not be longer than 300mm. if bearing load causes no discernable deformation. Insert shall extend 25mm. beyond sheet metal shield. 100mm. shields shall be 26 gauge minimum. Shields 130 to 230mm. long shall be 20 gauge minimum. Shields longer than 230mm. shall be 16 gauge.
- 1.1.18 Provide penetration shields to encase insulated pipes penetrating fire walls or floors in a 360 °, 24 gauge minimum sheet metal hanger shield with insert of high density, 100 psi. waterproofed calcium silicate the same thickness as insulation and further enclosed within the sleeve, sized for maximum 25mm. spacing between sleeve and insulation shield, pack annular space between sleeve and shield on both ends with double neoprene coated asbestos rope. Install an escutcheon plate to completely cover the wall penetration opening and fit snugly over the pipe insulation shield. Insert shall extend at least 25mm. beyond penetrated surface and escutcheon.
- 1.1.19 Provide oversize hangers with blocking the same thickness as the insulation to pitch vapor sealed insulated pipes accurately at time of insulation.

1.2 Horizontal Piping Support Schedule

- 1.1.1 Steel, Copper and PVC Pipes
- . ¾" and 1" (20 and 25 mm) steel pipe-----2.5 meter
 - . 1 ¼"-2" (32 and 50 mm) steel pipe-----3.0 meter
 - . 2 ½"-4" (65 and 100 mm) steel pipe -----4.0 meter
 - . 5"-6" (125 and 150 mm) steel pipe-----5.0 meter
 - . 8" (200 mm) and above steel pipe -----6.0 meter
 - . Up to 1 ¼" (32 mm) copper pipe-----2.0 meter
 - . 1 ½" (40 mm) and over copper pipe-----3.0 meter
 - . 2 ½" (65 mm) and smaller PVC pipe-----1.2 meter
 - . 3" (80 mm) and over PVC pipe-----1.8 meter

AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 Introduction

- 1.1.1 This section of specification includes the design, supply, installation testing and commissioning of the Air inlets and outlets for the complete air conditioning and ventilating system including fresh air intakes, louvers, grilles, diffusers etc.

1.2 Scope of Work

- 1.2.1 The contractor shall be responsible for submitting complete above works based on design consultant's approval of samples, submitted documents etc as per specifications and applicable standards.

1.3 Related Works Specified Elsewhere

- 1.3.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim.

- Common Works Results for HVAC
- HVAC Insulation
- Instrumentation And Controls for HVAC
- HVAC Piping and Pumps
- HVAC Air Distribution

1.4 Reference Standards

DW 142	British Heating & Ventilating Contractors association Code of Practice
NFPA 90A	Standard for the installation of air conditioning and ventilating systems
ADC	Air diffusion council

1.5 Air Distribution Outlets General Requirements

- 1.5.1 All air outlets shall be of, at least the sizes indicated on the Drawings. Irrespective of the sizes indicated on drawings, diffusers/grillers shall be sized such that the noise spectrum of the supply outlets not higher than NC-25 but in all cases outlet selected shall perform within the noise level requirement of the space it is supplying. Outlets shall be supplied with foam rubber gaskets to prevent air leakage.
- 1.5.2 Where supply or return outlets are installed in continuous line, omit intermediate frames and margins. Provide guides for each element to keep adjoining lengths aligned and butted without breaks. All outlets shall be constructed of aluminum of the color specified or as selected by the Engineer.
- 1.5.3 Outlets causing excessive air movement, drafts or objectionable noise shall be replaced at no cost to the owner.
- 1.5.4 All outlets shall be powder coated, samples showing finish and color shall be submitted to the Engineer for approval prior to supplying the outlets to Site.
- 1.5.5 The Contractor shall provide in his Tender for delaying the fixing of loose grilles until all other trades have completed their work, returning to the Site to fit the grilles as and when required to do so.

PART 2 PRODUCTS

2.1 Square - Air Diffusers

- 2.1.1 Air diffusers shall be of the diffusion and air mixing type and shall be made of anodized aluminum.
- 2.1.1 Supplied air shall be diffused with no air velocities in excess of 50 fpm. (0.25 m/s) at 1800 mm height or less above the floor line. Room air shall be mixed with the primary air by induction to effect subsequent uniformity of the room temperature without stratification.
- 2.1.3 Each diffuser shall be provided with an aluminum opposed blade damper.
- 2.1.4 Diffuser shall not project appreciably below ceiling or duct.
- 2.1.5 The inner assembly of the diffusers shall be attached to the outer assembly by means of a lock permitting assembly and disassembly without the use of tools.
- 2.1.6 The noise level shall be measured at a point one meter below the diffuser.

2.2 Linear Diffusers

- 2.2.1 Continuous slim line diffusers shall have extruded white anodized aluminum vanes and frames, unless otherwise indicated on the Drawings, and shall be designed for surface mounting on wall, ceiling or sill.
- 2.2.2 Diffusers shall be capable of diffusing air in a horizontal or vertical plane, combining discharge air diffusion, 20% aspiration and secondary air motion causing the discharge air to be diffused in such a manner that the air is delivered in a multiplicity of high and low pressure air currents causing turbulent air motion and insuring complete coverage and temperature uniformity within the space served.
- 2.2.3 The diffuser shall be provided with equalizing deflector and damper to accomplish uniform distribution throughout the length of the outlet.
- 2.2.4 The noise level shall be measured at a point 1800 mm below on either side of the diffuser.

2.3 Linear Bar Grilles

- 2.3.1 Linear grille shall have extruded polyester powder coated aluminum fixed bar and frames, unless otherwise indicated on the drawings and shall be designed for surface mounting.
- 2.3.2 Grilles shall be capable of diffusing air in a horizontal or vertical plane with 0° to 15° or 30° deflection. Air shall be diffused in such a manner that the air is delivered in a multiplicity of high and low pressure air currents causing turbulent air motion and insuring complete coverage and temperature uniformity within the space served.
- 2.3.3 The grille shall be provided with directional blades and damper to accomplish uniform distribution throughout the length of the outlet. All deflection bars shall be securely fixed and shall be parallel to the long dimension.
- 2.3.4 The noise level shall be measured at a point 1800 mm below on either side of the diffuser.

2.4 Grilles and Registers

- 2.4.1 All grilles shall be mounted upon substantial frames connected to the duct work, and shall be provided with soft plastic mounting rings inserted under the frame, so as to obviate leaks behind the grille.

- 2.4.2 All supply grilles and high level return grilles shall be double deflection, with horizontal face blade in the front, with airfoil blade construction, with minimum of 19 mm flange with gasket.
- 2.4.3 Supply registers shall be double deflection, horizontal face bars, airfoil blade construction, with aluminum opposed blade, key operated volume dampers, and 19 mm minimum gasket flange.
- 2.4.4 Return grille at low levels and fresh air grilles shall be single deflection fixed blade type with 19mm. flange with gasket where the sheet metal is visible behind the grille, paint the interior surface of the sheet metal flat black.

2.5 Fresh Air and Discharge Louvers

- 2.5.1 Louvers for fresh air intake, and for exhaust. They shall be white anodized aluminum.
- 2.5.2 Louvers shall be weatherproof, with fixed blades set at 30 degree and shall have a free area of 85%.
- 2.5.3 Louvers shall be furnished with ½" (13mm) mesh-bird screen secured in removable extruded Aluminum frames.

PART 3 EXECUTION

3.1 Installation

- 3.1.1 All outlets shall be erected, leveled and accurately set in position, to ensure symmetry with other grilles, light fittings, etc. It has been arranged that final minor adjustments to suspension levels to obtain final accurate alignment between the ceiling and light fittings, diffusers, etc., shall be executed by those responsible for erecting the false ceilings.

3.2 Fixing

- 3.2.1 All outlets shall be concealed fixing type with no screws.

3.3 Rejected

- 3.3.1 Any imperfect outlet scratched or damaged surfaces of fixing screws having damaged heads, or scratched plating, will be rejected and shall be replaced satisfactorily before the Contract Works will be taken over as complete.

TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 Related Documents

- 1.1.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and Specifications, apply to this Section.

1.2 Summary

- 1.2.1 A qualified and approved third party shall carry out and certify the commissioning, testing, adjusting and balancing of the installed systems as per the relevant commissioning code of the British Chartered Institute of Building Services (CIBS) or ASHRAE Standards.
- 1.2.2 Major equipment such as chillers, cooling towers, fresh air units, chilled water pumps and heat exchangers shall be tested and commissioned at factory and contractor shall arrange for the Client Representative and consultant to witness this test at factory.
- 1.2.3 Testing, adjusting and balancing for all the installed systems shall include chilled water distribution, air distribution, noise and vibration measurement, automatic controls as per the procedure herein after.
- 1.2.4 The Contractor shall be responsible to provide during installation all necessary provisions to carry out the above works as required by the third party.
- 1.2.5 All costs shall be paid by the Contractor.

1.3 General Requirements

- 1.3.1 All piping and equipment shall be tested as specified under the relevant subsection of the specification.
- 1.3.2 Labour, materials, instruments, power etc., required for testing shall be furnished by the Contractor unless otherwise indicated under the particular section of the Specification.
- 1.3.3 Test shall be performed in the presence of representatives of the Engineer and such other parties as may have legal jurisdiction.
- 1.3.4 In general, pressure tests shall be applied to piping system only, before connection of fixtures, equipment and appliances. In no case shall any piping, fixtures, equipment or appliances be subjected to pressure exceeding the ratings as prescribed by the manufacturers of fixtures, equipment and appliances or accepted engineering standards for piping and fittings.
- 1.3.5 All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Engineer and authorities having jurisdiction, and at no additional cost to the Employer.
- 1.3.6 Any damages resulting from tests shall be repaired and/or damaged materials replaced, all to the satisfaction of the Engineer, and at no additional cost to the Employer.
- 1.3.7 The duration of tests shall be as determined by all parties having jurisdiction, but in no case less than the time prescribed in each subsection of the specification.
- 1.3.8 In the event of any repair or any adjustment having to be made other than normal running adjustment, the test shall be void and shall be repeated after the adjustment or repairs have been made.

1.3.9 When pipes, valves, equipment etc., are to be covered or embedded or insulated; their specific tests shall be carried out on them before any covering is applied. These tests shall not relieve the contractor of any of his responsibilities and he shall take all necessary precautions to insure the safety and protection of such tested items until the termination of the work.

1.3.10 Three copies of all test results shall be submitted to the Engineer.

1.4 Submittals

1.4.1 Two copies of Testing, Adjusting and Air Balancing strategies plans to be submitted. Plans should show step-by-step procedures as specified in Part 3. Include also a complete set of report forms intended for use on this Project.

1.4.2 Submit two copies of reports prepared, as specified in this Section, on approved forms certified by Testing, Adjusting and Air Balancing firm.

1.4.3 Warranties if specified in this Section.

1.5 Quality Assurance

1.5.1 Ensure the participation of Testing, Adjusting and Air Balancing team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide notice in advance of scheduled meeting time and location.

1.5.2 Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist Testing, Adjusting and Air Balancing activities.

1.5.3 Certify Testing, Adjusting and Air Balancing field data reports by reviewing field data reports to validate accuracy of data, and certify that Testing, Adjusting and Air Balancing team complied with approved Testing, Adjusting and Air Balancing plan and the procedures specified and referenced in this Specification.

1.5.4 Use approved standard forms.

1.5.5 Calibrate instruments at least every six months or more frequently as required by instrument manufacturer.

1.5.5.1 Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 Project Conditions

1.6.1 Completed areas of the project might be occupied during Testing, Adjusting and Balancing or before Substantial Completion. Cooperate with Owner during Testing, Adjusting and Balancing operations to minimize conflicts with Client's operations.

1.7 Warranty

1.7.1 Provide a guarantee on National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that:-

1.7.1.1 The certified Testing, Adjusting and Balancing firm has tested and balanced systems according to the Contract Documents.

1.7.1.2 Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS

NOT APPLICABLE

PART 3 EXECUTION

3.1 Examination

- 3.1.1 Examine the Contract Documents to become familiar with Project requirements and to address conditions in systems' designs that may preclude proper Testing, Adjusting and Balancing of systems and equipment.
- 3.1.1.1 Contract Documents are defined in the General and Supplementary Conditions of Contract.
- 3.1.1.2 Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- 3.1.2 Examine approved submittal data of HVAC systems and equipment.
- 3.1.3 Examine Project Record Documents described in section "Project Record Documents."
- 3.1.4 Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- 3.1.5 Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
- 3.1.6 Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- 3.1.7 Examine system and equipment test reports.
- 3.1.8 Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- 3.1.9 Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- 3.1.10 Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

- 3.1.11 Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
- 3.1.12 Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- 3.1.13 Examine strainers for clean screens and proper perforations.
- 3.1.14 Examine motorized valves for proper installation for their intended function of diverting or mixing fluid flows.
- 3.1.15 Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- 3.1.16 Examine system pumps to ensure absence of entrained air in the suction piping.
- 3.1.17 Examine equipment for installation and for properly operating safety interlocks and controls.
- 3.1.18 Examine automatic temperature system components to verify the following:
 - 3.1.18.1 Dampers, valves, and other controlled devices are operated by the intended controller.
 - 3.1.18.2 Dampers and valves are in the position indicated by the controller.
 - 3.1.18.3 Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 - 3.1.18.4 Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 - 3.1.18.5 Thermostats and humidistats are located without adverse effects of sunlight, drafts, and cold walls.
 - 3.1.18.6 Sensors are located to sense only the intended conditions.
 - 3.1.18.7 Sequence of operation for control modes is according to the Contract Documents.
 - 3.1.18.8 Controller set points are set at indicated values.
 - 3.1.18.9 Interlocked systems are operating.
- 3.1.19 Report deficiencies discovered before and during performance of Testing, Adjusting and Balancing procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.
- 3.2 Preparation**
 - 3.2.1 Prepare a Testing, Adjusting and Balancing plan that includes strategies and step-by-step procedures.
 - 3.2.2 Complete system readiness checks and prepare system readiness reports. Verify the following:
 - 3.2.2.1 Permanent electrical power wiring is complete.
 - 3.2.2.2 Hydronic systems are filled, clean, and free of air.
 - 3.2.2.3 Automatic temperature-control systems are operational.
 - 3.2.2.4 Equipment and duct access doors are securely closed.
 - 3.2.2.1 Balance, smoke, and fire dampers are open.
 - 3.2.2.6 Isolating and balancing valves are open and control valves are operational.

- 3.2.2.7 Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
- 3.2.2.8 Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 Testing and Balancing Procedures

3.3.1 Testing Air Balancing General Procedure

- 3.3.1.1 Perform testing and balancing procedures on each system according to the procedures shown herein after.
- 3.3.1.2 Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- 3.3.1.3 Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed control levers, and similar controls and devices, to show final settings.
- 3.3.1.4 Take and report testing and balancing measurements in inch-pound (IP) and metric (SI) units.
- 3.3.1.5 Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- 3.3.1.6 Prepare schematic diagrams of systems' "as-built" duct layouts.
- 3.3.1.7 Develop a plan to simulate diversity for variable-air-volume systems.
- 3.3.1.8 Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- 3.3.1.9 Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- 3.3.1.10 Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- 3.3.1.11 Verify that motor starters are equipped with properly sized thermal protection.
- 3.3.1.12 Check dampers for proper position to achieve desired airflow path.
- 3.3.1.13 Check for airflow blockages.
- 3.3.1.14 Check condensate drains for proper connections and functioning.
- 3.3.1.15 Check for proper sealing of air-handling unit components.
- 3.3.1.16 Check for proper sealing of air duct system.
- 3.3.1.17 A complete set of special tools, oil and grease for all the plant and equipment supplied, adequate for 12 months operation shall be supplied by the Contractor at the completion date of the project.

3.3.14 Procedures for Heat-Transfer Coils

- 3.3.14.1 Water Coils: Measure the following data for each coil:

- 3.3.14.1.1 Entering- and leaving-water temperature.
- 3.3.14.1.2 Water flow rate.
- 3.3.14.1.3 Water pressure drop.
- 3.3.14.1.4 Dry-bulb temperature of entering and leaving air.
- 3.3.14.1.5 Wet-bulb temperature of entering and leaving air for cooling coils.
- 3.3.14.1.6 Airflow.
- 3.3.14.1.7 Air pressure drop.

- 3.3.14.2 Electric-Heating Coils: Measure the following data for each coil:
 - 3.3.14.2.1 Nameplate data.
 - 3.3.14.2.2 Airflow.
 - 3.3.14.2.3 Entering- and leaving-air temperature at full load.
 - 3.3.14.2.4 Voltage and amperage input of each phase at full load and at each incremental stage.
 - 3.3.14.2.5 Calculated kilowatt at full load.
 - 3.3.14.2.6 Fuse or circuit-breaker rating for overload protection.

- 3.3.14.3 Steam Coils: Measure the following data for each coil:
 - 3.3.14.3.1 Dry-bulb temperature of entering and leaving air.
 - 3.3.14.3.2 Airflow.
 - 3.3.14.3.3 Air pressure drop.
 - 3.3.14.3.4 Inlet steam pressure.

- 3.3.14.4 Refrigerant Coils: Measure the following data for each coil:
 - 3.3.14.4.1 Dry-bulb temperature of entering and leaving air.
 - 3.3.14.4.2 Wet-bulb temperature of entering and leaving air.
 - 3.3.14.4.3 Airflow.
 - 3.3.14.4.4 Air pressure drop.
 - 3.3.14.4.5 Refrigerant suction pressure and temperature.

- 3.3.15 Procedures for Temperature Measurements

- 3.3.15.1 During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

- 3.3.15.2 Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

- 3.3.15.3 Measure outside-air, wet- and dry-bulb temperatures.

- 3.3.19 Procedures for Vibration Measurements

- 3.3.19.1 Use a vibration meter meeting the following criteria:
 - 3.3.19.1.1 Solid-state circuitry with a piezoelectric accelerometer.
 - 3.3.19.1.2 Velocity range of 0.1 to 10 inches per second (2.5 to 254 mm/s).
 - 3.3.19.1.3 Displacement range of 1 to 100 mils (0.0254 to 2.54 mm).
 - 3.3.19.1.4 Frequency range of at least 0 to 1000 Hz.
 - 3.3.19.1.5 Capable of filtering unwanted frequencies.
- 3.3.19.2 Calibrate the vibration meter before each day of testing.
 - 3.3.19.2.1 Use a calibrator provided with the vibration meter.
 - 3.3.19.2.2 Follow vibration meter and calibrator manufacturer's calibration procedures.

- 3.3.19.3 Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.

- 3.3.19.3.1 Turn off equipment in the building that might interfere with testing.
- 3.3.19.3.2 Clear the space of people.

- 3.3.19.4 Perform vibration measurements after air and water balancing and equipment testing is complete.
- 3.3.19.5 Clean equipment surfaces in contact with the vibration transducer.
- 3.3.19.6 Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.
- 3.3.19.7 Measure and record vibration on rotating equipment over 3 hp (2.2 kW).
- 3.3.19.8 Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.
 - 3.3.19.8.1 Pumps:
 - a. Pump Bearing: Drive end and opposite end.
 - b. Motor Bearing: Drive end and opposite end.
 - c. Pump Base: Top and side.
 - d. Building: Floor.
 - e. Piping: To and from the pump after flexible connections.
 - 3.3.19.8.2 Fans and HVAC Equipment with Fans:
 - a. Fan Bearing: Drive end and opposite end.
 - b. Motor Bearing: Drive end and opposite end.
 - c. Equipment Casing: Top and side.
 - d. Equipment Base: Top and side.
 - e. Building: Floor.
 - f. Ductwork: To and from equipment after flexible connections.
 - g. Piping: To and from equipment after flexible connections.
- 3.3.20 Procedures for Sound-Level Measurements
 - 3.3.20.1 Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.
 - 3.3.20.2 Calibrate sound meters before each day of testing. Use a calibrator provided with the soundmeter complying with ANSI S1.40 and that has NIST certification.
 - 3.3.20.3 Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm (0.51 m/s), use a windscreen on the microphone.
 - 3.3.20.4 Perform sound-level testing after air and water balancing and equipment testing are complete.
 - 3.3.20.5 Close windows and doors to the space.
 - 3.3.20.6 Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.
 - 3.3.20.7 Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.
 - 3.3.20.8 Take sound measurements at a height approximately 48 inches (1200 mm) above the floor and at least 36 inches (900 mm) from a wall, column, and other large surface capable of altering the measurements.

- 3.3.20.9 Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.
- 3.3.20.10 Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.
- 3.3.20.10.1 Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.
- 3.3.21.5.6 Criteria for Acceptance:
 - a. The opening force on any door shall not exceed 30 lbf (133 N).
 - b. Code requirements.
- 3.3.21.6 Operational Tests:
 - 3.3.21.6.1 Check the proper activation of the stair-tower pressurization system(s) in response to all means of activation, both automatic and manual.
 - 3.3.21.6.2 Verify that each initiating occurrence produces the proper system response under each of the following modes of operation:
 - a. Normal.
 - b. Alarm.
 - c. Manual override of normal mode and alarm.
 - d. Return to normal.
 - 3.3.21.6.3 Verify that the smoke detector at the stair pressurization fan inlet de-energizes the fan and closes the damper at the fan.
 - 3.3.21.6.4 If standby power is provided for stair pressurization systems, test to verify that the stair pressurization systems operate while on both normal and standby power.
 - 3.3.21.6.5 Conduct additional tests required by authorities having jurisdiction.
 - 3.3.21.7 Prepare a complete report of observations, measurements, and deficiencies.
- 3.3.22.6 Operational Tests:
 - 3.3.22.6.1 Check the proper activation of each zoned smoke-control system in response to all means of activation, both automatic and manual.
 - 3.3.22.6.2 Check automatic activation in response to fire alarm signals received from the building's fire alarm and detection system. Initiate a separate alarm for each means of activation to ensure that the proper operation of the correct zoned smoke-control system occurs.
 - 3.3.22.6.3 Check and record the proper operation of fans, dampers, and related equipment as outlined below for each separate zone of the smoke-control system.
 - a. Fire zone in which a smoke-control system automatically activates.
 - b. Type of signal that activates a smoke-control system, such as pull station, sprinkler water flow, or smoke detector.
 - c. Smoke zone(s) where maximum mechanical exhaust to the outside is implemented and no supply air is provided.

- d. Positive pressure smoke-control zone(s) where maximum air supply is implemented and no exhaust to the outside is provided.
 - e. Fan(s) "ON" as required to implement the smoke-control system. Multiple-or variable-speed fans should be further noted as "MAX. VOLUME" to verify that the intended control configuration is achieved.
 - f. Fan(s) "OFF" as required to implement the smoke-control system.
 - g. Damper(s) "OPEN" where maximum airflow must be achieved.
 - h. Damper(s) "CLOSED" where no airflow should take place.
 - i. Auxiliary functions to achieve the smoke-control system configuration such as changes or override of normal operating pressure and temperature-control setpoints.
 - j. If standby power is provided for the smoke-control system, test to verify that the system functions while operating under both normal and standby power.
- 3.3.22.7 Conduct additional tests required by authorities having jurisdiction. Unless required by authorities having jurisdiction, perform testing without the use of smoke or products that simulate smoke.
- 3.3.22.8 Prepare a complete report of observations, measurements, and deficiencies.
- 3.3.23 Procedures for Indoor-Air Quality Measurements
- 3.3.23.1 After air balancing is complete and with HVAC systems operating at indicated conditions, perform indoor-air quality testing.
- 3.3.23.2 Observe and record the following conditions for each HVAC system:
- 3.3.23.2.1 The distance between the outside-air intake and the closest exhaust fan discharge, cooling tower, flue termination, or vent termination.
 - 3.3.23.2.2 Specified filters are installed. Check for leakage around filters.
 - 3.3.23.2.3 Cooling coil drain pans have a positive slope to drain.
 - 3.3.23.2.4 Cooling coil condensate drain trap maintains an air seal.
 - 3.3.23.2.5 Evidence of water damage.
 - 3.3.23.2.6 Insulation in contact with the supply, return, and outside air is dry and clean.
- 3.3.23.3 Measure and record indoor conditions served by each HVAC system. Make measurements at multiple locations served by the system if required to satisfy the following:
- 3.3.23.3.1 Most remote area.
 - 3.3.23.3.2 One location per floor.
 - 3.3.23.3.3 One location for every 5000 sq. ft. (500 sq. m).
- 3.3.23.4 Measure and record the following indoor conditions for each location two times at two-hour intervals, and in accordance with ASHRAE 113:
- 3.3.23.4.1 Temperature.
 - 3.3.23.4.2 Relative humidity.
 - 3.3.23.4.3 Air velocity.
 - 3.3.23.4.4 Concentration of carbon dioxide (ppm).

- 3.3.23.4.5 Concentration of carbon monoxide (ppm).
- 3.3.23.4.6 Nitrogen oxides (ppm).
- 3.3.23.4.7 Formaldehyde (ppm).

3.3.24 Procedures for Reliability Trial Test

- 3.3.24.1 After finishing the above tests and adjustments, the Contractor shall be responsible for running a reliability trial test for the whole plant installed.
- 3.3.24.2 The whole of the trial of the Cooling Plant shall take place during the period between the 15th June and 15th September, and the Heating Plant during the period between the 30th November, and 1st March. The Ventilation trial shall take place at any reasonable time subject to the approval of the Engineer.
- 3.3.24.3 The trial shall last for a period of 15 consecutive days and nights during which time the whole of the plant shall operate continuously, without adjustment or repair to the satisfaction of the Engineer.
- 3.3.24.4 During the reliability trial test, performance tests shall be conducted on the Refrigerating Plant, the Heating Plant and the air handling equipment.
- 3.3.24.5 The test data shall not deviate by more than three percent (3%) from the guaranteed capacity data.
- 3.3.24.6 Temperature readings shall be taken for the entering and leaving air of each air handling unit.
- 3.3.24.7 Should any part of the apparatus or system fail to meet the Contract requirements, it shall be adjusted, repaired or replaced to the satisfaction of the Engineer. The complete performance test shall then be repeated.
- 3.3.24.8 A 'Taking Over Certificate' with or without reservations shall be issued by the Engineer on the satisfactory completion of all the tests, provided that these reservations are of minor importance and will not hinder the satisfactory operation of the Plant.

3.3.25 Procedures for Testing, Adjusting, And Balancing Existing Systems

- 3.3.25.1 Perform a preconstruction inspection of existing equipment that is to remain and be reused.
 - 3.3.25.1.1 Measure and record the operating speed, airflow, and static pressure of each fan.
 - 3.3.25.1.2 Measure motor voltage and amperage. Compare the values to motor nameplate information.
 - 3.3.25.1.3 Check the refrigerant charge.
 - 3.3.25.1.4 Check the condition of filters.
 - 3.3.25.1.5 Check the condition of coils.
 - 3.3.25.1.6 Check the operation of the drain pan and condensate drain trap.
 - 3.3.25.1.7 Check bearings and other lubricated parts for proper lubrication.
 - 3.3.25.1.8 Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- 3.3.25.2 Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.
 - 3.3.25.2.1 New filters are installed.
 - 3.3.25.2.2 Coils are clean and fins combed.
 - 3.3.25.2.3 Drain pans are clean.
 - 3.3.25.2.4 Fans are clean.
 - 3.3.25.2.5 Bearings and other parts are properly lubricated.
 - 3.3.25.2.6 Deficiencies noted in the preconstruction report are corrected.

- 3.3.25.3 Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
- 3.3.25.3.1 Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.
- 3.3.25.3.2 Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
- 3.3.25.3.3 If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
- 3.3.25.3.4 Air balance each air outlet.

3.3.26 Procedures for Acceptance Tests

- 3.3.26.1 As soon as possible after carrying out the Reliability Trial Test, and during the Maintenance Guarantee Period, the Contractor shall carry out, unless otherwise agreed, the Acceptance Test Specified in the relevant American or British or approved equivalent Standard Specifications, as well as much additional tests at Site, deemed necessary by the Engineer, to determine that the Works comply with the Specifications and provided that the Works are put into operation.
- 3.3.26.2 The date of commencement of the above said tests shall be subject to agreement with the Engineer.
- 3.3.26.3 As soon as all tests prescribed in the section are carried out satisfactorily in the opinion of the Engineer, an official statement to that effect (herein referred to as Acceptance Certificate) shall be drawn up in three (3) copies and signed by the Engineer and the Contractor. One copy of the Acceptance Certificate shall be delivered to the Contractor.

3.4 **Guarantee and Warranted Period**

- 3.4.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.
- 3.4.2 All guarantee shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.
- 3.4.3 The Contractor shall guarantee every piece of equipment from any manufacturing or installation defects for a period of one year, starting from the date of issue of the substantial completion certificate.

3.5 **Maintenance During Defects Liability Period And Guarantees**

- 3.5.1 Starting from the date of issue of the Substantial/Provisional completion certificate the contractor shall be responsible, for the duration of one year, to provide the following services free of charge, at his own cost:-
- 3.5.2 The training of operators assigned by the client for operation of all major equipment and controls as decided by the Engineer.
- 3.5.3 Training should be provided by original suppliers of equipment for a period of at least one week and or when requested by client through out the liability period.

- 3.5.4 The replacement of parts or whole equipment that show any manufacturing or installation defects during operation.
- 3.5.5 Carry out routine preventive maintenance (fortnightly, monthly, quarterly, half yearly and yearly as applicable to the approval of the Engineer) including provision of labour, parts and supply of consumable materials such as Replaceable air filters, Chemicals for Chilled Water System, Chemicals for Swimming Pool, Lubricants and Refrigerant Gas, required for the safe operation and guarantee of performance of all the systems but not limited to;
- a) Pumps,
 - b) AHUs, FCUs,
 - c) Fans,
 - d) BMS
- 3.5.6 Necessary staff to carryout the above shall be provided to the job site during the said year.
- 3.5.7 On call emergency services (24 hours), particularly for elevators, escalators, travelators and fire alarm system.
- 3.5.8 Guarantee of every piece of equipment from any manufacturing or installation defects for a period of one year.
- 3.5.9 At the end of defects liability period the contractor shall be responsible for final handing over of all installed systems in a perfect condition to the satisfaction of both Engineer and client.

3.6 Extended Defects Liability and Guarantees

- 3.6.1 The Contractor shall issue a letter of guarantee for every compressor installed under his contract for a period of five years, starting from the date of issue of the completion certificate. Contractor shall remove the defective compressor and install a new one at his own expense including all necessary accessories and shall do the necessary testing and commissioning. Contractor shall submit a report to the Engineer explaining the reason of damage and methods to prevent it from happening.
- 3.6.2 The Contractor shall issue in favour of the client all original manufacturers extended guarantees as required by specifications or by Engineers approval conditions or by manufacturers initial proposal prior to final handing over to the client.