



**DESIGN AND SUPERVISION OF THE CONSTRUCTION OF GREENHOUSE PARK FACILITIES**  
**FINAL TECHNICAL SPECIFICATIONS - SECTION 5**



# Volume 3

## Specifications

### PROJECT INFORMATION

**Project Name:** Construction of Greenhouse Park Facilities

**Owner Name:** Government of St. Vincent and the Grenadines represented by Office of the National Authorising Officer for the EDF Operations

**Description:** Construction of Greenhouse Park Facilities

**Address:** Saint Vincent

**Owner Project No.:** BAN/2015/362-642 **(to be confirmed by Client)**

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## **100 GENERAL AND PRELIMINARY**

### **Construction of Greenhouse Facility at XX**

#### **101 Description of the Works**

The Works involves the construction of:

- A greenhouse facility consisting of XX greenhouses (approx. 9m x 18m each).
- A packing shed facility (approx. 185 m<sup>2</sup>)
- A piped irrigation system

The Works are to be carried over a 365 calendar day period.

#### Location of Works, Access to Works, Working and Storage Areas

- (a) The Works are located at XX. The precise extent of the Works is shown on Drawing # XX.
- (b) Working areas, storage areas and disposal area for excess excavated materials shall be agreed between the Contractor and the Supervisor's Representative.
- (c) Before exercising any right negotiated (by the Contractor) in connection with way leaves or accommodation outside the Site, the Contractor shall notify the Supervisor's Representative in writing of the arrangements that have been made.
- (d) All necessary facilities shall be given by the Supervisor for the access of the Contractor's employees to the Works and the Contractor shall be responsible for seeing that such employees obey all regulations made by the Supervisor in regard to the conditions of access to and over his property.

#### **102 Scope of Specifications**

The specifications cover all works under the Contract as described in Clause 101 above.

#### **103 Drawings and Specifications**

Copies of all working drawings are supplied with this bid document. Any queries should be communicated to the Supervisor's Representative and if necessary, addenda shall be issued. No extras shall be allowed due to omissions by contractors.

The specifications shall be read in conjunction with and applied in a well-coordinated manner with the relevant specifications of all other disciplines and sub-consultants providing associated inputs on this multidisciplinary project. Any areas of ambiguity or conflict should be immediately brought to the attention of the Supervisor's Representative.

## **104 Possession of Site**

Subject to the requirements of the Contract with respect to the programme of work submitted by the Contractor, the Contractor shall be given possession of the site in the sections and periods after Commencement of Contract as noted in the Letter of Commencement and the Particular Conditions of Contract.

## **105 Definitions**

For the purpose of this specification, the following definitions apply:

- (a) The term 'approved' 'directed' or 'selected' means the approval, direction and selection by the Supervisor's Representative unless otherwise described.
- (b) Where the term 'allow' occurs in this document the cost of the item is at the risk of the Contractor.
- (c) The Supervisor is the person or entity identified in the Special Conditions of Contract.
- (d) Where the term "Project Manager", "Engineer", "Architect", occurs in the Technical Specifications, it shall be read as meaning Supervisor's Representative as defined in the Special Conditions of Contract.
- (e) The abbreviations "BS", and "ASTM" mean the latest British Standard Specification, British Code of Practice, and American Society of Testing and Materials, respectively.
- (f) The term 'local' means Saint Vincent and the Grenadines.
- (g) Where the terms "him", "his" and "he" are used in this document in reference to the Contractor, they imply no gender bias but instead are for ease of reference.

## **106 Order of Work**

- (a) The Contractor shall execute the Works in a logical and practical order and in compliance with the approved performance programme of operations to be prepared by him. The Works are to be completed within the time limits laid down in the Contract and in a manner that is satisfactory to the Supervisor's Representative.
- (b) The Contractor shall execute the Works in a logical and practical order and in compliance with the approved construction programme of operations that he prepares. He must complete the Works within the time limits laid down in the Contract and in a manner that is satisfactory to the Supervisor's Representative.

## 107 Completion Period

The Contract Works are to be completed within the period of implementation stipulated in the Special Conditions of Contract.

## 108 Project Signs/Notice Boards

The Contractor shall provide and erect one (1) suitable notice board as detailed by the Supervisor's Representative, not less than 2.4 meters wide by 1.2 meters high mounted on suitable posts at a location to be advised by the Supervisor's Representative. Colours, text and size of lettering shall be to the approval of the Supervisor's Representative. Each sign shall provide the following information:

- Project title
- Name of supervisor
- Name of supervisor's representative
- Name of contractor
- Name and logo of the funding agency

No other notice boards or signs of any description shall be erected unless directed or approved.

## 109 Particular matters to be brought to the attention of the Contractor

Noise levels at properties adjacent to the Works shall be limited to  $L_{eq}$  70 dB (A) and  $L_{max}$  85dB (A) (maximum noise level in any hour).

The Contractor's hours of work shall be limited to normal working hours (07:00 to 17:00). Night working and weekend working shall only be permitted with the written approval of the Supervisor's Representative.

The Contractor shall ensure that any nuisance caused by dust is kept to a minimum by appropriate measures including the use of water sprayed on the surface. If in the opinion of the Supervisor's Representative the Contractor is taking insufficient precautions to avoid such dust nuisance the Supervisor's Representative may issue a written warning and in the event of subsequent dust nuisance the Contractor shall be liable to liquidated damages in accordance with the Conditions of Contract and be responsible, at no cost to the Supervisor, for any cleaning of property that the Supervisor's Representative deems to have been adversely affected by dust.

## 110 "Directed" and "Approved"

- (a) The terms "directed" and "approved" in the Specification mean "directed by the Supervisor's Representative" and "approved by the Supervisor's Representative" except where the context clearly implies another meaning.

### **111 Workmanship and Quality Control**

- (a)** The onus rests on the Contractor to produce work, which conforms in quality and accuracy of detail to the requirements of the Specifications and Drawings. The Contractor must, at his own expense institute a quality control system and provide experienced technical staff and equipment to ensure adequate supervision and control of the Works at all times.
- (b)** The costs of the supervision and process control including testing to be carried out by the Contractor in compliance with the above requirements shall be deemed included in the rates tendered for the related items of work.
- (c)** The Contractor's attention is drawn to the provisions of the various sections of the Specifications regarding the minimum frequency of testing that shall be required to be undertaken as part of the quality control process. The Contractor shall increase this frequency where necessary to ensure adequate control at his own discretion or as ordered by the Supervisor's Representative.
- (d)** The Contractor shall submit to the Supervisor's Representative the results of all relevant tests, measurements and levels indicating compliance with the Specifications on completion of every part of the work for the Supervisor's Representative's examinations.

### **112 Codes of Practice/Standards**

The whole of the Works shall be carried out in accordance with the rules, regulations or other requirements of the local and other authorities as outlined in the sections of this Specification. The Contractor shall pay all fees and charges in connection therewith.

Wherever Standards, Codes of Practice and other similar references have been quoted in the Specification, the latest current edition of such Standard, Code of Practice or other similar reference shall apply. The Contractor may propose the use of alternative standards provided that:

- (a)** The alternative is, in the opinion of the Supervisor's Representative, equal to or superior to that quoted in the Specification;
- (b)** The Contractor provides the Supervisor's Representative with a copy in English of the proposed alternative standard when he submits his design and calculations or other proposals.

### **113 Health and Safety Plan**

The Contractor shall provide the Supervisor's Representative with a copy of the written safety policy and any revisions thereof which he has prepared, relating to the execution of the Works. Prior to commencement of work on the Site, the Contractor shall provide the Supervisor's Representative with a copy of the relevant notices submitted to the Government of Saint Vincent and the Grenadines to satisfy Health and Safety Requirements and shall inform the Supervisor's Representative of the name and location of his appointed safety supervisor (s).

The Contractor shall also provide the Supervisor's Representative with written details of any control measures he proposes to institute in compliance with the control of substances hazardous to health.

#### **114 Suspension of Work in Unsafe Conditions**

Where the Supervisor's Representative judges that the Contractor is conducting work in unsafe conditions or that the workmen are in danger of death or injury, he shall instruct the Contractor to remedy the situation and render the working conditions safe. If the Contractor fails to do so within 24 hours, the Supervisor's Representative shall suspend work in that area until such time that the Contractor shall demonstrate that he has made the necessary provisions to remedy the situation and render the working conditions safe. The Supervisor's Representative shall suspend work immediately if the danger is deemed serious.

Where there is also a danger to the public and the Contractor has failed to remedy the situation within a reasonable time, the Supervisor's Representative shall take the necessary action for remedy and deduct the cost thereof from the moneys owed to the Contractor.

#### **115 Safety of Works and Adjacent Structures**

The Contractor shall at his own expense provide and erect to the approval of the Supervisor's Representative all supports required to protect efficiently all structures or works requiring support as a result of the Works and shall remove the same on completion.

#### **116 Environmental Impact and Protection**

The Contractor shall, and is required to, minimize the inconveniences to the public during execution of the Works, provide for safety to the public using the roads forming the site and avoid disruptions of utilities and damages to a minimum.

#### **117 Site Tidiness**

The Contractor shall be responsible for the proper tidiness of the Site and Works and remove rubbish and waste promptly from the Site. Disposal of site waste and rubbish shall comply with the regulations of the local Waste Management Authority. All materials, plant and equipment shall also be stored or positioned in an orderly manner.

#### **118 Traffic Control, Pedestrian Access and Demarcation of Site**

The Contractor shall observe all traffic regulations, the requirements of the Acts and By-Laws of Saint Vincent and the Grenadines, for regulation of traffic on roads forming part of the site or used to transport materials to the site. The Contractor shall ensure that movement of vehicles within the site is restricted to only equipment and vehicles required for the execution of the Works. For security purposes, no unauthorised vehicles shall be allowed to enter the site.

Prior to commencement, the Contractor shall erect barriers, signs and devices for the guidance of road users, the protection of pedestrians and the public and to limit and enclose the site as necessary, all to the approval of the Supervisor's Representative.

### **119 Abatement of Nuisance**

The Contractor shall adopt such measures, as the Supervisor's Representative may consider reasonable and necessary to minimize nuisance from dust, noise, or other cause. During periods of dry weather, the site shall be watered a minimum of 3 times a day if necessary to avoid the spread of dust arising from the execution of the Works.

### **120 Existing Utilities and Underground Services**

- (a) The Contractor shall adequately notify and seek the cooperation of all the utility owners well in advance of commencing any excavation works. He shall clearly mark the approximate locations of these utility lines or structures so indicated with the assistance of the Utility owners or operators.
- (b) If the Contractor and Utility operators are unclear of the precise location of a particular utility line or structure, the Contractor shall request and obtain permission for an approved test pit from the Supervisor's Representative.
- (c) The Contractor shall execute the Works in such a manner that he does not damage or interfere with existing services on or near the Site. If damage or interference is so caused, the Contractor shall make his own arrangements, to the approval of the Supervisor's Representative and the relevant authority, to execute the repairs at his own cost. If the service authority concerned elects to make good the damage, the Contractor shall give all facilities and shall pay all charges.
- (d) The Contractor shall make his own arrangements for any diversion or removal of services, which he may require for his own convenience or method of working, and shall obtain the prior approval of the Supervisor's Representative to such arrangements.
- (e) Where public utility services are to be diverted the works shall be carried out in such a way that the service is maintained while the diversion is installed. The existing service shall not be broken into until the diversion is in place. Should temporary diversions of services be required, the Contractor shall be responsible for arranging such temporary diversions with the relevant Authority who shall carry out the work of diverting the services.
- (f) The planning and coordination of the work with and of the service authorities shall be the Contractor's responsibility and due allowance for such shall be made in the Contractor's programme.

### **121 Condition Survey**

Prior to commencement, the Contractor shall, in conjunction with the Supervisor's Representative, conduct a condition survey of existing buildings, roads, pavements, sidewalks, fencing, poles, wires, survey bench marks and monuments adjacent to the site which may be affected by the Works. The Contractor shall record (and if necessary film) the survey and provide the Supervisor's Representative with a copy of the condition survey information for future reference if necessary.

### **122 Materials on and Under Site**

Materials arising from clearance of the Site, soil stripping and excavations shall belong to the Supervisor and shall not be removed from the Site except as required by the Contract and with the approval of the Supervisor's Representative.

### **123 Temporary Fences**

The Contractor shall erect and maintain at his own expense suitable and approved temporary fencing on the site and/or around the perimeter the works as may be necessary to ensure site safety and security and meet his obligations under the Contract. Access shall be provided in the temporary fencing as necessary for the use of the occupiers of adjacent properties.

### **124 Protection of Structures**

Heavy equipment shall not be operated in such a manner and in such proximity to existing or new structures or other permanent works as to cause their displacement or damage them in any way. New structures shall have attained adequate strength before being subjected to backfilling operations, impacts, vibrations or other such forces.

### **125 Accidents**

The Contractor shall as soon as possible after the event advise the Clerk of Works of any accident, injury, loss or damage to any workman or to any property of a third party or to property of the Supervisor. The Contractor shall comply with any regulations currently in force in Saint Vincent and the Grenadines regarding procedures to be followed subsequent to any accident or occurrence on site or connected with the construction of the Works which is stipulated in such regulations.

### **126 Drains, Streams, Watercourses etc.**

Drains, pipes, canals, channels, water courses or streams affected by the Contractor's operations are to be maintained by temporary channels or pumping if necessary and on completion restored to their original condition as soon as possible after the relevant operations have ceased. The Contractor shall notify the Supervisor's Representative in writing 14 days in advance of his intention to start any part of the Works affecting watercourses, canals, streams, drains, pipes, channels etc. The Contractor shall be responsible for maintaining the watercourses within the Site in effective working condition.

The Contractor shall execute the works in a manner that shall avoid the pollution or siltation of rivers, streams or the sea. If in the opinion of the Supervisor's Representative the Contractor is taking insufficient precautions to avoid such pollution or siltation, the Supervisor's Representative may issue a written warning and in the event of subsequent damage, pollution or siltation the Contractor shall be subject to liquidated damages in accordance of the Contract.

#### **127 Keeping Works Free from Water**

Except where underwater construction is required the Contractor shall execute all work in the dry, and shall construct any temporary drains or other works that may be necessary for the purpose. During excavation or otherwise during the execution of the works, the Contractor shall not obstruct flow of surface drainage or natural watercourses. The Contractor shall protect open excavation and the works against flood and damage due to surface runoff of water from any other source.

The Contractor shall keep excavations free from water while installation work is in progress. Disposal of water should be carried out in a manner not detrimental to the environment, the public or property and in keeping with the specifications.

#### **128 Damage to Access Roads**

The Contractor shall ensure that damage to any public or private roads, footpaths and tracks used by any vehicles or plant proceeding to or from the Site is kept to a minimum and he shall be responsible for the cost of all repairs necessary to restore such roads, tracks or footpaths to the satisfaction of the Supervisor's Representative and/or controlling authorities.

#### **129 Setting out of the Works & Surveys**

- (a) At least one bench mark and two horizontal control points shall be indicated to the Contractor by the Supervisor's Representative at the site.
- (b) The Contractor shall be responsible for checking that the basic survey points are in place at the commencement of the Contract, and if any are missing, or appear to have been disturbed, the Contractor shall inform the Supervisor's Representative who shall make arrangements to re-establish the points.
- (c) After this basic survey and setting out has been agreed by the Supervisor's Representative, the Contractor shall be responsible for its maintenance and re-establishment of any portion lost or destroyed.
- (d) Should the Contractor discover any error in line or level in basic setting out, he shall at once notify the Supervisor's Representative who shall then issue amended drawings or instructions regarding the correction of the error.

- (e) The Contractor shall establish temporary bench marks at intervals and shall provide the Supervisor's Representative with a schedule of their levels.
- (f) Prior to the construction of any earthworks, excavation or other work in any area of the site, the levels of the existing ground above or below water shall be agreed between the Contractor and the Supervisor's Representative. If the Contractor fails to take the requisite levels, then the ground levels shown on the drawings or determined by the Supervisor's Representative shall be taken as correct.
- (g) The Contractor shall give the Supervisor's Representative not less than 24 hours' notice in writing of his intention to set out or take levels for any part of the Works in order that arrangements may be made to carry out any joint measurements or any checks required.
- (h) During the progress of the Works, the Contractor shall not remove, damage, alter or destroy in any way any survey controls. Should the Contractor consider that any survey control shall be interfered with by the construction Works or shall ultimately be above or below the final level of the finished Works, he shall notify the Supervisor's Representative who, if he considers it necessary, shall make arrangements for the removal and replacement of the survey control.
- (i) If the Contractor removes or disturbs a survey control without the prior permission of the Supervisor's Representative, he shall be liable for the full cost of its replacement.

### **130 Datum, Co-ordinates, Surface Levels or Sea Bed Levels**

Levels shown on the drawings are given in metres above Ordnance Survey Datum. Local control points for construction use shall be indicated by the Supervisor's Representative.

### **131 Testing**

- (a) The Contractor shall provide all staff, labour and equipment necessary for the performance of all tests required, or he may employ an independent testing laboratory approved by the Supervisor's Representative to carry out all or part of the testing.
- (b) If the Contractor provides his own testing facilities, the equipment staff and method of operation shall be to the approval of the Supervisor's Representative, and up to 25% of all tests conducted by the Contractor shall simultaneously be carried out, on samples of the same material, by an approved independent testing laboratory. The cost of supplying samples shall be included in the Contractor's rates, but the cost of independent testing shall be under a provisional sum.
- (c) In either case, the Supervisor's Representative shall have access to the laboratory (ies) at all reasonable times.
- (d) The Contractor shall obtain the approval of the Supervisor's Representative for his proposed testing arrangements and shall submit all results without delay.

### **132 Faulty Work**

Any work, which fails to comply with these Specifications, shall be rejected and the Contractor shall, at his own expense, make good any defects as directed by and to the satisfaction of the Supervisor's Representative.

### **133 Assistance to the Supervisor's Representative**

The Contractor shall provide for the exclusive use of the Supervisor's Representative all instruments (which shall be new or in proven good condition) appliances, protective clothing, rubber boots, and labour required for checking the setting out of the Works, testing, inspection and for any other attendance on the Supervisor's Representative.

### **134 Photographs**

The Contractor shall supply to the Supervisor's Representative the negative and four unmounted, dated colour prints, approx. 150mm x 100mm size, of each progress photograph, taken of such portions of the work prior to commencement, in progress and completed as the Supervisor's Representative may direct and to a standard acceptable to the Supervisor's Representative. No prints from the negative shall be supplied to any person or persons without the authority of the Supervisor's Representative. Photographs are to be submitted monthly throughout construction in sets of 12 photographs. The Supervisor's Representative shall also utilize, for recording the day to day works, the digital camera supplied under the contract to record all relevant aspects of the construction of the works and archive these on the Supervisor's Representative computer for future reference, as may be called for.

### **135 Site Office for the Supervisor's Representative**

- (a) The Contractor shall provide, furnish, equip, maintain and clean a site office as detailed for the exclusive use of the Supervisor's Representative. Where a septic tank has to be provided, the Contractor shall be responsible for obtaining the relevant approvals, its installation, regular emptying etc. and removal on completion. The office(s) shall be ready for use and occupation within 7 days of the Date of Commencement of the Works and fully serviced within 14 days of that date.
- (b) The Contractor shall be responsible for providing all sanitary services necessary for keeping rest rooms in a clean, neat and hygienic condition. When no community public sewage treatment is available, the Contractor shall provide the necessary collection and disposal systems. The Contractor shall also make provision for the removal of all solid waste and rubbish.
- (c) The Contractor shall provide a constant supply of clean potable water suitable for human consumption and 110/220-volt electrical supply to the facilities. Power sources shall be suitable for office and laboratory use with an anticipated large variance in load factor. 3-phase power shall be supplied. The source of power shall be either from a recognized power-supply authority or by an on-site generator supplied by the Contractor.

- (d)** Power shall be distributed by means of enclosed distribution boards with adequate weather and tamper protection, suitably rated circuit breakers, earth-leakage units or fuses, and by means of adequately sized underground cables and earth conductors. Sizing of cables and rating of protective and control devices shall take into account the load and fault currents that can occur on the system. The Contractor shall maintain at all times the power supply, the distribution network and the wiring installation of all buildings and structures at the highest standard of safety and usability. The Contractor shall also provide a sufficient supply of liquid propane gas for the burners used in the laboratory.
- (e)** The Contractor shall supply emergency firefighting and ‘first aid’ medical equipment of a type acceptable to the Supervisor’s Representative at each facility. No separate payment shall be made in respect of such equipment and full compensation for the supply shall be deemed to be included in the tendered rates for the various items in the Bill of Quantities.
- (f)** The Contractor shall provide all labour, equipment and materials, which may be necessary for keeping the offices in a neat and clean condition. Any necessary repairs shall be made immediately at the request of the Supervisor’s Representative. The Contractor shall provide consumables (e.g. soap and towels) for the offices and miscellaneous materials for use in addition to the regular cleaning services required.
- (g)** The Contractor shall include in his rates in the Bill of Quantities, the cost of all such maintenance activities and no other payment shall be made. Should the Contractor fail to provide services to the satisfaction of the Supervisor’s Representative, the Supervisor’s Representative shall have the right to provide such services and the cost of such services shall be deducted from the monies due or that become due to the Contractor.

## **200 MATERIALS AND EQUIPMENT**

### **201 Standards and Alternative Standards**

- a) Materials and workmanship shall be of the best quality and executed in accordance with proper working practices conforming to the relevant British Standards. Codes of Practice and ASTM Standards referred to in these Preambles. The works shall be carried out in accordance with the drawings and specifications and the quality and standard of the materials and workmanship shall be to the reasonable satisfaction of the Supervisor's Representative.
  
- b) Where ASTM Standards are referred to in this document, these may be replaced by E.U. member state and/or ACP State standards provided they are equivalent or superior to the U.S. Standard.
  
- c) Accuracy in building shall be in accordance with the permissible values as set out in BS 5606.

### **202 Alternative Materials and Equipment**

- (a) The Contractor may propose, for the Supervisor's Representative's approval, alternative materials or equipment to those specified, provided either:-
  - (i) They are of at least equal quality and performance, or
  - (ii) They are of like quality and performance and comply with approved alternative standards.
  
- (b) If alternative materials or equipment is proposed, the Contractor shall submit comprehensive details including technical descriptions, drawings and specifications to demonstrate that the alternative complies with either requirement of this clause. The Contractor shall allow for the time necessary for review and approval of such alternative by the Supervisor's Representative.

### **203 Manufacturer's Instructions**

Materials and equipment shall be used or installed where relevant in accordance with the instructions of the manufacturer unless otherwise required.

### **204 Supply of Materials**

- (a) As soon as possible after Contract award, the Contractor shall submit a list of suppliers from whom he proposes to purchase the materials and equipment required for the Works.
  
- (b) Samples shall be taken and tested in accordance with the relevant, British Standards or any other E.U. member state and/or ACP State standards where applicable. Materials and equipment sources and suppliers shall not be changed without prior written approval.

### **205 Copies of Orders**

The Contractor shall, if required, by the Supervisor's Representative, submit to him copies of orders for materials and equipment to be incorporated in the Works.

### **206 Test Certificates**

Unless required otherwise in this Specification, the Contractor shall supply works test certificates, analyses, mill sheets, etc., as relevant to the particular materials and as required by relevant standards, etc.

## **300 SITE CLEARANCE**

### **301 General**

#### **(a) Scope of Work**

Site clearance shall conform to the general order or procedure for the Contract and shall be as detailed by the Contractor in his programme as submitted in accordance with the Conditions of Contract.

#### **(b) Interference with Adjacent Activities and Third Parties**

Demolition and alteration works shall be carried out in such a manner so as to cause as little dust, noise and inconvenience as possible to the occupants of the adjacent buildings and the public. The Contractor shall be held responsible for any claims which may arise from the disregard of this Clause. Debris and other materials arising from the demolitions must be lowered in baskets, barrows, covered chutes etc. and debris is to be kept well-watered during the works to prevent dust.

#### **(c) Old Materials**

All salvageable materials such as all fixed furniture and fittings, doors, windows etc. shall be handed over to the Supervisor for storage or re-use as directed by the Supervisor's Representative.

#### **(d) Existing Mains and Services**

The Contractor shall ensure that all temporary or permanent diversions of existing mains and services have been properly completed prior to commencing any site clearance or demolition work.

All other old materials are to be removed from the site by the Contractor. Old materials shall not be re-used in the works except with the written permission of the Supervisor's Representative.

#### **(e) Items of Value**

Any items of archaeological, historical or geological interest shall be safeguarded and the Contractor shall carry out the Clerk of Work's instructions concerning preservation or removal.

#### **(f) Hazardous Materials**

**(i)** The treatment of hazardous materials encountered in site clearance and demolition shall comply with best practice, and the Contractor shall seek consent from the Supervisor's Representative.

**(ii)** Compliance with this clause does not confer immunity from relevant legal requirements.

**(g) Use of Existing Roads**

The Contractor shall only use the existing roads and access routes for his operations that are designated on the Drawings. Such roads shall be kept in a clean and safe condition and any damage shall be reinstated on the day that it occurs and on completion of the Works as directed by the Supervisor's Representative. The Contractor shall supply, erect, maintain, and remove on completion of the Works all road signs and warnings as necessary for the safety of all.

**(h) Temporary Access Ways**

In addition to the requirements of the Conditions of Contract, the Contractor shall provide and maintain any additional temporary access ways to the site of the Works and tipping points as necessary and shall remove them on completion of the Works. All areas so disturbed shall be fully reinstated as directed by the Supervisor's Representative.

**302 Site Clearance**

**(a) Existing Fences, Hedges and Walls**

Where only partial clearance of an existing fence, hedge or wall is necessary, the severance shall be made good either by its continuation in a different direction or by its termination as shown on the Drawings.

**(b) Underground Structures**

Underground structures, chambers and foundations shall be demolished to the depths shown on the Drawings, properly cleaned out and filled. To permit free drainage, holes shall be made over at least 10% of the area of slabs, basements etc. that are not removed and that are liable to hold water.

**(c) Disused Pipes and Ducts**

- i)** Disused pipes and ducts, together with any bed, haunch or surround within 1m of the lowest level of any site clearance, demolition or excavation shall be removed and the trenches back-filled in accordance with the Earthworks specification, unless an alternative treatment is shown on the Drawings.
- ii)** Disused pipes and ducts, together with any bed, haunch or surround over 1m below the lowest level of any site clearance, demolition or excavation shall be left in place unless an alternative treatment is shown on the Drawings. In this case the ends of any such pipes or ducts shall be sealed with a structural grade of concrete to the satisfaction of the Supervisor's Representative.

**(d) Bushes etc.**

Bushes undergrowth or small trees, the trunks of which are less than 300mm in girth at 1m above ground level, tree stumps less than 100mm in diameter and hedges shall be uprooted and disposed of by the Contractor.

**(e) Existing Trees, Stumps and Roots**

Trees shall be uprooted or cut down as near to ground level as possible. Stumps and tree roots shall be grubbed up or blasted as directed by the Supervisor's Representative. The Contractor shall dispose of all felled timber unless otherwise stated. Holes left by removal of the stumps shall, within one week, be filled with acceptable material and compacted in accordance with the Earthworks Specification.

**(f) Trees etc. to be preserved**

The Contractor shall ensure that individual trees, shrubs, other features and areas that are shown on the Drawings to be preserved are suitably identified and protected.

**(g) Topsoil**

Topsoil excavated for the purposes of site clearance shall be reserved for re-use.

**(h) Disposal of Arisings**

Materials arising from site clearance shall become the property of the Contractor unless stated otherwise and shall be removed from the Site.

## 400 EARTHWORKS

### 401 Definition of Earthworks Material

- (a) The following definitions of earthworks materials shall apply to this and other clauses of the Specification in which reference is made to the defined materials:
- (i) Top soil shall mean the top layer of soil that can support vegetation;
  - (ii) Suitable material shall comprise all that material which arises from excavations within the Sites and which is approved by the Supervisor's Representative as acceptable for use in the Works
  - (iii) Unsuitable material shall mean other than suitable material and shall comprise:
    - 1) Material from swamps, marshes and bogs
    - 2) Peat, logs, stumps and perishable materials
    - 3) Material susceptible to spontaneous combustion, and
    - 4) Clay of liquid limit exceeding 90 and/or plasticity index exceeding 65
    - 5) Soft material shall mean all material other than that defined as hard material or rock hereunder
    - 6) Hard material shall mean all material that cannot be ripped with a Caterpillar D6 bulldozer with a single tooth ripper tyre or similar equipment
  - (iv) Original Surface means the surface of the ground before any work has been carried out.
  - (v) Final Surface means the surface indicated on the Drawings to which excavation is to be carried out.
  - (vi) Commencing Surface (in relation to individual Items in the Bill of Quantities) means the surface of the ground or underlying construction layer before any work covered by an individual Item has been carried out.
  - (vii) Excavated Surface (in relation to individual Items in the Bill of Quantities) means the surface elevation to which the excavation has been carried out under a particular Item of work.
  - (viii) Subgrade is the final compacted and prepared surface upon which a road pavement is to be constructed. The term 'formation level' is to be taken to be synonymous with 'subgrade'.
  - (ix) Road bed is the natural in situ material on which the fill or, in the absence of fill any pavement layers are constructed.
  - (x) Embankment (or fill) is that portion of earthworks utilizing generated native or approved imported material which lies above the road bed and is bounded by the side slopes shown on the Drawings and upon which the road base materials are to be placed. Material which is imported to replace unsuitable material excavated from the road bed shall also be classified as fill.
  - (xi) Pavement layers are the upper strata of the road comprising the sub-base if any, base and surfacing materials.

## 402 Classifications

- (a) Topsoil is fertile, friable soil of a loamy character and usually covered by natural vegetation that is native to the region. Topsoil shall not be taken from swampy areas unless authorised by the Supervisor's Representative.
- (b) Common Excavation Material is any material that can be excavated without recourse to the methods described under rock and shall be classified as 'common' excavation material.
- (c) **Rock**
  - (i) Any material that, in the opinion of the Supervisor's Representative (who shall take into account the situation in which the excavation is taking place), requires for its removal blasting or the use of a compressor and hand tools.
  - (ii) Material that can be effectively ripped and removed using a single tine operated by a tracked type machine of specified flywheel power <425 horsepower, shall not be classified as rock. The cost of proving rock shall be included in the Contractor's rates and no extra payment shall be made for this cost.
- (d) **Isolated Boulders**

Isolated and competent boulders of < 1m<sup>3</sup> in size occurring within any mass of material and that can be removed by the Contractor's ordinary earthmoving plant and suitably disposed of to the Clerk of Work satisfaction, shall be measured as 'common' material. Otherwise, such boulders shall be considered 'rock' material.
- (e) Cut is earthworks material generated by the various excavation processes.
- (f) **Unsuitable Material:**
  - (i) Refers to earthworks or excavated material, which in the opinion of the Supervisor's Representative, is not suitable as fill and is to be removed to an approved disposal site or spoiled outside the road reserve.
  - (ii) Such material shall include that deemed to be unsuitable in the opinion of the Supervisor's Representative, including any materials:
    - 1) Found in swampy areas such as peat, buried logs, tree stumps, perishable material and any that may be susceptible to spontaneous combustion;
    - 2) That are otherwise unsuitable for use in the location where they are required to be placed;
    - 3) That have an excessive moisture content and that cannot be effectively dried.
- (g) Surplus Material is that which is judged by the Supervisor's Representative to be suitable for use as fill but that is surplus to the filling requirement and must be 'spoiled'. The Supervisor's Representative shall direct whether such material shall be disposed of as 'overfill' in embankment side slopes or shall be disposed of in authorised spoil areas outside the road reserve.
- (h) Fill is common material and shall be compacted to 95% of BS Heavy Compaction as defined in BS 1377.

- (i) Selected Fill is common or selected material and shall be compacted to 98% of its maximum compaction (BS 1377). Selected fill shall have a minimum depth of 200 mm.
- (j) Borrow**
- (i) Borrow is any suitable earthworks materials that, with the prior approval of the Supervisor's Representative, can be obtained by over-excavation or from borrow sources outside the road reserve. All borrow shall be authorised by the Supervisor's Representative. His authorisation shall be granted only if the cut operation does not yield sufficient fill or the Contractor makes a request, accepted by the Supervisor's Representative, that he be permitted to use spoil material (paid for as material for re-use) located at a distance and to borrow material nearer at hand, for re-use without payment.
- (ii) The Contractor shall obtain the prior permission of the Supervisor's Representative before developing any borrow
- (iii) From Cuttings:**
- In certain circumstances, where widening of cuttings is necessary, borrow may be obtained from excavating within the road reserve, preferably on the inside of bends. Such widening shall be worked in single machine widths and extend to the full depth of the cutting or drain. When widening cuttings, the side drain shall generally be sited at the foot of the new cut face, the cut slope shall be to the same batter as the original face and the shoulder shall extend across the widening at the same cross fall as the original cross-section.
- (iv) From Borrow Areas:**
- The Contractor may be authorised to obtain borrow material from a source outside the road reserve. In that case, the Contractor shall be responsible for locating the source, undertaking all necessary negotiations with Local Government or other occupier, preparing and signing legal agreements, making payment and giving proper notice to enter upon the land, and obtaining all the necessary consents.
- (v) The Contractor shall include in his rates for all other costs, including prior investigation and sampling, fencing, stripping, removal of overburden, operating transportation, drainage and reinstatement at the conclusion of the borrowing operation, including the provision and maintenance of haul roads.
- (vi) Borrow areas that in the opinion of the Supervisor's Representative would provide materials suitable for the road pavement, or for selected fill, shall not be used for other purposes unless expressly authorised by the Supervisor's Representative.
- (vii) The Supervisor's Representative shall give prior approval to sites of borrow areas. When the use of the borrow area is terminated the Supervisor's Representative shall have the power to withhold payments in interim certificates for borrow pending reinstatement of such borrow area to his satisfaction.
- (k) Rock Fill** is broken material derived from hard non-weathering homogeneous rock and which contains more than 25% by volume of particles larger than 150 mm in greatest dimension. All rock fill must receive the prior approval of the Supervisor's Representative before use.
- (l) Spoil Areas**
- (i) By prior permission of the Supervisor's Representative, surplus material other than rock or rippable material may be disposed to spoil by the widening of embankments providing such widening and the Contractor's method of working shall not, in the opinion of the

Supervisor's Representative, affect adversely or endanger the embankments, or put embankment toes or toe drains outside the road reserve and providing that the shaping and trimming of the extended embankments is completed as specified. No additional payments shall be made.

- (ii) The Contractor shall on no account place spoil outside the road reserve without first obtaining the permission of the Supervisor's Representative and the owner of the land. He shall not dump or otherwise dispose of surplus material over precipices.
- (iii) The Contractor shall be responsible for locating suitable spoil areas outside the road reserve, undertaking all negotiations with the Local Government Authorities or other occupier, preparing and signing legal agreements, making payment and giving proper notice to enter upon the land. The Supervisor's Representative shall give prior approval to sites of spoil areas. When the use of the area is terminated, the Supervisor's Representative shall have the power to withhold payments in interim certificates for spoil pending reinstatement of such spoil areas to his satisfaction.
- (iv) The Contractor's rates shall be deemed to include any payments to be made to Local Government Authorities or private owners, as well as other costs, such as stripping the area, transportation, drainage provisions and reinstatement at the conclusion of works.

#### **403 Setting out of the works and Surveys**

- (a) Prior to the commencement of each type of excavation or filling the Contractor shall carry out a survey of the existing ground surface in conjunction with the Supervisor's Representative to establish the commencing surface for the purpose of measurement of quantities. Levels shall be taken at cross sections at not more than 5 meter intervals unless directed otherwise.
  
- (b) The Contractor shall plot the results on plans and sections and submit copies to the Supervisor's Representative for his approval and subsequent use in measurement.

#### **404 General Earthworks Operations**

This Section deals (after site clearance and removal of topsoil) with the excavation of cuttings including grading of site, the preparation of foundations, drainage works and landscaping.

##### **(a) Order of Works**

- (i) The construction of cuttings and embankments shall proceed in a methodical and orderly manner - generally from one end of the work section to the other. Work is to proceed after due regard for overall balancing of earthwork quantities, so that cuttings are excavated continuously and each embankment is completed before the next is commenced.
- (ii) The Contractor shall submit a general programme for earthworks to the Supervisor's Representative and having obtained the Supervisor's Representative's approval, shall as far as possible adhere to its provisions.
- (iii) All trimming of cuttings, embankments, ditches etc. to the specified slopes and shapes, shall be carried out concurrently with the earthworks that are being undertaken at any particular location.

## **(b) Use of Materials**

### **(i) General**

The Contractor shall (unless the Supervisor's Representative instructs otherwise) undertake cuts and fills in the manner specified in this Section and according to the approved earthworks programme. However the Supervisor's Representative may direct where materials of different quality shall be used and/or order borrow from approved sources, (whether from widened cuttings or elsewhere) to be introduced or for materials to be spoiled. The Contractor shall borrow or spoil only after verbal approval, which is to be subsequently confirmed in writing by the Supervisor's Representative.

### **(ii) Unsuitable Material**

Upon coming across unsuitable material, the Contractor shall, immediately bring this to the attention of the Supervisor's Representative. Any unsuitable material, which by the Contractor's operations or due to his method of working has been included in the Works (whether or not it has already been declared unsuitable by the Supervisor's Representative) shall be removed to spoil by the Contractor and replaced with suitable materials at the Contractor's expense.

### **(iii) Removal and Re-use of Topsoil**

- 1) The removal of topsoil, where directed, shall be to an average depth of 150mm, or as otherwise directed, prior to bulk excavation or filling operations, and shall be placed in thin layers on designated areas within the road reserve or stockpiled for re-use.
- 2) The Contractor shall notify the Supervisor's Representative at least 5 days before he intends to start topsoil stripping operations.
- 3) Slope areas to receive top soil shall be disked or scarified to a depth of 100 mm or as otherwise directed by the Supervisor's Representative prior to placing topsoil. After the Supervisor's Representative has approved the graded areas, topsoil shall be spread to a depth, which, after settlement, shall provide the nominal depth shown on the plans or as instructed. Spreading shall not be done when the ground or the topsoil itself is excessively wet or in a general condition detrimental to the work.
- 4) The roadway surfaces shall be kept clean during hauling and spreading operations.
- 5) After spreading has been completed, large clods, stones larger than 50 mm and any roots, stumps or debris shall be raked, removed, and disposed of at an approved location. Spread topsoil shall be lightly tamped as approved by the Supervisor's Representative in order to reduce erosion on the finished surface.

## **405 Excavation – General**

- (a) Excavation shall be carried out to the lines, levels and profiles shown on the Drawings or to such other lines, levels and profiles as the Supervisor's Representative may direct or approve in writing. The Contractor shall carry out the work in such a way to avoid disturbance to the

surrounding ground. Particular care shall be taken to maintain stability when excavating in proximity to existing works.

- (b) The work shall be carried out in a careful manner to ensure that the exposed surfaces are as sound as the nature of the material permits and that no point shall protrude inside the lines shown on the Drawings except as otherwise specified or agreed by the Supervisor's Representative. In soft excavation, which is to remain open permanently, exposed faces shall be formed accurately to the required slopes and profiles. Excavations in rock, which remain open permanently shall be so trimmed that no point protrudes within the required profile.
- (c) Excavation in areas of subsidence shall be carried out to the depth directed by the Supervisor's Representative and leaving side slopes to a maximum of 45°. The exposed formation surface shall be compacted to 95% of BS Heavy Compaction as defined in BS 1377. A permeable separator geotextile shall be placed at the bottom of the excavated area as may be decided by the Supervisor's Representative before commencing backfill. The geotextile should meet the minimum requirements of Section 2200.
- (d) Excavated material from the Works selected for reuse shall be placed directly in its final position or may be stacked on Site provided suitable precautions are taken to prevent excessive change in moisture content. Otherwise it shall be removed to spoil tips as noted above.
- (e) The Contractor shall be responsible for keeping all excavations free from water from whatever cause arising and shall provide such pumping capacity and other measures as may be necessary for this purpose.
- (f) The Contractor shall properly support the sides of excavations and shall be responsible for their safety.
- (g) Where shown on the drawings, cut slopes are to be formed to a benched profile with each bench being cut as the overall excavation proceeds. The dimensions of benches shall be sufficient to permit the operation of placing and compaction equipment thereon to generally a minimum width of 2-3 m. Dimensions of heights and widths of benches together with any required cut-off ditches and toe walls are included in the Drawings.
- (h) The Contractor shall notify the Supervisor's Representative without delay of any permeable strata, fissures or unusual ground encountered during excavation.

#### **406 Excavation beyond True Lines and Levels**

If from any cause whatsoever excavations are carried out beyond their true line and level other than at the direction of the Supervisor's Representative, the Contractor shall at his own cost make good to the required line and level with approved material and/or deal with the matter in such a manner as the Supervisor's Representative may direct.

#### **407 Approval of excavation**

- (a) When excavations have been taken out accurately to the profiles or dimensions required for the work, the Contractor shall inform the Supervisor's Representative so that he may carry out an inspection. If, after his inspection the Supervisor's Representative requires additional excavation to be carried out, the Contractor shall do so to such new profiles or dimensions as the Supervisor's Representative may direct.
- (b) Before any fill or pavement forming part of the permanent works is placed, the Contractor shall conduct the specified tests. The Contractor shall obtain the agreement of the Supervisor's Representative that the underlying layer is satisfactory prior to placing any further layer.
- (c) The Contractor shall maintain open excavations in an approved condition, and shall rectify the effects of deterioration due to weather.

#### **408 Excavation for Structural Foundations**

- (a) Prior to commencement of any excavation, the Contractor shall notify the Supervisor's Representative in advance to allow for checking of layouts and dimensions and for measurements, cross sections and control levels to be established.
- (b) Where suitable material is encountered during excavation against which the casting of concrete is permissible, that part of the trench or foundation pit shall be excavated neat to the dimensions of the base, unless directed otherwise by the Supervisor's Representative. Over excavation (over break) in such suitable stable material shall be backfilled with the same Class of concrete as that in the base - or with mass concrete fill as may be directed by the Supervisor's Representative.
- (c) Where in the opinion of the Supervisor's Representative, the casting of concrete against the excavated earth faces is not permissible or where formwork is to be provided, the extremities of the excavation shall be measured for payment purposes as shown on the relevant Drawings or otherwise to a maximum of 600 mm outside of and parallel to the net perimeter of the base or member.
- (d) When material suitable for founding is encountered above the designed founding level, excavation to final grade shall not be made until the Supervisor's Representative has inspected the excavation and before any working floor (blinding layer) is placed.
- (e) Where in the opinion of the Supervisor's Representative unsuitable material is encountered at founding level such material shall be removed and replaced with approved compacted granular fill. Boulders, logs or any other unsuitable material excavated shall be removed.
- (f) No concrete shall be placed before the excavation has been cleaned, inspected and approved by the Supervisor's Representative. A concrete working floor [blinding layer] of 75 mm thickness shall be placed underneath all bases except, where otherwise directed by the Supervisor's Representative.

- (g) Where required rock sockets shall be excavated for bridge pier foundations and to the dimensions shown on the drawings. They shall be formed in rock formations of adequate strength, quality and thickness and may be extended at the direction of the Supervisor's Representative until suitable for supporting the required loading.

#### **409 Founding on Rock**

Where a structure is required to be founded on rock but is not required to penetrate into it, all soft overburden shall be removed and the surface of the rock cleared of any loose material by barring and wedging. Where the foundation is required to penetrate into the rock, excavation of the rock may be carried out using a suitable excavator with a rock bucket, or by the use of approved pneumatic tools so that the exposed surface is sound.

#### **410 Trench Excavation**

- (a) Trench excavation shall be performed by the use of hand tools and approved mechanical equipment, in such manner as to minimize disturbance of the sides and bottom of the excavation.
- (b) Trenches for pipes shall be excavated to a sufficient depth and width to enable the pipe and the specified joint, bedding, haunching and surrounding to be accommodated.

#### **411 Trenches**

- (a) The Contractor shall carry out excavation in a safe manner such that the sides of the trench are adequately supported and stable.
- (b) The Contractor shall leave a clear adequate space between the edge of the excavation and the inner toes of the spoil banks.
- (c) Trenches shall be excavated to the lines and levels shown on the drawings. Trenches shall not be excavated too far in advance of pipe laying and shall be sufficiently wide to allow proper and efficient jointing to be carried out in clean and dry conditions. Due allowance shall be made for bedding and surrounds where these are specified.
- (d) The bottoms of all trenches shall be trimmed to grade and level and thoroughly compacted by ramming before any bedding is placed or pipes laid.
- (e) The widths of trenches crossing roads or at other locations as directed shall be as narrow as practically possible. The maximum width measured between undisturbed soil in the trench sides shall not exceed the outside diameter of the pipe being laid plus 550 mm for pipes up to and including 230 mm in diameter and plus 750 mm for pipes over 230 mm in diameter.

#### **412 Channels**

- (a)** Channels shall be excavated by methods, which shall not endanger the stability of the side slopes.
- (b)** Existing channels, which are to be reshaped, cleared and trimmed, shall be cleared of all weeds and growth and the beds graded to the required levels. The area of waterway shown is the minimum required and the sides of channels shall be trimmed to the required slope so as to provide widths not less than those shown on the Drawings.
- (c)** Side banks of channels shall be trimmed to a neat appearance and even surfaces.

#### **413 Disposal of Spoil Material**

- (a)** Possible spoil areas to be used for disposal of surplus excavated materials shall be as shown on the Drawings or as otherwise approved by the Supervisor's Representative.
- (b)** The Contractor shall organize and carry out the placing of spoil in such a way that flow passages to existing streams and creeks are not diverted. Contamination of existing rivers shall be avoided and suitable drainage, grassing and turfing shall be provided to prevent erosion of spoil materials.
- (c)** The Contractor shall submit to the Supervisor's Representative for approval all necessary data showing mucking areas, working methods and drainage and stabilizing provisions before placing of spoil in any areas.

#### **414 Quarries and Borrow Pits**

- (a)** The Contractor shall select his own quarry site or sites but before opening up any quarry he shall supply the Supervisor's Representative with: an adequate number of borehole logs and details of test pits; and any other such information that the Supervisor's Representative may require to satisfy himself that the quarry site or sites selected by the Contractor may be expected to provide sufficient stone of the specified quality to complete the Works. In the event of the site or sites selected by the Contractor being shown by such information in the opinion of the Supervisor's Representative to be incapable of supplying the requirements of the Contract for reasons of either quality or quantity, the Supervisor's Representative shall require the Contractor to investigate further sites in a similar manner until the Supervisor's Representative is satisfied that adequate supplies of the specified stone may be anticipated.
- (b)** Notwithstanding satisfactory borehole logs, the Supervisor's Representative shall have the right to reject unsatisfactory stone exposed when the quarry is opened. The Contractor shall make provision for the cost of all the exploratory work described above in the rates inserted in the Bills of Quantities.
- (c)** The quarries shall be run in a safe manner and on completion of the Works, they shall be left in a tidy state with all loose rock on the face barred down. No rock shall be left overhanging except with the approval of the Supervisor's Representative. All quarries shall be worked in

such a manner that they do not constitute a danger to health or a nuisance to the neighbourhood, either during the operation of the quarries or after completion of the works.

- (d) The Contractor shall obtain the Supervisor's Representative's approval for the sites of borrow pits. The Contractor shall leave all borrow pits in a tidy and regular state, and he shall ensure that where possible they are self-draining at all times and do not constitute a danger to health.

#### **415 Approval of Excavations**

The Contractor shall obtain approval of excavations prior to placing pavement layers, fill or concrete. The Contractor shall maintain open excavations in an approved condition, and shall rectify the effects of deterioration due to weather.

#### **416 Preparation of Ground for Filling**

- (a) The Contractor shall form benches in steeply sloping ground before placing fill over it.
- (b) In the areas designated "soft clay" or any other place so designated by the Supervisor's Representative, the top soil shall not be disturbed, only trees and bushes removed.
- (c) After site clearance, and before and/or after proof rolling, the Supervisor's Representative may order the excavation and removal of any material deemed unsuitable for supporting the fills or pavements to be placed thereon, and its replacement by suitable approved granular fill material compacted in 150 mm thick layers to 95% of BS Heavy Compaction as defined in BS 1377.
- (d) Paved or fill areas other than "soft clay" areas are to be proof rolled to the satisfaction of the Supervisor's Representative before placing any fill or pavement. A minimum of 5 passes shall be made by a pneumatic tired roller with mass per wheel of 1500 kg to 2000 kg or other roller as agreed by the Supervisor's Representative. On completion of proof rolling in areas where the sub-base is the succeeding layer, the formation shall have a dry density of not less than 95 per cent of the maximum dry density obtainable with BS Heavy compaction.
- (e) The limits of embankment foundation areas shall be marked on the commencing surface. The Supervisor's Representative shall inspect the layout or alternatively order the removal of unsuitable material to a spoil area to a specified depth prior to the placement of fill. The commencing surface for fill areas shall be compacted to 95% BS Heavy maximum dry density as defined in BS 1377.
- (f) Where fill is to be constructed across swampy, waterlogged or soft clayey ground that shall not support the weight of trucks or other hauling equipment, the Supervisor's Representative may direct that the lower parts of the fill be constructed by dumping successive loads in a uniformly distributed layer of thickness not greater than is necessary, to support the hauling equipment placing subsequent layers.

- (g) Light hauling equipment and light rollers shall be used whenever necessary so as not to overstress the underlying construction.
- (h) Where embankments are to be constructed over soft to cohesive lean clays, an additional removal of 500 mm may be required and the voids filled with selected granular materials.
- (i) The upper layers of embankments shall comply with the following requirements - for a depth of 300 mm below the subgrade, materials and construction shall comply with the requirements for selected material.
- (j) The Contractor shall be responsible for the location of suitable capping layer material and selected material fill to meet the above specified requirements. The use of any necessary borrow pits shall be subject to the approval of the Supervisor's Representative.
- (k) Any additional costs involved in excavation in small areas and depths - as a separate operation or location, shall be deemed to be covered by the rates for cut and fill, as entered in the Bill of Quantities.
- (l) Where material falling within the subgrade is classified as suitable for use but fails to meet the specified requirements for subgrade at formation level, the layers shall be scarified and mixed, water shall be added, or the material allowed to dry, to an appropriate moisture content – before the layer is re-compacted. Any such additional work incurred shall be considered to be at the Contractor's expense.
- (m) During the process, the final surface of each subgrade layer shall be graded to level, parallel to the cross-fall or camber and profile shown upon the Drawings unless otherwise directed by the Supervisor's Representative- and to the tolerances specified. The maximum compacted thickness which shall be processed and compacted at one time shall be 150 mm.

#### **417 Earth Filling**

- (a) Material for filling shall be obtained from approved sources or selected from excavations containing no vegetable or perishable matter, graded to ensure a dense, stable and homogeneous fill when compacted.
- (b) Prior to commencement of filling, the Contractor shall submit in writing to the Supervisor's Representative for approval his proposals for carrying out the work such that the optimum use may be made of excavated material and the proposals shall include the compaction plant and methods for adjusting the moisture content of the material which he intends to use. No filling shall be carried out until the Supervisor's Representative approves the proposals and the material intended to be used.
- (c) Construction equipment must operate over the whole area to ensure uniform compaction. Fill shall be placed in layers not exceeding 250 mm thickness, each layer being scarified and thoroughly compacted to obtain a dry density as specified below. More than 450 mm below top of fill level the density shall be not less than 90 per cent BS Heavy maximum dry density

as determined by BS 1377. The top 450 mm of fill shall be compacted to a density of at least 95 per cent BS Heavy maximum dry density and shall be capable of achieving a CBR of 8 per cent when so compacted. This CBR percentage should be realized on samples, which have been compacted at optimum moisture content and soaked for 96 hours. The in-situ dry density of the compacted fill shall be determined by the sand replacement method described in Test No. 15 BS 1377 at locations ordered by the Supervisor's Representative.

- (d) The fill material prior to compaction shall be brought to moisture content within an agreed range of the optimum, in order to obtain the required density. If watering is required it shall be carried out in such a manner as to ensure the even distribution of water throughout the layer to be compacted and the compaction operations shall follow whilst the moisture content remains within the specified range.
- (e) Filling in layers over 250 mm compacted thickness but not exceeding 500 mm compacted thickness may be approved by the Supervisor's Representative for mass filling where the nature of the work allows for unimpeded passage of compacting equipment, but not for backfilling of trenches or around isolated or confined foundations. Approval shall be given only if the Contractor carried out full scale compaction trials using the proposed procedures or amendments thereto shown during the trials as being necessary, and can demonstrate to the satisfaction of the Supervisor's Representative that the degree of compaction specified in sub-clause (c) hereof can be achieved throughout the full depth of the layer.
- (f) Longitudinal and transverse joints in any two successive layers shall be staggered by a minimum distance of 1.5 times the thickness of the layer.
- (g) The Contractor shall take all necessary measures to prevent any damage or defects to the Works, which may be caused by settlements, slips or falls of embankments and shall make good such damage or defects as may occur, to the satisfaction of the Supervisor's Representative.
- (h) Any instability of any adjacent excavation resulting from the embankment not being formed to the lines, levels and profile shown in the Drawings or as ordered by the Supervisor's Representative shall be the responsibility of the Contractor. Where double handling of excavated material is necessary, the Contractor shall be responsible for the temporary disposition of the material such that it does not endanger the stability of the excavation.

#### **418 Backfill – General**

- (a) Except around structures, excavations shall be backfilled with suitable excavated material and/or approved material compacted in layers of 300mm maximum thickness to achieve a density of at least 95% of the maximum dry density (heavy compaction) determined in accordance with BS 1377.
- (b) Materials shall be placed simultaneously on both sides of an abutment, wall, or pier where necessary to equalize forces. Backfilling shall be carried out with an approved material in horizontal layers not exceeding 150 mm in depth after compaction. Each layer shall be

moistened or dried as necessary, to reach the optimum moisture content before being compacted to 95% of the maximum dry density (heavy compaction) determined in accordance with BS 1377.

#### **419 Backfill to Structures**

- (a)** The Contractor shall not backfill around structures until the structural elements have attained adequate strength and the Supervisor's Representative grants approval to proceed. Unless otherwise directed, the backfill material shall be selected excavated material, thoroughly compacted in layers not exceeding 200mm deep to achieve a density of at least 95% of the maximum dry density (heavy compaction) as determined by BS 1377.
- (b)** Unless otherwise permitted, no filling shall be placed against retaining walls within fourteen days of casting. Strut walls shall be constructed as necessary to prevent movement during placing and compaction.
- (c)** Filling shall be placed and compacted over and around pipes, culverts, bridges and other structures so as to avoid unbalanced loading or movement.
- (d)** Unless otherwise detailed, the abutments and wings of bridges shall be filled as follows:
  - (i)** Where the gap between the structure and undisturbed ground is less than 900mm, backfill with sub-base material shall consist of clean, durable fill material.
  - (ii)** Where the gap between the structure and undisturbed ground exceeds 900mm but is less than 2m, backfill with select material, single-sized 10mm gravel.
  - (iii)** Where the gap between the structure and the undisturbed ground exceeds 2m, backfill the zone within 2m of the structure with select material as defined below, and backfill in the zone beyond 2m of the structure with general fill complying with General Fill requirements
  - (iv)** Selected well -graded granular material can consist of natural gravel, natural sand, crushed gravel, crushed rock etc. This is mainly frictional material with less than 15 per cent passing the 63 micron sieve and with a minimum acceptable uniformity coefficient of 10.

#### **420 Backfilling Materials to Structures**

- (a)** Unless otherwise specified or directed the materials used for filling shall be obtained from cuttings.
- (b)** The Contractor shall be required to manage and sort the materials so obtained from cuttings to ensure that the best available material, that is the most granular and least plastic is available for use in road embankments and that any loam material obtained from cutting is used for general fill over the top layers which are to be grassed.
- (c)** Material used in the top 150mm below subgrades shall be free of particles larger than 75mm; material used in the top 600mm below subgrades shall be free of particles larger than 150mm; and material used in the top 1 m below sub-grades shall be free of particles larger than

300mm. Elsewhere rock material shall be broken down to less than 600mm unless otherwise permitted.

- (d) Rock material shall be broken down and evenly distributed through the fill material, and sufficient fine material shall be placed around the larger material as it is deposited to fill the voids and produce a dense, compact embankment.
- (e) Stony patches with insufficient fine material to fill the voids shall be reworked with additional fine material being blended in to achieve a dense, compact upper layer. The Contractor shall bear the cost of any reworking.
- (f) After compaction, embankment material in the subgrade zone(s) below the pavement material (select material layer or sub-base layer, where there is no select material layer) shall conform to the requirements of Clause 425.
- (g) The Supervisor's Representative may direct that material unsuitable for road embankments be used elsewhere on site or run to spoil. If this should result in a deficiency of material available for filling, then additional material shall be obtained as specified in Clause 417.

#### **421 Filling Under Buildings Slabs**

The material to be used as general filling under raised foundations and building base slabs shall consist of suitable material obtained from adjacent excavations or approved borrow sources, and shall be placed in layers not exceeding 200 mm loose thickness. The material shall be compacted to the degree of compaction specified for earth filling.

#### **422 Embankments**

- (a) Embankments shall be formed of fill as defined and specified herein and compacted as described in the relevant Section hereafter.
- (b) Embankments shall be constructed in accordance with the profiles and true to side slope width and levels, as shown in the Contract Drawings, or as otherwise instructed or authorised or approved by the Supervisor's Representative.
- (c) Where the Contractor has been authorised to dispose of surplus fill by widening embankments, they shall be constructed to an approved size and made integral with the construction of the embankment proper.

#### **423 Placing Fill on Slopes**

- (a) Fills are normally to be formed of material generated by excavations for cuttings and side drainage ditches. Materials shall be as defined and specified, placed and compacted as described elsewhere in these Specifications.
- (b) Where the slope of the natural ground exceeds 20° it shall be cut into to form benches on which the fill is constructed, with each bench being cut as the fill is compacted and brought

up. The dimensions of benches shall be sufficient to permit the operation of placing and compaction equipment thereon with a minimum width of 2 m except in rock.

- (c) The slope shall be given an initial bench at the toe of the fill as set out from the specified levels and cross-sections and protective toe walls installed where specified.

#### **424 Rock Fill**

- (a) Where shown on the Drawings, or ordered by the Supervisor's Representative, rock fill shall be placed to a finished level of not less than 300 mm below formation level.

#### **(b) Placement of rock fill**

- (i) Rock fill shall be as defined and specified. Each layer of rock fill shall be spread, levelled and compacted by means of suitable equipment. Hauling, spreading and compacting equipment shall be operated over the full width of the layer. Layers of rock-fill spread for compaction shall not exceed 600 mm in thickness in the loose condition.
- (ii) The maximum particle size shall be 1.0 m in the greatest dimension. All larger particles are to be removed and disposed to spoil. Where a deficiency in fine materials is obvious during the spreading of the layer, additional material must be selected and added, as directed by the Supervisor's Representative.
- (iii) Compaction shall preferably be by a heavy roller of 15 tonne dead weight or by a vibrating roller, giving equivalent results and each layer shall be rolled over the full width of the fill with sufficient number of passes to provide no observable movement under the compacting equipment.

#### **(c) Treatment of Rock Fill Surfaces**

- (i) When the top level of the rock fill has been reached and compaction undertaken on the layer surfaces, the top shall be saturated then 'blinded' with, small size rock material and again compacted over the full width.
- (ii) This process is to be repeated until the surface no longer shows voids or crevices and in the opinion of the Supervisor's Representative is ready to receive any specified capping layer materials for compaction of the final 300 mm to formation level, in accordance with the specifications.

#### **425 Compaction**

This Section describes the work of placing materials in fills including the processing and compacting of the material, in formation preparation and related works in accordance with the requirements of the Specifications.

#### **(a) General**

- (i) Compaction shall be carried out in a series of continuous operations over the full width of the layer concerned. The length of any section of a layer being compacted shall, whenever possible, not be less than 300 m, unless otherwise authorised by the Supervisor's Representative.

- (ii) The thickness of any one layer, when measured after compaction, shall not exceed 150 mm, except where specifically indicated on the Drawings or otherwise directed.
- (iii) Any new layer of less than 75 mm in compacted thickness shall be bonded to the previous layer by scarifying the latter to a depth of not less than 75 mm.

**(b) Preparation**

The material to be compacted shall be thoroughly broken up over the width and depth of the layer by means of scarifiers or other suitable equipment and all large size aggregates, stone or lumps with a maximum dimension larger than 50% of the specified compacted thickness of the layer concerned, shall be broken down or removed.

**(c) Drying**

Should the material be too wet, due to rain or any other cause, it shall be harrowed and allowed to dry to a moisture content that is consistent with achieving the required degree of compaction.

**(d) Watering**

- (i) Any water required before the material is compacted, shall be added to the material in successive applications by means of water tankers fitted with proper sprinkler bars and capable of applying the water evenly and uniformly over the area concerned.
- (ii) The water shall be thoroughly mixed with the material to be compacted by means of motor graders or other suitable equipment. Mixing shall continue until the required amount of water has been added and until a uniform mixture is obtained before compaction is commenced.
- (iii) The moisture content of the material, when compacted, shall be such that the specified density is achieved.
- (iv) The Contractor shall provide, at his own expense, the necessary staff and equipment for controlling moisture content and for ensuring adherence to specified compaction requirements.

**426 Methods of Compaction**

- (a) Compaction shall be carried out by means of grid rollers, sheep's foot rollers, flat-wheel road rollers, vibratory rollers and/or pneumatic-tired rollers.
- (b) The types of rollers to be used and the amount of rolling to be undertaken shall be such as to ensure that specified compaction densities are obtained.
- (c) During compaction, layers shall be maintained to the required shape and cross-section and all holes, ruts and depressions eliminated by frequent blading with motor graders.

**427 Testing of Fill (To be carried out by the contractor)**

- (a) Classification tests shall be carried out to ensure that true comparisons can be made between in situ densities, laboratory compaction densities and field trial densities i.e. variations in properties of materials being used in the tests are not affecting the results.

- (b) Density shall be measured by either of the methods described in BS 1377. Moisture content shall generally be determined by the 'Speedy' method with spot checks by the oven method.
- (c) The CBR test shall be carried out in accordance with standard test procedure as set out in BS 1377 and all fill material shall be tested with surcharge rings compatible with the pavement thickness.
- (d) Except when it is specified that CBR specimens shall be soaked for 96 hours, the CBR shall be measured at the moisture content estimated by the Supervisor's Representative to correspond with the moisture content pertaining under the most unfavourable conditions to which the soil may be subjected. The Supervisor's Representative shall establish the value of the moisture content at the commencement of the Works.
- (e) In situ density and Clegg Hammer tests shall be carried out routinely at 30 meter intervals on each finished layer. CBR tests shall be carried out on materials sampled from the finished layer at intervals determined by the Supervisor's Representative.

#### **428 Finish of Subgrade**

The subgrade i.e. that layer which immediately underlies the sub base, shall be finished to within +0 mm to 40 mm of the levels indicated by the Supervisor's Representative and shall be free draining.

#### **429 Ancillary Earthwork Operations**

##### **(a) Finishing Slopes**

- (i) The slopes of cuttings and fills shall be trimmed to neat lines with all loose rock and loose boulders removed. Except in solid rock the tops and bottoms of all slopes, including the slopes of drainage ditches shall be rounded, as ordered by the Supervisor's Representative.
- (ii) When so directed by the Supervisor's Representative, adjustment in slopes shall be made to avoid damage to standing trees and to harmonize with existing landscape features. The transition to such adjusted slopes shall be gradual.
- (iii) All earth slopes shall be finished to smooth and uniform surfaces without any noticeable break. Embankment slopes shall be cleaned of loose materials and trimmed back to design profiles or where overfill has been permitted, back to material, which is compacted as specified.
- (iv) The slopes of cuts and fills, which are designated for grassing, shall, after finishing, be prepared for top soil and grass seed application as specified.

##### **(b) Drainage of Earthworks**

- (i) All cuttings, embankment and borrow areas shall be kept free of standing water and drainage during the construction period. The provision of any temporary drains etc., necessary for adequate drainage, shall be the Contractor's responsibility and be deemed to be included in his rates.

- (ii) Should water accumulate on any part of the earthworks during construction giving rise to soaking or erosion conditions in the earthworks, the Supervisor's Representative may order the Contractor to remove and replace, at the Contractor's expense, any material that has been so affected. All drains shall be maintained throughout the Contract in working order.
- (iii) Well in advance of commencing earthmoving operations over swampy or waterlogged areas, the Contractor shall cut drains and ditches and carry out any other works necessary to assist in draining the ground.
- (iv) The Contractor must allow in his rates for the satisfactory draining of the earthworks at all stages during the construction and arrange his methods and order of work accordingly. No work above the subgrade shall be executed until it has been inspected and approved by the Supervisor's Representative.
- (v) The subgrade shall be cleaned of all foreign matter and any potholes, loose material, ruts, corrugations, depressions or other defects, which have appeared in the subgrade layer, due to improper drainage, traffic or any other cause, shall be corrected. If so directed by the Supervisor's Representative, the Contractor shall scarify, grade and re-compact the subgrade to line and level at his own expense.

**(c) Tolerances**

- i) The finished surface of the formation (subgrade) shall be within  $\pm 25$  mm of the specified level. In the final trimmed slopes a tolerance of  $\pm 7.5\%$  shall be permitted.
- ii) The tolerance permitted in the overall width of the bottom of cuttings shall be 75 mm in the distance between the centre line of the road and the toe of the cutting slope.
- iii) The centre line dimensions of embankments, measured as the distance from the centre line of the road to the shoulder break point, shall be never less than the design width and shall not be more than 250 mm greater than the specified dimension.
- iv) The Contractor shall be paid for the net volume of the earthworks measured from agreed pre-construction cross-sections using the appropriate commencing surface.
- v) Any additional material excavated or filled within or beyond these tolerances shall be at the Contractor's expense.

**430 Termite Treatment**

Subterranean termite treatment of the site of the building shall be with one of the following toxicants as an emulsion in water at the minimum concentrations listed:

Aldrin - 9.5% by weight  
 Chlorphrifos - 1.0% by weight  
 Permethrin - 0.5% by weight

Toxicant emulsions shall be applied by spray immediately before pouring of concrete at the rate of 1 gallon per square yard of surface area of excavations and 2 gallons per square yard, on filling and sand beds, etc.

Treatment shall not be carried out when rain is falling or when ground is excessively wet. A warranty of at least 5 years is required against infestation by subterranean termites, during which period the Contractor shall carry out any remedial work free of charge.

#### **431 Top Soiling**

The Contractor shall obtain topsoil from temporary dumps or approved borrow pits and shall spread it on level or sloping surfaces, planters, where ordered, to the depth shown on the Drawings.

#### **432 Grassing**

- (a)** The topsoil shall be raked lightly and uniformly to give a fine tilth up to 25mm deep.
- (b)** The surface shall be grassed with a local grass with creeping habit, or which the source and variety shall be approved by the Supervisor's Representative. Grass sprigs shall be planted at 0.3 m x 0.3 m spacing. The grass shall be adequately watered until such time as the grass becomes established.
- (c)** Should the growth fail to become established for any reason the Contractor shall re-cultivate and replant grass as necessary in accordance with the above specification, for as many times as necessary for the grass to become established. When established between 50 and 75mm high, the grass shall be topped by cutting to leave between 25 and 50mm minimum growth and watering shall be continued as necessary until the grass is firmly established to the Supervisor's Representative's satisfaction.

## **500 CONCRETE**

### **501 Concrete**

Concrete shall consist of cement, graded aggregate and water thoroughly mixed, placed and compacted as specified in the following clauses.

### **502 Chlorides in Concrete**

The total combined content of calcium chloride and sodium chloride in any batch of concrete is not to exceed 0.33% by weight of the amount of cement.

### **503 Cement**

The cement used throughout the Works shall be obtained from manufacturers approved in writing by the Supervisor's Representative and shall as appropriate comply with the following specifications:

- (a)** Ordinary Portland cement: B.S. 12
  
- (b)** Sulphate Resisting cement: B.S. 4027

### **504 Cement Testing**

- (a)** All cements shall be certified by the manufacturers as complying with the requirements of the appropriate Specification. Before orders are placed the Contractor shall submit details of the proposed supplier(s) together with such information on the proposed methods of transport, storage and certification so that the Supervisor's Representative may satisfy himself that the quantity and quality required can be supplied and maintained throughout the construction period. Where necessary the Supervisor's Representative may require further representative samples of the proposed cement to be taken and forwarded to a nominated laboratory for analysis and testing before the source is approved.
  
- (b)** Having obtained the Supervisor's Representative's approval of the source(s) of supply, transport, storage and certification of the cement, the Contractor shall not modify or change the agreed arrangements without first having obtained the Supervisor's Representative's permission.
  
- (c)** In addition to routine test certificates which are to be supplied by the manufacturer to show the average results of sample tests made on batches of cement produced at the works, the Supervisor's Representative may also make any further tests which he shall consider necessary or advisable to satisfy himself that the cement on Site complies with the Specification and has not suffered deterioration in any manner during transit or storage.
  
- (d)** The Contractor shall ensure that the arrangements for the storage of the cement on the Site as hereinafter specified are sufficient for the segregation and identification of each consignment until the results of the sampling and testing referred to in sub-clause (3) above are available.

- (e) No cement shall be used in the Works until the Supervisor's Representative has passed it as satisfactory.

**505 Storage of Cement**

- (a) The cement shall be delivered to the site of the Works in bulk or in sound and properly sealed bags and while being loaded or unloaded and during transit to the concrete mixers whether conveyed in vehicles or by mechanical means, must be protected from the weather by effective coverings. Where directed by the Supervisor's Representative the Contractor shall supply and erect efficient screens at his own expense to prevent wastage of cement during strong winds.
- (b) If the cement is delivered in bulk, the Contractor shall provide at his own cost, approved silos of adequate size and numbers to store sufficient cement to ensure continuity of work and the cement shall be placed in these silos immediately it has been delivered on the Site. Approved precautions must be taken during unloading to ensure that the resulting dust does not constitute a nuisance.
- (c) If the cement is delivered in bags, the Contractor shall provide at his own cost perfectly weatherproof and well-ventilated sheds having a floor of wood or concrete raised at least 500 mm above the ground. The sheds shall be large enough to store sufficient cement to ensure continuity of work and each consignment must be stacked separately therein to permit easy access for inspection, testing and approval. On delivery at the Site, the cement is at once to be placed in these sheds and shall be used in the order in which it has been delivered.
- (d) Cement, which has been damaged in transit to the Site or has become stale or otherwise unsuitable, and hardened lumps or cakes of cement, which cannot be crumbled into fine powder in the hand shall not be used in the Permanent Works except with the specific approval of the Supervisor's Representative.

**506 Fine Aggregates**

- (a) Fine aggregate for concrete shall be clean sand complying with B.S. 882 "Aggregates from natural sources for concrete". The sand shall be from approved sources and a sand, which in the opinion of the Supervisor's Representative is not clean, shall be washed before use.
- (b) Crushed sand up to a maximum of 50% may be added to natural sand in order to achieve the required grading. Crushed sand alone may only be used with approval of the Supervisor's Representative.
- (c) Sand for use in mortar and rendering shall conform in all respects with B.S. 1198 1200, "Building sands from natural sources".
- (d) The amount of deleterious substances in fine aggregates shall not exceed the limits prescribed in the following table

**Limits for Deleterious Substances in Fine Aggregates for Concrete**

Items	Mass per cent of total
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	<b>sample, max</b>
Clay lumps and friable particles	3.0
Material finer than 75µm (No. 200) sieve:	
Concrete subjected to abrasion	3.0
All other concrete	5.0
Coal and lignita:	
Where surface appearance of concrete is of importance:	0.5
All other concrete	1.0

- (e) Should the amount of clay, fine silt and fine dust exceed the limits specified, then the Contractor shall refrain from using the aggregate until he satisfies the Supervisor's Representative of its suitability for making concrete of the quality required.
- (f) Fine aggregates shall be free of injurious amount of organic impurities. Except as herein provided, aggregates subjected to the test for organic impurities and producing a colour darker than the standard shall be rejected.
- (g) The use of fine aggregates failing in the test is permitted, provided that this coloration is due principally to the presence of small quantities of coal, lignite or similar discrete particles. The use of fine aggregates failing in the test is permitted, provided that, when tested for the effect of organic impurities on strength of mortar, the relative strength at seven days, calculated in accordance with test method C87, is not less than 95%.

### 507 Coarse Aggregate

- (a) Coarse aggregate for concrete and other purposes shall comply with B.S. 882 "Aggregates from natural sources for concrete". Subject to sub-clause (6) hereof it may be either natural gravel or stone broken to the desired size and shall be obtained from quarries, pits or other sources approved by the Supervisor's Representative.
- (b) Gravel or ballast shall be free from clay, earth, loam or other organic or similar material and shall be approved by the Supervisor's Representative. Any sand that may be amongst it shall, unless otherwise directed, be removed by screening if required and kept apart. Should the sand thus obtained be suitable in the opinion of the Supervisor's Representative for use in concrete, it may be used for the purpose if it complies with the conditions specified for sand in the preceding Clause. Gravel or ballast, which in the opinion of the Supervisor's Representative is not clean, shall be thoroughly washed before use.
- (c) Broken stone shall be of hard durable rock. Notwithstanding approval by the Supervisor's Representative of its source, the stone as delivered to the Works shall be subject to rejection if for any reason the Supervisor's Representative considers it unsatisfactory. It must be perfectly clean and no soft, clayey, shaley, decomposed or weathered stone shall be approved. The stone must be broken in a stone crusher of approved type to the sizes hereinafter specified and any dust or fine material below 5 mm in size made in the stone crusher is to be removed by screening

if so required and if the Supervisor's Representative so orders the stone shall be thoroughly washed by an approved method.

- (d) When so required and before the Work commences, laboratory tests shall be made of the aggregates to be used on the Works to establish their suitability for concrete. In addition to these laboratory tests, the Supervisor's Representative may require check tests of actual deliveries to be made at the Site from time to time.
- (e) The grading of coarse aggregate by analysis shall be within the limits laid down in B.S. 882 1201, Table 1, Coarse Aggregates. Should an analysis of the grain size of the material show a deficiency in any particular size such as to affect the density of the concrete, the Supervisor's Representative may require the Contractor to add such quantity of aggregate of any particular size that he may deem advisable. In every case, the material shall when mixed with sand produce a well graded mixture from the largest to the smallest size specified to ensure that concrete of high density shall be produced.
- (f) The "flakiness index" for coarse aggregate as determined by the sieve method described in B.S. 812, "Methods for sampling and testing of mineral aggregates, sands and fillers," shall not exceed 40 for 40 mm aggregate nor 35 for 20 mm and 10 mm aggregate.
- (g) The "ten per cent fines" value of the coarse aggregate determined in accordance with BS 812 shall not be less than 8 tonnes, and not less than 5 tonnes on a soaked specimen. Alternatively, the aggregate crushing value determined in accordance with BS 812 shall not exceed 35 per cent, and shall not exceed 40 per cent on a soaked specimen.
- (h) The material shall be subjected to 5 alternations of AASHTO Sodium Sulphate Soundness test T104. The weighted loss shall be not more than 12 per cent mass. Where the presence of weathering rock is suspected, petrographic tests shall be carried out to determine the proportion of secondary minerals present.

### **508 Storage of Aggregates**

All sand and aggregate for concrete shall be stored on close fitting timber, steel or concrete stages of approved design with drainage slopes or in bins of substantial construction in such a manner as to prevent segregation of sizes and to avoid the inclusion of dirt and other foreign materials in the concrete. All such bins shall be emptied and cleaned at intervals as instructed by the Supervisor's Representative. Each size of aggregate shall be stored separately unless otherwise approved by the Supervisor's Representative.

### **509 Water for Concrete**

- (a) Clean fresh water is to be used for the mixing of all concrete and mortar and is to be from a source approved by the Supervisor's Representative. If required by the Supervisor's Representative, samples shall be taken from the proposed source of supply and submitted to a nominated laboratory for testing in accordance with B.S. 3148 - "Tests for water for making concrete" and on the results of these tests the Supervisor's Representative shall decide whether the source is acceptable.

## 510 Admixtures

- (a) The use of non-corrosive additives or admixtures in concrete may be ordered or approved by the Supervisor's Representative according to circumstances. Such approval shall be given only when the Contractor has demonstrated to the satisfaction of the Supervisor's Representative that the resulting concrete is no less strong, dense and durable than that obtainable without the use of additives.
- (b) Samples of any additive or admixture proposed by the Contractor shall be submitted for testing at least 60 days in advance of use, which shall require the written approval of the Supervisor's Representative.
- (c) When additives or admixtures are used in the Works very strict control is to be maintained to ensure that the correct quantity is used at all times.

## 511 Integral Water Resisting Admixtures

- (a) The use of an integral water resisting admixture in concrete is recommended by the Supervisor's Representative for use in the concrete roof structure including slabs and supporting gable shaped beams. This integral water resisting admixture shall be based on a unique blend of fatty acid salts and hydrophobic materials, supplied as a white chloride free liquid; tested in accordance with BS EN 480-5:2005, BS EN 934-2:2009+A1:2012 or equivalent EU or ACP states standards.
- (b) Properties for this integral water resisting admixture shall be as follows:
  - Typical properties**
  - Appearance:** White liquid
  - Specific gravity:** Typically 1.05 at 20°C
  - Chloride content:** Nil to BS 5075
- (c) The integral water resisting admixture shall be suitable for use with all types of Portland cements and combination materials such as fly ash, PFA, GGBS limestone fines and microsilica.
- (d) Upon application of the admixture product very strict control is to be maintained to ensure that the correct quantity, dosage and curing technique is used at all times.

## 512 Steel for Reinforced Concrete

- (a) Steel reinforcement, other than steel for pre-stressing, used in reinforced concrete shall comply with the following British Standards as appropriate:
  - (i) B.S. 4449 Specification for Hot rolled steel bars for the reinforcement of concrete.
  - (ii) B.S. 4461 Specification for Cold worked steel bars for the reinforcement of concrete.
  - (iii) B.S. 4482 Hard drawn mild steel wire for the reinforcement of concrete

- (iv)** B.S. 4483 Steel fabric for the reinforcement of concrete
- (b)** Deformed bars of high tensile steel may be used if the Supervisor's Representative approves or it is shown on the Drawings.
- (c)** The Contractor shall furnish the Supervisor's Representative with copies of the manufacturer's certificates of tests for the steel reinforcement to be supplied. The Supervisor's Representative may, however, order independent tests to be made and any steel, which does not comply in all respects with the appropriate foregoing specifications, shall be rejected.
- (d)** Bends, cranks or other labours on reinforcement bars shall be carefully formed in accordance with the Drawings, B.S. 4466 "Bending dimensions and scheduling of bars for the reinforcement of concrete" and B.S. 8110 "Structural use of reinforced concrete in buildings". The bars shall be bent cold in a manner, which shall not injure the material. Bending hot at cherry red heat (i.e. not exceeding 850 0C) may be allowed except for bars, which depend for their strength on cold working. Bars bent hot shall not be cooled by quenching. Bends shall be made round a former having a diameter of at least four times the diameter of the bar except for bends in cold twisted steel bars and deformed bars of high tensile steel for which a former of at least six times the diameter of the bar shall be used. Where splices or overlapping in reinforcement is required the bars should, unless otherwise shown on the Drawings, have an overlap of not less than thirty diameters where a U-hook is employed on each of the overlapping bars and forty-five diameters for bars without hooks.
- (e)** Fabric reinforcement sheets are to overlap by two meshes.
- (f)** The number, size, form and position of all steel reinforcing bars, ties, links, stirrups and other parts of the reinforcement shall be in exact accordance with the Drawings and they shall be kept in the correct position and with the required cover without displacement during the process of compacting the concrete in place in a manner approved by the Supervisor's Representative. The Contractor shall provide all necessary distance pieces and spacer bars at his own cost to maintain the reinforcement in the correct position. The type of distance pieces shall be subject to the approval of the Supervisor's Representative. Timber blocks for wedging the steel off the formwork shall not be allowed. Any ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced and the inside of hooks and bends shall be in actual contact with the bars around which they are intended to fit. Bars shall be bound together with best black annealed mild steel wire and the binding shall be twisted tight with pliers. The free ends of binding wire shall be bent inwards.
- (g)** Before any steel reinforcement is embedded in the concrete any loose mill scale, loose rust and any oil, grease or other deleterious matter shall be removed. Partially set concrete which may adhere to the exposed bars during concreting operations shall likewise be removed.
- (h)** All further working drawings and lists of reinforcement necessary to carry out the Works shall be provided by the Contractor at his own cost.

### 513 Concrete Classes

- (a) The classes of concrete to be used in the Works shall be as shown on the Drawings, Bills of Quantities or as directed by the Supervisor's Representative. For each class of concrete the characteristic 28-day crushing strengths, when tested in accordance with the following clauses, shall be as set out in the table below, the 7-day strengths shall be used only as a guide.

Concrete type	Concrete class	Maximum aggregate size [mm]	Characteristic 28 day strength [N/mm <sup>2</sup> ]	Characteristic 7 day strength [N/mm <sup>2</sup> ]	Minimum cement content [kg/m <sup>3</sup> ]
Mass concrete	20/40	40	20	14	220
	20/20	20	20	14	250
	15/40	40	15	10	200
Blinding concrete	10/40	40	N/A	N/A	150

The term characteristic strength means the value of the strength of concrete below which not more than 5 per cent of the test results fall.

- (b) The characteristic strengths specified above are for concrete cured at a mean temperature between 75 and 23 degree F. Should the curing temperature be in excess of the higher values of these ranges, the acceptable cube strength should be increased by an amount to be determined by the Supervisor's Representative.
- (c) The actual cement contents and aggregate/cement ratios shall depend on the closeness of control, which the Contractor is prepared to exercise in production and upon the quality of materials used. Where necessary the Supervisor's Representative may impose an upper or lower aggregate/cement ratio, which shall not be exceeded for any class of concrete.
- (d) Before any concrete is placed in the Works the Contractor shall submit to the Supervisor's Representative for his approval full details of the mixes he proposes to use for each class of concrete together with their expected average strengths. These mixes shall be based on the results of trial mixes as specified hereafter.

### 514 Concrete Mix Designs

- (a) Preliminary tests are to be carried out jointly by the Contractor and the Supervisor's Representative to determine the mixes, which shall satisfy the Specification with the available materials. These mixes shall be designed with due regard for the workability necessary to allow the Contractor to place and compact the concrete with the equipment he proposes to use in any particular situation.
- (b) The mixes shall be designed to have mean strengths that are greater than the specified characteristic cube strengths by a margin of 1.64 times the standard deviation expected from the concreting plant. The standard deviation shall be calculated from at least 40 individual cube results each representing separate batches of similar concrete produced by the same plant and under the same supervision except that no standard deviation less than 3.5 N/sq.mm shall be

used as a basis for designing a mix. In the absence of such previous information, a standard deviation of 7 N/sq.mm shall be used for initial mix design purposes. It is assumed that the same standard deviation applies to both the 7 day and 28 day strengths.

### 515 Trial mixes

- (a) Unless there are existing data showing that the proposed mix proportions shall produce the grade of concrete required with adequate workability for full compaction by the method to be used in production, trial mixes shall be prepared under full scale conditions and tested in accordance with B.S. 1881 "Methods of testing concrete". Trial mixes shall also be made subsequently whenever a change is intended in materials or in the proportions of the materials to be used. Representative samples of the materials to be used shall be taken and three trial mixes using the proposed proportions shall be made on different days. The workability of each of these three mixes shall be determined and a batch of six cubes from each mix shall be made, three for tests at 7 days and three for tests at 28 days. The Supervisor's Representative shall normally approve the proposed mix proportions provided the average strength of the three trial mixes is not less than the designed mean strength minus the designed standard deviation and subject to the conditions noted below. Further trial mixes shall be made if the range of strength that is the maximum minus the minimum, of the three cube results in any batch exceeds 15% of the average of that batch, or if the range of the three batch averages exceeds 20% of the overall average of the batches.

### 516 Mixing Concrete by Machine

- (a) The concrete is to be mixed in machines of the batch mixing or other approved type. The machines are to ensure that all the concreting materials including the water are thoroughly mixed together between the time of their deposition in the mixer and before any portion of the mixture is discharged. The machines must be capable of discharging their contents while running. No hand mixing shall be permitted. Mixing shall continue until there is a thorough distribution of the materials, and the mass is of uniform colour and consistency.

#### (i) Central-mix plant.

- 1) Dispense liquid admixtures through a controlled flow-meter.
- 2) Use dispensers with sufficient capacity to measure, at one time, the full quantity of admixture required for each batch. If more than one admixture is used, dispense each with separate equipment.
- 3) Charge the coarse aggregate, one third of the water, and all air entraining admixture into the mixer first, then add remainder of the material.
- 4) Mix for at least 50 seconds. Begin mixing time after all cement and aggregate are in the drum. Add the remaining water during the first quarter of the mixing time. Add 4 seconds to the mixing time if timing starts the instant the skip reaches its maximum raised position. Transfer time in multiple-drum mixers is included in mixing time. Mixing time ends when the discharge chute opens.
- 5) Remove the contents of an individual mixer before a succeeding batch is charged into the drum.

#### (ii) Truck mixer:

- 1) Do not use mixers with any section of the blades worn 25mm or more below the original manufactured height.
  - 2) Do not use mixers and agitators with accumulated hard concrete or mortar in the mixing drum.
  - 3) Add admixtures to the mix water before or during mixing.
  - 4) Charge the batch into the drum so a portion of the mixing water enters in advance of the cement.
- (b) The entire contents of the drum shall be discharged before materials for the next batch are fed in. Should there, for any reason, be a stoppage of greater than 30 minutes duration, the drum of the mixer shall be thoroughly washed out with clean fresh water before mixing is resumed.

### 517 Works Test

- (a) Test cubes shall be made, cured, stored, transported and tested in compression in accordance with B.S. 1881 "Methods of testing concrete". The method of compacting cubes by vibration shall be subject to the approval of the Supervisor's Representative.
- (b) **Sampling and testing:**
- (i) A sample of concrete shall be taken at random on eight separate occasions during each of the first five days of using a mix. Thereafter a sample shall be taken from at least 4% of the batches made, and in any case at least one sample shall be taken each day of concrete of each grade made. The number of samples per day and the times, which they shall be taken shall be varied at random or as directed by the Supervisor's Representative.
  - (ii) From each sample, two cubes shall be made for testing at 28 days and one for testing at 7 days for control purposes.
  - (iii) To ensure that the mix proportions are suitable for a particular grade of concrete 28-day test cube results shall satisfy the four conditions given below.
  - (iv) The works test 28-day cube results shall be examined both individually and in consecutive (but not overlapping) sets of four, for which the average and the range of each set shall be calculated. The mix proportions shall be modified to increase the strength if, in the first ten consecutive (but not overlapping) sets, any of the following conditions are not satisfied:
    - 1) not more than two individual results of the 40 cube tests shall fall below the specified characteristic cube strength,
    - 2) no value of the range in any set shall exceed 3.2 times the designed standard deviation,
    - 3) no value of the average of any set shall be less than the specified characteristic strength plus the designed standard deviation, and
    - 4) not more than one set shall have an average which is less than the specified characteristic strength plus 1.3 times the standard deviation
- (c) After ten consecutive sets of results have been obtained, the overall average and the standard deviation of the 40 results shall be calculated and any appropriate modifications made to the mix proportions. Subsequently, if any of the foregoing conditions do not apply to the individual results or the sets of four, the overall average and the standard deviation of the previous consecutive 40 results, including the non-complying set shall be calculated. If the overall average strength minus 1.6 times the standard deviation is less than the specified characteristic works cube strength, then the mix proportions shall be modified.

### 518 Additional Cube Tests

In addition to the works test cube described above the Supervisor's Representative may order additional cubes to be made for the following purposes: to determine the strength of concrete at the time of stripping moulds; and to determine the duration of curing or to check testing errors.

### 519 Test Failure

- (a) Should any works test cube fail to attain the specified strength, an immediate examination shall be made to find the cause of the failure and a report sent to the Supervisor's Representative's Representative who shall take suitable action which may be one of the following:
- (i) He may order the concrete corresponding to the cubes to be cut out and replaced in accordance with Clause 39 of the Conditions of Contract.
  - (ii) When the failure relates to concrete used in structural members, which lend themselves to being load tested such as beams, columns or slabs, the Supervisor's Representative, may order the affected member to be so tested in accordance with his instructions. If cracking or any other sign of failure appears, the concrete shall be cut out to the extent ordered by the Supervisor's Representative and replaced with sound material. Otherwise, the member may be accepted as satisfactory.
  - (iii) When the failure, in the opinion of the Supervisor's Representative's Representative, is slight and occurs in a continuing concreting operation for a large mass of concrete, the next works test result may be awaited and, if the failure then persists, the Supervisor's Representative's Representative may order that concreting shall cease forthwith and not be resumed until further preliminary tests indicate that the mix has been corrected. Otherwise the concreting may be allowed to continue with the same mix.
  - (iv) When the failure is serious and relates to a concrete mass, which lends itself to it, the Supervisor's Representative's Representative may order one or more test cylinders to be drilled out and tested in accordance with B.S. 1881. According to the result of these tests, the Supervisor's Representative may order the suspected concrete to be cut out and replaced in accordance with Clause 39 of the Conditions of Contract.
- (b) The cost of these tests including the provisions and placing of jacks, kentledge, deflectometers, etc., and the cutting out and replacing of concrete of inferior quality shall be borne by the Contractor if the test results show the concrete not to be in accordance with the Specification.

### 520 Workability

- (a) The concrete shall be of such consistency that it can be readily transported, placed and compacted in the Works without segregation of the materials. The resulting concrete shall be uniform and free from honeycombing.
- (b) Where necessary and before the mixes are approved the Contractor shall supply a section of formwork complete with reinforcement fixed in position and generally representative of the sections comprising the Works. This formwork shall be filled with concrete produced for the trial mixes and compacted in the same manner and with the same equipment to be used on the Works. The appearance of the concrete after striking the formwork shall be to the satisfaction

of the Supervisor's Representative who may otherwise require the mix to be modified and further batches of concrete made and tested as before.

- (c) A simple and convenient system of varying the water released into each batch must be installed with graduated gauges fixed to the supply tanks, which can be set by the Supervisor's Representative. The method of releasing the water into the mixer shall be such that the full measured quantity is discharged in one operation and the flow is stopped by an automatic valve or siphon arrangement only when the full quantity of water has been released. No arrangement, which permits the discharge of partial quantities of water at the discretion of the mixer driver, shall be allowed.
- (d) The Contractor shall be required to have an accurate knowledge of the moisture content of all sand and coarse aggregate as they reach the mixer and he shall make such adjustments to the mix as are necessitated by change in the moisture content of all aggregates.

#### **521 Consistency**

- (a) The Contractor shall carry out slump, compaction factor or other workability tests as required during concreting of permanent works in order to relate the degree of workability of the mix with the numerical value obtained during the trial mixes.

#### **522 Concrete Return and Records**

- (a) The Contractor shall send weekly to the Supervisor's Representative return showing the quantities of cement and the number of mixings of each class of concrete used in each section of the Works.
- (b) Records shall be kept by the Contractor of the positions in the Works of all batches of concrete, of their class and of all test cubes or other specimens taken from them. Copies of these records shall be supplied to the Supervisor's Representative.

#### **523 Batching**

- (a) The aggregates and cement shall be proportioned by means of efficient weigh batching machines except when the Supervisor's Representative has approved the use of volume batching. The machines shall be carefully maintained and cleaned and they shall be provided with simple and convenient means of checking the accuracy of the weighing mechanism, and they shall be checked when required by the Supervisor's Representative.
- (b) For volume, batching suitable gauge boxes shall be used. Cement shall be taken as weighing 1440 kg/cu.m or such other amount as may be determined by the Supervisor's Representative as a result of tests.

#### **524 Mixing Concrete By Hand**

Where it is not possible to employ machine mixing and approval has been obtained from the Supervisor's Representative, concrete shall be mixed by hand as near as practicable to the site where

it is to be deposited. Clean mixing bankers or platforms of sufficient area for the proper execution of the work shall be provided. These platforms if constructed of timber shall consist of planks closely jointed so as to avoid the loss of any grout or liquid from the wet concrete. The whole of the aggregate and cement shall be turned over on the banker in a dry state at least twice. The water shall then be added gradually through a rose head, after which the materials shall again be entirely turned over in a wet state at least three times.

### **525 Transport of Concrete**

The concrete shall be discharged from the mixers and transported to the Works by means which shall be approved by the Supervisor's Representative and which shall prevent contamination, (by dust, rain or other causes) segregation or loss of ingredients. The means of transportation shall ensure that the concrete is of the required workability at the point and time of placing.

### **526 Placing Of Concrete**

- (a)** The concrete shall be placed in the positions and sequences indicated on the Drawings, in the Specification or as directed by the Supervisor's Representative. Except where otherwise directed, concrete shall not be placed unless the Supervisor's Representative or his Representative is present and has previously examined and approved the positioning, fixing and condition of reinforcement and any other items to be embedded and the cleanliness, alignment and suitability of the containing surfaces or formwork.
- (b)** The concrete shall be deposited as nearly as possible in its final position without re-handling or segregation and in such a manner as to avoid displacement of the reinforcement, other embedded items or formwork. Wherever possible bottom opening skips shall be used. Where chutes are used to convey the concrete, their slopes shall not be such as to cause segregation and suitable spouts or baffles shall be provided where necessary. Concrete shall not be dropped through a greater height than 1200 mm except with the approval of the Supervisor's Representative who may order the use of bankers and the turning over of the deposited concrete by hand before being placed.
- (c)** Where pneumatic placers are used the velocity of discharge shall be regulated by suitable baffles or hoppers where necessary to prevent segregation or damage and distortion of the reinforcement, embedded items and formwork, caused by impact.
- (d)** All concreting shall be carried out in sections previously ordered or approved by the Supervisor's Representative and shall proceed continuously in each section until completed and no interval shall be allowed to elapse while the work is in hand.
- (e)** The concreting shall be carried out in such a way that the exposed faces of concrete shall be sound and solid, free from honeycombing and excrescences. No plastering of imperfect concrete faces shall be allowed. Any concrete that is defective in any way shall, if so ordered by the Supervisor's Representative, be cut out and replaced to such depth or be made good in such manner as the Supervisor's Representative may direct.

- (f)** Where concrete is required to be placed against undisturbed ground, the entire space between the finished concrete surface and the ground, including any over break, is to be completely filled with concrete of the specified class. The concrete shall be well rammed and compacted to ensure that all cavities are filled and the concrete is everywhere in contact with the ground. Where permitted by the Supervisor's Representative, any extensive patches of over break may first be filled with concrete Class 10/40 as directed to within 100 mm of the payment line.
- (g)** The Contractor shall be required to furnish the Supervisor's Representative with satisfactory evidence that all preparations, precautions and provisions have been made to ensure that the concrete is placed and compacted in accordance with this Specification before the Supervisor's Representative gives his permission for concreting to proceed.
- (h)** For members involving "vertical" placing of the concrete (e.g. walls) each lift shall be deposited in layers extending for the full width between shuttering and of such depth that each layer can be easily and effectively incorporated with the layer below by the means of consolidation being employed. The layers shall be placed horizontally, sloping beds not being permitted unless particularly so specified.
- (i)** For members involving "horizontal" placing of the concrete (e.g. floor and roof slabs) the concrete shall be placed along the line of the starting point in such quantities as shall allow the member to be cast to its full depth along the full width between side shuttering and then gradually brought towards the finishing point along its entire front, parallel to the starting line. The tampers for giving the required surface and compaction shall follow as closely behind as practicable.
- (j)** All members shall be concreted at such a rate as shall eliminate any possibility of fresh batches of concrete being deposited immediately adjacent to batches which have commenced to set, and all members shall be poured in one continuous operation until completed; no interval being allowed to lapse while the work is in hand.
- (k)** Care shall be taken to ensure that the process of placing concrete does not cause any harmful vibration to adjacent work that has hardened insufficiently.
- (l)** Should any unforeseen occurrence result in a stoppage of concreting for such a time as might allow the concrete already in place to begin to set before the next batches can be consolidated in place the Contractor shall immediately insert, at this own cost, a proper end-shutter to form a proper tongue and groove construction joint, as specified normal to the work at that point which shall ensure that the section already cast is formed completely in accordance with this Specification. Any additional reinforcement required as a result of the joint shall be provided by the Contractor at his own expense.
- (m)** Large, exposed (horizontal) concrete surfaces may require protection from the direct rays of the sun or other adverse weather effects. The Contractor shall take all reasonable precautions to protect the concrete surfaces in accordance with these specifications, or as approved by the Supervisor's Representative. Failure to protect such surfaces may result in rejection of the work by the Supervisor's Representative.

- (n) Consolidation of the concrete shall be affected by either hand or mechanical means and all consolidating tools must be approved by the Supervisor's Representative before being used in the Works.
- (o) The concrete shall be worked well up against whatever surface it adjoins and consolidated to such a degree that it reaches its maximum density as a homogenous mass, free from air and water holds, and penetrates to all corners of the mould and shuttering and completely surrounds the reinforcement.
- (p) Care shall be taken to ensure that neither hand tampers or mechanical vibrators come into contact with the formwork, reinforcement, or any embedded fittings and to prevent the operation of consolidation from transmitting any harmful vibrations or shocks to concrete which has not yet hardened sufficiently.
- (q) Compliance with the conditions of this Clause may require working longer hours than usual and the Contractor must allow for this in his program for concreting and in the rates for the work inserted by him in the Bill of Quantities.

#### **527 No Partially Set Material to Be Used**

All concrete must be placed and compacted in its final position within 30 minutes of discharge from the mixer unless otherwise approved. No partially set material shall be used in this work.

#### **528 Compaction of Concrete**

The concrete shall be fully compacted throughout the full extent of the layer and shall be brought up in level layers of such depth that each layer is incorporated readily and properly with the layer below with the use of internal vibrators or by spading, slicing or ramming. It shall be thoroughly worked against formwork and around any reinforcement or embedded items without displacing them.

#### **529 Vibration of Concrete**

- (a) Except where otherwise permitted by the Supervisor's Representative, concrete shall, during placing, be compacted by hand held vibrators of a type to be approved by the Supervisor's Representative. The vibrators shall be suitable for continuous operation. The vibrators shall be disposed in such a manner that the whole of the mass under treatment shall be adequately compacted at a speed commensurate with the supply of concrete from the mixers. Vibration is to continue until the concrete being placed is fully compacted and all air bubbles have been expelled. Care must be taken that segregation of mortar and aggregate by excessive vibration is avoided.
- (b) Vibration is not to be applied directly, or through the reinforcement, to sections or masses of concrete, which have hardened or after the initial set has taken place. Vibration must not be used to make the concrete flow in the formwork to cause segregation.

### **530 Concreting in Adverse Weather**

No concreting shall be allowed to take place in the open during storms or heavy rains. Where strong winds are likely to be experienced, additional precautions to ensure protection from driving rain and dust shall also be taken. The Supervisor's Representative may withhold approval of commencement of concreting until he is satisfied that full and adequate arrangements have been made.

### **531 Concreting At Night or in the Dark**

Where approval has been given to carry out concreting operations at night or in places where daylight is excluded, the Contractor is to provide adequate lighting at all points where mixing, transportation and placing of concrete are in progress.

### **532 Concreting In High Ambient Temperature**

(a) Where the ambient shade temperature exceeds 32 °C, the Contractor shall take special measures in the mixing, placing and curing of concrete. The temperature of the concrete when deposited shall not exceed 30 °C. The Contractor shall carry out all necessary special measures to ensure that the maximum concrete temperature after placing shall not exceed 50 °C or 30 °C above the concrete temperature at the time of placing whichever is the lower.

(b) During placing, suitable means shall be provided to prevent premature stiffening of the concrete placed in contact with hot surfaces.

### **533 Curing and Protection**

(a) Concrete shall be protected during the first stage of hardening from the harmful effects of sunshine, drying winds, cold, rain or running water. The Contractor shall pay particular attention to the need to protect concrete immediately after the finishing operation and prior to its final set and shall submit his proposals to achieve this protection for the Supervisor's Representatives approval. Protection of concrete which has achieved its final set shall consist of one or more of the following:

(i) A layer of sacking, canvas, hessian, straw mats or similar absorbent material or a layer of sand, kept constantly moist by spraying with water as necessary for 7 days or such periods as may be directed by the Supervisor's Representative;

(ii) After thoroughly wetting, a layer of approved waterproof paper or plastic membrane kept in contact with the concrete for 7 days or such period as may be directed by the Supervisor's Representative;

(iii) Except in the cases of surfaces to which concrete has subsequently to be bonded, an approved liquid curing membrane at a rate specified by the manufacturer. On horizontal surfaces, the curing membrane shall be applied immediately after placing the concrete and on vertical surfaces immediately after removing the formwork.

(iv) The use of saline water for curing purposes shall not be permitted.

### **534 Concrete Placed Under Water**

(a) Concrete shall be placed under water only where particularly so specified and approved by the Supervisor's Representative. The quantity of cement in any concrete placed under water shall

be increased by at least 25% above the cement content of the appropriate approved mix. Concrete shall be placed in still water only and every precaution shall be taken to prevent the cement and fine materials from being washed out of the concrete. Concrete shall be placed either with a 'tremie' or a bottom-opening box of a type approved by the Supervisor's Representative.

- (b) Bottom opening boxes shall not be opened until they are resting on the work and the lower ends of 'tremie' pipes shall always be kept below the surface of the wet concrete already deposited.
- (c) No concrete shall be allowed to fall through water at any time. Concrete shall be placed evenly over the whole area closed by the shuttering and must not be raked over, only the minimum of screeding being allowed once the concrete has been placed.

### **535 Construction Joints**

- (a) Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be as indicated on the Drawings or as previously approved by the Supervisor's Representative. The Contractor is to allow for working beyond the ordinary working hours where necessary in order that each section of concrete may be completed without any lapse while the work is in hand. All construction joints are to be formed square to the work. Keyways are to be formed in all horizontal and vertical construction joints except where ordered to be omitted by the Supervisor's Representative.
- (b) Surfaces against which further concrete is to be placed shall be prepared as early as possible after casting. This preparation shall be carried out preferably when the concrete has set but not hardened by jetting with a fine spray of water or brushing with a stiff brush, just sufficient to remove the outer mortar skin and to expose the larger aggregate without its being disturbed. Where this treatment is impracticable and work is resumed on a surface, which has set, the whole surface shall be thoroughly roughened or scabbled with suitable tools so that no smooth skin of concrete that may be left from the previous work is visible. These roughened surfaces shall be thoroughly cleaned by compressed air and water jets or other approved means, brushed, and watered immediately before depositing concrete. If so ordered, the roughened surface shall be covered with cement mortar prior to placing the new concrete.

### **536 Movement Joints**

#### **(a) General**

Movement joints shall be formed as shown on the Drawings to permit relative movement between adjacent parts of a concrete structure, special provision being made where necessary for maintaining the water tightness of the joint. Movement joints shall include contraction joints, expansion joints, sliding joints and other special joints as may be detailed on the Drawings. The Contractor shall ensure that there is no obstruction to free movement, which the joints are intended to provide. The concrete surfaces shall be plane and smooth.

#### **(b) Jointing Materials**

Joints shall be provided with water stops, joint fillers, sealing compound, bond-breaking compound and other jointing materials as specified or detailed on the Drawings. All such materials shall be as approved by the Supervisor's Representative and their installation shall be strictly in accordance with the manufacturer's instructions. If required by the Supervisor's

Representative, the Contractor shall demonstrate that the jointing materials can be applied satisfactorily.

**(c) Contraction Joints**

Contraction joints shall be treated to prevent bond between joint surfaces by the application of two coats of an approved bond-breaking paint to the joint surface first constructed and allowing the paint to dry before placing new concrete against it.

**(d) Expansion Joints**

(i) A separating strip of preformed durable resilient joint filler shall form expansion joints, which shall be continuous through the joint. No broken pieces of joint filler shall be used.

(ii) Where dowel bars are to be incorporated in expansion joints as shown on the Drawings, they shall be round mild steel bars of the diameter and length indicated. The capped end of the dowel bar shall be sawn square and bar cropping, shall not be permitted. The capped section of the bar shall be painted with two coats of an approved bond-breaking paint. The cap shall be of such a diameter as to provide a sliding fit on the bar and of length indicated on the Drawings. The cap shall be partially filled with an approved compressible filler.

**(e) Sealing Compound**

Grooves shown on Drawings at the edges of joints for the placing of sealing compound shall be accurately formed. The sealing compound shall be stored, mixed and applied strictly in accordance with the manufacturer's instructions. Bituminous joint sealants shall be Plastic (for horizontal joints) and Plastijoint (for vertical joints). Polysulphide sealants shall be two part polysulphide sealants complying with BS 4254 "Two - part Polysulphide based Sealants for the Building Industry".

## 537 Preformed Expansion Joints

### Part 1 – General

**(a) Work Included**

The work shall consist of furnishing and installing waterproof expansion joints in accordance with the details shown on the plans and the requirements of the specifications. Preformed sealant shall be silicone pre-coated, pre-compressed, self-expanding, sealant system.

**(b) Submittals**

(i) Standard Submittal Package – Submit typical expansion joint drawing(s) indicating pertinent dimensions, general construction, expansion joint opening dimensions and product information.

(ii) Sample of material is required at time of submittal.

(iii) All products must be certified by independent laboratory test report to be free in composition of any waxes or wax compounds using Fourier Transform Infrared Spectroscopy (FTIR) and Differential Scanning Calorimetry (DSC) testing.

(iv) All products shall be certified in writing to be: a) capable of withstanding 150°F (65°C) for 3 hours while compressed down to the minimum of movement capability dimension of the basis of design product (-25% of nominal material size) without evidence of any bleeding of impregnation medium from the material; and b) that the same material after the heat stability test and after first being cooled to room temperature shall subsequently self-expand to the maximum of movement capability dimension of the basis-of-design product (+30% of nominal material size) within 24 hours at room temperature 68°F (20°C).

**(c) Product Delivery, Storage and Handling**

- (i) Deliver products to site in Manufacturer's original, intact, labeled containers. Handle and protect as necessary to prevent damage or deterioration during shipment.
- (ii) Handling and storage. Store in accordance with manufacturer's installation instructions.

**(d) Quality Assurance**

(i) The General Contractor shall conduct a pre-construction meeting with all parties and trades involved in the treatment of work at and around expansion joints including, but not limited to, concrete, masonry, mechanical, electrical, plumbing and other finish trade subcontractors. All superintendents and foremen with responsibility for oversight and setting of the joint gap must attend this meeting. The General Contractor is responsible to coordinate and schedule all trades and ensure that all subcontractors understand their responsibilities in relation to expansion joints and that their work cannot impede anticipated structural movement at the expansion joints, or compromise the achievement of water tightness or life safety at expansion joints in any way.

(ii) Warranty – Manufacturer's standard warranty shall apply.

(iii) BREEAM Building Performance Requirements: The volatile organic compound (VOC) of the silicone must not exceed 50 grams/liter.

**Part 2 – Product**

**(a) General**

i) Provide preformed, pre-compressed, self-expanding, sealant system with dual silicone pre-coated surface, water tight primary seal for expansion joints isolation joints in floors, between columns and walls as indicated on drawings designated expansion joint locations.

ii) Sealant system shall be comprised of three components: 1) cellular polyurethane foam impregnated with hydrophobic 100% acrylic, water-based emulsion, factory coated on both faces with water-resistant silicone; 2) field-applied epoxy adhesive primer, 3) field-injected silicone sealant bands.

iii) Material shall be capable as a dual seal of movements of +30%, -25% (55% total) of nominal material size. Standard sizes from 1/2" (12mm) to 12" (300mm). Depth of seal as recommended by manufacturer or customized as shown on details.

- iv) Silicone coating to be water/moisture resistant silicone applied to the impregnated foam sealant at a width greater than maximum allowable joint extension and which when cured and compressed shall form a bellows on two faces.
- v) The preformed expansion joint is to be installed into manufacturer's standard field-applied epoxy adhesive.
- vi) The preformed expansion joint is to be installed slightly recessed from the surface such that when the field applied injection band of silicone is installed between the substrates and the foam and silicone bellows, the system shall be essentially flush with the substrate surface.
- vii) Select the sealant system model appropriate to the movement and design requirements at each joint location that meet the project specification or as defined by the Supervisor's Representative.
- viii) Manufacturer's Checklist must be completed by expansion joint subcontractor and returned to manufacturer at time of ordering material.

**(b) Fabrication**

- (i) The preformed expansion joint must be supplied recompressed to less than the joint size, packaged in shrink-wrapped lengths (sticks).
- (ii) Directional changes and terminations into horizontal plane surfaces to be provided by factory-manufactured universal-90-degree single units containing minimum 12-inch long leg and 6-inch long leg or custom leg on each side of the direction change or through field fabrication in strict accordance with installation instructions.

**Part 3 – Execution**

**(a) Installation**

**(b) Preparation of the Work Area**

- (c) The contractor shall provide properly formed and prepared expansion joint openings constructed to the exact dimensions and elevations shown on manufacturer's standard system drawings or as shown on the contract drawings. Deviations from these dimensions shall not be allowed without the written consent of the Supervisor's Representative.
- (d) The contractor shall clean the joint opening of all contaminants immediately prior to installation of expansion joint system. Repair spalled, irregular or unsound joint surfaces using accepted industry practices for repair of the substrates in question. Remove protruding roughness to ensure joint sides are smooth. Ensure that there is sufficient depth to receive the full depth of the size of the preformed expansion joint being installed. Refer to Manufacturers Installation Guide for detailed step-by-step instructions.
- (e) No drilling, or screwing, or fasteners of any type are permitted to anchor the sealant system into the substrate.
- (f) System to be installed by qualified sub-contractors only according to detailed published installation procedures and/or in accordance with job-specific installation instructions of

manufacturer's field technician.

**(g) Clean and Protect**

**(h) Protect the system and its components during construction.** Subsequent damage to the expansion joint system shall be repaired at the general contractor's expense. After work is complete, clean exposed surfaces with suitable cleaner that shall not harm or attack the finish.

## **538 Expansion Joint and Access Cover System**

### **Part 1 – General**

**(a) Work Included**

**(i)** The work shall consist of furnishing and installing waterproof expansion joints for floor to floor application in accordance with the details shown on the plans and the requirements of the specifications therein. The expansion joint and access cover system shall be of typical wing seal design attached with elastomeric concrete header and other systems attached with thixotropic, non-sag epoxy or structural sealants that provide moisture protection at the expansion joint.

**(b) Submittals**

**(ii)** Standard Submittal Package – Submit typical expansion joint and access cover system drawing(s) indicating pertinent dimensions, general construction, expansion joint opening dimensions and product information.

**(iii)** Sample of material is required at time of submittal.

**(iv)** All products must be certified by independent laboratory test report to be free in composition of any waxes or wax compounds using FTIR and DSC testing.

**(v)** The epoxy or structural sealant should be flexible at temperatures as low as 20°F (-29°C) and retain its properties at temperatures as high as 300°F (149°C) in intermittent exposure.

**(c) Product Delivery, Storage and Handling**

**(i)** Deliver products to site in Manufacturer's original, intact, labeled containers. Handle and protect as necessary to prevent damage or deterioration during shipment, Handling and storage. Store in accordance with manufacturer's installation instructions.

**(d) Quality Assurance**

**(i)** Warranty – Manufacturer's standard warranty shall apply for all components and parts thereof for the expansion joint and access cover system.

### **Part 2 – Product**

**(a) General**

**(i)** Provide wing seal designed expansion joint and access cover system with thixotropic epoxy sealant, for all floor to floor joint applications both internally (within floor levels) and external (on exposed roof slab surface), as indicated on drawings designated expansion joint locations.

- (ii) The wing seal expansion joint and access cover is to be installed into manufacturer's standard field-applied epoxy adhesive.
- (iii) Manufacturer's Checklist must be completed by expansion joint and access cover subcontractor and returned to manufacturer at time of ordering material.

### **Part 3 – Execution**

#### **(a) Installation**

##### **(i) Preparation of the Work Area**

- 1) The contractor shall provide properly formed and prepared expansion joint openings constructed to the exact dimensions and elevations shown on manufacturer's standard system drawings or as shown on the contract drawings. Deviations from these dimensions shall not be allowed without the written consent of the Supervisor's Representative.
- 2) The contractor shall clean the joint opening of all contaminants immediately prior to installation of expansion joint and cover access system. Repair spalled, irregular or unsound joint surfaces using accepted industry practices for repair of the substrates in question. Remove protruding roughness to ensure joint sides are smooth. Ensure that there is sufficient depth to receive the full depth of the size of the preformed expansion joint being installed. Refer to Manufacturers Installation Guide for detailed step-by-step instructions.
- 3) No drilling, or screwing, or fasteners of any type are permitted to anchor the sealant system into the substrate.
- 4) System to be installed according to detailed published installation procedures and/or in accordance with job-specific installation instructions of manufacturer's field technician.

##### **(b) Clean and Protect**

- (i) Protect the system and its components during construction. Subsequent damage to the expansion joint system shall be repaired at the general contractor's expense. After work is complete, clean exposed surfaces with suitable cleaner that shall not harm or attack the finish. Preparation of Surfaces to Receive Concrete
- (a) Before concrete for reinforced concrete work is deposited on a foundation of soft ground, a screed of blinding concrete Class 10/40 of 75 mm minimum thickness shall be placed over the ground below the underside level of the reinforced concrete to form a hard even surface on which to construct the latter.
- (b) Immediately before depositing concrete on or against a surface of masonry, brickwork, old concrete or the like, the following preparation shall be done. All loose material shall be removed and the surface washed down; all seepages of water emerging at the surfaces shall be stopped as far as possible, or suitably channeled or piped away from the work. On upward facing horizontal or near horizontal surfaces a layer of 2:1 sand-cement mortar is to be spread over the surface of the section to be concreted if so directed by the Supervisor's Representative.

### **539 Formwork for Non-Exposed Concrete Surfaces**

Unless otherwise stated on the drawings, rough formwork may be used for all surfaces, which are not permanently exposed. Rough formwork may be constructed of plain butt-joined sawn timber but the Contractor shall ensure that all joints between boards shall be grout-tight. The finished

surface shall be within the tolerances specified and full cover to reinforcement steel shall be maintained.

**540 Preparation of Formwork for Concreting**

- (a) Before concrete is placed, the formwork shall be thoroughly cleaned and freed from sawdust, shavings, dust or other debris. Temporary openings shall be provided to assist in removal of the rubbish.
- (b) After cleaning, the formwork shall be coated with an approved release agent, which shall not be allowed to run on to reinforcement, other embedded steelwork or concrete at any construction joint.
- (c) All formwork shall be inspected and approved by the Supervisor’s Representative before concrete is placed in it, though this shall not relieve the Contractor from the requirements as to soundness, finish and tolerances of the concrete specified elsewhere.

**541 Removal of Formwork**

- (a) Formwork shall be removed in such a manner as shall not damage the concrete. No formwork shall be removed until the concrete has gained sufficient strength to support itself. Centres and props may be removed when the member being supported has gained sufficient strength to carry itself and the load to be supported on it with a reasonable factor of safety. The following table is a guide to the minimum periods, which must elapse, between the completion of the concreting operations and the removal of formwork. No formwork shall be removed without the permission of the Supervisor’s Representative and such permission shall not relieve the Contractor of his responsibilities for the safety of the structure.
- (b) Minimum stripping and striking times shall be as follows unless otherwise approved by the Supervisor’s Representative.

	<b>Ordinary Portland Cement Concrete</b>	<b>Rapid Hardening Portland Cement Concrete</b>
	<b><u>NORMAL WEATHER HOURS</u></b>	<b><u>NORMAL WEATHER HOURS</u></b>
Vertical surfaces	10	8
Vertical wall surfaces under 300 mm thick	30	20
Beam sides and columns	30	20
	<b><u>DAYS</u></b>	<b><u>DAYS</u></b>
Slabs (props left under)	4	2
Removal of props to slabs	9	4
Beam soffits (props left under)	7	4

#### 542 Cover to Reinforcement

- (a) The concrete cover to reinforcement shall be in accordance with the relevant British Standard Code of Practice or as shown on the Drawings.
- (b) The Contractor shall provide any necessary cement pads for ensuring the cover is attained and in no case shall timber packing be used.

#### 543 Concrete Surface Finish

- (a) The concrete surface finish on upward facing horizontal or sloping faces shall be, except for blinding concrete or otherwise stated on the drawings, a "fair" surface. A "fair" surface shall be obtained by screeding and trowelling with a wood float.
- (b) Screeding shall be carried out, following compaction of the concrete, by the slicing and tamping action of a screed board running on the top edges of the formwork or screeding guides to give a dense concrete skin true to line and level.
- (c) Wood float trowelling shall be carried out after the concrete has stiffened and the film moisture has disappeared. Working should be kept to a minimum compatible with a good finish and the surface shall be true to the required profile to fine tolerance. Whenever necessary the Contractor shall provide and erect overhead covers to prevent the finished surface from being marred by raindrops or dripping water.
- (d) The surface of blinding concrete shall be that obtained by screeding as described above.
- (e) Where a "fine" surface is indicated upon the drawings this shall be obtained in a similar manner to "fair" surface save that a steel float shall be used in lieu of the wood float.

#### 544 Monolithic Surface Hardening Compound Finish

- (a) The concrete surface finish for ground, first and second floor areas; staircase steps and landing and ramp surfaces shall be finished with a hardwearing monolithic surface hardening compound using the dry shake method of application to ensure wearing surface bonds monolithically, to the base concrete.
- (b) All base slab concrete areas so designated shall be applied with monolithic hard wearing, abrasion resistant floor hardener tested to BS 6431-Part 20 (Wet Abrasive Method).
- (c) Typical properties for this monolithic hard wearing compound finish shall include testing to ASTM.D 4060 – Taber Abrader and BS 6431 – Part 20 (Wet Abrasive Method), alongside concrete mortar control panels. Other specific properties include:

Mohs Hardness : >6  
Specific Gravity : 3.1  
Corrosive Elements: None

## Sieve Analysis

# 8 (2.5mm) :	>98% passing
#30 (0.5mm) :	< 5% passing

- (d) The base concrete should have a minimum cement content of 300kg/m<sup>3</sup>. The concrete mix should be designed to minimize segregation and bleeding. Free water: cement ratios of less than 0.55 are required. The concrete should have a slump of between 75 and 100mm. The base concrete should be laid and compacted in accordance with good concrete practice. Accurate finished profile and minimum laitance build up should be ensured. Particular attention should be paid to bay edges and corners to ensure full compaction. Vacuum dewatering is not recommended.
- (e) Upon application of the monolithic hardening compound very strict control is to be maintained to ensure that the correct quantity, dosage and curing technique is used at all times.

## 545 Precast Concrete

- (a) Concrete members specified to be fabricated as precast concrete units shall be fabricated with concrete of the specified class placed into a grout-tight mould. If so required the mould shall be laid on a vibrating table and vibration applied while the concrete is placed.
- (b) Permanently exposed surfaces shall have a finish obtained by casting the unit in properly designed moulds of closely jointed wrought boards or steel or other suitable material. The surface shall be improved by carefully removing all fins and other projections, thoroughly washing down and filling the most noticeable surface blemishes with a cement and fine aggregate paste matching the colour of the concrete.
- (c) Surfaces which shall subsequently receive grout or concrete to complete a structural connection or other composite structural component of which the precast unit forms a part, shall be prepared as early as possible after casting. This preparation shall be carried out preferably when the concrete has set but not hardened by jetting with a fine spray of water or brushing with a stiff brush, just sufficient to remove the outer mortar skin and to expose the larger aggregate without its being disturbed. Where this treatment is impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking is to be avoided.
- (d) With the approval of the Supervisor's Representative, the Contractor may be permitted to precast members, which were specified to be constructed in situ. In such cases, the Contractor shall carry out the work as described above but payment shall be made in the manner appropriate to the method of construction originally specified. Generally, members, which are structurally dependent on a rigid fixing with the adjoining structures, shall not be permitted to be constructed by pre casting.
- (e) Precast units shall be jointed with cement mortar as specified in Clause 448 hereof or other cement-sand proportions as shown on the Drawings, or as may be directed by the Supervisor's Representative, but mixed as dry as possible so that it is only "earth moist". The mortar shall be packed in layers between the units with steel tools until the whole of the joint is solidly filled

and the exposed surfaces of the joint shall be raked out to a depth of 5 mm. and flush pointed with similar mortar but of pointing consistency.

#### 546 Supply of Precast Concrete Units

- (a) The Contractor shall be permitted to obtain precast concrete units from outside suppliers provided that they comply with the Specification and that the Contractor obtains the Supervisor's Representative's approval for each supplier.

#### 547 Handling and Stacking Of Precast Units

- (a) The Contractor is to give the Supervisor's Representative full details of his proposed methods of handling and stacking precast concrete beams and units. The Supervisor's Representative shall examine these details and shall approve either the methods or order modifications designed to ensure that no excessive stresses are set up in the beams or units. The finally approved methods are to be adhered to at all times and the Contractor shall be deemed to have included in his rates for all measures required to handle and stack beams and units safely and without undue stressing.

#### 548 Tolerances

- (a) Concrete work shall be executed to the tolerances specified below:

(i) Maximum departure from horizontal position:	25mm
(ii) Maximum departure from vertical position:	25mm
(iii) Maximum surface tolerance – gradual:	12mm in 2m
(iv) Maximum surface tolerance - abrupt:	6mm
(v) Maximum departure in dimension:	-3mm +6mm

- (b) Reinforcement bar spacing shall not deviate by more than 25mm from the specified spacing.

- (c) Cover to reinforcement shall be not less than the amount specified, and not more than 10mm more than the amount specified.

#### 549 Cement Grout

Cement grout for general purposes shall consist of Portland cement and water mixed in the proportion of one part by volume of cement and one and a half parts by volume of water. The grout shall be used within one hour of mixing.

### **550 Cement Mortars**

Cement mortar shall, unless otherwise specified, consist of three parts of sand to one part of Ordinary Portland cement mixed and thoroughly incorporated together. Cement lime mortar shall, unless otherwise specified, consist of three parts of sand to one part of a mixture comprising one part of cement to one part of hydrated lime. In each mortar just enough water shall be added to give a workability appropriate to its use. The above proportions are by volume. Mortar shall be used whilst freshly mixed and no softening or re-tempering shall be allowed.

### **551 Dry Mix Concrete**

Should the Contractor wish to use dry mix concrete for any sections of the Work, he shall submit his proposals to the Supervisor's Representative for his approval. The Contractor must satisfy the Supervisor's Representative that the method he proposes to use shall produce a finished concrete of the specified strength and density.

## **600 BLOCKWORK & MASONRY**

### **601 Precast Concrete Blocks**

- (a) Precast concrete blocks shall be manufactured to BS 6073.
- (b) Blocks shall be either hollow or solid and the thickness of the blocks shall be as indicated in the Drawings. The blocks shall have minimum compressive strength of 3.5. N/mm<sup>2</sup>.
- (c) All blocks shall have a dense, even surface and a density of not less than 1700 kg/m<sup>3</sup>.
- (d) The Contractor shall submit samples of blocks for every batch brought to the Site to the Supervisor's Representative for approval. The Contractor shall arrange strength tests required by the Supervisor's Representative to be executed by a testing authority approved by the Supervisor's Representative.

### **602 Mortar**

- (a) Mortar for both masonry and blockwork shall be cement mortar consisting of one part of ordinary Portland cement complying to BS 12 to four parts of sand by volume, mixed with just sufficient water to make the mixture workable. No lime shall be added to the mortar.
- (b) Natural sand shall be used in cement mortar unless otherwise approved. The sand shall be obtained from sources approved by the Project.
- (c) Plasticisers, air entraining agents or other additives may be used in the mortar subject to the approval of the Supervisor's Representative.

### **603 Storage of Materials**

- (a) Blocks shall be loaded and unloaded by hand and not tipped, and shall not be used until 4 weeks after casting unless otherwise approved by the Supervisor's Representative.
- (b) All blocks shall be handled carefully from manufacture to laying and properly stacked in position convenient for the work. They shall be kept free from standing water and protected from rain, mud and contamination by other materials.
- (c) Sand shall be stored separately on clean hard dry standing and protected from contamination.
- (d) Cement shall be stored off the ground under cover and away from damp, and in such a manner as to enable it to be used in rotation in order of delivery and in accordance with the requirements of Clause "Concrete Work ", sub-clause "Supply".

### **604 Mortar Mixing**

All materials shall be accurately gauged by gauge boxes and mechanically mixed to a uniform consistency. Mortars shall be used within 1 hour of the addition of cement after which they shall be

discarded. Re-tempering of mortar shall not be permitted. Gauge boxes and mixers shall be kept clean.

### **605 Blockwork**

- (a) All blockwork unless otherwise specified shall comply with the recommendations of BS 8000; Part 3; 1989 (Code of Practice for masonry). All surfaces on which blockwork is to be built shall be clean from any foreign matter influencing the bond between the surface and blockwork. The use of chipped or defaced blocks shall not be permitted in any face-work. All work shall be built uniform, true and level, with all perpends vertical and in line, all cross joints shall be solid, filled with mortar in every course as the work proceeds.
- (b) All blocks shall be clean before placing and shall be moistened with water for at least 3 hours before using by a method which shall ensure that each block is thoroughly and uniformly wetted.
- (c) No work shall rise more than 1000 mm above the adjoining works and such risings are to be properly raked back. No blockwork shall be carried up higher than 1500 mm in one day. Joints in walling to be plastered or rendered shall be raked out 10 mm deep to form a key. All cross (vertical) joints shall be filled by well buttering the ends of the block with mortar and then sliding it against its neighbour.
- (d) Blockwork of single block thickness shall be laid in stretcher bond, and blockwork of double block thickness in alternate courses of headers and stretchers. No broken blocks shall be accepted except where necessary for bonding. All blocks shall be cut by means of a mechanical disc cutter.
- (e) Alternate courses of load bearing block walling at intersection shall be carried through the full thickness the adjoining wall.
- (f) Course heights shall not vary throughout the building and each course shall be level and set out so that bed joints occur in line with sills, lintels and other features.
- (g) Damp-proof Courses in Walls Damp-proof courses in walls shall be bituminous damp-proof course to BS 743 weighing not less than 3.8 kg/m<sup>2</sup> overlapped 75 mm at all jointings and bedded in mortar whilst the mortar is still wet.

### **606 Protection**

- (a) When constructing masonry or blockwork in unfavourable weather and in protecting the finished work, the Contractor shall observe the same instructions as are specified for concrete work.
- (b) All blockwork, including pointing, shall be cured by keeping the wall wet or moist with a method as approved by the Supervisor's Representative.

### **607 Non Load-Bearing Walls**

All walls which are not load-bearing shall not be brought up to final finished level until the construction of any reinforced concrete roof slabs has been completed and the roof finishes have been installed.

### **608 Ties to Concrete Structures**

Ties at junctions with reinforced concrete work shall be of the 'butterfly' type to BS 1243 and shall be cast into the concrete at such centres to be in line with the centre of the depth and width of mortar joints.

### **609 Movement Joints**

Movement joints shall comply with the requirements for movement joints in concrete work as the described in these specifications.

### **610 Plastering and Rendering**

- (a)** Before plastering or rendering is carried out all joints shall be raked out to depth of 10 mm, the surface of the wall cleaned and all foreign matter removed.
- (b)** External rendering shall be applied in two coats of cement/sand mortar of mix type II, Table 1 BS 5262 with a wood float finish to a minimum overall thickness of 20 mm.
- (c)** Plastering to internal walls and ceiling surfaces shall be applied in two coats to a minimum overall thickness of 20 mm as follows:
  - Undercoat: cement/sand - Type II, Table 2 BS 5492
  - Finish: anhydrous gypsum plaster to BS 1191: Part 2, Class C with smooth finish.
- (d)** Undercoats shall be thoroughly applied, straightened and scratched and brought to a true surface. Finished surfaces shall be left true, even and free from blemishes and all corners shall be finished true, vertical and even and carried out at the same time as adjacent wall surfaces.
- (e)** Re-tempering or reconstitution of mixes shall not be permitted after the initial set has taken place.

## 700 CARPENTRY AND JOINERY

### 701 TIMBER

#### (a) General

- (i) Timber for roofing, framing or finish work shall be unused and of the best quality, well-seasoned (air or kiln), and at least 85% heartwood, perfectly dry and free from splits, radial cracks, long loose or dead knots or other imperfections and shall be of a clean surface.
- (ii) Timber shall be stacked in such manner as to prevent warping and to have all elements readily available for inspection. All timber shall be subject to inspection on Site piece by piece by the Supervisor's Representative who shall reject such timber which is not to the specified quality. Any portion of the timber that warps or develops shakes or other defects shall be replaced.
- (iii) Timber shall in principal be sawn to scantlings of the required dimensions at least one month before use.
- (iv) Moisture content of all timbers used in the works shall not be more than twenty percent (20%) for Carpenters work and fifteen percent (15%) for joiners work.
- (v) Sizes stated shall be nominal unless otherwise described. Make allowances of 3/16" for each dressed face.

#### (b) Pitch Pine

Pitch pine shall be best imported quality of mature growth, free from gross defects, well-seasoned and having a minimum density of 673 Kgs/m<sup>3</sup> and an average equilibrium moisture content of 10 per cent in accordance with BS 1186 Part 1.

#### (c) Hardwood

Purple heart, mahogany and green heart shall be the best quality available and must be free from gross defects. The Contractor must exercise care in selecting this timber and shall notify the Supervisor's Representative and obtain his written approval of the type and sources of the hardwoods he proposes to use.

#### (a) Plywood

Plywood shall conform to BS 6566 and marine ply or equal and approved to conform to BS 1088 Grade "B" for paint finish, "C" where covered with laminated plastic sheeting veneer bonded with "weather and boil proof: synthetic resin adhesive unless otherwise specified.

#### (e) Particle Board

Particleboard shall comply with appropriate British Standard and be termite proof.

#### (f) Treated Timber

Treat against termite attack by pressure/vacuum impregnation with an approved preservative in order to obtain a minimum net dry salt retention of 0.23 kg per cubic metre of timber in accordance with the manufacturer's instructions and to the satisfaction of the Supervisor's Representative.

Where cross-cutting or boring of treated timber is unavoidable, liberally swab or dip treat all exposed faces with an approved preservative such as "Walmanol" containing a dye for checking purposes.

**(g) Exposed Faces**

- (i) Timber which is to be exposed in the finished work shall be “dressed” unless otherwise described.
- (ii) All joinery that is to be painted shall be knotted and primed with the primer before being fixed. This applies particularly to the covered up or hidden part of joinery work.
- (iii) Prices for Carpenter’s work and Joiners’ work shall include for all labours, cuttings, splays, notching, halving to other timbers, mortising, tenoning and wedging, hardwood pins, gluing and marking joints with lead plugging to concrete or block work where so described and for all short lengths, unless specifically measured separately.
- (iv) Prices for timbers described as “screwed” shall include for screws but for timbers described as “bolted” the bolts and holts are measured separately. Prices for timbers described as “plugged to block work” shall include for all cutting or drilling and plugging of block work and for timbers described as “plugged to concrete” for cutting or drilling and plugging of concrete or for casting in fixing blocks.
- (v) The use of an approved system, of fixing to block work or concrete with special nails, screws or bolts inserted with spring, cartridge power tools shall be permitted in lieu of plugging and if approved by the Supervisor’s Representative.

**(h) Natural Finish**

When natural finish of finish for staining, clear polish varnishing is specified, the timber in adjacent pieces shall be matched, uniform, or symmetrical in colour and grain.

**(i) Shrinkage**

Arrange, joint and fix all joinery work in such manner that shrinkage in any part and in any direction shall not impair the strength and appearance of the finished work and shall not cause damage to adjoining materials of the finished work and shall not cause damage to adjoining materials or structure.

**(j) Joints**

Construct joinery exactly as shown on the Supervisor’s Representative’s details. Where joints are not specifically indicated they shall be the recognized forms of joints for each position. All glued joints shall be cross-tongued.

**(k) Tolerance**

Provide reasonable tolerance at all connections between joinery work and the building carcass so that any irregularities, settlement or other movements shall be adequately compensated for.

**(l) Fabrication**

Put in hand all joinery work immediately on commencement of the works and store in a dry place and put together without wedging up for the inspection and approval of the Supervisor’s Representative.

**(m) Joinery Work**

- (i) The Joiner is to take all measurements for the joinery work from the Supervisor’s Representative’s drawings. The Contractor to be responsible for checking the dimensions and achieving accurate opening sizes. All joinery, unless specifically stated otherwise shall be “fixed-in”.

- (ii) Joinery works shall not be fixed in position until after all floors, walls and ceiling surfaces have been formed and constructed, unless otherwise specified.
- (iii) Where joinery works are shown “fixed-in” or inserted in the position, they are to occupy after the surrounding or enclosing carcass has been constructed. It shall be the responsibility of the Contractors to ensure that the necessary fixings are incorporated in the carcass. Alternatively, the Contractor shall construct such ground works as are required to provide a suitable base and fixing for the joinery work. Spaces behind and enclosed by such ground works shall be filled in solid with plaster.
- (iv) Where joinery works are shown built-in or erected in position before the surrounding or enclosing works of the main carcass have been carried out, it shall be the responsibility of the joinery to ensure that works are set plumb and true, shall not be damaged or be displaced by subsequent operations.
- (v) Where necessary, the joinery shall be temporarily braced and encased. The joiner shall also provide and secure suitable anchors or other fixings so that those may be “built-in” to the carcass while it is being constructed so that they shall permit settlement in the building carcass without stressing or otherwise loading the joinery work.
- (vi) The contractor shall perform all necessary tenoning, grooving, tonguing, housing, rebating and all other works necessary for the correct jointing. He shall provide all metal plates, screws, nails and other fixings that may be order by the Supervisor’s Representative, which may be necessary for the proper execution of the works, unless otherwise stated.

**(n) Joints**

- (i) All joints are to be the type specified or as most appropriate in the circumstances. The joints shall be designed and secured so that the stresses to which they are subjected may be either resisted or compensated. Loose joints are to be made where provision must be made for shrinkage or other movements acting other than in the direction of the stresses or fixing or loading. Glued joints are to be used where provision need not be made for shrinkage or other movements in the connections, and where sealed joints are required. All glued joints shall be cross-tongued or otherwise reinforced.
- (ii) All joinery that is to be painted shall be twice knotted before painted.

**(o) Holes**

All nails, sprigs, etc, are to be punched, holes to be filled for work to be painted, holes left unfilled for work to be waxed or oiled.

**(p) Scribing**

All architraves, plates, beds, etc, and other joinery works shall be accurately scribed to fit the contours or any irregular surface against which may be required to form a close butt connection.

**(q) Fixing of Timbers**

All timber framing shall be fixed to block work or concrete with Toggle Bolts.

**(r) Plugs and Toggle bolts**

- (i) “Rawl plugs” or equal are to be used for all plugging.
- (ii) The price for plugs shall be included for drilling holes in concrete and block work.
- (iii) Toggle bolts shall be galvanized with plastic washers and of approved manufacture. Bolts shall be of correct length to fall correctly into the various cavities.

**(s) Adhesives**

All adhesives shall be proof against mycological and insect attack.

**702 Nails and Screws**

All nails and screws shall comply with BS 1202:1974 and BS 1210: 1963. In all surfaces to be painted nail heads shall be punched and screws screwed below the surface and filled with leadless filler.

**703 Finished Sizes**

Sawn timber shall be the full size required. The sizes given in the Bills or otherwise for wrought carpentry are the nominal sizes; 3 mm shall be allowed off the nominal dimensions for each wrought face.

**704 Workmanship**

- (a)** The quality of workmanship shall not be less than that set out in BS 1186 Part 2.
- (b)** Carpenter's and joiner's work shall be framed and put together in a workmanlike manner with a sufficient number of nails of adequate size to maintain the work. All necessary notching, halving, nogging, etc. shall be carefully executed and bearing surfaces shall be in proper contact. All forms of joints shall be such to transmit safely the loads and stresses to which the timber shall be subjected and shall be to the satisfaction of the Supervisor's Representative.
- (c)** Glue shall comply with BS EN 301 and shall be classification WBP of the resorcinol-formaldehyde (CRF) or phenol-formaldehyde (PF) type, and shall be used strictly in accordance with the manufacturer's instructions.
- (d)** Beams, purlins and structural timbers are to be in as long lengths as possible. Where joints are unavoidable in beams or purlins they shall be properly scarfed and bolted and where practicable to be placed at points of support. Scarfs, unless otherwise directed, are to be of a length equal to twice the depth of the element, provided that the adjacent timbers are continuous. Wall plates shall be halved at angles and joints in length if otherwise unobtainable in one piece.
- (e)** Joiner's work shall be framed up as soon as possible and kept carefully stacked clear of the ground and protected until required. It shall not be glued and wedged or doweled until immediately before being required for use. Door frames, etc. shall have full mortise and tenon joints with hardwood dowels or wedges, glued and cleaned up. The quality of workmanship shall comply with BS 1186 Part 2 and shall be generally in accordance with that of the samples of joinery to be indicated by the Supervisor's Representative on the Site.

**705 Check Before Priming**

The priming specified in Clause "Painting and other Coatings" shall not be carried out until the prepared timber has been Inspected and approved by the Supervisor's Representative, but shall be done before the final assembly and fixing.

## **706 Defects**

If during the defects liability period any shrinkage, warping or winding should occur or any other defect appear in any of the joinery which is attributable to defective materials or workmanship, such defective work is to be taken down and replaced to the Supervisor's Representative's approval. Should any other work be affected by the removal and replacement thereof it also shall be made good at the Contractor's expense.

## 800 GYPSUM BOARD

### 801 General

#### (a) Section Requirements

- (i) Submittals: Product Data.
- (ii) Where ASTM or ANSI or AA Standards are referred to in this section, these may be replaced by E.U. member state and/or ACP State standards provided they are equivalent or superior to the U.S. Standard.

### 802 Products

#### (a) Performance Requirements

- (i) Fire-Resistance-Rated Assemblies: Provide materials and construction identical to those tested in assemblies per ASTM E 119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.
- (ii) STC-Rated Assemblies: Provide materials and construction identical to those tested in assemblies per ASTM E 90 and classified per ASTM E 413 by a qualified independent testing and inspecting agency.

#### (b) Panel Products

- (i) Provide in maximum lengths available to minimize end-to-end butt joints.
- (ii) Interior Gypsum Board: ASTM C 1396/C 1396M, in thickness indicated, with manufacturer's standard edges.
- (iii) Exterior Gypsum Soffit Board: ASTM C 1396/C 1396M, in thickness indicated, with manufacturer's standard edges.
- (iv) Water-Resistant Gypsum Backing Board: ASTM C 1396/C 1396M, in thickness indicated.
- (v) Glass-Mat, Water-Resistant Gypsum Backing Board: ASTM C 1178/C 1178M, of thickness indicated.
- (vi) Cementitious Backer Units: ANSI A118.9, ASTM C 1288, or ASTM C 1325.

#### (c) Accessories

- (i) Trim Accessories: ASTM C 1047, formed from galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized-steel sheet. For exterior trim, use accessories formed from hot-dip galvanized-steel sheet, plastic, or rolled zinc.
  - 1) Provide cornerbead at outside corners unless otherwise indicated.
  - 2) Provide LC-bead (J-bead) at exposed panel edges.
  - 3) Provide control joints where indicated.
- (ii) Aluminum Accessories: Extruded-aluminum accessories indicated with Class II, clear anodic finish; AA-C12C22A31.
- (iii) Joint-Treatment Materials: ASTM C 475/C 475M.
  - 1) Joint Tape: Paper unless otherwise recommended by panel manufacturer.
  - 2) Joint Compounds: Setting-type taping compound and drying-type, ready-mixed, compounds for topping.

- 3) Skim Coat: For final coat of Level 5 finish, use high-build interior coating product designed for application by airless sprayer and to be used instead of skim coat to produce Level 5 finish.
- 4) Cementitious Backer Unit Joint-Treatment Materials: Products recommended by cementitious backer unit manufacturer.
- (iv) Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.
  - 1) Adhesive shall have a VOC content of 50 g/L or less.
  - 2) Adhesive shall comply with Green Seal's GS-36 and with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- (v) Acoustical Sealant for Exposed and Concealed Joints: Nonsag, paintable, nonstaining latex sealant complying with ASTM C 834.
  - 1) Sealants shall have a VOC content of 250 g/L or less.
  - 2) Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
  - 3) Sound-Attenuation Blankets: ASTM C 665, Type I (unfaced).
  - 4) Textured Finish: Polystyrene aggregate ceiling finish where indicated.
  - 5) Textured Finish: Aggregate finish where indicated.
  - 6) Textured Finish: Acoustical finish where indicated.

## 803 Execution

### (a) Installation

- (i) Install gypsum board to comply with ASTM C 840.
  - 1) Isolate gypsum board assemblies from abutting structural and masonry work. Provide edge trim and acoustical sealant.
  - 2) Single-Layer Fastening Methods: Fasten gypsum panels to supports with screws.
  - 3) Multilayer Fastening Methods: Fasten base layers with screws, and face layers to base layers with adhesive and supplementary fasteners.
- (ii) Install cementitious backer units to comply with ANSI A108.11.
- (iii) Fire-Resistance-Rated Assemblies: Comply with requirements of listed assemblies.
- (iv) Finishing Gypsum Board: ASTM C 840.
  - 1) At concealed areas, unless a higher level of finish is required for fire-resistance-rated assemblies, provide Level 1 finish: Embed tape at joints.
  - 2) At substrates for tile, provide Level 2 finish: Embed tape and apply separate first coat of joint compound to tape, fasteners, and trim flanges.
  - 3) Unless otherwise indicated, provide Level 4 finish: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges.

- 4) Where indicated, provide Level 5 finish: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges. Apply skim coat to entire surface.
- (v) Glass-Mat, Water-Resistant Backing Panels: Finish according to manufacturer's written instructions.
- (vi) Cementitious Backer Units: Finish according to manufacturer's written instructions.
- (vii) Texture Finish Application: Mix and apply finish using powered spray equipment, to produce a uniform texture free of starved spots or other evidence of thin application or of application patterns.

## **900 DOORS AND WINDOWS**

### **901 General**

Unless specified otherwise, all doors and windows shall be in accordance with the following clauses.

- (a) All doors and windows both interior and exterior shall be completely weather and waterproof.
- (b) All window and door openings in blockwork walls shall be spanned by suitable reinforced concrete lintels.
- (c) The Contractor shall assemble one finished prototype of each component, fitted with ironmongery for approval of the Supervisor's Representative before any repetitive production, or fixing of prefabricated frames commences. The Contractor shall also submit to the Supervisor's Representative for approval samples of locks, handles, latches and similar ironmongery.

### **902 Doors**

Material and specifications including fire rating should be supplied as provided in the Door Schedules. Additional specifications are provided as follows;

- (a) All external glass doors to be hurricane resistant/rated
- (b) All doors to be fire rated as specified
- (c) Thresholds to be provided as specified
- (d) All hinges should be stainless steel

### **903 Fixed Windows**

- (a) Material for windows as per Window Schedule is specified as follows;
  - (i) Hurricane resistant/rated glass
  - (ii) Aluminium frames
  - (iii) 9mm thick tinted and laminated; outside glazed with DOW 995 silicone
  - (iv) 2" nominal frames; flange leg detail
  - (v) White electrostatic applied baked on powder finish
  - (vi) Stainless steel friction hinges, cam locks

## 904 Ironmongery

- (a) All moving parts of joinery components are to be fixed with equal tolerance spaces all round. Hinges, etc., are to be fitted in perfect alignment, locks and fastenings are to engage properly in their striking plates or sockets without clatter. Screws for fixing ironmongery shall be of the same metal as the hardware. On completion all joinery shall be adjusted and ironmongery oiled and the whole shall be in perfect working order. Removable ironmongery, except hinges, shall be removed for painting and refitted prior to the final coat of paint or on completion as ordered by the Supervisor's Representative.
- (b) Locks are to be fixed where shown in the Drawings or as directed by the Supervisor's Representative. All external door locks shall have three keys, and all internal locks two keys. All locks and moving parts are to be oiled and left in perfect working order and all keys shall be properly marked and labelled and delivered up to the Supervisor's Representative as required. All timber doors shall be fitted with an approved pattern of combined mortise lock and latch complete with aluminium lever handles.
- (c) All locks, handles, latches and other similar ironmongery shall be subject to the approval of the Supervisor's Representative.
- (d) In all cases, the Contractor is responsible for allowing adequate joinery members for fixing ironmongery as scheduled.
- (e) All ironmongery shall be of the best quality and the shape; size and manufacture shall be of a kind particularly made for the work for which it is to be applied. The Contractor must submit samples of all ironmongery for approval of the Consultant.
- (f) The Contractor is to allow for fixing all ironmongery not measured in the Bill of Quantities and/or Cost Summary.
- (g) All ironmongery is to be fixed with screws, which are to be of the same metal and finish as fittings. All screws damaged when driven by the turn-screw or by any other cause shall be removed and replaced by undamaged ones.
- (h) All fixing holes in the fittings shall receive screws of the appropriate type, size and material.
- (i) Ironmongery shall be marked or removed when painting, varnishing, etc. or when rough trades are being carried out in the vicinity and subsequently re-fixed.

## 905 Roll Up Service Doors

- a) **Wind Load:** Door Assembly should be designed to withstand wind/suction load of 958 Pa without damage to door or assembly components.
- b) **Operation:** Design Door Assembly, including operator, to operate for not less than 20,000 cycles.

- c) The door, track, motor and accessories must all be from one manufacturer.
- d) Manufacturer's data sheets must be provided including: (1) Preparation instructions and recommendations, (2) Storage and handling requirements and recommendation, (3) Details of construction and fabrication, (4) Installation instructions.
- e) Shop drawings must be provided including: Detailed plans, elevations, details of framing members, anchoring methods, required clearances, hardware and accessories.
- f) Manufacturer's certificates must be provided to certify that the product meets or exceeds the specified requirements.
- g) Operation and maintenance data must be provided and shall include: lubrication requirements and frequency as well as periodic adjustments required.
- h) **Warranty:** Manufacturer's limited door and operator system, to be free from defects in materials and workmanship for 3 years or 20,000 cycles; whichever occurs first.
- i) **Curtain:** Interlocking roll-formed galvanized steel slats, flat crown profile type CAW, 26 gauge. End of each slat shall be locked from lateral movement by a staking lock system. (Galvanised alternate malleable end locks)
- j) **Finish:** Curtain slats shall be galvanised in accordance with ASTM A and receive rust-inhibitive, road coating process. Non-galvanised exposed ferrous surfaces shall receive one coat of rust inhibitive primer.
- k) **Weather seals:** Vinyl bottom seal
- l) **Bottom bar:** Extruded aluminium
- m) **Guides:** Roll-formed galvanised steel shapes attached to continuous galvanised steel wall angle.
- n) **Brackets:** Galvanised steel to support counterbalance and curtain.
- o) **Counterbalance:** Helical torsion spring type housed in a steel tube or pipe barrel and supporting the curtain with deflection limited to 2.5mm per metre span. Spring tension shall be adjustable.
- p) Door shall be chain hoist with the option of electric motor operation.
- q) **Electric Motor Operation:**
  - Door shall move in either direction at a rate of 0.2 – 0.3 m/s.
  - Operator controls shall include the following:

- i. Push-button operated control station with open, close and stop buttons
- ii. Key operation with open, close and stop controls
- iii. Controls for interior location
- iv. Controls for exterior location
- v. Surface mounted controls

r) **Locking:**

- i. Chain keeper locks for chain hoist operation
- ii. Interior slide bolt lock for electric operation
- iii. Cylinder lock for electric operation

## **1000 PAINTING AND OTHER COATINGS**

### **1001 General**

Unless otherwise specified, the workmanship and quality of materials for painting shall comply with BS 6150; 1991; "Code of Practice for Painting of Buildings" and BS 5493; 1977; "Code of Practice for Protection of Iron and Steel Structures against Corrosion".

### **1002 Paints**

- (a) The Contractor shall submit certificates from an approved manufacturer giving the guarantee that the paint offered shall conform to the relevant standards (e.g. BS 5493), the Specifications, suitable for the locale climate and compatible with the surface of application. The manufacturer and types of paint shall not be changed unless prior approval is obtained from the Supervisor's Representative. The Contractor shall use the advisory services of the paint manufacturer. Should any such advice conflict with these Specifications, the Contractor shall obtain written instructions from the Supervisor's Representative before proceeding with the work. The paint manufacturer shall be allowed to inspect and check the preparation and painting during all stages of the Contract and to report to the Supervisor's Representative.
- (b) All coats of paint for a coating system shall be compatible with each other and shall be of the same manufacturer unless otherwise approved by the Supervisor's Representative.
- (c) Each consignment of paint shall be delivered in containers sealed by the manufacturer, accompanied by a certificate guaranteeing that the paint conforms to relevant Standards and Specifications. The date and results of tests and analysis performed during manufacturing shall be attached. The capacity of the containers shall not exceed 0.03 m<sup>3</sup>. The name of the manufacturer, type of paint, batch number, special storing conditions, etc. shall be clearly shown on each container. Containers shall remain unopened, apart from necessary sampling, until required for use and used in order of delivery.
- (d) Paint not used within the period specified on the containers or within 12 months of the date of manufacture, whichever is the less, shall be replaced.
- (e) Paint shall retain its properties during storage at Site and any paint which fails in this respect shall not be allowed to be used in the Works.
- (f) Livered, gelatinized, or otherwise deteriorated paints shall not be used.

### **1003 Preparation and Maintenance of Surfaces**

- (a)** Preparation of the initial surface of the material to be coated shall be as described in the relevant material related clauses.
- (b)** Immediately before any coat is applied the whole of the surface to be painted shall be thoroughly cleaned of all dust, loose paint or grease by washing down with fresh clean water and as necessary brushing with a bristle brush.
- (c)** The Contractor shall examine all surfaces before applying any coats. No paint shall be applied to wet, acid, alkaline, damp, rough or greasy surfaces. No coating shall be applied to any surface before the Supervisor's Representative has inspected the cleaned and prepared surface.

### **1004 Painting Workmanship and Conditions**

- (a)** All works shall be carried out by skilled labour experienced in the use of materials specified.
- (b)** All paints shall be thoroughly mixed until homogenous and, if necessary, be strained free from skins, lumps or sediment. Thinners and driers may only be added to enable the paint to comply with the specified application or drying requirements. Thinners and driers shall be compatible with the paint and shall not be used without approval of the Supervisor's Representative and paint manufacturer.
- (c)** To prevent loss of adhesion and solvent entrapment the paint manufacturer's instructions shall be followed particularly in respect of minimum and maximum periods between coats and temperature range for application.
- (d)** The methods of application of paint shall be subject to the approval of the Supervisor's Representative and be in accordance with manufacturer's recommendations. Where spoiling of adjacent surfaces are likely to occur, and in case of paints containing lead, no spraying shall be permitted.
- (e)** If brush or roller painted surfaces is not smooth, they shall be rubbed down and dusted off to obtain a smooth and mat surface to which the next coat shall firmly adhere.
- (f)** Rags, brushes and tools used in the preparation and painting of surfaces shall be cleaned with white spirit or a thinner as approved by the Supervisor's Representative.
- (g)** Paint film shall not have excessive or uneven thickness and the finished surface shall be free of defects. The final coat shall be smooth and free from defects, including those showing through from preceding coats.
- (h)** At the end of every working period paints with a limited "pot life" shall be discarded and not be mixed with fresh paint.

- (i) Painting work shall not be exposed to direct sunlight. Prepared, primed or undercoated work shall not be left exposed for an undue period before completion of the painting process.
- (j) Fitting such as ironmongery, switches, electrical fittings, etc. not required to be painted shall be removed before the painting process is commenced and refitted after completion of painting.
- (k) After each coat is applied the Contractor shall test the paintwork. The contractor shall provide the Supervisor's Representative with one day's notice of the test. The maximum dry film thickness shall not exceed the minimum figure specified for the particular class of protection by more than 20 %. The Contractor shall be responsible for the provision of all equipment for testing the protective coatings and shall remedy all defects to the Supervisor's Representative's satisfaction.
- (l) The Contractor shall take measures to prevent that any paint coat in any way at any stage is damaged. If not withstanding such measures a paint coat is damaged, the Contractor shall immediately repair such damages to the satisfaction of the Supervisor's Representative.

#### **1005 Protection and Painting of Metal**

- (a) All the iron and steel works shall be painted except works embedded in concrete.
- (b) Before painting the steel surface shall be cleaned and de-rusted and be free of dust, grease, rust and other materials.
- (c) Except where specified otherwise, the following coating systems shall be applied on steelwork
- (d) For steel in continuous contact with water;
- (e) One coat of two-zinc rich epoxy primer with a minimum film dry thickness of 25 micron
- (f) Two coats of two pack high build coal tar epoxy paint, each coat with a minimum dry film thickness of 200 micron.
- (g) For all other steelwork the following system shall be used;
- (h) One coat of two-zinc rich epoxy primer with a minimum film dry thickness of 25 micron
- (i) One or two coats of two pack high build epoxy coating pigmented with micaceous iron oxide, with a minimum dry film thickness of 150 micron.

- (j) Two coats of two pack epoxy enamel of a colour to be specified with a minimum dry film thickness of 50 micron per coat.

#### **1006 Protection and Painting of Concrete, Plasters and Blockwork**

- (a) Concrete, plasters, blockwork and other cementitious surfaces shall be painted according to coating system "J".
- (b) The surfaces of concrete, rendering, plaster and blockwork which are specified or ordered to be painted shall be allowed to dry out after completion and shall then be treated with a fungicidal wash. Subject to the approval of the Supervisor's Representative the fungicidal wash may be omitted if the first or priming coat of paint to be applied incorporates suitable fungicide.
- (c) The surfaces shall subsequently be painted with 2 coats of acrylic emulsion.

#### **1007 Colours**

- (a) Colours shall be as ordered by the Supervisor's Representative, generally with reference to BS 4800. Sample areas shall be prepared as required by the Supervisor's Representative for purpose of ascertaining colour, finish and workmanship and such areas shall be removed as directed.
- (b) Where two or more coats of paint with the same colour are specified, the undercoats shall be tinted so as to differentiate between the coats. The final coat shall not be tinted.

#### **1008 Testing of Paint**

- (a) Before ordering any materials for painting the Contractor shall give the Supervisor's Representative opportunity to have samples thereof tested, proposed by the Contractor and approved by the Supervisor's Representative, to establish that the painting system is capable of withstanding any handling or site conditions that are likely to occur. Test pieces shall be painted by the Contractor, separate for each type of paint
- (b) If the Supervisor's Representative so requires samples from the containers shall be taken and tested at any time after the delivery at the Site.

#### **1009 Painting of Galvanised Surfaces**

- (a) If galvanised surfaces as per system "C" or manufacture-galvanised surfaces of sheet, wire, doorframes, etc. are to be additionally painted this shall conform the requirements of this Clause, indicated as Coating System "D".

- (b) Galvanised surfaces shall be prepared or weathered before painting with an approved etch primer (other than a mordant containing copper), which shall be a two pack primer to be applied in accordance with the manufacturer's instructions.
- (c) After drying of the etch primer the surface shall be thorough rinsed with clean fresh water and allowed to dry. The finishing shall consist of coats of two pack epoxy enamel of a colour specified by the Supervisor's Representative, with a dry film thickness of 50 micron per coat.

#### **1010 Protection and Painting of Softwood**

- (a) The painting of softwood can be divided in two categories, both with their own coating system:
  - (i) visible softwood joinery and carpentry- System "E"
  - (ii) concealed softwood joinery-System "F"
- (b) All softwood shall receive preservative treatment with water-borne preservative in accordance with BS 4072 to the tropical proofing scheme.
- (c) Softwood surfaces which shall be visible and painted shall be cleaned, scoured and dusted down to a smooth surface. Holes, cracks and blemishes in exposed surfaces shall be stopped with putty, and knots shall be treated with an approved knotting. Priming shall be done with a solvent based wood primer complying with BS 5358. After priming the surface shall again be scoured and dusted down. Then the surface shall be painted with one undercoat and two gloss finishing coats of compatible oil based paints. The first gloss finishing coat shall be rubbed down on interior surfaces before the top coat is applied.
- (d) Softwood used for concealed or non-painted joinery shall be primed with one coat immediately after fabrication and preservation. The primer shall be lead-based complying with BS 2523. Holes, cracks and blemishes in exposed surfaces shall be stopped with putty, and knots shall be treated with an approved knotting. Contact surfaces with brick masonry or concrete shall be given a second coat of primer.

#### **1011 Protection of Hardwood**

The protection of hardwood shall be according to coating system "G".

All hardwood joinery shall receive preservative treatment with water borne preservative in accordance with BS 4072 to the tropical proofing scheme. Hardwood surfaces shall not be painted, but shall be treated with a water-repellent penetrating varnish of exterior grade and gloss finish.

## 1012 Protection and Painting of Concrete, R and Blockwork

- (a) Concrete, plasters, blockwork and other cementitious surfaces shall be painted according to coating system "J".
- (b) The surfaces of concrete, rendering, plaster and blockwork which are specified or ordered to be painted shall be allowed to dry out after completion and shall then be treated with a fungicidal wash. Subject to the approval of the Supervisor's Representative the fungicidal wash may be omitted if the first or priming coat of paint to be applied incorporates suitable fungicide.
- (c) The surfaces shall subsequently be painted with 2 coats of acrylic emulsion.

## 1013 Summary of Coating Systems

In the following table all coating systems as described in Clause "Painting and other Coatings" have been summarized.

### a) Coating Systems

System	Application	Description
A	for steel in contact with water, soil or exposed to humid conditions	<ul style="list-style-type: none"> <li>• Blast cleaning to SA 2.5</li> <li>• One coat of two-pack zinc rich epoxy primer with a minimum dry film thickness of 25 micron</li> <li>• Two coats of two pack high build coal tar epoxy paint, each coat with a minimum dry film thickness of 200 micron to be applied within 48 hours after priming</li> </ul>
B	for other steel structures	<ul style="list-style-type: none"> <li>• Blast cleaning to SA 2.5</li> <li>• One coat of two-pack zinc rich epoxy primer with a minimum dry film thickness of 25 micron</li> <li>• One or two coats of two pack high build epoxy coating pigmented with micaceous iron oxide, with a total minimum dry film thickness of 150 micron</li> <li>• Two coats of two pack epoxy enamel of a colour to be specified with a minimum dry film thickness of 50 micron per coat.</li> </ul>
C	for steel in special conditions and cast in concrete	<ul style="list-style-type: none"> <li>• Removal of slag, scale and other impurities</li> <li>• Pickling in hydrochloric acid, neutralising, washing and drying</li> <li>• Hot dip galvanizing in accordance with BS 729</li> </ul>
D	for galvanised steel	Not applicable

<b>System</b>	<b>Application</b>	<b>Description</b>
E	for softwood carpentry - visible	<ul style="list-style-type: none"> <li>• Preservative treatment conform BS 4072</li> <li>• Cleaning, scouring and dusting down</li> <li>• One coat of solvent based wood primer conforming to BS 5358</li> <li>• Scouring and dusting down</li> <li>• One oil based undercoat</li> <li>• Two oil based gloss finishing coats of a colour to be specified</li> </ul>
F	for softwood joinery - not visible	<ul style="list-style-type: none"> <li>• Preservative treatment conform BS 4072</li> <li>• One coat of lead or red lead/red oxide based wood primer, Two coats on contact surfaces to blockwork or concrete</li> </ul>
G	for hardwood - visible	<ul style="list-style-type: none"> <li>• Preservative treatment conform BS 4072</li> <li>• Water repellent penetrating varnish exterior grade - full gloss</li> </ul>
H	for wood in water or soil	<ul style="list-style-type: none"> <li>• Immersion in hot (117°C) mixture of 1:1 creosote-fuel oil for 40 minutes</li> </ul>
J	for cementitious surfaces as concrete, blockwork and rendering	<ul style="list-style-type: none"> <li>• One coat of primer or undercoat for cement surfaces with incorporated fungicide</li> <li>• Two coats of acrylic emulsion of a colour to be specified</li> </ul>

## **1100 FLOOR, WALL & CEILING FINISHES**

### **1101 General**

Where a manufacturer's name or the proprietary name of an article appears in this section, it is given as an indication to tendering contractors of the standard and description required and contractors may quote for any manufacturer's article, provided it is of the standard and description specified and approved by the Supervisor's Representative in writing, prior to inclusion into the works.

### **1102 Porcelain/Ceramic Tiles (non-skid)**

Porcelain/Ceramic tiles shall be unglazed, non-skid to BS 6431 Parts 2 & 6, and shall be laid in accordance with BS 5385. Tiles shall be laid with cement based tile adhesive to BS 5980, possessing Class AA water resistance with additive. Joints between tiles shall be a constant width 3 mm wide. Floor tiles shall be grouted with epoxy grout. The joints shall be completely filled. The manufacturer's printed instructions must be strictly adhered to. Unless specified otherwise, glazed tiles shall comply with BS 1281. They shall be laid on a bed of cement mortar (1:4) and pointed afterwards with accurate and straight joints.

### **1103 Glazed Wall Tiles**

Glazed wall tiles shall be of sizes and thicknesses specified and shall be accurately fixed to floated backing with cement and sand (1:5) and grouted with white cement. Alternatively, tiles may be fixed with an approved tile adhesive and grouted with white cement. All tiles shall be of the cushion-edge type. All external angles shall be rounded edge tiles of radius approved by the Architect. Tiles shall be in accordance with BS 1281 and BS 5385, Part 1.

### **1104 Granolithic Paving**

All granolithic paving to be carried out in accordance with CP 204. The mix is to be cement/sand/aggregate 1:1:2 by weight aggregate, size 5 - 10mm, laid monolithically 25mm thick with an approved hardener.

### **1105 Cement/Sand Screed**

- (a) Screeds shall be laid in accordance with CP 204.
- (b) Mix screeds of cement and sand (1:4) and lay to the thickness described. Finish screeded beds with a rough surface to receive ceramic tiles and a steel trowelled surface to receive vinyl asbestos tiles, ceramic tiles when fixed with approved adhesive and floor paint. Thoroughly brush clean surfaces to receive screeds of all foreign matter and well soak prior to laying screed.

- (c) Provide an adequate bond between screeds and in-situ concrete by the use of an approved concrete bonding agent or by well hacking, wetting and applying cement grout immediately prior to laying the screed.
- (d) Beds shall be laid in bays not exceeding 375 square feet. Edges of adjoining bays shall be well hacked and wetted prior to laying the next day. Immediately the beds are laid, they shall be cured and protected for at least five days to prevent damage or shrinkage of any kind. The method of curing is to be approved by the Supervisor's Representative.
- (e) Ensure that the levels of floors within any one area and between adjoining areas are constant unless specifically described or shown to be otherwise. Make up for any variations in the thickness of precast or pre-moulded floor finishings and irregularities in the surface of the structural base by adjusting the thickness of the screed as necessary.

#### **1106 Laying Of Tiles**

Tiles shall be laid with continuous joints and bedded in a cement and sand (1: 6) screed or backing not less than 30 mm thick and pointed or grouted with cement slurry to match the tiles. Tiles shall be accurately cut and fitted to all doors, thresholds, wall openings, projections, etc. The finished floor shall be perfectly true, level or to the falls specified and cleaned off on completion of the work to the satisfaction of the Supervisor's Representative.

#### **1107 Protection of Tiling**

- (a) After the tiles have been laid, the floor shall be covered immediately to give complete protection from dirt and damage during all subsequent stages of the work.
- (b) The Contractor shall be required at his own expense to remove any tiles which have been stained or damaged before completion of the work and replace them with new ones.

#### **1108 Rendering**

- (a) Mix rendering of cement and sand (1: 4) including a plasticiser additive at the rate as detailed in the manufacturer's printed instructions.
- (b) Proportion materials by measure and not by estimation and provide proper approved measuring boxes for this purpose. Make up mix on site in a close boarded wood platform with upstand edges.

- (c) Where approved mechanical batch mixers are employed, rotate each batch in the drum at least two minutes and use immediately thereafter. Mix only quantities which can be used at once and reject rendering which has begun to set before being required.
- (d) Carefully float all work and finish to the stated thicknesses with surfaces perfectly flat to stand the straight edge every way, free from all cracks and leave perfectly clean. External angles shall be true and slightly rounded.

#### **1109 Plasterboard**

- (a) Gypsum wall board to BS 1230 Part 1 type 1 shall be taper edged boards fixed with plasterboard screws or flat head nails as BS 8212 Clause 6.3. Boards shall be as manufactured by British Gypsum Limited and shall be installed in accordance with BS 8212 and the manufacturers printed instructions.
- (b) Wall boards shall be jointed by applying jointing compound to the depression between the boards, firmly embedding the jointing tape, covering it with the jointing compound and striking off flush.
- (c) Finishing compound shall be applied over the joint and feathered out approx. 2". This process shall be repeated and feathered out a further 2" beyond the first application, finished flush and smooth. Nail holes shall be filled and finished flush.

#### **1110 Spares**

The Contractor is to supply the Supervisor at practical completion of the works with the following spares:

- (a) -Floor and Wall tiles - 2% of quantity

## **1200 PLUMBING INSTALLATIONS**

### **1201 Materials and Workmanship**

- (a)** All materials and workmanship shall be of best quality and comply with the relevant British Standards. BS 6465; Part 1 for sanitary appliances and BS 6700 for Water Supply, where applicable. Piping for gravity and pressure lines shall be polyvinyl chloride (PVC).
- (b)** The Contractor shall submit full details together with drawings of his proposals for approval of the Supervisor's Representative before commencing the work and shall carry out all tests and inspections of the finished work as may be considered necessary by the Supervisor's Representative and specified below.
- (c)** Unless specified otherwise all piping on floors and ceilings shall be exposed.

### **1202 Plastic Pipes for Hot and Cold Water Services**

PVC pipes for use as soil and waste pipes shall comply with the provisions of BS 4514 and those for cold water service pipes with BS 3505. Fittings shall be of the solvent weldable type. Brackets and clips shall be of non-ferrous metal or PVC coated steel.

Traps shall comply with the provisions of BS 3943 and have a 75mm deep seal. Pipes for hot and cold water services shall be installed and fixed in accordance with manufacturer's printed instructions.

Polythene pipes for use as cold water service pipes shall comply with the provisions of BS 1972 or BS 3284. Fittings shall be of the solvent weldable type. Brackets and clips shall be of non-ferrous metal or PVC coated steel.

### **1203 Coupling Unions**

Coupling unions shall be installed at reasonable intervals on vertical and horizontal pipe runs to facilitate erection and dismantling of the pipework without interference to the structure. Similar union connections shall be provided for connecting the pipework to all valves, cisterns, electric heaters, etc.

### **1204 Valves**

- (a)** Stop valves shall be to BS 1010 and shall be of all gunmetal construction with union tails for connection to ABS pipework. Stop valves shall be located in connections to every single structure or building or where indicated on the Drawings.
- (b)** Chambers shall be as detailed in clause "manholes and chambers", or as otherwise specified.

### **1205 Draw-Off Taps**

Draw-off taps shall be chromium plated or natural finished gunmetal high pressure screw down easy clean pattern, threaded for union with crutch handles as BS 1010, fitted with hose union.

### **1206 Water Storage Tanks**

- (a)** Storage cisterns shall comply with BS 417; Part 2 Grade A. Cisterns shall be supplied complete with inlet connection and ball valve, overflow connection with pipe, outflow connections, suction line with foot valve and drain connection with gate valve.
- (b)** The galvanized storage tank for the fertigation system shall be fitted with the following elements:
  - PVC tarpaulin liner (0.5 mm thk.) with a felt protection installed on the underside and 40 cm protection on the edges with galvanized steel anchoring eyelets.
  - Floating anti-algae cover
  - Galvanized steel outlet

### **1207 Overflow Pipes**

- (a)** Overflows to water storage tanks and WC cisterns shall be in PVC tubing as specified for service pipes.
- (b)** Overflow pipes shall be visible externally, and shall incorporate a minimum of vertical drop of 300 mm. They shall project 60 mm beyond and discharge clear of the wall face. All external overflow pipes shall be painted.

### **1208 Soil, Waste and Vent Pipes**

- (a)** Soil, waste and vent pipes shall be of the highest grade to BS 5255 or shall be cast iron pipe with B spigot and socket joints to BS 416. PVC pipe shall be jointed with solvent welded fittings. Jointing shall be carried out strictly in accordance with the manufacturer's printed instructions.
- (b)** Soil pipes shall not be less than 110 mm nominal diameter. Vent pipes shall be not less than 50 mm nominal diameter while waste pipes shall not be less than 35 mm diameter.
- (c)** All waste and soil pipes shall be vented at roof-level and provided with gully traps at ground level.
- (d)** Waste pipes shall be fixed at least 25 mm clear of finished wall surfaces with PVC brackets.
- (e)** Fixing intervals shall be 0.5 m horizontally and 1.2 m vertically, except that 50 mm pipes shall be fixed at 0.6 m intervals horizontally.

- (f) Where soil waste and vent pipes pass through roofs they shall have an uPVC roof terminal and be positioned to enable the roof finish to be suitably weatherproofed. The vent shall terminate with a balloon guard to the approval of the Supervisor's Representative.

### 1209 Sanitary Appliances

(a) Hand Dryers

Hand Dryers with:

- Automatic operation with 15 second dry time
- Electro-mechanical time with 25 Amp switch and 20 second cycle
- 1600 Watt nichrome wire heating element protected by an automatic-resetting, thermal cut off
- 50° temperature rise
- IPX1 ingress protection
- Surface mounted
- Thermally-protected, universal brush-type motor operating at 12,000 RPM delivering 238 CFM air flow at a velocity of 8,624 (98MPH)
- Cover material: cast iron with porcelain enamel finish

(b) Bowl Urinals with;

- Waste 1-1/2" plastic domed strainer waste, 45mm unslotted tail
- Trap 1-1/2" plastic bottle with 75mm seal, multi-purpose outlet
- Urinal concealed hangers, steel
- Spreader top inlet
- Material: vitreous china to BS 3402
- Colour: white

(c) Water Closet with:

- Close coupled cistern 4/2.6 liter dual flush valve bottom supply and internal overflow
- Seat and cover with stainless steel hinges
- Material: vitreous china to BS 3402, BS EN 997 and BS EN 33
- Colour: white

(d) Kitchenette Sink

- Inset stainless steel single bowl and drain complete
- Single level taphole mixer, 1/2" basket strainer waste

(e) Cleaner Sink w/ Bucket Grating:

- Sink 51 x 31cm high back and fitted stainless steel bucket grating
- screws
- Quadrant 1/2" quarter turn bib taps with ceramic discs and lever handles
- Bib tap wall mounts 1/2" for exposed plumbing
- Leg 350mm stainless steel with 355mm screw to wall; aluminum alloy bearer, 305mm stud
- Waste 1-1/2" unslotted strainer waste, 80mm tail, brass
- Trap 1-1/2" plastic resealing bottle with 75mm seal, multi-purpose outlet

- Material: fine fireclay
- (f) Surface Mounted Paper Towel Dispenser B-262;
  - Cabinet: surface mounted 18-8 S, type 304, 22 gauge (0.8mm) stainless steel.
  - Door: 18-8 S, type 304, 22 gauge (0.8mm) stainless steel with satin finish
  - Operation: dispenses C-fold and multi-fold paper towels 3-1/8" to 3-13/16" (79-97mm) deep.
  - Capacity: 400 C-fold or 525 multifold paper towels

## 1210 Pipework and Fittings

- (a) Bends shall be used where practicable in preference to elbows. Square elbows shall not be accepted for soil, waste and vent pipes.
- (b) Pipework shall be fixed to walls using an approved pattern plastic brackets for screwing into walls or concrete. The brackets shall be such that the pipe is held 15 mm clear of the finished wall surface. Brackets shall be fixed at regular intervals appropriate to the pipe diameter in order to ensure that the pipe is securely fixed to the wall.
- (c) Pipelines shall be straight except at changes of direction which shall be made using standing fittings.
- (d) Eccentric reducing sockets shall be used (to facilitate air venting and draining) where changes of diameter are made in runs of normally horizontal pipework.
- (e) Pipework shall be installed to permit even fluid flow, draining and dismantling of the system.
- (f) The expansion and contraction of pipelines shall be taken up in the geometry of the layout.
- (g) Pipes passing through walls, partitions and ceilings shall be provided with pipe sleeves. Sleeve sizes shall allow for the free movement of the pipes. Sleeves passing through finished surfaces or exposed to view shall be flush with the surface of the partition through which they pass and they shall be provided with suitable end covers of approved pattern and finish.
- (h) Connections to water-closets and floor mounted soil fittings shall be made by using the correct sized socket for the outlet of the fitting.
- (i) All services shall be laid to drain with a minimum cover of 600 mm unless otherwise shown on the Drawings.
- (j) Piping shall be as straight and direct as possible forming right angle with or parallel to wall and other piping.
- (k) All piping and fixtures shall be adequately protected during construction. All cut pipes shall have ends reamed and be free from burrs.

- (l) Pipes carrying cold water for drinking purposes shall be located so as not to be liable to heat gain or alternatively shall be effectively insulated from such gain.
- (m) All necessary precautions shall be taken to prevent water-hammer and should it occur it shall be rectified.
- (n) All piping shall be so installed that there is a clearance of at least 25 mm between the finished covering and adjoining work. All pipes at or in the ceilings shall be hung from the construction above and as close as possible to bottom of slab, beam etc. All risers shall be plumb and true, neatly spaced and parallel to walls and other pipes.
- (o) All pipes shall be so arranged as to be accessible for repairs and replacements without disturbing adjacent work. Central valves shall be located to give complete regulating control of all systems, plumbing fixtures and other equipment. All valves shall be easily accessible and no valves shall be installed with handles pointing down.
- (p) All pipes shall be quite free of each other and easily accessible for their full length where in ducts. In no instance whatever, are any pipes to be fixed behind other pipes and all shall be easily accessible from access openings. Access panel openings shall be suitably located at all stop taps on service lines and at inspection openings on bends and junctions in suitable locations to allow rodding of all waste and soil lines. Particular attention shall be given to location of inspection openings to soil pipes to closet pans to ensure adequate accessibility.
- (q) The Contractor, before installing any of his work, shall see that it does not interfere with clearances required for finish columns, pilasters, partitions and walls, as shown on the Drawings and details. If any work is so installed and if later develops that such details of design cannot be followed, the Contractor at his own expense shall make such changes in his work as are directed by the Supervisor's Representative and as shall permit the installation of the architectural work shown on the plans and details.
- (r) Runs and locations of piping are shown on the Drawings. The Contractor shall be responsible for the correct setting out of the PVC piping sleeves for pipes through walls and floors and locations of PVC pipe brackets and the like, and shall prepare the required Working Drawings which shall be submitted to the Supervisor's Representative's Representative for approval prior to starting any construction work.
- (s) Variations from the original lay-out, location of valves, cleaning and other inspection openings shall be shown on the As-Built Drawings.

### **1211 Rainwater Pipes and Gutters**

All rainwater pipes and gutters shall be asbestos cement pipe or UPVC pipes to 4576. Jointed and fixed in accordance with the manufacturer's printed instructions. All rainwater pipes shall be perpendicular and fixed to the wall with approved brackets.

## 1212 Manholes and Inlets

### (a) General

Invert channels shall be smooth and semi-circular in shape conforming to inside of adjacent sewer section. Make changes in direction of flow with a smooth curve of as large radius as size of structure shall permit. Make changes in size and grade of channels gradually and evenly. Construct invert channels by one of the listed methods:

- Forming directly in concrete base of structure
- Building up with brick and mortar
- Floor of structure outside the channels shall be smooth and slope toward channels not less than 1:10 nor more than 1:5. Bottom slab and benches shall be concrete.

Types:

- (i) Square Manholes: As shown of reinforced concrete.

## 1213 Testing

- (a) Pipelines shall be submitted to a hydraulic test before trenches are completely backfill. Test pressures shall be 1 ½ times the working head. If any leaks are discovered the joints shall be resealed and pressure re-applied until they are proved to be watertight. Defective pipes shall be removed and replaced with sound pipes. The Contractor shall provide water and attend upon the Supervisor's Representative while tests are being carried out.
- (b) During the testing the backfilling of the trenches shall be complete except that the joints of the pipe and fitting shall remain exposed for visual inspection. Upon satisfactory completion of the test the remainder of the backfill shall be undertaken.

## **1300 UV STERILIZER**

### **1301 General**

- a) **UV reactor chamber:** Stainless Steel
- b) **Optimum UV Dosage:** 30 -90 mJ/cm<sup>2</sup> @ specified flow rate
- c) **Sleeve Material:** Quartz
- d) **UV lamp output:** 254 nm
- e) **Lifespan of UV lamps :** 9000 -13000 hours
- f) **Electronic ballast lifespan:** min. 25,000 hours
- g) **Flow Rate @ 30,000 uW/sec/cm<sup>2</sup>:** 110 l/min
- h) **Flow Rate @ 90,000 uW/sec/cm<sup>2</sup>:** 35 l/min
- i) **Power input :** 80 W
- j) **UV intensity (microwatt/cm<sup>2</sup>/m per lamp):** 240

## **1400 MECHANICAL WORKS**

### **1401 Pumping Equipment**

#### **Scope**

This specification together with the requisition, purchase order/inquiry and data sheet covers the requirements to be met by Contractor in the procurement, inspection, testing and construction conditions of pumps, drivers and power transmissions and other auxiliary equipment.

#### **Pump Selection**

Pump selection should be according to the drawing specifications. Where the specifications are silent about technical requirements, the following aspects should be considered for pump selection by the Contractor:

- quality of water (corrosivity, abrasiveness);
- solar power supply characteristics;
- electrical power supply characteristics;
- hydraulic characteristics of the supply system;
- pump cost and operating costs;
- hydraulic efficiency;
- availability of operation and maintenance services;
- standardisation of equipment;
- Small low lift pumps may be either horizontal or vertical.

High lift pumps shall preferably be horizontal, for ease of maintenance and longer life. Wherever possible a single-stage pump shall be preferred to a multi-stage, and lower speed motors are preferable to high speed motors. It is not considered advisable to use multi-stage high speed pumps due to increased wear despite possible initial cost savings.

#### **Design Specifications**

- **General**
  - All operation and maintenance instructions, indicator plates, manuals etc. to be available in English.
  - Engine and Pump spares for 3 years maintenance to be included

- Single stage, volute centrifugal pump
- Nominal Casing thickness of 10 mm min
- **Pumps**
  - Pump to be close coupled
  - Diesel Power Unit
  - Engine either air or water cooled
  - Pump unit to be mounted on a wheeled chassis to allow easy removal from the site (unless otherwise stated in the Bill of Quantities)
  - 12v Electric start
  - Integral fuel tank to have capacity for 24 hour operation or fuel probe with 4m fuel hose
  - Exhaust to discharge outside of the pump house
  - Pump unit to have soft packed gland - not mechanical seal
  - Pump Shut-Down Head to be within 1.5 bar of Duty Point

Pumps shall be guaranteed for capacity, head, power consumption and NPSH at the specified rated conditions.

Intake pumps for surface water duty shall be designed for pumping raw water with a high silt content, to be capable of passing 75mm diameter solids and to avoid possible choking by weeds or other tough sinuous material.

Water velocities in the suction or delivery branches of a pump shall not exceed 3.5 m/s when the pump is operating within its specified duty range and within this working range there shall be no discernible noise due to hydraulic turbulence or cavitation within either the pump or its associated pipe-work and valves.

The pump efficiency shall be well maintained over the whole of the specified duty range, even if this necessitates the use of a larger motor to provide the peak power demand.

Pumps shall be arranged for priming by means of an adequate positive suction head in all possible operating conditions.

Pumps rated point for furnished impellers shall not be beyond the best efficiency point. Vendor shall make his endeavour to select the pumps having the best efficiency point nearest to the rated point.

The NPSH requirements of the pumps, based on the 2% output drop criterion shall be at least 1 m less than the NPSH available at every working condition.

The head/quantity characteristic of any pump shall be stable at all rates of flow between closed valve and open valve and shall be steep enough to permit satisfactory operation in parallel with other pumps under all conditions specified.

Effective means shall be provided for the collection of gland leakage water and piping it to a suitable floor drain.

The speed of any main pump shall not exceed 1,500 rpm without approval of the Supervisor's Representative.

- **Control Panel**

To have the following components as a minimum requirement:

- Pressure gauge
- Low/High pressure cut out with warning light
- Low oil pressure cut out with warning light
- High engine temperature cut out with warning light
- Timer
- Low water level cut out (suction intake sump) with warning light

- **Suction Assembly**

- A ridged suction pipe must be used (unless otherwise stated in the Schedule of Prices).
- Foot valve must be spring-loaded and have drain release fitted.

Pump priming to be achieved with either:

- An automatic exhaust primer
- Hand operated priming pump.
- Priming by-pass assembly from the pump delivery (providing there is a static delivery head)

Hand priming with a priming funnel will not be allowed.

- **Delivery fittings**

Minimum components to include:

- Control Valve
- Pressure relief valve with discharge outside of pump house
- Slow opening and closing hydraulic check valve
- 10 bar pressure gauge
- Water meter, m<sup>3</sup>/hr with totalize
- All delivery pipe work and fittings to the underground main line to be galvanised steel.

- All nuts and bolts to be suitably plated

- **Pump House**

- Block construction pump house with galvanised steel roof complete with lockable steel mesh door, window and ventilation grills as appropriate. Pump house to be a sufficient size to allow for unrestricted access to the pump unit (at least 1.0m clear space to each side of the pump). The size of the door to allow pump to be removed if and when required.
- Engine exhaust to be extended to the outside of the building
- If fuel probe is supplied, building must be sufficient size to allow for fuel drum to be stored inside building
- Full construction detail and drawing to be supplied and approved by the Supervisor's Representative prior to construction
- Floor to have drainage channel discharging outside the pump house

- **Shaft and Shaft Sleeves**

Shafts shall be made in one piece except for vertical pumps having a long shaft subject to the Supervisor's approval, and shall be provided with sleeves securely locked to the shaft. When the size of the pumps makes the use of shaft sleeves impractical, the shaft shall be made of wear resistance material for packed pumps and of a corrosion resistance material for pumps with mechanical seal.

Pump shafts shall be forged from a material compatible with the impellers. If the pumps are fitted with packed glands, the shafts shall be provided with replaceable sleeves where they pass through the gland.

- **Shaft Sealing**

Pumps may be fitted with mechanical seals in place of packed glands only if they have proved satisfactory over a long period when fitted to the design of pump in question and with prior approval. They shall be designed for easy adjustment and seal removal.

Where suction pressure is a vacuum, impellers shall be so arranged that stuffing box pressure is positive. Otherwise, the stuffing box shall be effectively sealed to be positive in pressure.

For conventional packing, lantern rings shall be used so that self-flushing can be made. External flushing shall be specified on the data sheets if necessary. Ample space shall be provided for repacking without removing and dismantling any part, other than gland components and guards.

Where mechanical seals are used, flushing port shall be provided near the seal surface so as to remove heat effectively from the seal.

Hydraulically balanced seals shall be furnished for sealing pressure above 5 bar.

For tandem type mechanical seals, throttle bushing shall be provided.

- **Bearing and Bearing Houses**

Unless otherwise specified, all pump bearings shall have a design running life of not less than 100,000 hours. Bearings shall be designed for loading 20% in excess of calculated maximum loading and shall be suitable for reverse rotation at 150% rated speed or the maximum reverse speed the pump can reach in installed conditions when driven backwards by reverse flow, if this is greater.

Bearing housings and brackets may be of cast iron for any services.

Bearing housings shall be effectively sealed against the invasion of water or dust.

Bearing lubrication system and cooling system shall be selected for the service conditions, and shall be capable of operating continuously with the temperature at any bearing housing not exceeding 70°C or ambient temperature plus 30°C, whichever is lower.

Bearing cooling arrangements if used shall be designed on the closed-circuit principle. Open discharge of cooling water into the pumping station drainage system is not permissible.

Lubrication arrangements shall be designed to avoid any contamination of the pumped fluid.

- **Nozzles and Miscellaneous Connections**

Each pump shall be complete with all necessary ancillary equipment and fittings to render the unit complete and ready for service. This shall include isolating valves, non-return valves, air-valves, cooling water pipe-work, gland leakage pipe-work, air release pipe-work, pressure gauges, gauge pipe-work, holding down bolts, access platforms and other items as appropriate.

Pump casings shall have flanged suction and discharge nozzles. Flanged connections shall be designed for bolting.

Flange ratings and facings shall be specified on the data sheets by the Contractor.

The piping and equipment shall be designed and arranged for easy disassembly and maintenance.

Orifice opening shall not be less than 1.5 mm in diameter.

- **Materials of Construction**

The pump impeller, shafting, sleeves, wear rings, casing, etc. shall be of suitable material to cope with the pumped medium and the Contractor shall have satisfied himself that sufficient detail has been provided to make this assessment.

Typical materials of pump construction have been given in the following Clauses and are intended only as a general guide.

If the grade of materials of Manufacturer's selection is better than the specified one, Manufacturer's standard materials may be used with the Engineer's approval.

Castings shall be sound and free of shrink or blow holes, scale, blisters and other similar injurious casting defects. Cast iron shall not be repaired by welding without specific approval of the Engineer.

Casing corrosion allowances shall be 3 mm minimum for carbon and low alloy steels and 0 mm for high alloy steels and non-ferrous materials unless otherwise specified.

Gaskets shall be of anti-corrosion type.

Copper or its alloys shall not be used for any components of auxiliary piping without Engineer's approval.

- **Impellers**

Impellers of the maximum or the minimum diameters in relation to size of casings shall not be used. Wearing rings shall be replaceable if furnished.

- **Couplings and Guards**

Connections between horizontal pumps and drivers shall be made with suitable flexible type couplings.

Spacer type couplings shall be furnished.

Removable coupling guards made of steel plate shall be supplied and mounted by Vendor for horizontal pumps. A limited end float coupling shall be provided when the drivers have no thrust bearings.

- **Critical Speeds**

The rotating assemblies shall be statically and dynamically balanced and designed so that the first critical speed of a flexible shaft pump and its drive is at least 50% higher than the maximum operating speed.

The first lateral critical speed of a stiff-shaft pump shall be at least 10 % over the maximum operating speed. Where the rotating assemblies are small and any out of balance forces are negligible this requirement shall not be necessary. The manufacturer is required to state whether balancing has been completed.

- **Pressure Lubrication System**

A pressure lubrication system shall be furnished if specified by Supervisor or if recommended by Vendor. All oil containing pressure components shall be of carbon steel. Carbon steel oil pumps shall be pickled at Vendor's shop. Casings of shaft-driven oil pumps may be made of cast iron.

The pressure lubrication system shall be incorporated into a base plate of the equipment.

### **Pump Performance Guarantee**

The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's works. The pump shall operate at its design point within the acceptance tolerances for flow rate and total head.

### **Marking and Painting**

Nameplates and rotation arrows on pump drivers shall be 18-8 stainless steel or monel, attached by pins of similar material at a readily visible location.

The following data as a minimum shall be clearly stamped on the name plates:

Item no.:

- Manufacturer's name;
- Pump serial number;
- Date of manufacture;
- Size and type;
- Rated capacity (m<sup>3</sup>/h);
- Rated pressure (bar);
- Rated speed (rpm).

## **Preparation for Shipment**

- Packing and Preparation for Shipping

Vendor shall clean all components, and preserve and protect them on the basis that equipment and all accessories shall be stored unprotected in the field for a minimum period of 6 months.

All openings shall be provided with substantial metal closures.

All tapped openings shall be plugged.

All items shall be suitable packed, securely fastened and protected from damage during shipment.

No package or container shall contain items of plant intended to be incorporated in more than one part of the works.

Electrical plant shall be enclosed in sealed airtight packages with dehydrating salts before being placed in packing cases on shock absorbent materials and secured by fasten bolts.

- Shipping

Equipment shall not be transported to job site as deck cargo without the Supervisor's approval.

Centrifugal pumps shall be shipped as assembled units with drivers, unless otherwise specified by the Engineer.

No equipment shall be released for shipment from Manufacturer's shop until it has been approved by the Supervisor.

## **End Suction Pumps**

The pump shall be horizontally mounted complete with drive motor on a common baseplate. The pump/drive coupling shall be of the spacer type to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipework or drive motor.

The dimensions of the pump shall be metric conforming to BS 5257 or its equivalent. Flanges shall conform to BS 4504.

The bedplate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts, etc. shall be supplied with the units.

The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.

Impellers shall be provided with means to prevent abrasive matters reaching the glands and with fully shrouded impellers, to prevent the trapping of matter between the impeller vanes and the casing.

Rotating assemblies of pumps of 100 mm diameter inlet and over shall be statically and dynamically balanced and shall be designed so that the first critical speed of the pump and its drive is at least 50% greater than the maximum operating speed.

Glands may be fitted with suitable mechanical seals or conventional soft packing. The gland arrangement shall be designed for ease of adjustment or removal of the seal or packing material. Shafts shall be sleeved around the area of the gland when soft pack glands are used.

Flushing facilities shall be provided for mechanical seals or packed glands where pumped fluid may be contaminated with abrasive material. Where soft packed glands are used, means shall be provided for collection of the gland leakage water, which shall be piped into the drainage system through adequately sized ports.

Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

The pumps and associated pipework shall be, wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.

Trappings shall be provided at both the suction and discharge flanges for pressure gauge equipment.

### **Replacement Pump Units**

The replacement pump unit shall be the same or updated model from the manufacturer of the existing units. Only in the second instance may the pump unit be from another manufacturer satisfying the technical requirements.

In all cases the works shall include all design and execution of any modifications required to existing plinths or building works, pipework and valves, cables and electrical work necessary to adapt the existing installation to suit the proposed pump unit.

Each pump unit shall be complete frame mounted with its electric motor and inclusive of all accessories, unless otherwise specified.

### **1402 Dosing Controller Unit**

The dosing controller unit to be used in the fertigation system should have the following minimum requirements:

- Control of minimum 6 valves
- Control of minimum 2 motors
- Control of 2 stations (fertiliser station and clean water station)
- Simultaneous or sequential valve control
- Control of a mixing tank
- Watering by time or by volume, valve optimisation module
- EC and pH control
- Alarm management
- Ability to start at fixed times, cyclically or by date
- Ability to start according to the watering flowmeter
- Forced operation switches on every output

## 1500 GREENHOUSES

### 1501 Foundation

- Reinforced concrete pillar foundation with reinforced concrete beam supports. Curtain wall 1m above the ground (all around the chambers and across the partition portion between the chambers). Damp proof course in accordance to BS 6515 and BS 8215.
- Grouting of side poles in reinforced concrete (1:2:4) up to Damp proof course level.
- 600mm of plinth protection all around the periphery of the greenhouse with cement concrete (1:5:10) with standard waterproofing and top layer to be provided with 50mm thick cement concrete (1:2:4).

### 1502 Structure

- Wind resistance: 150 km/hr
- Vertical column posts and other structure materials should be made with Hot Dipped GI min. 46,000 psi and should be anti-corrosive, humidity resistant and zinc coated
- Roof trusses shall be factory welded, the welds shall be re-galvanised with a flame spray process. No painting of weld areas will be permitted.
- Roof purlins shall be fabricated from 16 ga. Galvanised steel tubing as a minimum. Purlins shall be bolted to the truss top chords, no screw attachments are allowed.
- Bolts and nuts are zinc-coated and dichromated.
- There will be one line of continuous peak vents fixed on each span.
- Insect-proof net (Ultra Vent or similar) on all peak vents.

### 1503 Flooring

- Sub base consisting of 100mm thick sand filling, 100 mm thick lean concrete (1:5:10) with proper compaction.

### 1504 Covering (Celloclim)

Thickness	190 – 210 $\mu$ m
Solar radiation (Kly/year)	70/100
Design Life	> 57 months
Elongation at break (machine)	> 500% (ISO 527-3)
Tensile stress at break (machine)	>19 Mpa (ISO 527-3)

Elongation at break (cross)	>500% (ISO 527-3)
Tensile stress at break (machine)	>19 Mpa (ISO 527-3)
Creep	<25% (NF EN 13206)
Dart drop test on full film	> 650 gr (ISO 7765-1)
Dart drop test on folds	> 450 gr (ISO 7765-1)
Thermal efficacy	> 88% (EN 13206)
Light transmission	Global: 87% (EN 2155-5) Diffused: 65% (EN 2155-9)

### 1505 Insect-Proof Netting

Mesh Size	250 $\mu$ m x 730 $\mu$ m
Shade	< 6%
Strength in daN/m (warp/weft)	380 x 250
Min. Design Life	5 years

## 1600 ELECTRICAL WORKS

### 1601 General

#### (a) Regulations and Standards

The electrical installation shall comply with all relevant statutory regulations and standards current at date of tender, unless otherwise indicated within this Specification. In general the following shall apply:

- The IEE Regulations for Electrical Installations, 16th Edition.
- The Health and Safety at Work Act, etc.
- Factories Act (UK)
- British Standards (BS)
- British Standards Codes of Practice (CP)
- International Electrotechnical Commission (IEC)
- Regulations under the Electricity Acts of Saint Lucia.

If no standard is specified, the relevant British Standard or, in the absence of such standard, International standard shall apply.

#### (b) Abbreviations of Electrical Terms

For the purpose of this Specification the following abbreviations of electrical terms have been used:

L1	-	red phase
L2	-	yellow phase
L3	-	blue phase
N	-	neutral
ac	-	alternating current
dc	-	direct current
A	-	amp
mA	-	milliamp
V	-	volt
kW	-	kilowatt
kWH	-	kilowatt hour
kVAr	-	kilovar
kVA	-	kilovolt amp
MVA	-	megavolt amp
Hz	-	hertz (cycles per second)
SP	-	single pole
SPN	-	single pole and neutral
DP	-	double pole
TP	-	triple pole
TPN	-	triple pole and neutral
SPSwN-	-	Single pole and switched neutral

TPSwN-	triple pole and switched neutral
MCB -	miniature circuit breaker
MCCB-	moulded case circuit breaker
RCD -	residual current device
MCC -	motor control centre

**(c) Polarity**

The polarity of all electrical apparatus used for the Works specified shall be arranged as follows:

- for two pole apparatus the phase of 'live' pole at the top (or left hand side) and the neutral or 'earthed' pole at the bottom (or right hand side),
- for three or four pole apparatus the phases in order of red, yellow, blue and neutral reading from top to bottom or left to right in the case of vertical and horizontal lay outs respectively and as viewed from the front.

All non-flexible cables shall be so connected between main switchboards, distribution boards, plant and accessories so that the correct sequence or phase colours are preserved throughout the system.

All non-flexible cable cores shall be identified with phase colours for three and four wire circuits. Single phase circuits shall be red and black.

**(d) Voltages and Frequencies**

Unless otherwise indicated in the Particular Specification, all apparatus and wiring shall be suitable for use with the Saint Vincent and the Grenadines Standard Electrical Power Supply, which conforms to the EC standard of 3 phase, 4 wire, 230/400 volt, 50 Hz earthed neutral supply. The supply waveform shall be a sine wave.

Supplies for control, tripping, alarm and indication circuits shall be 24 V dc. Circuit breaker spring charging motors shall also operate at 24 V dc.

Control voltage within motor starters shall be 240 V ac. Extension of 240 V circuits outside the starter shall not be permitted except for the circuit to the emergency stop button, where fitted.

Tap changer motors and electrical panel heating and lighting shall operate at 230 V, single phase. All equipment operating at 230 V shall be fully shrouded and clearly labelled.

Where 230 V lighting and heating is used within a panel which otherwise contains equipment with a nominal operating voltage of 24 V, the 220 V equipment shall be insulated, sheathed and protected in accordance with standard practice for installing such equipment in buildings. No live terminals shall be accessible without the use of tools, no single-insulated wires shall be used, and no 220 V cables shall share cable trays or other routes with 24 V circuits.

All references to voltages shall relate to the nominal, or rated value of the supply.

**(e) Units of Measurement**

All information shall be in metric SI units. Where plant design exist in imperial units, the dimensions and tolerances of lay outs and terminal points shall be presented in SI units to a degree of accuracy which permits the precise matching of existing components.

**(f) Electricity Supplies**

The Contractor shall liaise with the relevant Utility Company to undertake any testing and inspection necessary for the electricity supplies to be connected when required. On completion of the tests and inspections, not less than two weeks prior to the power supply being required, the Contractor shall supply to the Supervisor's Representative a copy of his Electrical Installation Completion Certificate and of the test certificates.

**(g) Electrical Safety**

The Contractor shall be responsible for the electrical safety of all equipment supplied and installed. Whilst any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on site. If necessary, this shall include erecting warning notices and fencing off areas which are considered to pose a risk.

The Contractor shall be responsible for ensuring that the electrical installation is carried out by competent personnel and that the work is carried out in accordance with standard procedures and test requirements. Before any piece of apparatus is energised it shall be thoroughly examined for the presence of dirt, water or other foreign bodies.

**(h) Electrical Motors**

Electrical motors shall comply with BS 4999 and BS 5000, or equivalent.

Motors shall be three phase squirrel cage induction type. They shall be capable of withstanding without damage an overload equivalent to 150% of full load torque for 15 seconds.

The motor rating shall be not less than 105% of the maximum power demand of the driven plant when operating in its normal range. For motors above 15 kW, the input power factor over the normal operating range shall not fall below 0.85 lagging.

The motor terminal box shall allow adequate clearance for an air termination of the specified cable, cable lugs and glands.

Motors of 15 kW and above shall be fitted with anti-condensation heaters. The heaters shall be separately fused and energised when the main circuit contractor is open.

A motor rating plate shall be fitted to every motor giving the following information:

- manufacturer's name
- motor type and serial number
- power rating
- current, voltage and winding connection

- supply frequency
- duty power factor
- duty speed
- class of insulation
- IP rating
- maximum number of starts per hour

Unless otherwise specified the motors shall be capable of starting at least 5 times, equally disposed in any one hour at maximum ambient temperature.

Motor insulation shall be rated to thermal class F and temperature rise shall not exceed the limits of class B.

The degree of protection of the motor enclosure shall be as follows:

- Outside in temperate climates IP 55;
- Where hosing down may take place IP 55;
- Inside adjacent to water carrying equipment or in uncontrolled environment IP 44;
- Inside in controlled environment IP 22.

All motors shall be provided with a frame earth terminal of sufficient size to take full fault current.

All motors operated on an HV supply, and all motors rated at 250 kW or greater shall incorporate winding temperature protection in the form of six thermistor (or thermocouple) temperature detectors embedded in the stator windings. The temperature detectors shall be wired to a connection box mounted on the motor frame. The box shall be dedicated to the connection of the temperature devices and shall not be used for any other purpose. The box shall incorporate over-voltage protection devices.

All motor rotating parts together with their couplings shall either be enclosed within the motor frame or be fitted with guards, removable only by the use of tools, to prevent accidental contact.

## 1602 Transformers

### (a) Voltage Transformers

- (i) Voltage transformers shall comply with the latest Standards. The secondary winding shall produce an output line voltage of 240 V, three phase. The accuracy class and VA rating shall be as specified or shall match the requirements of all connected instruments and relays.

- (ii) The primary circuit shall be protected by HRC fuses having a short-circuit rating of not less than that of the switchgear. The connections between the fuses and the switchgear primary conductors shall be of sufficient cross section and be supported to withstand the short-circuit rating of the switchgear.
- (iii) The secondary circuit shall be protected by HRC fuses mounted as close as possible to the secondary terminals. Fuses shall be accessible without the need for isolating the switchgear.
- (iv) Isolatable voltage transformers shall have the facility for padlocking in the service position.  
Safety shutters shall automatically cover the busbar spouts when the transformer is withdrawn. Shutters shall have the facility for padlocking in the closed position.

**(b) Current Transformers**

- (i) Current transformers shall comply with the latest Standards and shall be of the wound-primary or bar-primary type according to ratio required. All current transformers shall have a short-time current rating of not less than that of the switch panel in which they are incorporated. For bar-primary current transformers this rating shall be for a period of 3 seconds. For wound-primary patterns the rating shall preferably be for a period of 3 seconds but may be reduced to not less than 0.5 second subject to the Supervisor's Representative's approval.
- (ii) Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.
- (iii) Current transformers shall be of Class 1 accuracy for use with measuring instruments and Class 10P for use with protective relays.
- (iv) Class 5P shall be used for combined overcurrent and earth fault protection of the inverse time overcurrent type.
- (v) The secondary windings of each set of star-connected three phase current transformers shall be earthed at one point only, via a bolted link.
- (vi) Separate sets of CTs shall be used for metering and protection.
- (vii) Shorting links shall be provided at test blocks.

**(c) Control Transformers**

Unless otherwise specified all contactor control circuit supplies shall be obtained from the 240 V secondary winding of a single phase integral control transformer.

Transformers shall be of the double wound pattern in accordance with the latest Standards and shall have an earth screen between primary and secondary windings. One leg of the secondary winding shall be earthed. The primary winding shall be protected by cartridge fuses, and the secondary winding shall be protected by a fuse and link.

A spare control transformer shall be provided with each new switchboard.

## 1603 Protective Relays

### (a) General

- (i) Protective relays shall be mounted on the front of the switchgear or relay panel in such a position that operation and maintenance can be conveniently carried out. Auxiliary relays may be mounted inside a cubicle provided that they are readily accessible.
  - (ii) Each relay shall be contained in a dust proof case with a clear front cover. All metal bases and frames shall be earthed except where there are technical reasons where this is impracticable.
  - (iii) All relay contacts shall be capable of making the maximum current which can occur in the circuit without causing damage to the contacts.
  - (iv) Relays shall have provision for testing the operation and calibration without disconnecting the permanent wiring.
  - (v) Flush, draw out type relays are preferred. Each relay shall have an indicator device to show when the relay has operated and if necessary, which phase element. Each indicator shall be hand resettable. Resetting devices shall not require the removal or opening of the relay. It shall not be possible to operate the relay without opening the case.
  - (vi) Where solid state relays are specified, these shall be of the module type comprising a number of plug in elements allowing interchange of functions. Each of the protection elements shall have adjustable controls for current and time settings as required. Solid state relays of a particular type shall have interchangeable protective elements with other similar relays supplied under this Contract.
- (b) All relays shall be provided with a name plate giving manufacturer, type, serial number, year of manufacture, ratings and connection diagram.
- (c) All relays using a DC auxiliary supply shall operate down to 60% of the nominal voltage and up to boost charge voltage of the battery.
- (d) Protection relays shall comply with the latest Standards where appropriate and shall conform to the following provisions:
- Generator or Transformer Biased Differential Protection  
The protective relay system shall be suitable for generators or two or three winding transformers. The relay shall not operate due to magnetising or line switching current surges or tap change ratio changes provided on the transformer, nor for through fault currents.
  - Transformer Restricted Earth Fault Protection  
These relays shall be instantaneous in operation, consistent with normal operating due to transient switching currents. Each relay shall be capable of being set to operate under service conditions with primary currents likely to occur on site by means of relay adjustment.

- Overcurrent and Earth Fault Protection  
Relays shall be of the attracted armature or rotating disc type having instantaneous, inverse or very inverse definite minimum time, directional or non-directional characteristics as specified.
- Under Frequency Relays  
The setting range shall be variable between -10% and + 2% from the rated frequency. Two different settings shall be provided to give alarm and trip facilities. A low pass filter unit shall be fitted where the harmonic distortion exceed 5% of the fundamental.
- Under and Over-voltage Relays  
Variable settings shall be provided as required together with a 0 to 5 second time delay.
- DC Trip Relays  
Relays shall be suitable for operating with the voltage reduced to 60% of normal.
- Motor Thermal Relays  
Relays for motor protection shall give protection against overload, stalling, current unbalance, and single phasing. The relay shall have variable current settings and overload tripping time.

#### 1604 Motor Starters

##### (a) Motor Starters - Low Voltage

Motor starters shall be of the "direct on line" (DOL), Autotransformer, Soft Starter or Star-Delta type as specified in the "Specific Requirements".

All starters shall comply with the latest Standards.

(i) Utilisation category	AC3
(ii) Co-ordination type	C
(iii) Intermittent duty class	0.3
(iv) Mechanical endurance	3 million

The starter shall have motor circuit HRC fuses or MCCB's or motor circuit protector type moulded case circuit breakers to protect each contactor and overload unit against short circuit conditions. The contactor shall not be used for short circuit protection.

The starter shall incorporate the following features:

- Fault rated, door interlocked, fused switch or MCCB with mechanical operating handle, ON/OFF indication and pad-lockable OFF facility. The fused switch or MCCB shall be fitted with not less than one "make" and one "break" spare auxiliary contacts in addition to those used within the starter circuitry;
- Thermal overload device with inherent temperature compensation and single phasing protection, time lagging to cover the starting period, and overload setting adjustment. Operation of the device shall open the main contactor circuit and this shall be locked out until reset via a door mounted hand operated reset push button.
- For motors up to 30 kW direct connected thermal overload devices integral with the motor contactor shall be accepted. For motors rated at over 30 kW the

overload devices shall be separately mounted. For motors of 100 kW and above the starters shall be equipped with motor protection relays which provide thermal imaging type overload detection, earth leakage protection, instantaneous overcurrent protection, and phase current unbalance protection;

- Local/remote and/or manual/auto (or manual/off/auto) control selector switch as required by the application;
- Triple-pole air break contactor complying with the latest Standards and with inherent under voltage release;
- Fault reset push button;
- HRC cartridge fuse(s) and wiring via main contactor N/C auxiliary contacts to supply the motor anti-condensation heaters;
- HRC cartridge fuses for control and indication circuit protection;
- Ammeter and single CT (fitted to blue phase) for 3 phase motors between 2.5 kW and 25 kW. Ammeters shall be fitted on all phase for motors larger than 25 kW. Where power factor correction capacitors are fitted, the ammeter shall read uncorrected current;
- Pilot lights to indicate:
  - Power available - White
  - Running - Red
  - Stopped - Green
  - Motor tripped alarm - Amber
  - Flow failed alarm - Amber
  - Winding temp alarm - Amber (motors>250 kW)
  - General alarms - Amber

Individual alarm lights shall be provided for each fault condition. They shall remain in the alarm condition until the protective device is manually reset.

- Hours run counter;
- Start push button, operable in local or manual modes only;
- Stop push button of the latching, mushroom-headed type, coloured red and latching in the stop position. The push button shall be of the twist to reset type. The stop push button shall be operational in all control modes. The starter circuitry shall also provide connections for an emergency stop push button located at the plant. This shall be connected in series with the starter mounted stop button to directly break the main contactor control supply.

- Power factor correction capacitors shall be supplied when necessary, to correct the power factor of the motor to a minimum of 0.95 lagging. Where the motor rating is 50 kW or greater, the capacitors shall be separately switched. In this case the capacitors shall be fitted with discharge devices.  
Power factor correction capacitors shall comply with the latest Standards and shall be of the polypropylene film and aluminium foil type and be "self-heating".
- For motors of rating 250 kW or greater, winding temperature detector relay to the latest Standards arranged to continuously monitor three temperature detectors.
- Lamp test push button.
- Panel anti-condensation heater, fuses and thermostat.
- Control relays as required.
- Flow failed protection relay.
- All necessary links, wiring, terminals, terminations, and insulated barriers.

**(b) Motor Starters - High Voltage**

- (i) High voltage motor starters shall comply with IEC 694 and shall be fully compartmentalised to avoid the possibility of fault propagation (metal clad).
- (ii) Contactors shall be operated by 240 V DC (full-wave rectified AC) derived from a transformer-rectifier in each starter. Contactors shall be vacuum or air as specified. Operation of vacuum contactors shall be such that current is broken at, or very near to zero current to minimise current chopping.
- (iii) All HV starters shall be equipped with motor protection relays which provide thermal imaging type overload detection, earth leakage protection, instantaneous overcurrent protection, and phase current unbalance protection.
- (iv) Each starter shall comprise:
  - 1) bus bar;
  - 2) switch disconnecter (suitable for switching stalled motor current);
  - 3) on-load circuit earthing switch;
  - 4) HRC fuses;
  - 5) vacuum contactor;
  - 6) motor protection relay;
  - 7) control transformer;
  - 8) ammeter and phase selector switch;
  - 9) Controls as specified.
- (v) The contactor or contactor and fuse assembly shall be withdrawable with positions for 'service', 'test' and 'disconnected'. Removal from the 'service' position shall automatically apply the circuit earth.
- (vi) Facilities shall be provided for operation of the starter in the 'test' position.
- (vii) Fuses shall be fitted with striker pins. An associated tripping mechanism shall ensure the de-energization of the vacuum contactor on the operation of any fuse.

- (viii) Contactors shall be rated for utilisation category, AC4 and duty Class 0.3. Surge suppressors shall be fitted when recommended by the motor manufacturer. However, as a general rule they shall be fitted when motors are less than 600 kW.
- (ix) The motor current ammeter physical size shall be in keeping with the size of the starter and shall have an adjustable and sealable red pointer to indicate full load current.
- (x) The control transformer shall be double wound, single phase. The windings shall be encapsulated with an earthed metal screen between the windings. The motor protection relay shall be solid state and provide protection for:
  - (xi) The relay shall be of the self-supervisory type with continuous monitoring of hardware and software.
  - (xii) The relay shall be hand resettable and give clear indication of the reason for operation.
  - (xiii) Where specified starters shall be provided with power factor connection capacitors to raise the power factor to 0.95 lagging when operating at the duty point.
  - (xiv) The starter cable box shall provide provision for the connection of a power factor correction capacitor supply cable such that the capacitor current does not pass through the motor protection relay.
  - (xv) Provision shall be made to supply a motor anti-condensation heater from each motor starter. The heater shall be energised via the cubicle isolator and controlled by a normally closed auxiliary contact on the main contactor. The heater circuit shall be protected by an internal circuit breaker.

## 1605 Circuit Breakers

### (a) High Voltage Circuit Breakers

- (i) Circuit breakers shall be vacuum or SF6 type as specified. The equipment shall comply with the latest Standards as appropriate and be fully rated for the ambient conditions specified.
- (ii) Circuit breakers shall be capable of clearing any fault condition which may occur on the system without damage to equipment or personnel.
- (iii) Circuit breakers of the same pattern and rating shall be interchangeable.
- (iv) Vacuum circuit breakers shall comprise separate vacuum interrupters designed to prevent welding of contacts and sharp current chopping during fault interruption or switching or motor loads.
- (v) All circuit breakers shall be provided with operating mechanisms as detailed in the specification, the selection being from the following types:
  - 1) independent manual spring;
  - 2) hand charged spring with electrical or manual release;
  - 3) motor charged spring with electrical release;
- (vi) All operating mechanisms shall have mechanical 'ON' and 'OFF' indicators and a manual trip device fitted with means for locking. Hand charged and motor charged spring mechanisms shall have mechanical indicators to show 'SPRINGS CHARGED' and 'SPRINGS DISCHARGED'.
- (vii) The operating mechanisms of hand charged and motor charged spring types shall be arranged so that release of the springs to close the circuit breaker can only be achieved by a deliberate action. It shall not be possible for vibration or mechanical shocks to release the charged springs. Motor charged spring

mechanisms shall be arranged to that charging is initiated automatically following a discharge. The necessary limit stops and switches for the automatic control of the charging shall form an integral part of the mechanism. The facility shall be provided to hand charge a motor charged spring mechanism.

- (viii) Spring operated mechanisms shall be provided with volt-free contacts to give indication that the springs are charged.
- (ix) To facilitate maintenance and the adjustment of contacts, it shall be possible to 'slow-close' the circuit breaker but this operation shall only be possible in the fully withdrawn position. Any operating handle or lever necessary shall be supplied.
- (x) All circuit breakers shall be provided with interlocks to ensure that:
  - 1) The circuit breaker cannot be racked into or out of the service or earth position whilst it is closed. Attempts to rack out a closed circuit breaker shall not cause it to trip;
  - 2) The circuit breaker can only be closed when fully engaged in the service, earth, or fully isolated positions;
  - 3) The circuit breaker cannot be closed in the service position without completing the auxiliary circuits between the fixed and moving portions;
  - 4) The circuit breaker cannot be 'slow-closed' except in the fully isolated position;
  - 5) With hand charged or motor charged spring mechanisms, the springs cannot be discharged until they have been fully charged or until the means for charging has been fully removed and disconnected;
  - 6) When the circuit breaker is closed in the earth position, tripping can be effected only by the manual device on the operating mechanism;
  - 7) Where mechanical key interlocking is employed, tripping of a closed circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism.
- (xi) Circuit and/or busbar earthing shall be by the transfer circuit-breaker method without the requirements of any loose attachments. The earthing operation shall be completed by the closing of the circuit breaker by its normal operating means using local control. Selection of either circuit or busbar earthing shall be possible only after the circuit breaker has been fully isolated. Mechanical key interlocks shall remain operative when the circuit breaker is in either earthing position.
- (xii) Facilities shall be provided on all incoming and feeder circuit breakers for earthing the circuit side. On at least one circuit breaker panel in any section of busbars, facilities shall be provided for busbar earthing.
- (xiii) A set of safety shutters shall be provided to cover each three phase group of stationary isolating contacts. The shutters shall be opened automatically by a positive drive from the circuit breaker moving portion and when closed shall prevent access to the stationary isolating contacts. When the circuit breaker is withdrawn each set shall be capable of being individually operated and of being padlocked in the closed position.

- (xiv) Shutters in bus-section units shall be coloured red and shall be labelled with a large white arrow pointing in the direction of the section of busbars to which the contacts are connected.
- (xv) Circuit breaker moving portions shall be fitted with positive guides to ensure correct alignment of the isolating contacts in both the service and the earth positions.

**(b) Low Voltage Circuit Breakers**

- (i) All 415V circuit breakers for incoming circuits, and bus section circuits on 415V switchboards and interconnector circuits shall be of the air break metal clad type complying with the requirements of the latest Standards.
- (ii) Circuit breakers shall switch three phase poles. The neutral pole shall either be switched or established through a bolted link. Access to the link shall not be possible when the equipment is in the "Service Position".
- (iii) Provision shall be made for easy access to the circuit breaker contacts for maintenance purposes.
- (iv) Arc chutes shall be so arranged that the emission of hot gasses shall not damage any part of the equipment.

**(c) Moulded Case Circuit Breakers**

- (i) Moulded case circuit breakers (MCCBs) shall be manufactured to the latest Standards.
- (ii) MCCBs shall have thermal overload and adjustable magnetic short circuit tripping devices with a trip-free mechanism to ensure that the contacts cannot be held closed against a fault. Contacts shall be silver tungsten tipped and shall operate with a wiping, arc resisting material and incorporate arc chutes based on the de-ionising principle.
- (iii) MCCBs shall have a factory calibrated and sealed trip unit, interchangeable with similar units for varying the rating of the circuit breaker.
- (iv) Where dust and damp proof enclosures are to be used, then the circuit breakers shall be fully enclosed in a case with a gasketed door. Circuit breakers mounted in a composite control panel shall be segregated from other equipment and have a matching purpose-made cover plate. Where possible, circuit breakers shall be mounted vertically and be arranged so that one breaker can be removed without interfering with other circuit breakers. The switch dolly and protruding face shall be engraved with the circuit rating and the ON and OFF positions.
- (v) Tripping due to overload or short-circuit shall be clearly indicated by the handle automatically assuming a position midway between the manual ON and OFF positions. To reset from the 'tripped' position, the dolly shall first pass through the OFF position. All phase poles shall operate simultaneously.
- (vi) MCCB's used for short circuit protection (only) in motor starters shall provide instantaneous short circuit protection by means of an adjustable magnetic element on each pole. The adjustment knob(s) shall have the end and mid-setting points marked and adjustment shall follow a linear scale so that each point has a significant value within calibration tolerances. MCCB's shall not be used to provide thermal protection or switching of motors.

- (vii) MCCB's shall be ambient temperature compensated. Compensation shall allow the breaker to carry rated current between 25°C and 50°C with tripping characteristics that are approximately the same throughout this temperature range.

**(d) Miniature Circuit Breakers**

- (i) Miniature circuit breakers (MCBs) shall be manufactured and tested to the latest Standards.
- (ii) MCBs shall have a short circuit rating of at least M4 and shall be Type 3 with a breaking capacity of 4.5 kA at 220/380 V unless otherwise specified.
- (iii) The fault capacity of the MCB shall be not less than that of the switchboard. If this is not the case, back up HRC fuses shall be fitted. MCB's for dc circuits shall provide a double break (one pole protected plus one switched).

**(e) Earth Leakage Circuit Breakers**

- (i) Earth leakage circuit breakers (ELCBs) shall be of the current operated type complete with current balance transformer, test push button, trip coil and thermal overloads. They shall be double pole for single phase and four pole for three phases and neutral circuits. ELCBs shall comply with the requirements of the latest Standards.
- (ii) The out of balance current shall not exceed 30 mA for circuit breakers up to 60 amp rating and 500 mA for above this rating.
- (iii) Current operated ELCBs shall not be used where the product of the operating current and the earth loop impedance exceeds 40.

**1606 Fused-Switches and Disconnecter Combination Devices**

**(a) General**

- (i) Fused switch disconnectors, switch-disconnectors and disconnectors, shall be rated at 500 V and shall be to the latest Standards.
- (ii) Fuse switch disconnectors shall be of the air break triple pole or single pole and neutral type. They shall have not more than one fuse in any one pole. The neutral shall be either switched or taken through a removable link. If a switched neutral is required, the neutral shall be arranged to make first and break. A separate brass earth terminal shall be provided.
- (iii) Operating mechanisms shall be of the independent spring type and fitted with mechanical ON and OFF indicators. Operating handles shall be of semi-flush or telescopic pattern to reduce front projection to a minimum.
- (iv) Disconnectors shall be identical to fuse-switches but the fuse links shall be replaced by hard drawn high conductivity copper links.
- (v) Facilities for locking the operating handles by padlock shall be provided.
- (vi) All switch-disconnectors shall be rated to make the full short circuit current of the system. Units used on distribution circuits shall be rated to break full load current and units used in motor starters shall be rated to break stalled motor current.

**(b) Fuses and Links**

- (i) Fuses shall comply with the latest Standards as appropriate.
- (ii) Fuses and links shall be provided to enable any circuit to be isolated as necessary for maintenance and test purposes without isolating the whole panel. All fuses shall be of the cartridge type. Fuse carriers and solid link carriers and bases shall be made of plastic moulded insulating materials; ceramic materials shall not be accepted. Accessible live connections shall be effectively shrouded and it shall be possible to change fuses and remove links with the circuit alive without danger of contact with live metal. The fuses shall be rated to give maximum protection to the apparatus in circuit and the rating shall be inscribed on the fuse label.
- (iii) Earthing and neutral links in main supply circuits shall be solid copper bolted pattern.
- (iv) Fuses and links functionally associated with the same circuit shall be mounted side by side.

**(c) Circuit Protective Conductors**

An independent Circuit Protective Conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

- a separate core within a multicore cable;
- a separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor;
- the metal sheath of an armoured cable. The sheath shall be bonded to the metalwork of the apparatus and to the apparatus earth bar if any;
- the copper sheath of a mineral insulated copper sheathed cable;
- an independent insulated copper conductor run adjacent to the circuit it protects.

Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e. motors in excess of 75 kW shall form a separate core of a multicore cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.

The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

Where the cable armouring or sheath is used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

## 1607 Distribution

### (a) Local Control Stations

- (i) Local control stations shall be of heavy duty construction and where appropriate, constructed in accordance with safety and general construction equipment with the Clause entitled 'Switchboard, Cubicle and Enclosure Construction'. Local control stations shall be mounted directly onto the plant to be controlled, or be provided with a floor mounting tubular pedestal with provisions to accommodate the incoming cables.
- (ii) Small covers shall be secured by screws or bolts and be totally removable. In larger sizes and where instruments are to be fitted, the covers shall be provided with heavy duty hinges.
- (iii) The bottom face shall be arranged to accept, with adequate space for the use of spanners, gland terminations for the number of cables required.
- (iv) Terminals shall be provided for interconnections arranged vertically at the side for easy access, and marked with identification numbers/letters corresponding with the associated diagrams.
- (v) Pendant type local control stations for cranes, hoists, etc. shall be of moulded neoprene or equivalent heavy, flexible, high impact strength materials. The station shall be connected by a long moulded-in cable strengthening sleeve, to minimise the possibility of cable fracture at the bending point. The enclosure shall be self-coloured in safety yellow.

### (b) Marshalling Boxes

Marshalling boxes shall be constructed of sheet steel with ample space for routing and terminating cables and cores.

Enclosure protection shall be the same as that for switchboards i.e.

- Outdoor IP65
- Indoor IP54

Every marshalling box shall be provided with the following:

- undrilled gland plate arranged for bottom entry;
- anti-condensation heater with thermostat and fuse;
- padlocking facility and padlock;
- earthing bar with terminal holes;
- door-switch operated internal light with fuse;
- labels for front door, fuses, terminal blocks, and terminals;
- transparent plastic covers on terminal blocks operating at greater than 24V;

## 1608 Power Transformers

### (a) General

- (i) Transformers shall be sized for continuous operation at the maximum rating at the ambient conditions specified.
- (ii) The transformer load factor shall be taken as 80% for normal operation.
- (iii) The core construction shall be built up of on-aging, low loss and high permeability, cold rolled, grain oriented silicon steel. Lifting eyes or lugs shall be provided for removal of the core assembly.
- (iv) The cores shall be earthed at one point only with a readily accessible removable connection which may be conveniently opened to check the core insulation.
- (v) The windings shall be double wound connection Dy11.
- (vi) Transformers shall be supplied complete with oil level indicator with drain cock, sample cock, oil change valves, jacking pads, pulling lugs, Buchholz relay, thermometer pocket with thermometer, and earthing terminal.
- (vii) Transformers rated above 150 kVA shall be fitted with separate oil and winding temperature gauges.
- (viii) Transformers rated above 250 kVA shall be provided with offload tap changers manually operated by a lockable wheel or handle. The tappings shall be provided on the HV windings at +22% and 5% of the no load primary voltage.
- (ix) Cable boxes with wiping or screwed glands shall be provided for the cables specified. A non-magnetic gland plate shall be fitted for single core cables and insulated glands provided for 400 mm<sup>2</sup> cables and above. It shall be possible to remove the cable boxes without breaking the cable seal or draining the oil. Disconnecting link boxes shall be fitted on the high and low voltage sides of the transformer for cable pressure testing.

**(b) Insulators and Bushings**

- (i) Porcelain insulators and bushings shall comply with the requirements of the latest Standard as appropriate.
- (ii) Porcelain for insulating purposes shall comply with the requirements of the latest Standards. Each porcelain insulator shall bear the manufacturer's mark and batch identification, which shall be applied before firing. The clamping surfaces of all porcelain insulators shall be accurately ground and shall be free of glaze.

**(c) Insulating Oil**

- (i) Insulating oil shall comply with the requirements of the latest Standards. Insulating oil shall be provided by the Contractor for all oil-filled apparatus and 10% excess shall be provided for topping up purposes in sealed drums.
- (ii) If equipment is to be filled with oil at Site, the Contractor shall provide oil for filtration equipment of suitable capacity.
- (iii) The Contractor shall supply a schedule of insulating oils and greases which the Contractor recommends for use with his equipment.

**1609 Earthing**

**(a) General**

- (i) Earthing systems shall comply with the latest Code of Practice and IEE Wiring Regulations (16th Edition).

- (ii) The metalwork of all items of electrical plant, electrical system neutral points, power and control cable armouring and screens, and extraneous metalwork including structural steelwork, pipework, fences and gates, shall be connected to the earthing installation.
- (iii) Earth continuity in non-electrical plant shall normally be achieved via metal to metal faces, pipe flanges, metal hinges, and metal fixings. Earth straps to bond pipework sections shall be supplied where earth resistance is high or there is risk of corrosion or similar which could in the future increase resistance and affect earth continuity.
- (iv) Perimeter fences shall be either bonded to the earthing system. Metal gates shall be bonded to the fence using flexible connections.

**(b) Installation**

- (i) The earthing installation shall comprise an earth terminal, earth busbars, circuit earthing conductors, equipotential bonding conductors, main earthing conductor and earth electrodes. The circuit earthing and equipotential bonding conductors shall be of the radial, grid or ring form as dictated by the plant lay out.
- (ii) The earthing installation shall be protected from mechanical damage and corrosion.
- (iii) Joints in tape conductors shall be riveted and soldered, brazed, clamped, bolted or exothermically welded. Non-corrosive flux shall be used for soldered joints. Clamped and bolted type joints shall be tinned and shall only be used above ground.
- (iv) The interconnection of conductors below ground shall be by means of exothermic welding or brazing. Compression type lugs shall be provided for the termination of cables.
- (v) Earthing conductors shall be buried directly in the ground or secured to building structures, cable racks and trays using proprietary fixings.
- (vi) Where the soil is aggressive to copper, buried earthing conductors and joints shall be protected by an approved serving.
- (vii) An equipotential bond shall be provided to all buried metal pipework at the point of entry into a building or chamber where electrical apparatus is installed. Electrical continuity across all pipe joints within the structure shall be ensured. Normally the connection of the pipe flanges shall suffice, but where pipework incorporates a compression coupling (e.g. Viking-Johnson coupling), a bond shall be provided to any otherwise isolated section.
- (viii) Cable armouring and screens shall be bonded to earth at both ends unless otherwise specified. Cable armour shall not be used as the sole earth protective conductor.

**(c) Conductors**

- (i) Circuit and main earthing and equipotential bonding conductors shall be high conductivity copper tape or 1000 V grade PVC insulated multi-stranded cable. PVC cable insulation shall be striped green/yellow. Cable lengths shall be continuous and intermediate jointing is not permitted.
- (ii) The main bonding conductor shall be not less than 16mm<sup>2</sup> and supplementary bonding of non-electrical plant not less than 10 mm<sup>2</sup>. All connections shall be made

using compression type cable lugs, taped on completion to completely seal the lug and any bare copper from the atmosphere.

- (iii) The surface to which earthing bonds are fixed shall be cleaned free from paint and other non-conducting material and coated with petroleum jelly.

#### **(d) Earth Electrodes**

- (i) Earth electrodes where used shall be solid copper or copper clad high tensile steel rods with a copper plate thickness of not less than 0.25mm. The outer diameter shall be not less than 16mm. The rod shall penetrate a minimum of one metre below ground level. Where multiple rods are used they shall be separated by a distance of not less than the driven length.
- (ii) Earth rods shall have hardened tips and caps and be extendable.
- (iii) Where soil conditions make the use of rod type electrodes impracticable a grid configuration may be used comprising horizontally buried bare high conductivity copper tape of dimensions 15mm x 4mm minimum. Tape shall be buried at a minimum depth of 600mm.
- (iv) Each earth rod shall be provided with a clamp fabricated from non-ferrous metal for the connection of the earthing conductor. The connection shall be made in a concrete inspection chamber set flush with the finished ground level. The inspection chamber shall be permanently marked "ELECTRICAL EARTH".
- (v) Marker posts and plates shall be provided to mark the position of the electrodes and buried connections. The markers shall be similar to those provided for cable routes.

#### **(e) Main Earth Bar**

- (i) Where specified, a main earth bar shall be installed in a convenient location. This shall comprise a high conductivity copper bar of sectional area at least that of the main earthing conductor. The earth bar shall be wall mounted, supported on insulators. The earth bar shall be complete with disconnecting links for test purposes, and connection points for the outgoing and incoming earth cables and tapes.
- (ii) Earth studs shall have a minimum size of M8.

#### **(f) Main Earth Terminal**

- (i) A main earth terminal shall be installed in an approved location adjacent to the incoming supply to a building. This shall be labelled and comprise a 50 mm x 6 mm minimum cross section copper bar supported on porcelain barrel type insulators and wall mounted.
- (ii) The bar shall be of sufficient length to accommodate bolted earth bonding connections from transformers, major items of plant and electrical switchgear, building structural steelwork, concrete reinforcement, the earth electrode system and the lightning protection system.
- (iii) The earthing conductor shall be clearly marked as such and shall be accessible for disconnection to facilitate testing of the earth electrode system.

(iv) For small installations an earthing terminal comprising a single brass stud of 12 mm minimum diameter shall be acceptable with the approval of the Supervisor's Representative.

**(g) Tests at Site**

(i) On completion of the earthing installation the Contractor shall measure the resistance of each electrode installation and of each complete earthing system to the general body of the ground. All other tests stipulated in the Reference Standards, shall also be carried out.

(ii) The resistance to earth of each complete earthing network shall not exceed one ohm.

**1610 Neutral Earthing Resistors (Transformers and Generators)**

**(a) General**

The resistors shall comply with the relevant parts of the latest Standards and shall be formed from continuous grids or strips of chrome aluminium steel or equivalent material.

**(b) Material Temperature**

The material shall have a temperature coefficient of less than 1.2% increase in resistance per 100°C rise over the operating temperature range, a high resilience against breakage and be free from any flaw likely to cause local overheating. The resistors shall be assembled into standard units having an inherent inductance of less than 10 degrees phase shift between current and voltage when operating on a 50 Hz supply.

**(c) Temperature Switch**

A temperature switch shall be provided within the resistor enclosure to detect uncleared earth faults or faults within the resistor.

**(d) Interconnections**

Interconnections between tiers shall be of plated copper connectors bolted to stainless steel terminals.

**(e) Resistance**

(i) The resistance units shall be clamped securely in tiers by mica insulated bolts so as to prevent loops or grids coming into contact due to short-circuit forces. The resistance tiers shall be mounted in a box formation between pressed steel and frames, adequate allowance being made for any thermal expansion.

(ii) The resistance units shall be mounted in drip proof enclosures with protective classification of IP23. All protective and supporting steelwork shall be plated with zinc.

**(f) Terminals**

Terminals shall be provided for the connection of external cables and these shall support the cables or interconnecting copper work firmly holding them well clear of other parts. Cables shall not be run above hot resistance material.

**(g) Air Break Isolators**

An air break isolator and a current transformer of suitable rating shall be provided for mounting in the same enclosure with each neutral earthing resistor.

**1611 Lighting Protection**

- (a)** Where buildings or sections of the plant are to be protected against lightning or static charges, an earthing system shall be provided. The installations shall be carried out in accordance with the latest Standard.
- (b)** The down connectors shall be of hard drawn high conductivity copper of 25mm x 3mm section. The tape shall be fixed to the outside of the structure by means of stand-off saddles. Where indicated, connections shall be made to the concrete reinforcing. The route of the tapes and the fixings shall be approved by the Supervisor's Representative before installation.
- (c)** Where the conductors specified shall be PVC insulated to prevent corrosion and to blend with the building fabric.
- (d)** A test link shall be installed in each down conductor adjacent to the earth rod at a height of 1200 mm above ground level. The overall resistance of the earth termination system to earth shall not exceed 10 ohms. If this requirement is not met the number of earth electrodes shall be increased or they shall be interconnected until a value of 10  $\Omega$  is attained. After this resistance value is obtained, the lightning protection system shall be bonded to the main earthing system.
- (e)** Earth rods and connection chambers provided for the lightning protection system shall be in accordance with the requirements of rods for the earthing system.

**1612 Cables and wires**

**(a) General**

- (i)** Cables and wires shall be supplied by an approved manufacturer and where possible the same manufacturer shall be used for all cables and wires. Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, rating of cable, result and date of tests. Cables manufactured more than 12 months before delivery shall not be accepted.
- (ii)** All cables shall be delivered with cable ends effectively sealed. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.
- (iii)** Cables and wires shall be adequately rated for current carrying capacity under normal and short time fault conditions at the specified voltage.

- (iv) The Contractor shall ensure that cable and wires associated with the power distribution and control systems throughout the Works are adequately rated for their use. When assessing the rating and cross section of any cable or wire, the following factors shall be taken into account:
- 1) Maximum voltage drop permissible;
  - 2) Type and magnitude of load;
  - 3) Fault level and duration related to circuit protection relays and fuses;
  - 4) Overcurrent setting of relays;
  - 5) Route length and disposition of cables;
  - 6) Ambient temperature;
  - 7) Method of laying;
- (v) The design current of any circuit shall exceed the full load current of the supplied device by at least 10%. The voltage drop for any circuit from origin of the installation (i.e. supply authority's terminals) and the load under steady state conditions shall not exceed 4% of the nominal voltage. Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energization.
- (vi) The Contractor shall submit cable schedules for approval detailing ratings, sizes, lengths, method of installation and function of all individual cables.

**(b) Cable Types**

- (i) Cables complying with BS, IEC, or approved equivalent standards shall be accepted provided that all cables which are supplied for a specific operating voltage are to the same national standard. Each cable shall be in accordance with a standard which relates to its application.
- (ii) Standards specified in the following clauses indicate the type of cables which may be used in the design. If the Contractor wishes to use cables to an alternative standard then details of current carrying capacity, derating factors, etc, shall be submitted to the Supervisor's Representative for approval.
- High Voltage Power  
XLPE/SWA/PVC - semi-conducting conductor screen, cross linked polyethylene insulation, stranded copper conductors, core screen of semi-conducting compound, semi-conducting tape, and metallic layer, extruded PVC bedding, galvanised steel wire armoured, flame retardant red PVC sheathed overall, suitable for use on an earthed system of the voltage specified. Cables shall comply with the latest Standards.
  - Medium/Low Voltage Power Cables  
XLPE/SWA/PVC - cross linked low density, polyethylene insulated, stranded copper conductors, extruded PVC bedding, galvanised steel wire armoured, flame retardant black PVC sheathed overall, suitable for use on an earthed system at a rated voltage of 0.6/1kV or 1.9/3.3kV as specified. Conductor

temperature shall not exceed 90°C for continuous operation and 250°C for short circuit. Cables shall comply with the latest Standards.

PVC/SWA/PVC - PVC insulated, extruded PVC bedding, galvanised steel wire armoured, flame retardant black PVC sheathed overall, stranded copper conductors suitable for operation on a system at a rated voltage of 0.6/1kV. Conductor temperature shall not exceed 70°C for continuous operation. Cables shall comply with the latest Standards.

PVC/PVC - PVC insulated, extruded PVC bedding, flame retardant PVC sheathed overall, stranded copper conductors suitable for operation on a system at a rated voltage of 0.6/1kV. Maximum conductor temperature shall not exceed 70°C. Cables shall comply with the latest Standards.

PVC - PVC insulated single core copper conductor rated at 450/750 V. Insulation shall be phase coloured. Conductor temperature shall not exceed 70°C for continuous operation. Cables shall comply with the latest Standards.

Copper conductors shall be used throughout. Cores of cross-sectional area greater than 1.5 mm<sup>2</sup> shall be stranded. Lighting wiring shall be of a minimum cross-section of 1.5 mm<sup>2</sup>. Small power and control cables shall be of a minimum cross-section of 1.5 mm<sup>2</sup>.

- Flexible Cables and Cords

General purpose-PVC insulated stranded copper conductors white PVC sheathed overall, rated at 300/500 V in accordance with the latest Standards.

- Analogue signal cables

Cables shall be PVC or polyethylene insulated, twisted pair laid with individual or collective screen, tape bound with extruded PVC bedding, galvanised steel wire armouring and overall PVC sheath. Conductors shall be multistrand copper, 24/0.2 mm (0.75 mm<sup>2</sup>) or as specified. Solid cores shall not be permitted. The cables shall be rated at 300/500 V and shall comply with the latest Standards.

Cables with a collective screen only are permitted for use where the signal is a high level carrier (e.g. 4-20 mA dc) and the route length is not greater than 30 m. Where the route length exceeds 30 m or the signal is low level (e.g. from a strain gauge) cables shall have both individual and collective screens.

- Digital signal and control cables

Where the signal is based on a supply not greater than 24 V dc and the maximum ON-state loop current does not exceed 20 mA, then analogue type cables shall be used. Where the voltage and/or current exceeds these limits the cables shall comply with one of the following specifications:

- PVC/SWA/PVC - PVC insulated, extruded PVC bedding, galvanised steel Wire armoured, flame retardant black PVC sheathed overall, stranded copper conductors suitable for operation on a system at a rated voltage of 0.6/1kV. Conductor temperature shall not exceed 70°C for continuous operation. Cables shall comply with the latest Standards.
- PVC/PVC - PVC insulated, extruded PVC bedding, flame retardant PVC sheathed overall, stranded copper conductors suitable for operation on a system at a rated voltage of 0.6/1kV. Conductor temperature shall not exceed 70°C for continuous operation. Cables shall comply with the latest Standards. Internal wiring of control panels shall be of a minimum cross-section of 1.0 mm<sup>2</sup>, flexible and stranded.

Instrumentation and control cabling shall be of a minimum cross-section 1.5 mm<sup>2</sup> for outdoor use and 1.0 mm<sup>2</sup> for indoor use.

### **(c) Cable Labelling**

- (i) At each end of each cable, in a uniform and visible position a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of PVC, brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corroding binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.
- (ii) Three phase power cable cores shall be identified A, B, C or colour coded red, yellow, blue so that the correct three phase sequence is preserved throughout the system. Single phase power cable cores shall be colour coded red, black.
- (iii) Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends.
- (iv) Each cable and core shall bear the same number at both ends of the cable and core respectively.
- (v) Terminals shall bear permanent identification as follows:
  - 1) Power terminations -colour, number or letter
  - 2) Control terminations -letter or number or both

### **(d) Cable Installation**

#### **(i) General**

- 1) Non-sheathed single insulated wire shall only be installed in galvanised steel conduit or trunking.
- 2) Cables with sheaths but without any form of armouring shall only be installed in protected indoor locations such as floor ducts, conduits, or covered cables trays and ladders.

- 3) Cables with underground quality PVC sheaths and steel wire armouring may be installed in all locations including being direct buried in the ground, pulled into underground ducts or clipped direct to a surface or uncovered cable tray.
- 4) Single core cables shall not be used unless absolutely necessary (e.g. feeder cables from transformers to switchboards). Where the installation method requires armouring this shall be of the non-magnetic type formed from hard drawn aluminium strip or wire. No single core cables shall be direct buried in the ground.
- 5) Where cables are run together in the same tray, trench or conduit they shall be suitably de-rated or spaced to maintain current rating. Crossovers shall be avoided where possible. Large power cables (e.g. those carrying in excess of 50 A), and signal cables shall be run separately to minimise interference.
- 6) Where a number of cables are terminated in equipment, they shall finally approach the equipment from a common direction. Top and bottom entry methods shall not be mixed in the same panel.
- 7) Cables shall be complete with all saddles, cleats, hangers, brackets, trays, ladders, ties, nuts, bolts, screws, washers, packing, ducts, sand, concrete covers, marker tape and route marker posts as may be necessary to complete the installation.
- 8) Marker tape shall be placed in the ground above cables laid underground either direct buried or in ducts. The tape shall be 150 mm wide, yellow with black printing "DANGER-ELECTRIC CABLES".
- 9) All cables of less than a complete drum length shall be installed without joints except where approved by the Supervisor's Representative.
- 10) Unless unavoidable, cables shall not be installed in areas of direct sunlight. Where it is necessary, sunshields constructed to the approval of the Supervisor's Representative shall be supplied and installed.
- 11) Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.
- 12) Cables grouped together shall have an insulation capable of withstanding the highest voltage present in the group.
- 13) Cables shall be laid in a manner such that any electrical interference between cables have no detrimental effect on the life and operation of equipment installed within the installation. As a general rule the following minimum clearances shall be adhered to where ever practical:
  - a. There shall be a minimum separation of 600 mm between HV power and all other cables and 300 mm between all other categories. These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.
  - b. Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation of 150 mm shall be maintained between power and non-power cables when run on the same support system.

- c. In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.
- d. In order to make the most economic use of cable ladder/tray and duct capacity, multicore cabling shall be utilised in order to connect instrumentation groups by using suitably located sub-distribution junction boxes. The junction boxes shall be suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labelled junction boxes shall be constructed of steel or GRP and provide degree of protection IP 55.
- e. Separate cables shall be used for digital and analogue signals at all times.

14) Digital and analogue signals shall be segregated within junction boxes.

**(e) Submissions by the Contractor**

(i) Submissions which the Contractor is required to make in relation to the cable installation shall include, where relevant, the following:

- Drawings and Schedules;
- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings

(ii) For those items which are underground these drawings shall include the following:

- Route plans for all cables, cable ducts, and cable trenches;
- Sectional views of all cable ducts, trenches etc. for each different section throughout the route;
- The position of all marker posts, joints, draw pits etc.

(iii) Route plans and section views for all cable trays and cable runs.

(iv) Cable schedules, which shall detail the cable number, type, voltage, size, route, length, and number of cores. Control cable schedules shall detail the connected and spare core numbers, diagram numbers of connected equipment, core ferrule and terminal reference numbers.

**(f) Data and Calculations**

(i) Manufacturers catalogues and data sheets for all cables and fittings.

(ii) Cable sizing calculations

(iii) Test certificates for all witnessed and routine tests carried out at the manufacturer's works and at site.

**(g) Installation Direct in the Ground**

(i) Power cables of rated voltage up to 1000 V shall be buried at a depth of 500 mm to the cable centre.

- (ii) Power cables of rated voltage above 1000 V up to and including 12 kV shall be buried at a depth of 1000 mm to the cable centre. The depth of laying shall only be varied due to the presence of other cables or services. The laying of cables at excessive depth shall not be accepted. Unless unavoidable, cables shall not be routed below pipes.
- (iii) On cross roads the cable shall be run through a uPVC duct as specified hereafter.
- (iv) The bottom of excavated trenches shall be free of sharp stones and other obstacles and shall be covered with sand or fine sifted soil compacted to a depth of 50mm.
- (v) Cables shall be unrolled from the drums in such a manner as to avoid loops and kinks, and care shall be taken when laying or pulling into ducts to avoid damage to the outer sheath by drawing over sharp obstacles, edges, or stones. Cables pulled in either by machine or by hand shall be pulled in using rollers to prevent contact between the cable and the ground.
- (vi) Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. Trenches shall be provided with a layer of 75mm of sifted soil before laying of the cable. After laying, cables shall be covered to a minimum depth of 75mm of compacted sand or sifted soil and shall have a layer of protective concrete cable tiles laid above. The tiles shall overlap the cables at both sides with minimal 50mm
- (vii) Where cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.
- (viii) Control, instrumentation and communication cables shall be laid not closer than 1000 mm to high voltage cables.

**(h) Installation in Underground Ducts**

- (i) Underground ducts shall be constructed of impact resistant uPVC and shall be laid at a minimum depth of 500 mm (to the duct centre). The duct shall be surrounded by not less than 75 mm of sieved sand on all sides. At road crossings, uPVC ducts of minimum diameter 100 mm shall be laid at a minimum depth of 1000 mm (to the duct centre). The duct shall be surrounded by not less than 150 mm of concrete on all sides.
- (ii) When installing cables in ducts the following measures shall be observed:
  - cables shall be pulled in a straight line;
  - rollers shall be positioned at the ends of the ducts both at the drawing in and drawing out points over which the cables are to be drawn;
  - uPVC ducts and cables sheaths shall be coated with an approved lubricant;
  - the maximum distance between draw-pits shall be the guaranteed minimum length of cable on each drum, making allowance for jointing;
  - adequate space shall be allowed in each draw-pit for the installation and jointing of cables;
  - the pulling rope shall be guided by rollers;

- only one large cable shall be drawn into each duct;
- Where more than one small cable is to be pulled into the duct, all cables shall be pulled in simultaneously.
- Whenever a duct is laid in the ground, a draw wire or man-made fibre rope shall be pulled in and at least 1000 mm excess length shall be left at each end.

**(i) Sealing Cable Entries into Buildings**

Where cables pass in or out of duct entries into or within buildings, these entries together with any spare ducts shall be effectively sealed against the ingress of moisture. The sealing method shall have a fire resistance of not less than 30 minutes.

**(j) Marking of Underground Cables**

**(i)** The location of all underground cables shall be identified by:

- engraved plates fixed to the exterior surface of the walls of buildings 300 mm above ground level, directly above the point where cables pass through the wall;
- marker posts on road verges, etc. at intervals of not more than 100 m and at all junctions and changes of direction along the route;
- marker posts at 10 m intervals within an enclosed site and at all junctions and changes of direction along the route.

**(ii)** Marker posts shall be of concrete, not less than 200 mm high and shall have an enamelled metal plate affixed giving the details of the cable the below including the depth and voltage rating. A drawing or sample of a typical marker post shall be submitted to the Supervisor's Representative for approval.

**(k) Installation in Cable Trunking**

**(i)** Cable trunking shall be manufactured from hot dipped galvanised mild steel of thickness not less than 1.25 mm. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge steel. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking. Retaining straps shall be fitted to hold cables within the trunking when the cover is removed. Barriers formed from continuous sheet steel with the bottom edge welded to the trunking shall be installed where it is necessary to segregate cables.

**(ii)** The size of the trunking shall be adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50 mm x 50 mm.

**(iii)** Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

**(iv)** Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors.

- (v) Conduit connections to trunking shall be made by flanged couplers and internal brass bushes.
- (vi) Trunking shall be supported at intervals not greater than 2 m horizontally or 2.5 m vertically.
- (vii) Crossings over expansion joints shall be made in flexible conduit.
- (viii) Whenever trunking is cut or drilled the bared sections shall immediately be given a coat of zinc rich cold galvanising paint.
- (ix) Cable and trunking runs shall be determined by the Contractor and agreed by the Supervisor's Representative before any work is started. A clearance of not less than 150 mm shall be maintained between the trunking and plumbing or mechanical services.
- (x) Trunking systems erected outside a building shall be weatherproof.

**(l) Installation in Troughs and Trenches**

- (i) Where the building structure incorporates purpose built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables shall be segregated and installed on cable trays or ladders fixed to the walls of the trench.
- (ii) Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on cable tray or ladder fixed to the trench walls. Crossovers shall be kept to a minimum and cabling shall be taking above wet service pipework.

**(m) Cable Tray and Ladder**

- (i) Cable trays and ladders shall be of hot dip galvanised perforated steel or PVC coated of thickness not less than 1 mm for trays up to 100 mm width, not less than 1.25 mm for trays from 100 mm to 150 mm width, and not less than 1.5 mm for trays from 150mm to 300mm width. Cable tray and supports shall be manufactured in accordance with the latest Standards.
- (ii) Cable tray and ladder supports shall be of ample strength to maintain rigid support to the fully laden cable tray along its entire length. All brackets and tray work shall be suitable for withstanding the normal weight of the cables fixed to it together with a temporary weight of 125 kg.
- (iii) Wherever possible, cable trays shall be installed in full lengths without cutting. Where tray is cut or drilled the bared sections shall be dressed and immediately be given a coat of zinc-rich cold galvanising paint. Similarly for PVC coated trays, the bared sections shall be immediately sprayed using a PVC aerosol.

**(n) Installation in Buildings**

- (i) Cables to be run on walls, ceilings, or other structures shall be supported on tray or ladder racks, or enclosed in conduit or trunking.
- (ii) All cables shall be neatly run vertically or horizontally parallel to adjacent walls, beams or other structural members.
- (iii) Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They

shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

- (iv) Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.

**(o) Cable Installation in Conduit**

- (i) Conduits shall be either galvanised heavy gauge steel screwed type or light-gauge steel non-screwed type steel. Accessories shall either be malleable cast iron or pressed steel.
- (ii) A space factor of 40% shall not be exceeded, and in any case conduit of less than 20 mm diameter shall not be permitted. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed with all sharp edges removed before erection.
- (iii) Where conduits converge, adapter boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type.
- (iv) Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings may be used.
- (v) Hexagonal lock nuts shall be used at running joints and shall seat firmly and evenly onto mating faces. Lock nuts shall not be used at non-running joints.
- (vi) All junction boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.
- (vii) Generally not more than two bends or offsets or one coupling shall be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.
- (viii) Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.
- (ix) Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150 mm movement shall be allowed.

- **Surface Installation**

Surface conduits shall be secured and fixed by means of distance spacing saddles or clips which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. Runs shall be properly ventilated and allow for drainage of condensation. All surface conduit runs shall be marked out for approval by the Supervisor's Representative before the installation is carried out. Where large multiple parallel conduit runs occur, galvanised trunking may be used instead.

Conduits installed on structural steelwork shall be secured by girder clips, drilled and tapped to the metalwork. Power driven fixings shall be used only with the approval of the Supervisor's Representative. Any drilling or access which is required through any structural member of the building shall be agreed with the Supervisor's Representative before carrying out the work.

Exposed threads and plates where galvanising has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

- Concealed Installation

Concealed conduits shall be securely fixed to prevent movement before laying of screed, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crampets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails shall not be accepted.

At least 15 mm shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted over the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing. Concrete shall be prevented from entering conduit boxes when being poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for surface conduits. Draw-in wires shall not be pulled into the conduits during erection. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

The conduit installation shall be inspected by the Supervisor's Representative before the building operation conceals the work.

- Flexible Conduits

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough type box. The flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the

box and to the piece of equipment. The use of lid facing screws, etc. shall not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

- PVC Conduit

Where galvanised conduit is liable to corrosion, PVC conduit shall be installed. PVC conduit shall be of the oval or round high impact non-flame propagating type as specified and self-extinguishing. Surface and concealed installations shall be generally as described for steel conduit.

PVC conduit fittings shall all be white unless specified otherwise.

Jointing shall be carried out using a PVC solvent and socketed accessories. Expansion couplers shall be fitted in straight surface rings every 12 m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit shall be rejected.

The conduit shall be suitable for use in ambient temperatures of between -5°C and 60°C and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16 mm or less shall be 1.5 mm. For deeper boxes the minimum wall thickness shall be 1.5 mm. For deeper boxes the minimum wall thickness shall be 2 mm. All boxes which are intended to support luminaries or other heat sources shall have either external fixing lugs riveted to the metal fixing inserts or utilise steel insert clips.

- Metal Cable Trunking

Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50 mm x 50 mm minimum size.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining 'quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2 m horizontally or 2.5 m vertically. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanising paint.

Cable and conduit/trunking runs shall be determined by the Contractor and agreed by the Supervisor's Representative before any work is started. The run shall be at least 150 mm clear of plumbing and mechanical services.

Conduit/trunking systems erected outside a building shall be weatherproof.

- Installation of Mineral Insulated Metal Sheathed Cables

Before any length of MIMS cables is installed it shall be tested for insulation resistance and if below the manufacturer's required standard it shall be warmed by a suitable means to expel any moisture. Should this prove ineffective the cable ends shall be cut back until a satisfactory insulation value is obtained. If for any reason a cable has to be left unconnected for a period of time, it shall be adequately supported and the end made off with a dummy pot to prevent mechanical damage and the ingress of moisture.

All terminal ends of the cables shall be sealed to prevent the entry of moisture, and at all terminations pot type seals shall be fitted complete with a PVC shroud. Where the cables terminate at equipment sufficient allowance shall be made in the length of the cable to enable glands with tails to be withdrawn from the equipment without damage to the cable. Where the equipment is subject to vibration, adequate anti-vibration loops shall be left in the cable run.

Combined neoprene sleeving shall be used for the insulation and protection of the cores of the cables from the points at which they leave the seal to the terminals of the equipment served. The sleeving shall be marked with the appropriate cable size and reference.

Where cable glands are exposed to onerous atmospheric conditions and in all instances where they are screwed into aluminium or zinc based alloy fittings, either inside or outside the building, cadmium plated cable glands shall be used.

Care shall be taken to ensure that all seals for MIMS cable are made in an approved manner as laid down by the cable manufacturer. Insulation tests shall be carried out immediately the joint has been made and again 24 hours later. Readings below 200 m Ohms shall not be accepted.

Where MIMS cables pass through concrete, blockwork or brickwork, walls, floors, etc. they shall be suitably protected by a length of conduit throughout the concealed length. MIMS cables shall not be installed directly in concrete, blockwork or brickwork, walls, flooring, etc.

Where a number of MIMS cables are scheduled to be installed in a multiple cable run, the cables shall be fixed to perforated cable tray, by means of single or multi-way copper or aluminium strip saddles complete with two fixing holes and PVC finish.

**(p) Cable Terminations and Joints**

- Power Cable

Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors. Each cable entry into a terminal box shall be made through a suitable gland.

Boxes shall be of adequate proportions to accommodate all cable fittings including stress cones or other means of insulation grading. Boxes shall be open able for inspection without disturbing the gland plate, cable or termination.

Where air insulated terminations are used, the cable crutch shall be protected by a heat-shrink trifurcating sleeve.

Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

Glands for armoured cables shall provide a positive armour clamp to the box or switchgear coating. This clamp shall completely support the cable weight so that no tension is applied to the termination. The clamp shall also provide earth continuity and be of adequate size to withstand the full fault current of the system for one second.

Where single core glands are required, these shall be non-magnetic. The gland plate shall also be of a non-magnetic material. Removable connections for bonding across the gland insulation shall be provided. The gland insulation shall withstand a test of 2 kV ac for one minute.

Glands shall seal the inner and outer cable sheaths against ingress or dirt and moisture and provide mechanical support. All glands shall be provided with an earthing tag.

Where cable glands are exposed to the weather these shall be protected by heat shrink or purpose moulded sleeves covering the gland continuously from the cable sheath to the gland neck.

Where the apparatus enclosure classification requires sealed cable gland entries, sealing shall be achieved by using threaded cable gland holes and polytetrafluoroethylene (PTFE) tape.

- Multicore or Control Cable Terminations

A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

Terminal blocks for terminating up to and including 35mm<sup>2</sup> cable shall securely clamp the conductor, without damage, between two plates by means of a captive screw; pinch screw type terminal blocks shall not be used.

For cables above 35mm<sup>2</sup>, stud or bolted terminals shall be used, each cable core being fitted with a suitable lug.

Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose made solid links shall be incorporated in the design of the terminal blocks.

Terminals which remain energised when the main equipment is isolated shall be suitably screened and labelled.

Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labelled.

Plant which has to be dismantled for maintenance shall have multicore cable terminations made of through glands onto an adaptable box. The box shall have terminal blocks, and connections shall be made to the equipment by single core wires and flexible waterproof plastic conduit. A separate earth core shall link the box to the equipment.

- Joints

Through joints shall only be allowed on long cable runs outside buildings. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint

and inspected by the Supervisor's Representative prior to filling the box with compound. Wrapped pressure type joints shall not be accepted.

Conductor cores shall be jointed number-to-number or colour-to-colour.

### **1613 Small Power and Lighting Installations**

#### **(a) Distribution Boards**

- (i)** Distribution boards shall be of folded sheet steel enclosed construction, braced to form a rigid structure. Doors shall be lockable, hinged and gasketed to give a damp and dustproof enclosure. The degree of protection shall be IP43 (indoors and IP55 (outdoors).
- (ii)** The busbars shall be mounted on non-hygroscopic insulators, completely shrouded or PVC insulated, coloured to denote the appropriate phase. The current rating of the busbars shall be not less than the sum of the maximum current rating of all outgoing circuits. A neutral bar shall be provided with a separate terminal for each circuit.
- (iii)** A separate earth terminal block shall be provided with a separate terminal for each circuit. Distribution boards shall have a fault rating at least that of the system for one second. Removable top and bottom undrilled gland plates shall be provided with a brass earthing stud.
- (iv)** A switch fuse or isolator shall be connected on the incoming side of the board. The device shall be triple pole and neutral with overcurrent protection.
- (v)** Each outgoing circuit including spare ways shall be protected by an HRC fuse or miniature circuit breaker (MCB). HRC fuse bases and carriers shall be of non-hygroscopic insulation.
- (vi)** Barriers shall be fitted over all live parts and spaces between phases. Each distribution board shall have a permanent circuit identification chart mounted on the inside of the front door.
- (vii)** Boards for use on dc systems shall be double pole types with fuses on the incomer.

#### **(b) Bulk Switching Contactors**

- (i)** Bulk switching contactors (e.g. for large lighting or heating loads controlled from a single switch) shall be of the air break electromagnetic type. The contactors shall be continuously rated for the duty specified, shall have an utilisation category AC1, and an intermittent duty class 0.3 with the characteristic mechanical endurance of that class. The current ratings specified shall be eight hour rated duty.
- (ii)** Contactors shall be single or triple pole as required, each type with a neutral terminal. Contactors shall be fitted with a continuously rated operating coil having both terminals brought out.
- (iii)** Enclosures shall be similar to those of distribution boards and shall have a degree of protection not less than IP52.

#### **(c) Socket Outlets**

- (i)** Domestic pattern socket outlets shall comply with the latest Standards. Industrial pattern socket outlets shall comply with the latest Standards.

- (ii) In areas having plaster, tiled or other decorative finish, socket outlets shall be fitted flush with the finished area. In all other areas fittings shall, unless otherwise specified, be surface mounted.

**(d) Lighting Switches**

- (i) Internal lighting switches shall be supplied complete with box, cover plate and fixing screws. They shall be surface mounted metal clad type with aluminium or steel finished box.
- (ii) At multi-switch positions, the switches shall be contained in multi-gang boxes.
- (iii) External lighting switches shall be of the metal clad, galvanised and weatherproof pattern with rotary action. They shall be surface mounted.

**(e) Internal Lighting**

- (i) Lighting shall be complete with all supports, suspensions, flexible cables, pendants and plugs. They shall be connected to the main circuit wiring with heat resisting flexible cables of a minimum core size of 24/0.20 mm.
- (ii) Protective classification shall be IP42.
- (iii) The earthing of all lighting shall be by a separate core in the connecting flex or cable, securely bonding the earth terminal on the fitting to that of the interconnecting cables.
- (iv) Where adjacent lighting are connected to different phases of the supply, a label shall be fitted internally, warning of the presence of the phase-to-phase voltage.
- (v) Lighting shall not transmit load to suspended ceilings unless the ceiling and lighting is of integrated design with the appropriate supports.
- (vi) Where high bay discharge lighting are suspended from the structural ceiling, the connection between the fitting and fixed wiring shall be by plug and socket.
- (vii) Lamp holders for flexible pendants shall be of the all-insulated skirted pattern with cord grips.
- (viii) The fixings, connection boxes and other parts of the lighting shall be erected at times to suit the building programme. The glassware, diffusers, shades, lamps and tubes shall not be fitted until all building work is complete. Fittings shall be left clean inside and outside and ready for use.

**(f) Types of Lighting**

- Fluorescent  
Diffusers shall be of flame retardant extruded acrylic or GRP material. They shall be either opal or prismatic pattern as specified.

A gasket shall be fitted between the diffuser and the body to form an effective seal.

The lighting comply with the latest Standards.

- Incandescent Lights

Recessed down lighter lights shall be constructed from an aluminium alloy reflector and housing with adequate top ventilation holes. An adjustable position, porcelain BS lamp holder shall be incorporated, pre-wired with heat resistant cable. Re-lamping shall be from below only.

Surface incandescent lights shall be of the white opal glass type suitable for wall or ceiling mountings.

- External Lighting

All external lights shall be of the totally enclosed fully weatherproof pattern with vandal-proof polycarbonate diffusers having a minimum degree of protection IP55.

Security lighting systems shall be designed to be inaccessible to intruders. Bulkhead lights shall have a cast aluminium alloy body, polycarbonate diffuser, and gasket and porcelain lamp holder.

- Emergency Lighting

Emergency lighting lights shall be of the self-contained or slave type as specified. The lights shall be fully automatic in operation, providing instant illumination in the event of a mains failure. The battery capacity shall be sufficient to operate all lights connected to the emergency lighting system for a period of 3 hours.

**(g) Lamps**

All lamp holders shall be fitted with a lamp of a type and size specified by the manufacturer or as stated on the drawings.

- Fluorescent Lamps (Designations MCFE/U and MCFA/U)

Fluorescent lamps shall comply with the latest Standards. Unless otherwise specified, lamps shall be coloured 'white' for industrial use and 'warm white' for commercial and domestic lighting. Lamp caps shall be of the bi-pin type. The guaranteed minimum life shall be not less than 3000 hours.

Metal strip lamps (MCFE/U) shall be used in glass reinforced polyester lights or where the metalwork is not within 20 mm of the lamp.

- Incandescent Lamps

Incandescent lamps shall comply with the latest Standards. General lighting service lamps shall have a coiled coil up to 150 W and single coil above this wattage. The lamps shall have standard bayonet cap and have an internally frosted glass envelope.

General lighting service lamps used for emergency lighting or lamps operating at a voltage different from the normal mains voltage, shall be fitted with an Edison screw cap. Lamps rated at 300 W and above shall have a Goliath Edison screw cap. Guaranteed minimum life shall be not less than 2000 hours for lamps rated at 300 W and above and 1000 hours below 300 W.

**(h) Low and Extra Low Voltage Supply Transformers**

(i) Low and extra low voltage supply transformers shall comply with the latest Standards and shall, unless otherwise specified, be of the single phase type. Transformers shall be supplied complete with fixing bracket.

(ii) The rated output voltage and VA shall be as specified.

**(i) Automatic Earth Proving Supply Points**

(i) Where supplies are taken to portable tools or machinery at 230/400 volts the supply point shall incorporate a device for continuously monitoring the effectiveness of the earth connections to the appliance.

(ii) The apparatus shall comprise a metal cased totally enclosed damp and dust proof unit incorporating a double pole or triple pole hand operated circuit-breaker, relay, low voltage transformer and non-linear resistor together with a socket outlet facilitating the connection of a flexible cable having two separate earth cores in addition to the supply cores. In addition to the mains operated no-volt trip and relay, a current operated earth leakage trip shall be incorporated.

(iii) The plug and socket arrangements for the outgoing lead shall be suitable for the system of protection and shall not be interchangeable with other types.

(iv) Earth proving supply points shall be to the latest Standards.

**(j) Time Switches**

Time switches shall be of the synchronous motor wound clockwork type with a 30 hours spring reserve. The time switch shall incorporate a test ON/OFF switch which shall not interfere with the time clock and auto winding mechanism.

**(k) Wiring**

(i) Internal wiring shall be carried out using single core PVC insulated cable installed in surface run conduit or trunking and shall be fixed to walls of structured steelwork.

(ii) The copper conductor size shall be not less than 1.5 mm<sup>2</sup> for circuits feeding lighting or fixed apparatus or less than 2.5 mm<sup>2</sup> for socket outlet circuits.

(iii) No conduit serving a single phase socket outlet, lighting point or switch shall contain more than one supply phase.

**(l) Batteries and chargers**

(i) Battery units shall comprise a floor standing or wall mounted front access type steel cabinet accommodating batteries, battery charger and distribution facilities.

• Batteries

Unless otherwise specified, batteries shall be of the high performance nickel-cadmium type having cells housed in translucent, high impact plastic containers. The containers shall be fitted with vented filler plugs. High and low electrolyte levels shall be permanently marked on the container.

Cell terminals shall be of the bolted type. The terminal polarity shall be permanently marked.

Battery cells shall be arranged so that each is accessible for test and inspection. Cells shall be located in the lower section of the cabinet and shall be not less than 300 mm above floor level.

Batteries shall be supplied complete with all necessary connections. The connections between tiers, and cells and disconnection links and fuses shall be of the multi-stranded plastic insulated type.

The nominal battery voltage shall be 24V unless technical considerations otherwise dictate. The battery capacity shall be adequate to supply all connected loads for a minimum period of 8 hours.

At the end of the 8 hour period the battery shall have sufficient capacity to complete the operations listed below, at the end of which the battery voltage shall not have fallen below 90% nominal value with the standing loads connected:

- two closing operations on all automatic circuit breakers;
- two tripping operations on all circuit breakers;
- charging of one D.C. motor wound circuit breaker closing spring.

Detailed calculations and loading data used to determine the battery capacity shall be submitted to the Supervisor's Representative at an early stage in the Contract.

- Battery charger

The battery charger shall be of the solid state design incorporating 'Float' and 'Boost' charging facilities. In the 'Float' charge mode, the charger shall automatically maintain the battery in a fully charged condition whilst supplying its rated current. In the 'Boost' charge mode the charger shall be capable of fully charging the battery from a fully discharged state in a period not exceeding 7 hours.

Boost mode is not required for standby batteries for fire detection, emergency lighting or intruder alarm systems.

The charger output voltage regulation shall not exceed  $\pm 2\%$  for load variations of 0 to 100% with a.c. supply voltage variations of  $\pm 6\%$ .

The charging characteristics shall minimise battery water loss.

The charger shall be equipped with the following:

- Incoming supply On/Off switch;
- Supply On indication;
- Output voltmeter;
- Output ammeter;

- Float/Boost charge selector switch;
- Charger Failed alarm relay;
- Charger Failed indication.

The minimum requirement for the 'Charger Failed' alarm shall be the detection of a.c. supply or D.C. output failure. The alarm relay shall not operate under a transient a.c. supply failure condition.

An individual pair of volt-free contacts for 'Charger Failed' shall be provided. The contact shall be wired to terminals.

Double pole moulded case or miniature circuit breakers shall be provided as required.

## **1700 PHOTOVOLTAIC POWER SYSTEM**

### **1701 System Configurations and Operational Requirements**

- The photovoltaic power system shall include an array of PV modules and support structures, a battery bank and enclosure, an inverter/charger and battery charge controllers and an associated balance-of-system (BOS) components including wiring, conduits, disconnects, overcurrent devices, surge suppression and grounding equipment, load sub panels and metering equipment.
- The PV power system shall be installed as such, and must be capable of operation in either stand-alone mode or interconnected in parallel with the utility supplied electrical service to the facility. The inverter/charger shall be designed specifically for operation with battery subsystems.
- The inverter/charger and battery system will be connected to the grid for battery charging purposes and load consumption only, and will not feed excess energy back into the utility network. Under normal circumstances, the inverter sub panel loads will be powered directly from the battery subsystem and inverter, which is recharged from either the PV array or utility grid. In the event the battery becomes discharged below the specified DOD limit, the inverter will transfer the loads connected to the inverter sub panel to utility power, and the batteries will start being recharged. Once the battery has been recharged to a pre-determined limit, the system will again power the sub panel loads from the inverter/battery system.

### **1702 Photovoltaic Modules and Array**

- All PV modules shall meet or exceed the requirements of IEEE Standard 1262-1995 Recommended Practice for Qualification of Photovoltaic modules and Underwriters Laboratories (UL) Standard 1703 Standard for Safety for Flat-Plate Photovoltaic Module or equivalent standards.
- Either crystalline or polycrystalline silicon flat-plate PV are preferred; thin-film PV modules will be considered if their performance, size and warranties are consistent with the site conditions and requirements of the project.
- Unless otherwise specified or dictated by site conditions, all PV arrays should be oriented facing from southeast to southwest, at tilt angles between 10 and 30 degrees from the horizontal for maximum solar energy exposure. Wherever possible, arrays should be located to prevent shading from trees, poles or other structures at any time.
- To guard against high wind loads and the subsequent potential for damage from flying debris, all PV arrays must be securely installed to the facility roof.

- To promote cooling and to maximise air circulation around PV arrays, rooftop mounted arrays should have a minimum of 75mm between the top surface of the module and roof surface with no obstructions preventing air flow between (beneath) the array and the roof surface.

### 1703 Batteries and Charge Control

- The batteries must be capable of sustained operation in a warm, tropical climate and must deliver at least three (3) years of service while maintaining at least 50% of its initial rated capacity. Two sizes of battery systems should be specified, one option for at least 4 kWh of storage, and another option for at least 8 kWh of storage.
- Sealed lead-acid batteries are preferred, however flooded lead-acid batteries will be considered if the bidder can clearly demonstrate that these batteries will not require maintenance or water additions more than once a year. To meet this requirement for flooded batteries, the batteries must be purpose-built photovoltaic batteries and have adequate reserve electrolyte volume and incorporate special battery caps to prevent excessive water loss from the batteries.
- All systems must include battery charge control to protect the battery from overcharge and overdischarge, with appropriate control set points for the type of battery used. Specifications and sources of batteries and controls needed for replacement must be clearly identified, set appropriately, and documented in the System Manual.
- The following are additional requirements for the batteries and charge control:
  - The nominal battery and system operating voltage shall be either 24 or 48 volts DC.
  - The maximum allowable depth of discharge (DOD) should be no more than 75 percent of the nominal battery capacity for the given discharge rates. The specification of the inverter low battery transfer voltage should be consistent with this maximum allowable DOD for the battery.
  - Battery enclosures should be designed to minimize large temperature variations of the battery, and to protect the batteries from creating a hazardous condition. When located outdoors, shading from direct sunlight, and surface coating of battery enclosure should be used to minimize direct solar gain and heating of the battery subsystem. Battery subsystem design and location should minimize the risk of electrolyte spills, corrosion, fire, vandalism, theft and personal injury, and be accessible to maintenance and service personnel.

- Battery charge control must be used between the PV array and battery bank. All charge controllers must have appropriate listing from UL or other recognized laboratory. Any type of charge algorithms are acceptable, however constant voltage or (pulse-width-modulated) PWM type controls are preferred. Either series or shunt type switching is acceptable, and the regulation switching elements must be solid-state (not electro-mechanical relays). The charge regulation set points must be specified, and be consistent with the type and size of battery used.

- Battery charge voltage temperature compensation must be provided as part of the charge controller and inverter/charger circuits, either on board or via an external probe, and the temperature compensation coefficients must be appropriate for the type of battery used.

### **1704 Inverter and Battery Charger**

- Each system shall include an inverter/battery charger with a peak rated AC output of at least 4 kW, with a nominal AC output voltage of 120V single-phase or 120/240V split-phase, at 60 Hz. The inverter/charger shall be designed specifically for operation with battery subsystems, and be capable of automatic and continuous operation either in stand-alone mode, or interconnected in parallel with the electric utility service to the site.
- As configured initially, the inverter/charger and battery system will be connected to the grid for battery charging purposes and load consumption only, and will not feed excess energy back into the utility network. Under normal circumstances, the inverter sub panel loads will be powered directly from the battery subsystem and inverter, which is recharged from either the PV array or utility grid. In the event the battery become discharged below the specified DOD limit, the inverter will transfer the loads connected to the inverter sub panel to utility power, and the batteries will start being recharged. Once the battery has been recharged to a pre-determined limit, the system will again power the sub panel loads from the inverter/battery system.
- The following are other specific requirements for the inverter/battery charger subsystem and components:
  - Each inverter/charger shall be compliant with IEEE Std. 929-2000 (Recommended Practice for Utility Interface of Photovoltaic Systems) and be listed to UL Standard 1741 (Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems) by a recognized conformity assessment laboratory. Any ancillary equipment or modifications of inverter hardware required to install the inverter in parallel with the utility grid to meet the above standards must be provided with the inverter.
  - A bypass circuit shall be provided as part of the inverter/charger power-processing package. These bypass breakers shall allow isolation of the inverter,

battery and PV array components from the rest of the electrical system, and allow electrical loads connected to the load sub panel to be directly powered from the primary electrical service.

- For inverters than only produce 120V single-phase output, the inverter AC input shall be connected to a dedicated single-pole overcurrent device (circuit breaker) at the main electrical panel. For inverters that produce 120/240-volt split-phase, the inverter AC input shall be connected to a double-pole overcurrent device with appropriate ratings. These circuit breakers shall be fastened into the panel such that they cannot be removed by simply pulling on the breaker, and clearly labelled as the inverter AC input connection to the main electrical service.

- Special attention should be paid to voltage drop between the inverter and battery system. Oversize cables are strongly recommended to minimize voltage drop and to achieve maximum inverter efficiency. Maximum distance between the inverter/charger and battery shall be no more than three (3) metres.

- Battery charge voltage temperature compensation must be provided as part of the inverter/charger circuit, using an external temperature probe, and the temperature compensation coefficients must be appropriate for the type of battery used.

### **1705 Electrical Loads**

- A standard main-breaker 60-amp 120/240-volt AC electrical load sub panel shall be provided on the AC output circuit of the inverter for each system. This sub panel shall be installed on the premises, in a location adjacent to the existing electrical panel.
- For inverters than only produce 120V single-phase output, the inverter AC output shall be connected to a single-pole 60-amp overcurrent device (circuit breaker) in the inverter sub panel, and the panel shall be wired such that both halves of the panel are supplied by the single 120-volt output of the inverter (L1 and L2 are connected). Inverters with only 120-volt output must not be connected to any multi-wire branch circuits. For inverters that produce 120/240-volt split-phase, the inverter AC output shall be connected to a double-pole 60-amp overcurrent device in the sub panel, which feeds 120-volts to both halves of the panel, and provides 240-volts between L1 and L2.
- The electrical load panel should be clearly labelled to identify it as the critical load sub panel connected to the inverter output, and which is served directly from the customer's main electrical panel when the inverter/battery subsystem is in bypass mode. All critical loads connected to branch circuits on the inverter sub panel must be clearly identified and labelled on the panel.

- The following is additional information concerning the installation of the load sub panel and the connected electrical circuits:
  - Certain critical loads currently operating from existing utility-supplied Electrical panels may be added to the inverter sub panel. New branch circuits may also be added to this sub panel. To facilitate these circuit changes and additions, existing branch circuit conductors in electrical panels shall remain in place and removed from the existing breakers. Additional conductors shall be spliced/connected to these existing branch circuit conductors, and routed through conduit to the new inverter sub panel as required. In the event the PV system and equipment is ever removed, the existing load circuits can be restored to the original electrical panels as needed.
  - A standard utility watt-hour meter socket and enclosure shall be provided between the inverter AC output and the critical load sub panel, and must include a simple bi-directional mechanical utility wathour meter, wired for operation at 120 V or 120/240 V, as applicable. The display for this wathour meter shall read in digits, as opposed to dial readings. This meter should be installed within the premises, and should be labelled as “Energy to Critical Load Sub Panel”.

#### **1706 Replacement and Spare Parts**

- All system components must be clearly specified as to the type, manufacturer, and model number for later needs for replacement and service as required, and documented in the System Manual. Sources for this equipment should also be identified. It is highly recommended that the supplier/installer either maintain or have a ready source for replacement components for each system as needed for required warranties or service.
- Following are spare parts must be supplied with each system:
  - Complete set of replacements fuses of the same type and rating for all fuses used in the system.

#### **1707 System Documentation Requirements**

- The installer and system supplier must provide a complete documentation package and a System Manual.
- At a minimum, the following items must be supplied as part of this System Manual:
  - a) An overview of major system components, principles of operation and safety considerations
  - b) A complete parts lists and specifications for the overall system and individual components, including all electrical components, mechanical hardware and other equipment required for installing the systems.

- c) A diagram indicating the overall layout of entire system, including the PV array, and the location of BOS hardware and inverter and battery subsystems with respect to the array and building facilities.
- d) Electrical schematics and diagrams showing all major components and devices, including conductor types and sizes, connections of individual modules and array source circuits, inverters, batteries, terminations at junction boxes, and connections to the customer's electric service and utility grid.
- e) Mechanical drawings showing details of module/array mechanical support structure and instructions for assembling/disassembling and installing arrays on rooftops or the ground as required.
- f) Complete assembly and installation instructions for mounting array and junction boxes and enclosures, routing conduit, wiring arrays and terminating conductors at array, combiner boxes and inverter/battery system.
- g) Procedures for operating, disconnecting, servicing and maintain the complete system and the individual components.
- h) Warranty information on the individual components
- i) All the equipment manufacturers' specifications and operations manuals, including those for PV modules, inverterchargers, charge controllers and BOS.

### **1708 Electrical Design and Installation Requirements**

- All equipment and electrical hardware used in these systems, including overcurrent protection, disconnects, surge suppression devices, conduit, wiring and terminals, must be approved, recognized, or listed for the intended application by UL or other recognized laboratory, and have appropriate voltage, current and temperature ratings for the application.
- All circuit breakers, fuses and disconnects must be listed or recognized for use in DC circuits where applicable. Equipment only rated for use in AC circuits will not be permitted for use in DC circuits.
- All wiring (conductors) must be properly sized and rated for the application, including ampacity (including temperature and other deratings), location/application (exposure to elements, enclosure) and voltage drop. Voltage drop in array DC source circuits should be limited to no more than 5 percent, including losses in conductors, and through all fuses, blocking diodes and termination points as applicable. All wiring shall be listed for a minimum operation up to 600 volts and temperature rating of 90° C in wet locations. With exception of the PV module interconnect wiring, the use of any exposed conductors or

cabling (excluding grounds) is not acceptable. All conductors must either be installed in conduit or directly buried in the earth, as applicable.

- PV module interconnect wiring must be sunlight-resistant USE-2 or equivalent rated conductor, and must be attached to module junction boxes using weather tight strain relief. The module wiring interconnections shall use a connector device that allows quick assembly and disassembly of the arrays under no load conditions.
- With the exception of module interconnect wiring, all terminations must use listed box terminal or compression type connections, and must be made within an appropriate junction box or enclosure. Exposed, field splices between conductors will not be permitted. Twist on wire splices, crimped, soldered or taped connections are not permitted for the required field installed wiring of and DC circuits. Proper torque specifications should be provided for all of the required field connections, and all termination points should be liberally coated with an anti-corrosion spray to preserve the quality of all connections over time.
- All system conductors must have appropriate means for disconnecting and overcurrent protection, and require the use of switches, fuses and circuit breakers as applicable. In all cases, means of isolating the battery subsystem must be provided. All overcurrent devices shall have trip ratings no greater than the derated ampacity of the conductors that it protects.
- All series connected strings of modules (source circuits) must include a series fuse to prevent excessive reverse current flow through modules in source circuits under fault conditions, and the diodes must be contained in a listed junction/combiner box. Parallel connections of modules in individual source circuits are discouraged, and are only allowed as long as the module listing allows for a series fuse with high enough capacity required for this configuration. All series source circuit fuses shall be rated for at least 1.56 times the source circuit short-circuit current rating, and no greater than that specified on the module listing. Blocking diodes for array source circuits are optional. If used, these diodes must have voltage and current ratings (at temperature) at least twice the open-circuit voltage and short-circuit ratings of the source circuits.
- All metallic module frames, panel/array support structures, metal enclosures, panel boards and the inverter/battery cabinets must be properly bonded to a common grounding conductor and terminate at a ground rod installed at the utility service entrance point. If a ground rod or system is not already present, a grounding rod or network must be installed at each system with a preferred maximum earth resistance of 25 ohms. All grounding connections and terminations should be made accessible for routine inspections and maintenance as required. The neutral conductor of the inverter output shall be grounded at the electrical service panel. No other AC connections to the grounding system are required.
- Surge suppression on the DC and AC side of the inverter must be provided. Silicon oxide varistors (SOVs) commonly used to protect electrical panels and equipment may be used for this purpose, and may be provided and/or required by the inverter manufacturer.

- An array ground-fault protection device must be included for all systems. This device protects the array from creating a fire hazard under fault conditions, and it must be capable of detecting array ground faults, shunting the fault current to ground, and disabling the array until the fault has been cleared.
- A weather-tight, vented, locking, pad mountable enclosure shall be supplied, suitable for housing the batteries, inverter/charger, controllers, AC/DC disconnect devices, and source circuit combiner boxes (as required), in an outdoor or indoor environment as required for the specific application. Provisions to separate the battery subsystem from the inverter/charger and from other power processing components will be required for some applications, but in no circumstance is this separation distance to be greater than three (3) metres due to constraints on battery to inverter cabling sizes and voltage drop. The enclosure shall be rated as NEMA 4, 3R or better and have superior strength and corrosion resistance properties for the humid, salt-air marine environment. Aluminium or durable plastic construction is preferred for all battery enclosures to be mounted outdoors.
- An outdoor rated disconnect device must be installed in all systems at the interface between the PV system inverter/charger and the primary electrical system served by the utility grid. This disconnect device shall be a visible break, lockable device, and shall be installed at a convenient location on the outside of the premises.
- A standard utility watt-hour meter socket and enclosure shall be provided on the PV system side of this disconnect, and shall include a simple bi-directional mechanical utility watt-hour meter, wired for operation at 120 V or 120/240 V as applicable. The display for these watt-hour meters shall read in digits, as opposed to dial readings, and will record net energy supplied to or from the inverter/battery system.
- All electrical equipment, enclosures, disconnects and overcurrent devices must be clearly marked and identified.

### **1709 Mechanical Design and Installation Requirements**

All hardware required for installing PV arrays and other system equipment must be provided for the installations. The following are the requirements for mounting the PV arrays, equipment and other materials and mechanical design considerations.

- Rooftop mounting systems are required for the PV arrays. The roof mounting system must be adaptable to the various types of roofing designs and materials at each site, must be corrosion resistant and have adequate structural support for the arrays and attachment to the structure, and any attachment points and penetrations to the building must be properly weather sealed using accepted roofing practice. The array mounting and orientation should be selected to maximize solar gain, and avoid any excessive shading of the array.
- The array mounting systems and overall installation must meet all applicable building codes, and be capable of withstanding hurricane force winds of Category 3 or greater

(130 miles per hour), for all attachment points, which are consistent with the module manufacturer's installation instructions, and the requirements of ANSI/ASCE 7-98.

- Array mounting hardware supplied for this installation should be compatible with the site considerations and environment. Special attention should be paid to minimizing the risk from exposed fasteners, sharp edges, and potential damage to the modules or support structure. Corrosion resistance and durability of the mechanical hardware is emphasized. All materials should be selected to avoid corrosion and degradation. The use of ferrous metals, contact of dissimilar metals and the use of any wood or plastic components is not permitted. Aluminium and stainless steel components and hardware are preferred.
- As much as possible, all mechanical hardware, conduit, junction boxes and other equipment should be concealed beneath and/or behind the array, and all other electrical work performed neatly and as inconspicuously as possible.

### **1710 System Warranties and Maintenance**

Warranties must be provided on both the complete system and the individual components. The methods for implementing a warranty provision must be clearly established. At a minimum the following warranties are required:

- A two-year, complete system-level warranty for the no-cost replacement of any defective component required for safe and as-specified system operation.
- PV modules must have a minimum ten-year limited manufacturer's warranty to maintain at least 80 percent of their initial rated output.
- Inverter/chargers and charge controllers must have a minimum 2-year warranty.
- Batteries must be warrantied for a minimum of three (3) years to deliver at least 50 percent of initial rated capacity.

Training shall be provided by the installer, to perform routine maintenance, as required.

## **1800 DIESEL GENERATOR SET**

### **System Description**

The diesel generator units shall supply automatically all the equipment in the event of required electricity demand. Manual mode of starting and shut down shall also be provided.

The diesel engine and the generator shall be directly coupled and mounted on a skid. Suitable foundation bolts shall be provided. Provision shall be made to avoid transmission of dangerous vibrations to the supporting structures.

The 8 KVA generators shall be water cooled.

The generator control panel shall be installed separately from the diesel generating set.

### **Operating Conditions**

The standby diesel generator units shall be designed for continuous operation and for long periods of standstill.

The following additional particulars shall be taken into account for the design of the units:

1. maximum inlet air temperature according to climatic site condition,
2. possible sand storms with concentration of 3  $\mu\text{m}$  particles.

### **Design Criteria**

The diesel generator units shall be sized according to the following criteria:

1. Supply the maximum load to be automatically connected, plus extra capacity margin.
2. Minimum capacity under the site conditions shall be for the WTP. (8 KVA)

The diesel generator units shall be provided to start/operate/stop in complete autonomy with their own automatic/manual starting systems and with independent ventilation and cooling systems.

### **Workshop Tests**

#### ***Diesel Engine***

The test shall include a period of running at rated full load, to be followed immediately by one hour at 10% overload, sufficient to demonstrate that the engine is mechanically sound and capable of sustaining the loads.

## **Fuel Consumption**

The fuel consumption at full load, three quarters and half of this load, shall be measured over a minimum period of 30 minutes for each load. The weight of fuel used shall be accurately determined by an agreed method. Any other specific values shall be obtained from samples of the actual fuel used for the test. Fuel consumption shall be stated in grams/kWh.

If the load is provided by the generator, the total energy output during the test period shall be measured by the kilowatt-hour meter suitable for measuring unbalanced loads in case of poly-phase circuits.

## **Governing Tests**

This test shall be done when the engine is coupled to the generator. The steady load/speed band shall be measured over a period not less than two minutes and not more than five minutes.

## **Overspeed Test**

The engine shall be operated for a period of one to three minutes at 110% of the normal speed.

During this test, resonant vibration, abnormal temperature rise or damage to any part of the unit shall not be allowed.

## **Generator**

Temperature Rise Test: The temperature rise test for stator and rotor windings of the generator shall be carried out as per the Resistance method of clauses 14 & 15 of IEC 34-1.

Dielectric test under 2,000 Volts, as per clause 17 of IEC 43.1.

Determination of Losses and Efficiency: The total losses shall be computed at 50%, 100% and 110% of rated capacity by summation of various losses determined as per section 4 of IEC 43-2. Tolerance allowance as per section 9 of IEC 34-1 shall apply.

AVR tests to determine the performances of the voltage regulator.

## **Auxiliaries**

Throughout the tests, the engine shall be equipped with all its auxiliaries.

## **Fuel and Lubrication Oil**

The tests shall be carried out with oil fuel of grade No.4. Lubricating oil tests shall be carried out as specified by the manufacturer.

## **Nature of Load**

The test loads shall be adjusted to take into account the actual operating conditions at the test platform. The engine may be loaded either by a calibrated dynamometer or by the generator itself. In this latter case the generator efficiency shall be defined for the actual power factor of the test load current.

## **Measurement of Shaft Outputs**

The accuracy of the dynamometer used to measure the output of the engine shall be at least within 2% of the reading at full load.

## **Running-In**

Before starting the tests, the engine shall be run for a sufficient duration to ensure steady state conditions.

### **1801 Diesel Engine**

1. The Diesel Engine shall be of heavy duty type to continuously drive the electric generator at the synchronism speed of 1,500 rpm maximum for three phase generators, solid injection, compression ignition, four stroke, multi-cylinder with changeable cylinder liners, forced oil lubrication, suitable flywheel for flicker-free operation, exhaust silencer with necessary piping. The 8 KVA generators shall be water-cooled by closed circuit with radiator. All parts shall be easily accessible for inspection and repairs.
2. The engine shall be suitable to run with fuel oil, grade No. 4.
3. The Contractor shall guarantee, with a tolerance of 5%, the fuel consumption of the engine under the site operating conditions at :
  - the rated power output, and
  - half of the rated power output.

- Fuel consumption shall be stated in g/kWh, based on the use of Diesel fuel oil, grade No. 4.
4. The rated power output of the engine is the net output, at brake, which the engine is able to deliver continuously at the rated speed under the site operating conditions provided that the oil fuel grade No.4 and the lubricating oil approved by the manufacturer, are used. The rated output shall take into account the guaranteed speed regulation performances.
5. Starting System  
The starting system includes the following components:
- one electro valve for starting up the diesel engine
  - checking devices for the speed of the diesel engine
  - one valve for manual starting all necessary pipes, valves and fittings.
6. Cooling System
- The diesel engine of the 8 KVA generators shall be water cooled by means of a closed water cooling system. Proper inhibitors shall be added in the water to protect the cooling system against corrosion & sludge.
  - The water shall be boosted by a centrifugal pump fitted on the engine, it shall be cooled by a fan directly driven by the engine. The radiator shall be rated for a maximum ambient temperature of 40°C.
  - The radiator shall be provided with a thermostat and a bypass line between the thermostat and the cylinder block to reduce the warm up time and to avoid overheating of the cylinder head.
  - The radiator may also be provided with a thermostatic automatic shutter system to adjust the air discharge in order to maintain the engine temperature within the design limits under ambient temperatures.
  - The Contractor shall define all air circuits between the diesel room and the outside and supply necessary metallic air ducts, sound traps and fittings.
7. Fuel Oil System  
The capacity of the main storage tanks shall be able to satisfy the consumption of the diesel engine for five (5) consecutive days of operation without refilling. It shall be sized in order to permit its transport in one piece only. Especially for the WTP which is not connected to the Public electricity distribution network, and where two generator sets will be installed each (one on duty and one stand-by), the storage tank shall be able to satisfy the consumption of the diesel engine for thirty (30) consecutive days of operation without refilling.

The supply includes all installation supports, fixing devices, filling pipes, air vents, piping system, earthing terminals, level switches and electrical equipment between the tank and the control panel such as electrical level gauge, indicator and cables. Each tank shall be equipped with:

- one level gauge,
- high and low level limit switches,

- necessary connections for filling, emptying, drainage, with aeration valves, etc,
- necessary shut-off valves, isolating valves, drainage valve, etc.,
- one special connection for fuel oil sampling,
- lifting lugs.
- The minimum wall thickness of the main tank shall not be less than 4 mm including a corrosion allowance of 1.5 mm.
- The tank shall be welded on both sides with suitable filler materials and without substantial edge mismatch. Strengthening sheets shall have a continuous weld on the tank wall. Stub pipes welded into the tank wall shall be welded on both sides. A welding joint factor of at least  $V = 0.9$  is required. The length of the supporting feet shall take into account the necessary space for draining valve, etc.

#### 8. Lubricating Oil System

The lubricating oil system with closed forced circuit, oil filters with replaceable elements, shall be equipped with an automatic bypass to not stop the oil circulation. It shall be installed in the diesel room and it shall include:

- one oil pressure gauge,
- too high and too low oil temperature protections.

#### 9. Exhaust System

The exhaust system shall include the silencer, manifold, expansion joints, flexible couplings, the pipe insulation and a drainage pipe.

#### 10. Critical Speeds

No dangerous vibration between the engine and the generator shall appear. Vibration stresses and amplitudes resulting from critical speeds in the generator shall not exceed any maximum permissible limits specified by the generator manufacturer.

### **1802 Generator**

The AC generator shall be of constant voltage 230/400 V, 50 Hz, air or water cooled, self-excited type with a power factor of 0.85. Damper windings shall be uniformly distributed around the rotor.

Voltage variation between 0 and 100% of rated load :  $\leq \pm 2.5\%$  of rated voltage.

The generator shall be able to withstand 1.2 times the rated speed.

Protection index of the enclosure of generator: IP23.

Type of duty: Continuous running duty type S1 as per IEC-34-1.

The generator and control panel shall be fitted with earthing terminals.

### **Insulation and Temperature Rise**

1. The insulation class as per IEC-34-1 is class “F”.
2. Winding temperature rise, under the rated conditions and ambient temperature of 40°C should be less or equal 90°K.
3. Thermal sensors shall be installed in the stator windings.

### **Ratings**

1. OUTPUT IN KVA..... 8 KVA
2. VOLTAGE..... 230/400 VOLTS
3. PHASES..... THREE PHASE
4. NEUTRAL..... SOLIDLY GROUNDED
5. FREQUENCY..... 50 HZ
6. POWER FACTOR..... 0.85 LAGGING
7. SPEED..... 1,500 / 3,000 RPM

### **Vibration**

1. The rotor shall be dynamically balanced to avoid vibration. No resonant vibration shall be induced between the rotor and the engine.
2. The shaft current shall be eliminated to avoid damage to rotor bearings. If not possible the rotor bearings shall be electrically insulated.

### **Control Panels**

The control panel shall be installed near the generator. They shall include all necessary switchgear and equipment for the control, protection and monitoring of the diesel generator unit and its auxiliaries, in particular:

1. the general protection and distribution circuit breaker(s),
2. the 4-pole contactor,
3. the circuit breakers and contactors for the auxiliaries (fuel oil pump, etc.),
4. the Automatic Voltage Regulator,
5. the selector switch for manual/automatic modes,
6. the push-button switches for starting/stopping the unit
7. the indicators for the diesel engine : oil pressure, temperatures, speed, etc.,
8. the operation and fault signaling lights,
9. the protection relays as follows:
  - no starting (3 starting trials without results),
  - fuel oil pump fault,
  - tank low oil level,

- water flow fault (8 KVA generators),
  - high water temperature (8 KVA generators),
  - low oil pressure,
  - high oil pressure,
  - diesel engine overspeed,
  - over current,
  - under and over voltage,
  - min. and max. frequency,
  - generator overload.
10. The operation of each protection shall be indicated by a flashing light on the local control panel and a sound alarm.
11. The diesel generator unit shall be provided with its own DC source including one battery/charger assembly, capable for 10 contiguous startings, with 5 sec interval of time between them.

### **Enclosures**

The enclosures will be so designed that they reduce the sound level to 70 dBA (maximum) at 7 meters, according to the E.U. regulations. They will be designed to allow the maximum aspiration and cooling airflow required so the engine does not overheat.

The enclosure will be suitable for outdoor installation, corrosion proof, with anti-rust protection. They will be powder coated to give them durability features.

The enclosure will consist of metal sheet outside and inside of proper noise insulating material suitable to reduce the noise to the desired level. There will be two doors for inspection and maintenance of the generator, and two openings with air louvers for the cooling air.

A residential silencer which is insulated from inside with glass wool, will be provided to suppress exhaust noise from the engine.

Finally the enclosure will have pitched roof to prevent water accumulation.

### **Spare Parts and Special Tools**

The following spare parts and tools shall be supplied for each diesel generator unit. For the engine and its auxiliaries:

- one (1) set of injection nozzles (100% of installed parts)

- one (1) set of cylinder liners
- two (2) pistons with rings and all fittings
- two (2) rocker arms
- two (2) sets of any kind of filters (fuel oil, lubricating oil, air, water)
- two (2) sets of belts
- two (2) sets of seals
- one (1) detector/sensor of each type

For the generator:

- one (1) set of diodes
- one (1) set of spares for the AVR
- one (1) detector/sensor of each type

For the control, protection and monitoring equipment:

- one (1) MCB, contactor, switch of each type
- two (2) auxiliary relays of each type
- two (2) sets of fuses, light bulbs

### **Execution/ Field Quality Control**

All the facilities for carrying out the tests including material, consumable and non-consumable, shall be provided by the Contractor.

1. Installation checks as per manufacturer/supplier instructions
2. Operation/Functional tests of: manual/automatic starting and shutdown, protections and monitoring circuits.
3. Continuous Heat Running Test
  - The test shall be carried out at a constant temperature. The measurement of temperature shall be made by thermo-electric couple sensors.
  - The engine shall be run continuously for 6 h at full load with measurements at 30 min intervals. All operating values shall be measured, such as: oil consumption, temperature and pressure, water consumption and temperature fuel consumption, speed/frequency, load and voltage.
  - The colour of exhaust gases, running condition, misfiring, vibration, abnormal noises, leakages of gas, water and oil shall be observed and recorded.

## **1900 COOLER ROOM UNIT (CHILLERS)**

Two (2) complete Cooler room units (Chillers), 3.00m (W) x 4,57m (L) x 2.4m (H) with a heavy duty hinged central door on the 3.00m wall of the unit. Refrigerator unit and evaporator unit to be included.

### **1901 Panels**

- a) Panels shall consist of foamed-in-place polystyrene insulation between interior and exterior skins of colour steel.
- b) Wall thickness 100mm, polystyrene core
- c) Edges of panels shall be tongue and groove, with Speed-Lok fastening devices foamed-in-place at the time of fabrication.
- d) Flame spread rating of 25 or less
- e) A PVC gasket located on the tongue side of panels forms an air tight seal.
- f) Insulation shall be of non-ozone depleting polystyrene

### **1902 Doors**

- a) Dimension: 900mm x 1,900mm
- b) Flush mounted, positioned and hinged, 3 x hinges
- c) Shall be provided with suitable sweep and magnetic gaskets.
- d) Shall be provided with door closer, one pre-wired vapour proof light fixture, light switch with pilot light, dials thermometer, manual internal lock override (inside safety release). Chrome plated can lift hinges, and chrome plated heavy duty door latches with strike.
- e) Deadbolt handle latch, using padlock.
- f) Exterior ramp, diamond treads plate.

### **1903 Refrigeration Equipment**

- a) Refrigeration system can either be a packaged system or separate units of;
- b) Evaporator and condensing units: storage volume 10cum/4tonnes, 8kW, 27,200BTU, 4HP
- c) The cooler is for storage of fresh vegetables for up to two weeks
- d) The unit must be able to maintain +5 - +10<sup>0</sup> Celsius
- e) The unit or units to be single phase, 240volts/50Hz

### **1904 Rack and Shelving Unit**

Internal rack system on both side of centred door and the rear wall to hold up to 40 plastic vegetable baskets.

- a) The rack system shall be of the dimensions,
- b) 1,500mm (L) x 750mm (W) x 1,850mm (H)
- c) There shall be six (6) shelvings

**1905 Installation of Walk-in Cooler Unit**

- a) The Walk in Chiller unit is to be installed inside the Packing Facility and positioned as shown in the drawings. The final position to be finalised prior to installation of the unit. Refer to APPENDIX III
- b) The Contractor is to furnish all necessary applications for the power connection to the electrical system.
- c) All tests are to be carried out to test the integrity of the unit and accessories
- d) Provide 1 year warranty on parts and installation.

**1906 Manuals**

- a) Operational manual shall be provided
- b) Maintenance manual shall be provided

## **2000 AIR-CONDITIONING SYSTEM**

### **2001 General**

- The Air-Conditioning units shall be of the ceiling mounted type and suitable for operation on 220 V- 240 V.
- These units shall have electronic control valves to control refrigerant flow rate in response to load variation in the room.
- The unit shall be basically a fan coil unit suitable to be installed within the ceiling. Each unit shall have: a cooling coil, blower, filter, BLDC motor, drain pan and accessories. All the units installed are to have cordless remote controls.
- The unit shall have a cleanable type filter to an integrally molded plastic frame. The filter shall be slide away and neatly inserted.
- It shall be possible to clean the filters either with compressed air or water. The cooling coil shall have aluminum fins and copper tubes. The fan section shall be dual suction, aerodynamically designed and balanced turbo, multi blade type blower to ensure low noise and vibration free operation and having multiple speed motor. The fan shall be direct driven type, mounted directly on motor shaft having support from housing.
- The noise level for these unit should not exceed 46db (A)  $\pm 2$ .

### **2002 Refrigerant Piping**

- Refrigerant piping for the air-conditioning system shall be up to 19.1 mm dia. of soft seamless copper tubes and for above 19.1 mm dia. the pipe material shall be of hard seamless copper tubes with pipes material being hard drawn copper pipe.
- Before jointing any copper pipe or fittings, its internals shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently it shall be thoroughly blown out using nitrogen gas.
- After completion of installation of the refrigerant piping, the piping system shall be pressure tested using nitrogen gas at a suitable pressure as specify by OEM (Original Equipment manufacturer).
- Pressure shall be maintained in the system for 48 hours. The system shall then be evacuated to a vacuum of not less than 700 mm Hg and held for minimum 24 hours.
- The suction line pipe size and the liquid line pipe sizes shall be selected according to the manufacturer's specified diameter. All refrigerant pipes shall be properly supported and anchored to the building / structure using steel hangers, fastener, brackets and supports which shall be fixed to the building / structure by means of inserts or expansion shields or anchor fasteners of adequate size and number to support the load imposed thereon.
- All exposed copper pipes have to be covered by 24 G GI sheet.

- Entire liquid and suction refrigerant pipe lines including all fittings, valves and strainer bodies etc. shall be insulated with 19 mm / 13 mm thick Nitrile rubber.
- GI / PVC condensate drain pipe in the drain point of indoor units shall be provided.

## 2100 CHAIN LINK FENCES AND GATES

### 2101 Standards

Where ASTM standards are referred to in this section, these may be replaced by E.U. member state and/or ACP State standards provided they are equivalent or superior to the U.S. Standard.

### 2102 Fence Components

**Fabric:** Metallic-coated steel, 1-3/4 inch (44 mm) mesh, 0.120 inch- (3 mm) diameter wire with polymer coating.

**Polymer Coating:** ASTM F 668, Class 2a or 2b.

**Colour:** Dark green.

**Selvage:** Knuckled on both selvages.

**Fabric:** Aluminium, ASTM F 1183, 2 inch (50 mm) mesh, 0.148 inch (3.76 mm) diameter wire.

**Posts and Rails:** Aluminium pipe complying with ASTM F 1043 requirements for heavy industrial fence, and colour coated to match fabric.

**Tension Wire:** Metallic-coated steel, ASTM A 817 and ASTM A 824.

**Fittings and Accessories:** ASTM F 626, colour coated to match fabric, and as follows:

**Post and Line Caps:** Provide watertight cap for each post. Provide line post caps with loop to receive tension wire or top rail.

**Post Brace Assembly:** Same material as top rail with 3/8-inch (9.5 mm) diameter rod and adjustable tightener.

**Bottom and Centre Rail:** Same material as top rail with cap on each end.

**Gate Posts, Swing Gates, and Accessories:** ASTM F 900, same metal and finish as posts and rails, with galvanized hardware and accessories.

**Privacy Slats:** PVC, UV-light stabilized, not less than 0.023 inch (0.58 mm) thick, sized to fit mesh specified for direction indicated.

### 2103 Installation

- (a) Install fence to comply with BS 1722: Part 1 or ASTM F 567 or equivalent European Standard.
- (b) **Excavation:** Drill post holes 8 inches (200 mm) in diameter and 18 inches (450mm) to 23.62 inches (600 mm) in depth, equally spaced, but not more than 10 feet (3.05 m) apart.
- (c) **Setting Posts:** Set posts in holes approximately 4 inches (102 mm) above bottom of excavation. Align posts vertically and align tops. Pour concrete footings with tops 2 inches (50.8 mm) above grade, troweled to a crown to shed water 2 inches (50.8 mm) below grade.

## **2200 GEOTEXTILES (GEOMATERIALS)**

### **2201 General**

#### 1) Scope of Work

The Contractor shall place all geomaterials in the areas shown on the drawings and as instructed by the Supervisor's Representative and in accordance with the following specification.

#### 2) Contractor's Obligations

The Contractor shall be fully responsible for the supply of all equipment, materials and services and for the complete co-ordination of all the activities for the successful installation of the geomaterial foundation. The Contractor shall bear full and sole responsibility for the supply, installation and performance of the geomaterial supplied by him.

#### 3) Consent

a) The Contractor shall submit geomaterial samples and data sheets to the Supervisor's Representative for inspection and review, and shall not proceed with procurement of any geomaterial or equipment until the consent of the Supervisor's Representative is given. Samples of approved geomaterial shall be retained on Site for reference throughout the construction period.

b) The Supervisor's Representative may instruct tests to be carried out on the geomaterial to demonstrate its compliance with this Specification. An independent certificated laboratory approved by the Supervisor's Representative shall carry out the tests. Notwithstanding the foregoing, the Supervisor's Representative may require observe tests on the proposed material prior to approval of the laboratory being granted.

c) The Contractor shall permit the Supervisor's Representative to take random samples of geomaterials from the Site for further check tests at all times.

#### 4) Testing

Tests to check the properties of the geomaterial shall comply with the methods of testing set out in the following standards or acceptable equivalent standards:

<b>BS EN ISO 10319</b>	Geotextiles- Wide-width Tensile Test
<b>BS EN ISO 12236</b>	Geotextiles and Geotextile-related Products- Static Puncture Test (CBR Test)
<b>BS EN 918</b>	Geotextiles and Geotextile-related Products- Dynamic Perforation Test (Cone Drop Test)
<b>BS EN 964 &amp; BS EN ISO 9863</b>	Geotextiles and Geotextile -related Products, Determination of Thickness at Specified Pressures
<b>BS 2471</b>	Methods of Test for Textiles - Woven Fabrics – Mass per Unit Length and Mass per Unit Area
<b>ASTM D4533</b>	Test Method for Trapezoid Tearing Strength of Geotextiles.

5) Ordering

The geomaterials shall be ordered in advance of the site trials and in good time for incorporation into the Works.

6) Delivery and Storage

All geomaterials shall be delivered to site in the wrapping applied by the manufacturer or, as a minimum, 50 micron black Polyethylene wrapping. Any damage to the wrapping shall be repaired immediately by the Contractor at his own cost. The rolls shall be stored in a well-aired area and protected from direct sunlight. The wrapping shall only be removed immediately prior to use. Each roll shall have an individual roll number and have a roll label with the following details:

- a) Name and address of manufacturer
- b) Roll number
- c) Name and type of product
- d) Length and width of the roll
- e) Unit weight
- f) Raw materials
- g) Method of manufacture

7) Handling

The geomaterial shall be handled with due care, following all of the manufacturer's recommendations such that it is undamaged for incorporation into the Works. All damage, including physical damage, or where the geomaterial has been exposed to chemical contamination, shall be reported to the Supervisor's Representative. The Supervisor's Representative shall have the power to instruct the removal of the damaged or contaminated portion of the geomaterial or in cases of severe damage or contamination, the rejection of the entire roll.

8) Method Statement

- a) Thirty (30) days prior to commencement of the installation of the geomaterial in the Works and before any site trials are carried out, the Contractor shall submit to the Supervisor's Representative for his consent, a method statement for the successful installation of the geomaterial and its incorporation into the Works. The method statement shall list all plant, labour, methods, activities and sequencing of operations required for laying the geomaterial.
- b) Any alternative method to that previously approved shall be subject to the consent of the Supervisor's Representative. Notwithstanding the above, the Supervisor's Representative's consent to the Method Statement shall not absolve the Contractor of his duties or obligations under the Contract.

9) Site Trials

- a) Prior to commencement of full-scale installation of the geomaterial, the Contractor shall demonstrate his working method described in the Method Statement by conducting a site trial in the presence of the Supervisor's Representative. The trial shall consist of laying a minimum of 20m of geomaterial and the full layer of rip-rap. The site trial may be conducted on the Site and be incorporated in the Works at the discretion of the Supervisor's Representative and following a successful trial.
- b) Providing that upon completion of the trial, the work and working method are acceptable to the Supervisor's Representative they shall be designated the "standard" for the installation of geomaterial and the Method Statement shall be modified to suit the results of the Site trial. All subsequent work shall comply with the established "Standard."
- c) The Contractor may submit revisions to the approved "standard" but shall not modify his working methods until additional trials have been conducted in the

presence of the Supervisor's Representative and the Supervisor's Representative's consent has been given.

#### 10) Preparation for Installation

The Contractor shall notify the Supervisor's Representative whenever installation of the geomaterial foundation is to be carried out. The Contractor shall also permit and afford all facilities for the Supervisor's Representative to inspect the laying of the geomaterial and placement of the bedding layer. The Contractor shall replace or repair any geomaterial damaged during installation and shall remove and replace any bedding stones that do not conform to Specification.

#### 11) Installation Above Water

- a) The installation of the geomaterial foundation shall be carried out by experienced personnel with suitable equipment, to the "Standard" established during the Site Trials. The geomaterial shall be laid in such a manner as not to damage the geomaterial or unduly disturb the formation.
- b) The formation to receive the geomaterial foundation shall be free from debris and material greater than 100mm in size. The formation shall be generally free of any mounds or hollows and shall not exceed a gradient of 2% different from that shown on the Drawings. The Contractor shall not proceed with the installation of the geomaterial until the Supervisor's Representative has granted specific consent for the sections concerned.
- c) The geomaterial shall be laid on the prepared formation without wrinkles, gaps, folds, slack, stressing or deformation. The geomaterial shall be laid line to line and to the level of the formation and there shall be no gaps or voids under the geomaterial or bulges in the surface and to the tolerances in formation above. The Contractor shall follow the manufacturer's recommendations for overlapping or sewing of the geomaterial, subject to the consent of the Supervisor's Representative and following a successful Site Trial.

#### 12) Installation Under Water

- a) Experienced personnel shall carry out the installation of the geomaterial foundation with suitable equipment to the "Standard" established during the Site Trials. The geomaterial shall be laid in such a manner as not to damage the geomaterial or unduly disturb the formation.

- b) The formation to receive the geomaterial foundation shall be free from debris and material greater than 100mm in size. The formation shall be generally free of any mounds or hollows and shall not exceed a gradient of 2% different from that shown on the Drawings. The Contractor shall not proceed with the installation for the geomaterial until the Supervisor's Representative has inspected the formation and the Supervisor's Representative has granted specific consent for the sections concerned.
  
- c) The geomaterial shall be laid on the prepared formation without wrinkles, gaps, folds, slack, stressing or deformation. The geomaterial shall be laid line to line and to the level of the formation and there shall be no gaps or voids under the geomaterial or bulges in the surface and to the tolerances in formation above. The Contractor shall follow the manufacturer's recommendations for overlapping or sewing of the geomaterial, subject to the consent of the Supervisor's Representative and following a successful Site Trial.
  
- d) The Contractor shall secure the geotextile to the river bed by the method agreed in the Site Trial and place a 0.5 metre thick layer of the rip-rap material onto the geomaterial as soon as possible after sufficient geomaterial has been laid, subject to the consent of the Supervisor's Representative.

## Geomaterial Type

- 1) Type: Needle-punched Geofabric

1	The main functions of a geotextile used beneath Rip-rap are filtration and separation. The geotextile shall be manufactured under factory production control guidelines set out within EN 13253; Geotextiles and geotextile related products – characteristics required for use in erosion control works (coastal protection, bank revetments). The manufacturer must be able to supply accompanying CE documentation upon request. The functional characteristics and relevant test methods to this specific condition of use are identified below.
2	The geotextile shall have the following properties:

<b>2.1 Physical Properties:</b>	
Polymer type:	Prime quality virgin polypropylene fibre containing 1% carbon black by weight.
Fabric construction:	Needle punched nonwoven fabric manufactured from mechanically entangled staple fibre.

	Approved test method	Units	Typical Mean value	Allowable tolerance to 95% confidence limits
Thickness @ 2kPa:	EN ISO 9863-1: 2005	mm	4.3	n/a*
<b>2.2 Mechanical Properties:</b>				
Static puncture strength (CBR)	EN ISO 12236	kN	2	-10%
Push-through displacement	EN ISO 12236	mm	78	n/a*
Tensile strength	EN ISO 10319	kN/m	15	-10%
Tensile extension	EN ISO 10319	%	100	+/-30%
Cone drop perforation hole diameter	BS EN 13433	mm		+3mm
<b>2.3 Filtration Properties:</b>				
Water flow normal to the plane of the geotextile @50mm head	EN ISO 11058	l/s/m <sup>2</sup>	80	-30%
Characteristic opening size: 90% finer [O90]	EN ISO 12956	□m		+/-30□□
<i>* Indicates property not used for quality control as part of harmonised testing within EN 13253</i>				

<b>2.4 Durability (according to annex B: EN 13253):</b>			
Resistance to weathering (UV) @ 50MJ/m <sup>2</sup> radiant exposure	EN 12224	Retained Strength	>80%
Resistance to Oxidation (150 years)	EN 12225	Retained Strength after 84 days	>80%
Microbiological Resistance	EN 12225	Retained Strength	>80%
Resistance to liquids	EN 14030	Retained Strength	>80%
<i>* Durability test data can be supplied by the manufacturer – test frequency must not exceed 3 years.</i>			

3	<p>Geotextiles shall be delivered to site in packaging, which will protect the product from damage during handling, storage. Packaging must be suitable to protect the product from UV degradation. Product must be kept in appropriate packaging until such time that it is required for installation.</p> <p>The geotextile shall be clearly and indelibly marked with the product name along the edge of the roll at regular intervals no greater than 5mts. The labelling shall clearly identify the product supplied in accordance with EN ISO 10320: Geotextile and Geotextile related products – Identification on site.</p>
4	The geotextile manufacturer shall provide production test certificates on mechanical properties at the rate of one set of tests per 6,000m <sup>2</sup> delivered to site and a minimum of one set per contract. Test

	methods employed shall be in accordance above specification and the reporting laboratory should be accredited by UKAS to carry out the required tests. Certificates relevant to a batch of geotextile shall be furnished to the Supervisor's Representative prior to that batch of Geotextile being incorporated in the works.
5	The rolls of geotextile shall be stored on level ground and stacked not more than five rolls high and no other materials shall be stacked on top of the geotextiles.
6	The geotextile shall be laid and installed in the positions and to the line and levels described on the drawings. Construction plant must not operate directly on the geotextile.
7	Joints shall be formed by overlapping by a minimum of 1metre. A reduction in overlap to 0.3m may be considered by the Supervisor's Representative where the sub-layer is firm and above water level.
8	<p>On site quality control should be performed in accordance with CEN/TR 15019.</p> <ul style="list-style-type: none"> <li>a) Test specimens should be taken every 30,000 m<sup>2</sup> , with a minimum of 1 test above 1000 m<sup>2</sup></li> <li>b) For sampling EN 963 should be applied, i.e. samples should be taken not less than 5m from the end of the roll in machine direction and over the whole width in the cross machine direction. The location of the sample should be described exactly.</li> <li>c) For evaluation of conformance, statistical procedure should be used in line with section 5.2 of CEN/TR 15019: 2004.</li> </ul>
9	<p>The following definitions shall apply when considering test results:</p> <ul style="list-style-type: none"> <li>a) A set of test results shall be those results derived from specimens cut from one sample.</li> <li>b) The mean value for any set of test results shall be the arithmetic mean of that set of results.</li> <li>c) The characteristic value is the value below which not more than 5% of the test results may be expected to fall. This represents the value at 1.645 standard deviations below the mean value.</li> </ul>

## 2300 QUALITY ASSURANCE

### 2301 Quality System

- (a) The Contract (including any investigations, design, construction, provision, erection, setting out work, testing and maintenance, whether carried out by the Contractor or a sub-contractor) shall be executed in accordance with a quality system, which satisfies the relevant requirements of BS5750 and the particular requirements of this Specification.
- (b) The Contractor shall prepare an overall Contractor's Quality Plan describing the quality system to be implemented for the Contract. The Contractor's Quality Plan shall describe in detail the quality management policies, organisation, responsibilities and procedures to be applied, identifying the applicable requirements of **BS 5750**.
- (c) The Contractor's Quality Plan shall be prepared and issued within 4 weeks of award of Contract.
- (d) The Contractor shall require and verify that sub-contractors comply with the Contractor's Quality Plan.
- (e) The Contractor shall prepare management and technical procedures supporting or implementing the Contractor's Quality Plan. The procedures shall cover such activities as required by **BS 5750**.
- (f) The Contractor shall control quality related activities for key processes to ensure that quality objectives are met. The submission of any item at any stage to the Supervisor's Representative shall not form part of the direct quality control process and shall not relieve the Contractor of his responsibility for meeting specified requirements. Such submissions shall be regarded as part of the commitment and responsibility of the Contractor to interface with the Supervisor's Representative to ensure confidence in the output and work.
- (g) The Contractor shall, in writing:
  - (i) Within two weeks of award of Contract appoint a Quality Manager with the responsibility for and the authority to resolve quality matters;
  - (ii) Appoint a Quality Representative at each location of work two weeks before work starts at that location;
  - (iii) Inform the Supervisor's Representative of the initial appointees on appointment and any subsequent changes.
- (h) The Contractor shall make available to the Supervisor's Representative records of internal audits, external audits, management reviews and corrective actions.

### 2302 Release Certificates

The Contractor and his sub-contractors shall only deliver to Site for incorporation in the Works, items, which comply with Contract requirements and have satisfactorily passed all inspections and tests required under the Contract or the Contractor's Quality Plan.

Each item shall be accompanied by a Release Certificate in accordance with a set procedure

## **2400 HEALTH AND SAFETY**

### **2401 General**

- (a)** The Contractor shall appoint a Safety Officer.
- (b)** The Contractor shall be responsible for health and safety on the Site. He shall co-ordinate his own activities and those of his sub-contractors and suppliers to achieve safe and healthy working environments.
- (c)** Not later than two weeks before work is due to start on the Site, the Contractor shall provide the Supervisor's Representative with a copy of the written safety policy which he has prepared under International Standards and which relates to the execution of the Works at the Site.
- (d)** Prior to commencement of work on Site, the Contractor shall provide the Supervisor's Representative with a copy of the Notice of Building Operation or Works of Project Managed Construction submitted to the Health and Safety Officer.

### **2402 Safety Plan**

- (a)** The Contractor shall prepare a Health and Safety Plan covering all aspects of the Works and ensure that safety procedures are enforced.
- (b)** The Health and Safety Plan shall be co-ordinated with other Contractors working on the Site, and other relevant authorities.
- (c)** The Health and Safety Plan shall be submitted to the Supervisor's Representative within 4 weeks of the award of Contract, and shall be regularly reviewed and updated.
- (d)** For the duration of activities at or adjacent to the Site the Contractor shall arrange and chair a monthly Site Safety meeting, to which the Supervisor's Representative or his nominated representative shall be invited.

### **2403 Substances Hazardous To Health**

Notwithstanding his general duties under health and safety legislation and regulations, the Contractor shall advise the Supervisor's Representative in writing of any substances which he: proposes to bring onto the Site or incorporate into or use about the Works; or which he discovers existing on the Site, which fall within the Control of the Substances Hazardous to Health Regulations; or otherwise require special precautions to be taken.