



CONTRACT DOCUMENTS

PROPOSED MODIFICATIONS TO THE PATHOLOGY DEPARTMENT AT MULAGO HOSITAL

VOLUME	DESCRIPTION
1	Bid & Contract Information
2	Drawings
3	Fixtures and Fittings Schedules
4	Bills of Quantities
5	Technical Specifications

Precision & Formation SMC

Architects, Engineers, planners & Project Managers

Kyanja Heights, Suite No. 3. Senkumba Close
off Kisasi- Kyanja Road- Kyanja - Kampala
P. O. Box 23471, Kampala **Tel.:** +256-702409277

2026 05 29

Table of Contents

	<u>Page</u>
1.1 GENERAL MATTERS.....	2
1.1.1 General Conditions of Contract	2
1.1.2 Instructions to Bidders	2
1.1.3 Scope of Contractor's obligations	2
1.1.4 Interpretation of Terms.....	3
1.1.5 Workmanship	3
1.1.6 Codes of Practices.....	3
1.1.7 Materials	4
1.1.8 Ordering of Materials	4
1.1.9 Proprietary of Materials.....	4
1.1.10 Samples	5
1.1.11 Prove Vouchers	5
1.1.12 Tests.. ..	5
1.1.13 Payment of Tests.....	6
1.1.14 Test Samples	6
1.1.15 Rejected Workmanship and Materials.....	6
1.1.16 Material intended for Works.....	6
1.1.17 Overtime or Nightwork.....	7
1.1.18 Nuisance to adjoining buildings and property.....	7
1.1.19 Existing and adjacent property	7
1.1.20 Damage to Public and Private Roads	7
1.1.21 Existing Services	8
1.1.22 Watching and Lighting	8
1.1.23 Licenses and Permits	8

1.1.24 Notices and Fees	8
1.1.25 Definition of “Fix only”	9
1.1.26 Attendance of Nominated Sub Contractors	9
1.1.27 Temporary Roads	10
1.1.28 Temporary Fencing.....	10
1.1.29 Storage of Materials.....	10
1.1.30 Sheds for Operatives	10
1.1.31 Site Office	10
1.1.32 Site Meetings	11
1.1.33 Work Diary	11
1.1.34 Foreman-in-Charge	11
1.1.35 Temporary Latrines and Ablutions.....	11
1.1.36 Water for Works	12
1.1.37 Light and Power	12
1.1.38 Signboards.....	12
1.1.39 Protection of Works	12
1.1.40 Keep and Deliver Site and Works Clean	13
1.1.41 Contingencies	13
1.2 WORKS OF DEMOLITION AND ALTERATIONS	14
1.2.1 Demolition	14
1.2.2 Obstruction of Public Road etc	14
1.2.3 Prevention of dust and Fans.....	14
1.2.4 Removal of Rubbish.....	14
1.2.5 Disposal of Rubbish	14
1.2.6 Use of suitable material for hardcore.....	14
1.2.7 Dustproof Screens	15
1.2.8 Shoring.....	15

1.2.9 Building Openings.....	15
1.2.10 Cutting Openings in existing Walls	15
1.2.11 Existing Public Service Mains.....	15
1.2.12 Government to retain ownership of old Materials.....	15
1.2.13 Materials to be cleared away	16
1.2.14 Definition out and Making Good	16
1.3 EXCAVATION	17
1.3.1 Clear Site	17
1.3.2 Trees and Bushes to be Preserved	17
1.3.3 Felling Trees	17
1.3.4 Anthills.....	17
1.3.5 Remove Vegetable Soil	17
1.3.6 Excavate to reduce level.....	18
1.3.7 Excavate for Embankment.....	18
1.3.8 Excavate for Foundations	18
1.3.9 Steps in Foundations	18
1.3.10 Excess Excavations.....	18
1.3.11 Bottoms to be Approved	18
1.3.12 Soft Spots	18
1.3.13 Excess Excavations.....	19
1.3.14 Working Space	19
1.3.15 Rock Excavation	19
1.3.16 Definition of Rock Excavation.....	19
1.3.17 Determination of Rock Excavation	19
1.3.18 Payment for Rock Excavation	19
1.3.19 Blasting	20
1.3.20 Return, fill and ram	20

1.3.21 Filling to Make-up Levels	20
1.3.22 Borrow Pits.....	20
1.3.23 Replace Vegetable Soil	21
1.3.24 Disposal of Surplus Excavated Material.....	21
1.3.25 Definition of “get out”	21
1.3.26 Planking and Strutting.....	21
1.3.27 Keep Excavation free of Water.....	21
1.3.28 Hardcore	22
1.3.29 Temporary Retaining Boards.....	22
1.4 CONCRETE WORK.....	23
1.4.1 General Requirements.....	23
1.4.2 Cement.....	23
1.4.3 Aggregate for Concrete.....	24
1.4.4 The grading of aggregates shall be within the limits in the following tables:-	25
1.4.5 Sand... ..	25
1.4.6 Grading of Aggregates.....	26
1.4.7 Maximum Sizes of Coarse Aggregates	27
1.4.8 Storage of Aggregates	27
1.4.9 Concrete Mixes by Volume or Weight	27
1.4.10 Concrete Mixes.....	28
1.4.11 Design Mixes	30
1.4.12 Trial Mixes.....	30
1.4.13 Mixing of Concrete.....	32
1.4.14 Hand Mixing	32
1.4.15 Transporting and Placing Concrete	33
1.4.16 Ready Mix Concrete	33
1.4.17 Compaction of Concrete.....	34

1.4.18 Construction Joints	34
1.4.19 Protection of Concrete	35
1.4.20 Concrete Surface Finishes	35
1.4.21 Fair Face and Fine Face Finishes of Concrete	36
1.4.22 Form hole chases, etc.....	36
1.4.23 Steel Reinforcement	36
1.4.24 Bending Reinforcement	37
1.4.25 Spacing of RC bars.....	37
1.4.26 Fixing and Assembly of Reinforcement.....	37
1.4.27 Cover to Concrete.....	38
1.4.28 Inspection of Reinforcement.....	38
1.4.29 Formwork	38
1.4.30 Formwork Non-Exposed Concrete	39
1.4.31 Formwork for exposed Concrete	39
1.4.32 Preparation of Formwork before concreting	39
1.4.33 Approval of Formwork.....	40
1.4.34 Removal of Formwork.....	40
1.4.35 Composite Concrete/Hollow Clay Block Structures	41
1.4.36 “Freespan” and “Maxspan” Suspended Structures	42
1.4.37 “Freespan” Units or Beams	42
1.4.38 “Maxspan” Precast Rib and Filler Block Structures.....	43
1.4.39 Concrete Lintels	44
Table 4.39.1 – Concrete Lintels for Normal Spans and Loading	44
1.4.40 Precast Concrete	46
1.4.41 Concrete Apron.....	47
1.4.42 Attendance.....	47

1.5	WALLING.....	48
1.5.1	General Requirements.....	48
1.5.2	Brick Walling	49
1.6.	ROOFING	55
1.6.1	General	55
1.6.2	Steel Sheet.....	55
1.6.3	Aluminum Sheets.....	56
1.6.4	Roof Tiling	57
1.6.5	Bituminous Felt Roofing.....	58
1.6.6	Roofing Shingles.....	59
1.6.7	Proprietary Roofing Systems	59
1.6.8	Roof Screeds	59
1.6.9	Make Good.....	60
1.7	CARPENTRY	61
1.7.1	Timber	61
1.7.2	Timber for Special Structures	63
1.7.3	Preventive treatment for Timber	63
1.7.4	Seasoning	63
1.7.5	Samples and Testing	64
1.7.6	Sawn Timber	64
1.7.7	Wrot Timber	64
1.7.8	Workmanship	64
1.7.9	Jointing.....	65
1.7.10	Connectors.....	65
1.7.11	Nails, Bolts etc	65
1.7.18	Roofs.....	65
1.7.19	Ends of Timber	66

1.7.20 Fixing slips, Plugs, etc	66
1.7.21 Insect Damage.....	67
1.7.22 Cleaning.....	67
1.8.0 JOINERY AND IRONMONGERY	68
1.8.1 Timber	68
1.8.2 Species of Timber for Joinery Works.....	69
1.8.3 Preventive Treatment.....	71
1.8.4 Seasoning	71
1.8.5 Samples for Testing	71
1.8.6 All Joinery be wrot.....	71
1.8.7 Selected Timber for Polish etc.....	71
1.8.8 Plywood.....	71
1.8.9 Block boards	72
1.8.10 Wood chipboards.....	72
1.8.11 Veneers.....	72
1.8.12 Adhesives	72
1.8.13 Nails, Screws etc	72
1.8.14 Workmanship.....	73
1.8.15 Joints.....	73
1.8.16 Moulding	74
1.8.17 Fixing or Building Frames.....	74
1.8.18 Fixing Beads etc	74
1.8.19 Scribing	74
1.8.20 Grounds	74
1.8.21 Flush Doors.....	75
1.8.22 Priming.....	75
1.8.23 Polish or clear finishes.....	75

Specifications	Architectural, Structural and General works
1.8.24 Inspection.....	75
1.8.25 Storage and Delivery	76
1.8.26 Protection of Joinery	76
1.8.27 Ironmongery.....	76
1.8.28 Dowels	76
1.8.29 Mosquito Gauze.....	76
1.8.30 Making Good	77
1.9.0 METAL WORK.....	78
1.9.1 Materials generally.....	78
1.9.2 Structural Steel	78
1.9.3 Welding	78
1.9.4 Bolts.....	78
1.9.5 Metal Windows and Doors.....	78
1.9.6 Hanging.....	79
1.9.7 Fittings.....	79
1.9.8 Glazing Clips	79
1.9.9 Fixing lugs and screws.....	79
1.9.10 Composite Windows	80
1.9.11 Protective Finish	80
1.9.12 Fly screens.....	80
1.9.13 Aluminum security grilles	80
1.9.14 General Specification of steel cabinets, drawers and shelves	82
1.9.15 Particular Specification for Laboratory Casework	84
1.10 PAVING.....	103
1.10.1 Cement	103
1.10.2 Sand... ..	103
1.10.3 Granolithic Coarse Aggregate	103
1.10.4 Water.. ..	103

1.10.5 Granolithic paving	103
1.10.6 Granolithic Paving (Separate Construction)	104
1.10.7 Granolithic Paving (Monolithic)	105
1.10.8 Chemical Surface treatment etc	105
1.10.9 Screeds	105
1.10.10 Terrazzo Paving	105
1.10.11 Concrete and Quarry Tile Paving	106
1.10.12 Cork Tile Paving	106
1.10.13 Flexible P.V.C Floor Tiling	106
1.10.14 Dividing Strips	107
1.10.15 Cover up and Protection of Paving	107
1.11 WALL AND CEILING FINISHES	108
1.11.1 Cement	108
1.11.2 Lime	108
1.11.3 Sand	108
1.11.4 Plastering Generally	108
1.11.5 Internal Plastering	109
1.11.6 External Rendering	110
1.11.7 Tyrolean Finish Rendering	110
1.11.8 Expanded Metal Lathing	110
1.11.9 Wall Tiling	110
1.11.10 Expanded Polystyrene Tiles	111
1.11.12 Insulation Board	112
1.11.13 Flat Sheets	112
1.11.14 Make Good	112

1.12 GLASS WORKS	113
1.12.1 Glass.....	113
1.12.2 Putty... ..	113
1.12.3 Glazing.....	113
1.12.4 Bedding Strips.....	114
1.12.5 Cleaning, etc on completion	114
1.13 PAINTING.....	115
1.13.1 Workmanship.....	115
1.13.2 Sub-letting Work	115
1.13.3 Materials	115
1.13.4 Paint... ..	115
1.13.5 Linseed Oil	115
1.13.6 Knotting.....	115
1.13.7 Wax Polish	115
1.13.8 Lacquer Treatment	115
1.13.9 Generally.....	116
1.13.10 Preparation	117
1.13.11 Preparation of Existing surfaces.....	118
1.13.12 Backs of Frames.....	118
1.13.13 Remove Ironmongery	118
1.13.14 Cover up and Protect.....	118
1.13.15 Cleaning up.....	119
1.14 SUBTERRANEAN STORM AND SURFACE WATER DRAINAGE ..	101
1.14.1 Site.... ..	120
1.14.2 Roof.....	120
1.14.3 Surface water.....	120

2.1 GENERAL REQUIREMENTS FOR MECHANICAL AND DRAINAGE INSTALLATIONS.....	122
2.1.1 General	122
2.1.2 Quality Of Materials	122
2.1.3 Regulations And Standards	122
2.1.4 Electrical Requirements	123
2.1.5 Transport And Storage	123
2.1.6 Site Supervision	124
2.1.7 Installation	124
2.1.8 Material Tests	124
2.1.9 Manufactured Plant And Equipment- Work Tests	124
2.1.10 Pressure Testing.....	125
2.1.11 Colour Coding	126
2.1.12 Welding	126
2.1.13 Welding Code And Construction	126
2.1.14 Welders Qualifications	126
2.2 PLUMBING AND DRAINAGE	127
2.2.1 General	127
2.2.2 Approval.....	127
2.2.3 Materials	127
2.2.4 Valves..	130
2.2.5 Waste Fitment Traps	131
2.2.6 Workmanship	131
2.2.7 Pipe Supports For Suspended Pipework	133
2.2.8 Underground Pipe Lines	135
2.2.9 Cold Water Booster Pumps	139
2.2.10 Testing And Inspection	140

2.2.11 Colour Coding In General.....	143
2.2.12 Sterilization Of Hot And Cold Water Supply System	143
2.2.13 Chambers And Manholes	143
2.2.14 Testing Of Manholes.....	144
2.2.15 Cold Water Storage Tanks	144
2.2.16 Sanitary Fittings	144
2.3 FIRE FIGHTING.....	145
2.3.1 Hose Reel System	145
2.3.2 Fire Extinguishers	148
2.4 SPECIFICATIONS FOR REFUSE CHUTE SYSTEM.....	152
2.4.1 Equipment.....	152
2.4.2 Service And Parts	152
2.4.3 Submittals	152
2.4.4 Supply	152
2.4.5 Material Trunking	152
2.4.6 Spc Hoppers	152
2.4.7 Floor Support Frames.....	152
2.4.8 Discharge	152
2.4.9 Chute Cleaning	153
2.4.10 Disinfectant And Sanitising Unit	153
2.4.11 Ventilation	153
2.4.12 Exhaust Fan.....	153
2.4.13 Sound Damping	153
2.4.14 Chute Construction	153
2.4.15 Equipment.....	154
2.4.16 Construction Waste	154
2.4.17 Inspection Prior To Installation	154

2.4.18 Installation	154
2.4.19 Testing And Commissioning	154
2.4.20 Acceptance	154
2.5 VENTILATION AND AIR CONDITIONING	155
2.5.1 General	155
2.5.2 Scope Of Work	155
2.5.3 Drawings	155
2.5.4 Materials And Workmanship.....	155
2.5.5 Climatic Conditions	156
2.5.6 Design Conditions For Air Conditioning	156
2.5.7 Ductwork	157
2.5.8 Instruments	163
2.5.9 Filters.....	163
2.5.10 Dampers	165
2.5.11 Grilles, Diffusers And Louvres	166
2.5.12 Fans.....	167
2.5.13 Air Cooled Liquid Chillers	168
2.5.14 Air Handling Units	169
2.5.15 Variable Refrigerant Volume (Vrv) Systems.....	170
2.5.16 Variable Frequency Drive / Controllers (Vfd).....	171
2.5.17 Programmable Logic Controllers (Plc)	171
2.5.18 Room Pressure Monitor.....	172
2.5.19 Split Units.....	172
2.5.20 Electrical Installations	172
2.5.21 Commissioning	174
2.5.22 Operating And Maintenance Instructions	175
2.5.23 Spare Parts	176

2.5.24 Documentation And As Built Drawings.....	176
2.5.25 Design Review Meeting	176

3.1 GENERAL SPECIFICATIONS FOR ELECTRICAL WORKS.....178

3.1.1 Introduction	178
3.1.2 Polyvinyl Chloride (Pvc) Or Cross Linked Polyethylene (Xlpe) Insulated, Single Wire Armoured And Pvc Sheathed Cables	181
3.1.3 Elastomer And Polyvinyl Chloride Insulated Cables Enclosed In Heavy Gauge Conduit And Metal Trunking	184
3.1.4 Cable Trays And Racks	190
3.1.6 Wiring Systems	192
3.1.6 Elastomer And Polyvinyl Chloride Insulated Cables Enclosed In Heavy Gauge Conduit And Metal Switchgear And Distribution Boards	193
3.1.7 Fuses And Miniature Circuit Breakers	196
3.1.8 Distribution Boards	198
3.1.9 Lighting Installation	199
3.1.10 General Power Installation	202
3.1.11 Luminaires	203
3.1.12 Emergency Lighting Installation.....	203
3.1.13 Main Equipotential Earthing And Bonding.....	204
3.1.14 Lightning Protection	205

**3.2 SCOPE OF ELECTRICAL WORKS AND DESIGN CONSIDERATIONS
.....209**

3.2.1 Scope Of Works.....	209
3.2.2 Description Of The Building.....	209
3.2.3 Fire Ratings.....	210
3.2.4 Supports And Fixings.....	210
3.2.5 Clearance For The Removal Of Items.....	211
3.2.6 Maintenance Access.....	211
3.2.7 Climatic Conditions	211
3.2.8 Supply Characteristics	212

3.3 PARTICULAR SPECIFICATIONS FOR ELECTRICAL SERVICES.....	212
3.3.1 General	213
3.3.2 Suitability Of Materials And Products	214
3.3.3 Lighting Installation	214
3.3.4 13 Amp Socket Outlets	216
3.3.5 Earthing And Bonding.....	217
3.3.6 Lightning Protection	218
3.4 INFORMATION AND COMMUNICATION TECHNOLOGY	220
3.4.1 Generally.....	220
3.4.2 Scope... ..	220
3.4.3 Intent... ..	221
3.4.4 Cable Plant	221
3.4.5 As-Built Diagrams	227
3.4.6 Cctv For Security And Monitoring.....	227
3.4.7 Access Control System.....	229
3.4.9 Authorization	232
3.4.10 Audit... ..	232
3.4.11 Schedule Of Unit Rates	234

PART 1

GENERAL SPECIFICATIONS FOR

ARCHITECTURAL, STRUCTURAL AND

GENERAL WORKS

1.1 GENERAL MATTERS

1.1.1 General Conditions of Contract

All clauses, definitions and procedures described in the General Conditions of Contract, issued 2003 by PPDA will apply to these specifications unless specifically ruled otherwise in Special Conditions of Contract.

1.1.2 Instructions to Bidders

All clauses, definitions and instructions issued in the Invitation to Bid will apply to these specifications unless otherwise ruled in the Contract Documents

1.1.3 Scope of Contractor's obligations

The Contractor shall provide everything necessary for the proper execution and completion of the works, according to this specifications, the particular specification and/or the bills of quantities whether the same is particularly described or not.

The contractor shall provide all labour, carriage, freightage, building materials, implements, tools, tackle and plant and whatever else may be required for the proper and efficient execution and completion of the works.

The contractor shall obtain necessary consents, pay any charges for, provide, erect, maintain and remove all necessary self supporting and other scaffolding, staging, gangways etc together with the necessary planks, ladders, trestles, etc. for the use of all trades engaged upon the buildings.

The contractor shall provide, erect, maintain and alter as necessary and remove on completion all internal scaffolding, planks, trestles, ladders etc to all floors for the use of all trades engaged upon the building.

The contractor shall include in his rates, unit prices or tender for all charges for waste, establishment and overhead charges and profit.

1.1.4 Interpretation of Terms

Wherever the words – ‘selected’ as ‘directed’ ‘as required’, or words of similar meaning are used in these documents, it is to be understood that the selection, direction or requirements of the Project Manager are intended. Similarly the words ‘approved’, ‘satisfactory’ or other synonyms shall mean ‘approved by’ or ‘satisfactory to’ the Project Manager and the Project Manager’s approval must first be obtained before the materials are ordered or the works to which the words refer are put in hand.

Where the words ‘necessary’, ‘proper’ or words of similar meaning are used in these documents with respect to the extent conduct or character or work described, it is to be understood that they shall mean that the said work shall be executed to the extent, must be conducted in a manner or be of a character which is ‘necessary’ or ‘proper’ in the opinion of the Project Manager.

1.1.5 Workmanship

All workmanship shall be carried out by skilled operatives well versed in their respective trades.

All persons carrying out Plumbing and Drainage works shall hold licenses for carrying out such work in accordance with Rule 76 of the Drainage and Sanitation Rules.

1.1.6 Codes of Practices

Where certain classes of work are described as in accordance with a Code of Practice (C.P.) this shall be understood to mean the most recent and up to date editions of Ugandan Codes of Practices. In absence of such codes, most recent version of the British Standard Code of Practice as published by the council for Codes of Practice, British Standards Institutions or such other Code of Practice as shall be expressly stated herein by the Project Manager may be applied.

1.1.7 Materials

All materials shall be new unless otherwise directed or permitted by the Project Manager and in all cases where the quality of goods or materials is not described or otherwise specified is to be the best quality obtainable in the ordinary meaning of the word 'best' and not merely a trade signification of that word.

A reference to Standard Specification shall be understood to mean the most recent and up to date edition of that specification as published by the MOWHC.

In absence of a specification of intended material does not exist in that Standard Specification, reference to a British Standard Specification may used and shall be understood to mean the most recent and up to date edition of that specification as published by the British Standard Institution. The initials 'B.S.' used in this document are the abbreviated form of British Standard Specification.

The Project Manager reserves the right to substitute, amend, alter, enlarge upon, correct or revise any of the foregoing and where this is intended it will be expressly stated herein.

1.1.8 Ordering of Materials

The Contractor shall be solely responsible for ordering all materials required for use on the works.

The Contractor shall order all material, other than those covered by Prime Cost or Provisional Sums, as early as necessary after the Contract is signed to ensure that such material will be on site when required for incorporation in the works.

Materials which are the subject of Prime Cost or Provisional sums in these documents shall be ordered immediately after written instructions are received to do so from the Project Manager.

The Contractor is to take his own measurements for the ordering of materials. No responsibility will be accepted by Government for surplus, shortage, loss or expense if the goods are wrongly ordered.

The Contractor shall be responsible for and shall replace or make good at his own expense any materials lost or damaged, no matter how arising.

1.1.9 Proprietary of Materials

All proprietary materials and goods, i.e. those specified to be obtained from a particular manufacturer are to be used and fixed strictly in accordance with their instructions.

Where proprietary materials are specified hereafter the Contractor may propose the use of materials of other manufacture and equal quality for approval by the Project Manager. If such approval is given, in writing, then these alternative materials may be incorporated in the works at no extra cost to the Government.

1.1.10 Samples

The Contractor shall furnish at the earliest possible opportunity before work commences and at this own cost, any samples of materials or workmanship that may be called for by the Project Manager for his approval or rejection and any further samples in the case of rejection until such samples are approved. Such samples when approved shall be of not less than the minimum standard for the work to which they apply.

Samples shall be as representative as possible and no attempt shall be made to be unduly selective, samples shall be taken separately from a number of places in a particular load, heap, stock pile, batch deposit pit or suppliers store as the case may be, as directed by the Project Manager.

1.1.11 Prove Vouchers

The contractor shall upon, request by the Project Manager, furnish vouchers to prove that materials are being supplied in accordance with the specifications.

1.1.12 Tests

The Project Manager shall, as stated in the GCC, clause 34, be at liberty to make all tests necessary in order to satisfy himself that the materials and workmanship of every kind are in accordance with the Specification.

Where tests are carried out on the Works or samples taken by the Project Manager, the Contractor shall give all necessary assistance when called upon to do so.

The testing of materials will, unless expressly stated to the contrary, be carried out either by the Chief Materials Engineer, at the Central Materials Laboratory, Kampala, or equivalent laboratory as determined by the Project Manager. Tests may also be carried out by Project Manager or his representative on site when adequate facilities for such site tests exist.

1.1.13 Payment of Tests

In case the Contract Documents include a Provisional Sum to meet the cost of testing all materials other than concrete work cube tests as later described.

The Contractor shall keep an accurate record of the costs incurred in the successful testing of materials and such costs will be adjusted in the final account and set off against the Provisional sum.

The Contractor will not be paid for unsuccessful tests due to the submission of materials which for any reason whatsoever are not of the required standard.

1.1.14 Test Samples

Each sample submitted to the laboratory for testing shall be properly packed, adequately labeled and have affixed to it the following information for the purposes of identification:-

- (a) Name of project and location
- (b) Type of material
- (c) Intended use
- (d) Date sample taken
- (e) By whom sampled
- (f) In cases of aggregate or other naturally occurring material, the location of the pit or deposit.
- (g) Name of contractor and contractor's sample reference number.

1.1.15 Rejected Workmanship and Materials

Any workmanship or materials not complying with the requirements of the specification or approved samples which have been damaged, contaminated or have deteriorated, must be immediately removed from the site and replaced at the Contractor's expense, as directed by the Project Manager.

1.1.16 Material intended for Works

No timber or other materials required in the permanent construction of the works will be allowed to be used as plant or scaffolding.

1.1.17 Overtime or Nightwork

If the contractor determines for the purpose of expediting the Works or for any other reason to permit the working of overtime or nightwork necessary so that the works or any part thereof, shall be completed in every respect ready for occupation and use within the time stated, he must include for same in his tender as no extra payment will be allowed for this at the settlement of the accounts.

When the Project Manager directs the Contractor in writing, for any reasons whatsoever; to carry out work outside normal working hours, he will be reimbursed the net difference in cost between the operatives normal hourly or daily rate of pay and the enhanced overtime rate where this applies.

1.1.18 Nuisance to adjoining buildings and property

The Contractor is to make every reasonable and practical effort, consistent with good and expeditious work, to avoid nuisance from noise, dust, transport or any other cause to the occupants of existing buildings and adjoining property and to the public generally.

1.1.19 Existing and adjacent property

The Contractor must take all steps necessary to safeguard the existing property and adjacent property, make good at his own expense any injury to persons or damage to property caused thereon, and hold the Government indemnified against any such claim arising.

The Contractor shall take all necessary precautions to avoid damage to the surrounding ground, grass, plants, shrubs and trees and reinstate at his own expense any damage caused thereto.

1.1.20 Damage to Public and Private Roads

The Contractor will be required to make good at his own expense, any damage he may cause to the present road surfaces and pavements during the period of the works.

1.1.21 Existing Services

Prior to commencement of any work the Contractor is to ascertain from the relevant Authorities the exact position, depth and level of all existing electric and telephone cables water pipes or other services in the area and he shall make whatever provisions may be required by the Authorities concerned for the support and protection of such services. Any damage or disturbance caused to any service shall be reported immediately to the Project Manager and the relevant authority and shall be made good to their satisfaction at the Contractor's expense.

1.1.22 Watching and Lighting

The Contractor shall provide at his own cost all requisite day and night watching and lighting including that for use by his Sub-Contractors, whether nominated or otherwise and everything else necessary for the protection and security of the Works, plant, materials on site, the Public, and all persons lawfully using the premises during the execution of the works.

The contractor shall provide red warning lamps at night to all obstructions and excavations either on, in or adjacent to the public highway.

1.1.23 Licenses and Permits

The Contractor must ensure that he, as sole proprietor or as an authorized director of his company and his workpeople are in possession

He must also ensure that he or his suppliers are in possession of valid import licences for materials which are required to be obtained from outside Uganda.

1.1.24 Notices and Fees

The Contractor shall allow for giving all notices to Public Authorities and Statutory undertakings and for payment all fees and charges legally demandable. (see separate clause regarding water charges).

1.1.25 Definition of “Fix only”

For all items described in these documents as ‘Fix only’ the Contractor shall allow in addition to the foregoing for taking delivery where directed, checking with invoices or indents, reporting and claiming damages for shortages and damaged goods, defraying demurrage charges, transporting, unloading, storing and protecting until the time of fixing, unpacking, replacing anything lost or damaged, sorting, assembling, distributing, hoisting to required levels and fixing complete in accordance with the directions supplied or specified.

1.1.26 Attendance of Nominated Sub Contractors

The Contractor is to afford both general and specific attendance upon all Nominated sub-contractors, specialists and other executing works for which prime cost or provisional sums or prices are included hereafter.

The Contractor is to give such facilities to all firms employed upon the Works as the Project Manager considers reasonable and afford them use of scaffolding and ladders, alter standing scaffolding as required, or erect and remove any special scaffolding which they may require for the purpose of carrying out their work, supply them with labour and tackle for unloading, getting in, storing, hoisting and distributing their materials, use of electric light, power, and water and allow them use of storage for their materials, and the use by the Nominated Sub-Contractors employees of all messroom, sanitary accommodation and welfare facilities and clear away all rubbish.

The contractor is to give Nominated Sub-Contractors and other parties working on the premises all information reasonably necessary to enable them to properly set out and execute their work in harmony with the surroundings and other trades, and is not to allow them to proceed otherwise.

The Contractor shall be responsible in every respect for Nominated Sub-Contractors and in particular to see that their work proceeds regularly with the general progress of the building works and in accordance with the Progress Schedule.

The value of the foregoing services to be rendered by the Contractor to the Sub-Contractors, as described in this Clause is to be allowed for in the Bills of Quantities or particular specification under the item “Attendance’ which follows each Prime Cost or Provisional Sum.

The Contractor must allow for hacking surfaces to receive special finishes as required by Nominated Sub-Contractors.

1.1.27 Temporary Roads

The Contractor shall provide and maintain as necessary, all temporary roads, ramps, hard-standing, tracks, crossings and the like for the efficient running of the Works for all vehicles entering and on the site, including those of Nominated Sub-Contractors and afterwards remove and reinstate the ground to its original condition if so directed by the Project Manager.

1.1.28 Temporary Fencing

The Contractor will not, unless otherwise expressly instructed in the Contract Documents, be expected to provide a temporary fence or hoarding around the site. He will however be required to afford adequate protection and security from theft or other loss by the provision of a safe area or compound for the storage of materials which cannot be properly stored in a lockable store as provided hereafter. The compound must be properly constructed and have adequate means of access and locking facilities and afterwards it must be dismantled and clear away from the site.

1.1.29 Storage of Materials

The Contractor shall provide erect and maintain and clear away on completion suitable watertight sheds and other protection for the storage of materials including those of all Sub-Contractors.

Floors of sheds used for the storage of cement and other perishable materials shall be raised at least 150 mm above ground level. Cement stacks or bags shall be placed on timber pallets approved by the Project Manager.

1.1.30 Sheds for Operatives

The Contractor shall similarly provide suitable watertight sheds for the use of the operatives and those of all Sub-Contractors.

1.1.31 Site Office

The Contractor shall provide erect and maintain and clear away on completion suitable watertight temporary office accommodation for the use of his site staff and a similar separate-office for the use of the Project Manager's Supervising Officer.

Each office shall be of suitable size for the purpose for which it is intended and shall have a lockable door, windows of a size proportionate to the floor area, adequate means of ventilation, and be fitted with a desk with a drawer for the storage of plans and chair for the use of the staff.

1.1.32 Site Meetings

Site Meetings will be held in the Site Office at intervals as directed and the contractor will be required to summon the attendance of Sub-Contractors and specialists, prepare and distribute minutes and generally organize the meetings.

1.1.33 Work Diary

The Project Manager will issue to the Contractor one copy of the Standard works Diary which shall be kept on the site at all times.

1.1.34 Foreman-in-Charge

The Contractor shall keep a Foreman-in-Charge in constant attendance upon the works. He shall be capable of reading, writing and speaking English and he shall keep copies of all drawings; details, specifications, letters, instructions, etc. on the works.

He will also be required to keep a day today record in the Works Diary of the weather on the site.

1.1.35 Temporary Latrines and Ablutions

The contractor shall provide the necessary temporary latrines, water closets and ablutions for his staff and workmen to the requirements and satisfaction of the Health Authorities and maintain the same in a thoroughly clean and sanitary condition and pay all conservancy fees and connection charges during the period of the Works and remove when no longer required and make good all distributed surfaces.

1.1.36 Water for Works

The Contractor shall provide at his own risk and cost all water for use in connection with the Works (including the work of Sub-Contractors whether Nominated or otherwise). Where a mains supply is not available locally he will be required to bring in water by tanker or other approved method and pay all costs and fees in connection therewith. He shall also provide temporary storage tanks and tubing, etc. as he may consider necessary and clear way at completion.

All water shall be fresh, clear and pure, free from earthly vegetable or organic matter, acid or alkaline substance, in solution or suspension.

1.1.37 Light and Power

The Contractor shall provide all artificial lighting and power for use on the Works, including all Sub-Contractors and Specialists whether nominated or otherwise, requirements and including all temporary connections, wiring, fittings etc and clear away on completion. The Contractor shall pay all fees and obtain all permits in connection therewith.

Before submitting his tender the Contractor must ascertain for himself whether a supply will be available or not at commencement of or during the course of the Works as no claim will be entertained due to failure of the Uganda Electricity Board to provide such a supply.

1.1.38 Signboards

The Contractor shall provide, erect and clear away on completion a signboard for the display of the General Contractor's names which shall be of an approved size and design with the Employers' names painted thereon.

Particulars of all parties to the contract shall be given and words shall be printed in 50 mm letters. No other signboard or advertising signs shall be permitted without the permission of the Project Manager.

1.1.39 Protection of Works

The Contractor shall allow for covering up and protecting the Works during inclement weather and provision of all temporary covers, gutters, down pipes surface water drains, etc. as required.

1.1.40 Keep and Deliver Site and Works Clean

He will also allow for carefully protecting all work including all Sub-Contractors Work liable to injury and provide all necessary temporary casing, linings, coverings to steps, floors, tiles, paving, walls, ceilings, fittings and fixtures of all kinds to the complete satisfaction of the Project Manager and finally clear all away on completion.

1.1.41 Contingencies

The Contractor shall allow for cleaning out drains, gullies, interceptors, manholes, etc. Cleaning glass inside and out, cleaning metalwork and woodwork, sweeping and scrubbing all floors pavings etc. or treating with special finishes as described, cleaning all cisterns, sanitary fittings, etc, testing all water supplies, cisterns and sanitary fittings and leaving drip dry, oiling all door and window hinges, bolts and locks and removing all paint and cement stains and clear and cart away all rubbish as it accumulates to a tip to be provided by the Contractor and leave the whole of the site and Works clean and tidy ready for occupation to the complete satisfaction of the Project Manager.

The Contractor shall include in his Tender the Contingency Sum as directed in the Particular Specification or Bills of Quantities which will be used as directed by the Project Manager and deducted in whole or in part if not required.

1.2 WORKS OF DEMOLITION AND ALTERATIONS

1.2.1 Demolition

All taking down and demolition is to be carried out without damage to the remaining structures or the adjoining property, Where any such damage occurs the Contractor shall reinstate and make good at his own expense

1.2.2 Obstruction of Public Road etc

The Contractor shall not obstruct the Public Thoroughfares or Private Rights of Way without the approval of the Local authority and shall pay all their charges and conform to all instructions issued by them.

1.2.3 Prevention of dust and Fans

The Contractor is to thoroughly water the work during all demolition to prevent any nuisance from dust, dirt, etc., and is to provide all necessary protecting fans, barricades, dust sheets, tarpaulins etc to protect the new and existing work, the public, the occupants and the workmen.

1.2.4 Removal of Rubbish

All items of taking down etc., are to be included for removing, basketting, getting out and clearing away from site all debris and rubbish whether specifically mentioned or not from the relevant floor levels.

1.2.5 Disposal of Rubbish

The contractor is to make his own arrangements for a shoot or spoil heap for disposal of all materials arising from demolition works and he is to pay all charges in connection therewith

1.2.6 Use of suitable material for hardcore

The Contractor may use the broken brick and other approved material arising from the pulling as hardcore filling under floors, paths etc., provided such materials are suitably broken down and cleaned to the approval of the Project Manager.

1.2.7 Dustproof Screens

The Contractor is to allow for providing and fixing temporary waterproof and dustproof screens, coverings, etc. To all sections of the existing building, which may be exposed by reason of the pulling down and is to efficiently keep the premises watertight and dust free whilst building work is in progress.

1.2.8 Shoring

The Contractor's price for shoring where described is to include for all shoring, needling, strutting etc., to all walls, floors, roofs, etc., as required, altering and adapting same as necessary and the Contractor is to be responsible for the sufficiency and maintenance of the same and removal when no longer required and making good all works disturbed at completion.

1.2.9 Building Openings

The contractor 's price for building up openings in existing walls are to include for all temporary strutting to heads, preparing jambs, oils and wedging and pinning at heads.

1.2.10 Cutting Openings in existing Walls

The contractor's prices for cutting openings etc., in external walls at various floor levels and all other works necessitated shall be deemed to include for all necessary scaffolding, ladders, etc.

Similarly, this shall equally apply to his prices for external painting.

1.2.11 Existing Public Service Mains

The contractor is to allow for protecting supporting or diverting as required any Public Service Mains encountered during the execution of the works or he must allow for and pay all fees chargeable if this work is executed by the Public Authorities concerned.

1.2.12 Government to retain ownership of old Materials

Where materials as described "to set aside for re-use" they shall remain the property of the Government and shall be carefully preserved by the Contractor and loaded and carted to a store where directed by the Project Manager, and the Contractor shall allow in his prices for this.

1.2.13 Materials to be cleared away

All old materials described to be “cleared away” are to become the property of the Contractor and are to be removed from the site by him and he is to state in the place provided any credit he is prepared to allow. The Government reserves the right, however, to retain ownership in any of the materials arising from the pulling down and the Contractor will be reimbursed at the credit value he has allowed for those materials.

1.2.14 Definition out and Making Good

The words “making out” and “make good” are to be read as including all necessary labour and new materials required to match in every respect the existing surrounding work, unless the same are described as ‘measured separately’.

1.3 EXCAVATION

1.3.1 Clear Site

Clear the site of the Works to the extent as directed by the Project Manager but not otherwise. Demolish and remove all obstruction, remove rubbish, cut down vegetation, shrubs, bushes and trees and grub up stumps and roots and burn or clear away from site. Holes made in grubbing up stumps and roots shall be filled in and rammed solid with approved material deposited in layers not exceeding 150mm thick.

1.3.2 Trees and Bushes to be Preserved

Trees and bushes which are to be preserved will be marked with paint by the Project Manager's Supervising Officer on site and the Contractor shall carefully protect these as required until completion of the Works.

1.3.3 Felling Trees

All useable timber trees shall remain the property of the Government. Trees shall be cut down as near to the ground as possible, leaves and branches removed and burnt, and useful trunks cut into suitable lengths and removed and placed in stocks on the site where directed.

1.3.4 Anthills

All anthills, nests, Queen ants and grubs are to be removed as necessary, sterilize the ground either by lighting fires and burning for not less than 24 hours or use of an approved insecticide and fill any holes excavated with approved material filled in and rammed solid in layers not exceeding 150 mm thick.

1.3.5 Remove Vegetable Soil

Excavate over surface of site of roads, paths, embankments, terraces, etc., and to a distance of not less than 3 m around any building, and remove vegetation and top soil to a depth of not less than 150 mm below the average existing ground level or to such other average existing ground level or to such other depth as directed by the Project Manager, Vegetable soil is to be removed to a spoil heap within the boundary of the site or as otherwise directed and carefully preserved for reuse in top soiling to embankments and areas of cut or fill.

1.3.6 Excavate to reduce level

Excavate over surface of site to reduce level and get out. Formation level is deemed to be the underside or murrum base courses of roads, hard standings and the like. Grassed areas or unpaved areas, are unless directed to the contrary to be reduced to 150 mm below finished ground levels to allow for the replacing of top soil for grassing.

1.3.7 Excavate for Embankment

Excavate to reduce levels to form embankments where required and get out. Unless otherwise shown on the drawings the face of the bank shall be finished to an even slope not greater than 2:5.

1.3.8 Excavate for Foundations

Excavate for basements, foundation, ducts, pier holes, stanchion bases, etc., all to the widths and depths as shown on the drawings or as directed by the Project Manager to an approved.

1.3.9 Steps in Foundations

Steps in foundation are to be provided in accordance with the drawings or the Project Manager's instructions.

1.3.10 Excess Excavations

Level or trim to falls and cross falls as indicated on the drawings and well ram and consolidate surface of ground and bottom of all excavations to receive concrete foundations, beds, etc.

1.3.11 Bottoms to be Approved

The bottom of all excavations and ground surfaces under foundations, beds and the like shall be inspected and approved by the Project Manager before concrete or hardcore is laid.

1.3.12 Soft Spots

Where pockets of soft or other unsuitable material are found to extend below the general approved foundation or formation level these shall be removed to such extent and levels as directed by the Project Manager and filled up to the underside of the adjacent foundations, later described in the case of concrete mix 'E' as later described in the case of concrete work or with approved excavated material when under hardcore beds.

1.3.13 Excess Excavations

Should any excavation be made below the depths shown or required to obtain a solid bottom the Contractor must fill up the excess excavation in the same manner as described for Soft Spots Clause 3.12.

1.3.14 Working Space

Where work carried out by other trades demand it, or when instructed by the Project Manager, the Contractor shall excavate working space sufficient to facilitate the proper carrying out of such work, i.e. vertical tanking, formwork to ground beams, etc.

1.3.15 Rock Excavation

The Contractor's prices for all excavation work will be deemed to include for excavations in any material other than solid rock.

1.3.16 Definition of Rock Excavation

Solid rock shall mean any naturally occurring material found in ledges or masses in its original position which by the use of compressors or by blasting and also solid boulders or detached pieces of rock in size:-

- (i) Exceeding 0.25 m³ in trenches.
- (ii) Exceeding 1.25 m³ in general excavation

1.3.17 Determination of Rock Excavation

The Contractor shall inform the Project Manager as soon as rock is exposed so that he may inspect and determine that the material is rock within the meaning of the definitions given herein and instruct the contractor accordingly either to remove it or redesign the affected foundation works as he sees fit.

1.3.18 Payment for Rock Excavation

The Contractor will be paid extra for the removal of solid rock so defined at the rates inserted by him in the Contract Documents or in the absence of such rates. By rates to be agreed with the Project Manager. The "extra rates for rock excavation shall include for excavating with compressors or for blasting, if allowed, and the extra cost of leveling, trimming and disposal.

1.3.19 Blasting

Blasting shall be allowed only when expressly authorized by the Project Manager.

If in his opinion it would be dangerous to persons or adjacent buildings to blast or if blasting has been authorised and is being carried out in a reckless or dangerous manner he may prohibit it and order the rock to be excavated by other means.

The greatest care shall be taken by the contractor when blasting to ensure that no injury be done to persons or any finished work. The shorts shall be properly loaded and covers and lonely moderate charges shall be used and where directed by the Project Manager the Contractor shall provide heavy mesh blasting nets or blast mounds. Blasting shall be restricted to such times as the Project Manager shall direct.

The Contractor shall make good at his own expense any damage resulting from blasting operations irrespective of whether the Project Manager has directed that special precautions be taken or not.

1.3.20 Return, fill and ram

Return and fill selected excavated material around foundations, to backs of walls etc., up to formation level or as directed by the Project Manager, in layers not exceeding 230 mm thick and well ram and consolidate and water as required. No back filling is to be done until the foundation work has been inspected and approved by the Project Manager.

1.3.21 Filling to Make-up Levels

Filling to make up levels under floors, terraces and the like shall be selected excavated material. The material is to be wheeled from wherever it is located on the site and filled in layers not exceeding 150 mm thick each watered as required and well rammed and consolidated up to the required levels.

1.3.22 Borrow Pits

Where there is insufficient filling material arising from the excavations the Contractor will be required to obtain it from other sources to make up the required quantity. The Contractor shall open up a suitable borrow pit excavate as necessary, transport the material to site and deposit and fill as previously described.

1.3.23 Replace Vegetable Soil

Remove vegetable soil from spoil heaps and wheel and deposit over the area of excavated and filled areas around buildings including sloping faces of embankments to a finished depth of not less than 150 mm or to such other depth as directed by the Project Manager.

Any surplus vegetable soil is to be deposited, spread and leveled on site where directed. Under no circumstances is the contractor to sell, remove from site or otherwise dispose of vegetable soil.

1.3.24 Disposal of Surplus Excavated Material

All surplus excavated material is to be wheeled, deposited, spread and leveled on site where directed by the Project Manager, or where otherwise expressly provided in these documents to be removed from the site to a tip to be provided by the Contractor who is required to pay any fees and charges in connection therewith.

1.3.25 Definition of “get out”

The words “get out” shall be construed as meaning all basketting out, and any re-excavation from spoil heaps which may be required in connection with items of filling and disposal.

1.3.26 Planking and Strutting

The contractor is to include for maintaining and upholding the sides of all excavations by means of planking and strutting or such other method as he deems necessary, including excavations next public roadways, filled areas and existing hardcore or any other material. No claim for additional excavation, concrete or other material required due to the Contractor's failure to observe this clause will be allowed.

1.3.27 Keep Excavation free of Water

Keep the whole of the excavations free from water, slop and mud arising from surface water, rain, drains, floodwater or any other similar cause by baling pumping, temporary drains or otherwise until completion of the Works. Where hidden underground springs are encountered or where foundations extend below the level of the water table which requires continuous pumping, the Contractor will, where this is properly authorised in writing by the Project Manager be paid for this at rates to be agreed for the use of such pumps.

1.3.28 Hardcore

Provide and lay hardcore beds under all concrete beds,, pavings, etc., to the thickness as shown on the drawings.

Hardcore shall consist of approved hard dry broken brick rubble or crushed stone to pass a 65mm ring, laid in layers not exceeding 150 mm thick and each well watered, rammed and consolidated and leveled or finished to falls as shown on the drawings blinded with fine stuff to receive concrete or other topping.

Form all sinking for ducts and thickenings in floor to the dimensions as indicated on the drawings.

1.3.29 Temporary Retaining Boards

The contractor shall supply and maintain all temporary retaining boards for hardcore beds.

1.4 CONCRETE WORK

1.4.1 General Requirements

All concrete work shall be carried out in accordance with the specification except that in the case of reinforced concrete the provisions of B.S Code of Practice C.P. 114 -The Structural Use of Reinforced Concrete in Buildings Part 2 : 1969 (Metric) shall apply in so far as they override, modify or supplement the clauses contained herein. The contractor shall submit to the Project Manager full details of all materials which he proposes to use for making concrete.

1.4.2 Cement

The cement shall, unless specifically stated to the contrary be common cement complying with the requirements of Uganda Standard US 310 – 1& 2: 2001. Where other cements are specified they shall comply with the requirements of the relevant European Norms (EN) Standards.

All cement shall be obtained from manufacturers in Uganda. Where cement is to be imported, prior approval of the Project Manager shall have to be obtained.

The Contractor shall supply, when requested by the Project Manager, test certificates relating to each type of cement used certifying that it complies with the appropriate Uganda Bureau Standards requirements.

Unless approval is given for bulk handling, all cement shall be transported and delivered in sound and properly secured bags and stored in a dry, weatherproof, well ventilated shed with a raised floor or in such a building as is approved by the Project Manager.

Each delivery of cement in bags shall be stacked in one place. The bags shall be closely stacked to reduce air circulation but shall not be stacked against an outside wall. Where pallets are used, they shall be constructed so that the bags are not damaged during handling and stacking. No stack of cement bags shall exceed 3 m in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks. Cement in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weatherproof silos, which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

Cement shall be delivered or stored on site in such quantities to ensure that the concrete work on any section of the Works can be carried out without interruption. Each consignment shall be kept separate and distinct.

Any cement that has been injuriously affected by dampness or any other cause shall not be used and shall immediately be removed from the site. Cement which has become hardened and lumpy shall be removed from site.

Cement which has been stored on site for longer than one month shall be tested by an approved laboratory either or at the Central Materials Laboratory, Kampala or at the Uganda Bureau of Standards Laboratories as directed by the Project Manager.

1.4.3 Aggregate for Concrete

Aggregates for concrete shall consist of clean natural sands, gravel, crushed stone or other material which have been approved for use by the Project Manager and shall apply in respect of quality with the requirement of BS EN 12620:2002 "Coarse and Fine Aggregates from Natural Sources for Concrete".

Tests shall be made at frequent intervals or when called for to determine the amount of impurities in the aggregates and if ordered by the Project Manager fine aggregates shall be washed at the Contractor's own expense.

BS EN 12620:2002 requires that aggregates shall be hard, durable clean and free from adherent coatings such as clay.

They shall not contain harmful materials such as iron pyrites, iron oxide, mica, shale or similar laminar materials, or flaky or elongated particles, in such a form or in sufficient quantity as to adversely affect the strength or durability of the concrete or any materials which might attach reinforcement where this is required.

The various sizes of particles of which an aggregate is composed shall be uniformly distributed throughout the mass. The quantities of clay, silt and fine dust shall not exceed:-

- (i) Sand or crushed gravel sand, 3% by weight when using the test given in BS 812 Clause 13
- (ii) Crushed stone sand, 5% by weight when using the test given in BS 812 Clause 12.
- (iii) Coarse aggregate, 1% by weight when using the test given in BS 812 Clause 13.
- (iv) All in aggregate, 2% by weight when using the test given in BS 812 Clause 13.

A guide to the silt and clay content of sand and crushed gravel sand can be obtained by the field settling test described in B.S. 812 Clause 14 when the silt and clay content should not exceed 65 by volume.

1.4.4 The grading of aggregates shall be within the limits in the following tables:-

Table 4.4.1 Fine Aggregate

B.S.Sieve	Percentage by weight passing B.S. Sieves			
	Grading Zone 1	Grading Zone 2	Grading Zone 3	Grading Zone 4
9 mm	100	100	100	100
4.5 mm	90-100	90-100	90-100	95-100
No. 7	60-75	75-100	85-100	95-1000
No. 14	30-70	55-90	75-100	80-100
No. 25	15-34	35-59	60-79	80-100
No. 52	5-20	10-30	15-40	15-50
No. 100	0-10*	0-10*	0-10*	0-15*

* For crushed stone sands the permissible limit is increased to 20%

A fine aggregate whose grading falls outside the limits of any particular Grading Zone on sieves other than No. 25 by a total amount not exceeding 5% shall be regarded as being in that Grading Zone. The 5% can be split up, for example, as 1% on each of three sieves and 2% on another or 4% on one sieve and 1% on another, etc.

No tolerance is allowed for fine aggregate on the coarsest and finest limits of grading in all four Grading Zones.

Grading Zone 4 material should not be used in reinforced concrete unless tests have been made to ascertain the suitability of the proposed mix proportions.

1.4.5 Sand

All sands for making mortar shall be clean well graded silicious sand of good, sharp, hard quality equal to samples which shall be deposited with and approved by the Project Manager. earth, loam, dust, salt, organic matter and any other deleterious substances, sieved

1.4.6 Grading of Aggregates

TABLE 4.4.2 – COARSE AGGREGATES

B. S Sieve	Percentage by Weight Passing B.S. Sieves							
	Nominal Size of Graded Aggregate							
	38 mm to 5 mm	19 mm to 5 mm	12 mm to 5 mm	64 mm	38 mm	19 mm	12 mm	9 mm
75 mm	100	-	-	10	-	-	-	-
64 mm	-	-	-	85- 100	100	-	-	-
38 mm	95-100	100	-	0-30	85- 100	100	-	-
19 mm	30-70	95- 100	100	0-5	0-20	85- 100	100	-
12 mm	-	-	90- 100	-	-	-	85- 100	100
9mm	10-35	22-55	40-85	-	0-5	0-20	0-45	85- 100
5 mm	0.5	0-10	0-10	-	-	0-5	0-10	0-20
No. 7	-	-	-	-	-	-	-	0-5

The use of All-in aggregate may, with the specific approval of the Project Manager, be permitted in the case of mass concrete, unreinforced work etc., and where such approval is given the proportions of All-in aggregate to cement shall so gauged as to give a mix equivalent to that using separate aggregates.

The All-in aggregate shall comply with the requirements of B.S. 812 the grading being in accordance with the following table

TABLE 4.4.3 – ALL IN AGGREGATES

B.S Sieve	Percentage by Weight Passing B.S. Sieve	
	38 mm Nominal Size	19mm Nominal Size
78 mm	100	-
38 mm	95-100	100
19 mm	45-75	95-100
5 mm	25-45	30-50
No. 25	8-30	10-35
No. 100	0-6	0-6

1.4.7 Maximum Sizes of Coarse Aggregates

The maximum size of the largest size coarse aggregate shall not be larger than a quarter of the least size of the member in which it is being used and at least 6 mm less than the smallest space between reinforcing bars where the member is reinforced.

1.4.8 Storage of Aggregates

Aggregates of different sizes shall be stored in separate bins on hard clean floor free from contamination of any kind. Samples shall be supplied to the Project Manager for testing prior to the Works being commenced. These samples shall consist of not less than ...Kg of fine aggregate and ...Kg of coarse, or all-in aggregate.

Aggregates shall be kept in sufficient quantity to enable the work on any section to be completed without interruption.

All aggregates shall be tested regularly as directed by the Project Manager, and any material which is below standard or which has become contaminated or adulterated in any way shall be immediately removed from the site.

Water for concrete mixing shall be from an approved source and shall be clean and free from acids, vegetable matter and any other deleterious material in solution or suspension. Potable water shall be suitable for concrete preparation.

1.4.9 Concrete Mixes by Volume or Weight

The proportion for concrete mix sizes shall be specified either by:

- a) Volume
- b) Weight

Concrete mixes by volume will be permitted in the case of mass concrete work, unreinforced foundations and beds and for small isolated structural members such as lintels and isolated beams providing that in all cases the Project Manager is satisfied that the required strengths are being obtained.

Weight batching shall be used for all other concrete work in reinforced concrete ground beams, column bases, structural frames, floors, roofs, staircases, retaining walls and the like.

1.4.10 Concrete Mixes

Concrete mixes shall be designed to satisfy the specified characteristic strengths. The mean strength of the designed mix shall exceed the specified values by twice the expected standard deviation so as to take into account the inevitable variation.

Both fine and coarse aggregates shall be from natural sources and shall be graded such as to produce a concrete of specified proportions which will work readily into position without segregation and without excessive water content.

Table 4.10.1: Standard Mixes for Ordinary Structural Concrete per 50 kg Bag of Cement

Concrete Grade	Nominal max. size of Aggregate (mm)	40		20		14		10	
	Workability	Medium	High	Medium	High	Medium	High	Medium	High
60 to 120	Limits of slump that may be expected (mm)	30 to 60	60 to 120	20 to 50	50 to 100	10 to 30	30 to 60	10 to 25	25 to 50
55030 - 450.2-75	Total Aggregate (kg) Fine Aggregate (%) Vol. of finished concrete (m3)	64030 - 450.312	55030 - 450.275	54035 - 500.277	48035 - 500.252	—	—	—	—
33030 - 450.1-83	Total Aggregate (kg) Fine Aggregate (%) Vol. of finished concrete (m3)	37030 - 450.200	33030 - 450.183	32035 - 500.178	28035 - 500.160	—	—	—	—
27030 - 400.1-55	Total Aggregate (kg) Fine Aggregate (%) Vol. of finished concrete (m3)	30530 - 350.165	27030 - 400.155	28030 - 400.156	25035 - 450.143	25535 - 450.146	22040 - 500.130	24040 - 500.137	20045 - 550.121
24030 - 400.1-37	Total Aggregate (kg) Fine Aggregate (%) Vol. of finished concrete (m3)	26530 - 350.147	24030 - 400.137	24030 - 400.137	21535 - 450.127	22035 - 450.130	19540 - 500.118	21040 - 500.124	17545 - 550.110
21530 - 400.1-27	Total Aggregate (kg) Fine Aggregate (%) Vol. of finished concrete (m3)	23530 - 350.134	21530 - 400.127	21030 - 400.124	19035 - 450.115	19535 - 450.115	17040 - 500.106	18040 - 500.109	15045 - 550.097

1.4.11 Design Mixes

The strengths attained for each mix shall be in accordance with those stated in Table 3.13.1 as described later.

If, because of the nature of the aggregates available, it becomes impossible to achieve the desired strength and workability, the Project Manager reserves the right to vary or “design” the mix proportion in order that concrete of the necessary quality will be produced.

The Contractor shall include for this and for a minimum increase of 10% in the cement content of any specified mix, whether by volume or weight, without extra charge.

1.4.12 Trial Mixes

When directed by the Project Manager, the Trial Contractor shall make trial mixes for his approval mixes, before general manufacture of concrete commences.

Trial mixes shall be made using the identical plant and compaction methods which will be used in the works and deposited in suitable representative formwork.

Careful measurements of the cement, aggregate and water: cement ratios, slump and workability shall be made and the time of mixing noted for each mix.

Six “Preliminary” test cubes shall also be made for each mix. Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days. The density of all the cubes shall be determined before the strength tests are carried out.

Mixes shall be made in such numbers as directed until the desired qualities are obtained.

Every precaution shall be observed to ensure that the manufacture and placing of concrete in the works is carried out in the same fashion as that used in the manufacture of the selected trial mix.

The Project Manager may direct that fresh trial mixes be made should there be any change in the source or grading of the aggregate, manner of making and compacting, or other change from the trial mix adopted originally.

The crushing strength of “preliminary” test cubes taken from trial mixes, shall at 28 days be not less than 25% more than that specified for the minimum crushing strength of “Works” test cubes as later described, for the same quality of concrete.

Concrete cubes shall be submitted to the Project Manager for "Preliminary" and "Work" Cube Tests. The Contractor shall equip himself with accurately made metal moulds for casting 100mm square concrete cubes.

The moulds and method of preparing such cubes shall be in accordance with B.S 1881 "Method of Testing Concrete".

Batches of six "Preliminary" cubes shall be taken from the trial mixes as previously described. Six "Work" cubes shall be taken for testing from any batch or class of concrete in use on the works as directed by the Project Manager.

Three cubes shall be tested at 7 days and three at 28 days.

All concrete cubes when tested shall give the minimum compressive strengths for the appropriate class of concrete shown in the following table:-

Table 4.12.1: Compressive strength and modulus of elasticity of concrete (N/mm²)

Grade	Characteristic compressive strength at 28 days (N/mm ²)		Cube strength (N/mm ²)		Characteristic tensile strength at 28 days (N/mm ²)	Modulus of elasticity at 28 days (N/mm ²)
15	15	12	90	100	1.1	25x10 ³
20	20	16	13.5	25.0	1.3	27x10 ³
25	25	20	16.5	31.0	1.5	29x10 ³
30	30	24	20.0	37.0	1.7	32x10 ³
40	40	32	28.0	50.0	2.1	35x10 ³
50	50	40	36.0	60.0	2.5	37x10 ³

Concrete test cubes shall be submitted to the Central Materials Laboratory, Kampala, for testing and the Contractor shall carefully identify each cube and provide all information relative thereto, e.g. contract number, mix proportions, date cast, where the rest of the batch has been incorporated in the works and the Contractor's name and test cube reference number.

In the event that any cubes representative of concrete which has already been incorporated in the work failing to give the required compressive strength, the Project Manager reserves the right to instruct the contractor to cut out and remove all work affected by these cubes and replace it entirely at his own expense.

1.4.13 Mixing of Concrete

Concrete shall be thoroughly mixed to a uniform consistency in measured batches in a mechanical mixer of capacity proportionate to the amount of concrete required in any section of the works under construction. Mixing shall continue for not less than two minutes after all the materials including water, which shall be added last of all, have been passed into the drum and before any portion of the batch is discharged but in all cases the actual shall conform to that required for the selected trial mix.

The water content shall be carefully controlled and shall be added in sufficient quantity to make up the amount found to be necessary in the trial mix under no circumstances will the water; cement ratio be exceeded and any batch which is mixed too wet shall be rejected. The entire contents of the mixer drum shall be discharged before the succeeding batch is introduced into the drum.

Mixers and or batching plant shall be properly maintained throughout the contract and any mixer of plant which is faulty in any respect shall not be used. Drums of all mixers shall revolve at a constant speed recommended by the manufacturers. A mixer which has been standing idle for twenty minutes after mixing the last batch shall be thoroughly washed and cleaned before any fresh mix is made. Mixers shall be thoroughly cleaned at the finish of each run of concrete mixing or at the end of each day. All mixing plant shall be thoroughly cleaned if used for High Aluminium or other specialised cement concretes after Common Cement concretes and vice-versa.

1.4.14 Hand Mixing

Hand mixing shall only be allowed with the express permission of the Project Manager.

The mixing shall be done on a clean, watertight, non-absorbent platform. The cement and fine aggregate shall be mixed dry until the mixture is thoroughly blended and uniform in colour. The coarse aggregate shall then be added and mixed in until it is uniformly distributed throughout the batch. The correct quantity of water shall be added using a can with a rose nozzle and the mixing continued until the entire batch of concrete appears to be homogenous and has the desired consistency. Each batch of concrete shall be turned over at least three times dry and three times wet.

The platform shall be emptied before a subsequent batch is mixed and thoroughly cleaned if not in use for more than 20 minutes before the next batch is prepared or if a different type of cement is used as previously described.

For hand mixing the cement content of each mix shall be increased by 10% over that required for machine mixing and this shall be done at the Contractor's own expense.

1.4.15 Transporting and Placing Concrete

Concrete shall be transported in a manner which will avoid any segregation, loss consolidation or drying out of the consistent materials and placing in the forms shall be completed before the initial set takes place. Concrete shall not be dropped through a height greater than 2m. Chutes and pumps may be used provided they shall be so arranged as to avoid segregation.

All equipment for the transporting and placing of concrete shall be constantly cleaned and kept free of all coatings of hardened concrete or other obstructions.

Concreting of any unit or section of the work shall be carried out in one continuous operation and no interruption of the concrete will be allowed without the approval of the Project Manager.

In no case shall more than 20 minutes elapse between mixing and placing of any concrete in its final position.

1.4.16 Ready Mix Concrete

The term "Ready Mix" concrete is applied in cases where concrete is obtained from a firm which specializes in the manufacture of concrete in bulk at a central plant whence it is transported to the site in transit mixers which keep it agitated until it is delivered. This term also applied to concrete in which the aggregate and cement are batched dry at a central plant and fed into the drum of a mixer mounted on a lorry in which it is transported to the site. Water is carried in a special container and is measured and fed into the drum and wet mixing started, either during the journey or when the mixer lorry reaches the site.

This type of concrete will only be allowed on the specific instructions of the Project Manager who will require a certificate with every batch of concrete delivered giving the actual weights of aggregate, cement and water used so that a guarantee is provided that the concrete is in accordance with the Specifications.

1.4.17 Compaction of Concrete

After concrete has been placed in the forms it shall be compacted with approved tools and in such a manner as to produce a dense homogenous mass, free from segregation honeycombs and entrained air, filling all spaces between and around forms and reinforcement without voids of any kinds.

Where vibrators are used they shall be of the immersion type, approved by the Project Manager and have a frequency of not less than 5000 hertz (HZ). Vibrators shall not be attached to or allowed to come into contact with reinforcement or used in such a manner as to damage concrete in other parts of the structure, which has taken its initial set. Care is also to be taken so that concrete is not over vibrated or compacted and segregation taken place.

Partially set concrete shall not be disturbed in any way and the Contractor shall ensure that it is not subjected to unnecessary loads, shocks or vibrations from adjacent plant or vibrators in the vicinity nor allow his workmen to walk on it or disturb it in any other way.

1.4.18 Construction Joints

Construction joints shall be made where shown on the drawings or as directed by the Project Manager, but in either case they shall be so arranged that their number is kept to the minimum.

Construction joints shall be formed at right angles to the axis of the member concerned by the insertion of rigid stopping off forms.

Construction joints in slabs shall be vertical and in general, parallel to the main reinforcement, but, when required at right angles to the main reinforcement they shall be constructed in the middle of the span.

The upper surface of lifts of concrete in walls and columns shall be horizontal and in the case of exposed finished work shall be so constructed so that they cannot be seen.

Lifts in walls and columns shall not exceed a height of 1m unless approved otherwise by the Project Manager.

Forms at construction joints shall be so made that they shall produce within the thickness of the joint a suitably grooved or keyed surface to act as a bond for the subsequent concrete.

As soon as the concrete is sufficiently set stop boards are to be removed and the face hacked and wire brushed to form a key and washed. Before placing of the adjacent concrete the surface of the joint is to be coated with a neat cement grout and left ready to receive

the new adjacent concrete which is to be tightly packed up against its face.

1.4.19 Protection of Concrete

Freshly placed concrete shall be protected from the sun, drying winds and rain until it has properly set and shall be kept damp with hessian, sand, polythene or other waterproof sheeting for not less than seven days after laying. In the case of rapid hardening cements being employed this shall be reduced to three days.

Concrete which has not been properly protected and is damaged or adversely affected in any way whatsoever shall be carefully cut out and replaced at the Contractor's own expense.

1.4.20 Concrete Surface Finishes

The surface of all concrete foundation beds shall be finished to a level even surface to receive the walling.

The upper surface of floors, roofs, landings etc. shall either be trowelled smooth or where they are to be covered with screeds for other finishes shall be floated while onset to a smooth even finish free of all projection and irregularities either level or to falls as shown on the drawings.

The trowelling and floating shall be done in such a manner that the surface is free of laitance or cement slurry. After the removal of formwork, all surfaces in contact with same shall be drenched with water, and carefully rubbed down with a carborundum block to remove fins and other irregularities. Any honeycombing or other damaged surface shall be carefully filled up with neat cement slurry and rubbed down to finish flush with the surrounding work. Such work shall be prevented from drying too rapidly by the use of damp sacking or similar means to ensure a good key between the concrete and the grout.

When the concrete surfaces are to be left exposed the required surface finish will be specifically stated in either the Particular Specification or the Bills of Quantities.

No rubbing down, repairing or patching of concrete will be carried out until the surfaces have been inspected by the Project Manager

1.4.21 Fair Face and Fine Face Finishes of Concrete

When exposed concrete is required to have a “Fair Faced Finish” it means that it is to be finished to a perfectly plane smooth surface free from all blemishes, irregularities, honeycombing, joint or grain marks.

The manner of obtaining this type of finish will be left to the discretion of the Contractor but the Project Manager reserves the right to instruct the Contractor to adopt an alternative method where he thinks the method in use is unsatisfactory.

Where “Fine Face” concrete finish is specified, the exposed surfaces where produced by formwork shall have all fins and other small protuberances rubbed down but no pittings nor large fins or other protuberances will be allowed. The face of the concrete shall be finished perfectly smooth and even.

1.4.22 Form hole chases, etc

Form all holes, pockets, chases, etc. required for services and other fittings as indicated on the drawings or otherwise by the use of liners, sleeves, cardboard tubes, temporary boxings and timber fillets attached to the framework.

Holes and chases shall not be cut in structural concrete after it has set except on the specific instructions of the Project Manager.

1.4.23 Steel Reinforcement

Mild steel reinforcement shall consist of plain round mild steel rods as specified in BS 6722:1986.

Twisted mild steel reinforcement shall be cold twisted mild steel reinforcement as specified in BS 449: 1969.

Fabric reinforcement shall be hard drawn steel fabric reinforcement in accordance with BS 4483:1998.

All steel reinforcement shall be of approved manufacture and shall be free from loose rust, mill scale, oil and grease or any other material which may impair the proper adhesion of the reinforcement and the concrete or cause corrosion of the reinforcement and subsequent disintegration of the concrete cover. If directed by the Project Manager, all the reinforcement shall be wire brushed to remove such imperfections before concrete is poured around it.

The Contractor shall produce Certificates of Manufacture indicating that the material complies with the requirement of the appropriate B.S. or UBS standards for the inspection of the Project Manager. Random samples from any consignment may be taken for testing at the Central Materials Laboratory; Kampala and any material found to be brittle, cracked or unsatisfactory in any way whatsoever shall be rejected and removed from the site at once.

Reinforcement shall be stored on site in level tiers raised above the ground.

1.4.24 Bending Reinforcement

All steel reinforcement shall be bent cold and shaped as shown on the drawings before placing in position and shall comply with the bending dimensions and tolerance laid down in BS 4466:1989 "Bending Dimensions of Bars for Reinforced Concrete"

An approved former shall be used to produce gradual and even bending and no steel shall, once, bent, be straightened and rebent.

Bends made whilst the reinforcement is hot or welding either by gas or electricity shall not be carried out without the prior approval of the Project Manager.

1.4.25 Spacing of RC bars

The spacing of bars, amount of reinforcement and the type of fabric, mesh size, disposition, etc. shall be in complete accordance with the drawings and bending schedules.

1.4.26 Fixing and Assembly of Reinforcement

All reinforcement shall be accurately placed, fixed and maintained in the positions shown on the drawings. Intersecting bars shall be securely wired together with No. 16 gauge (1.626 mm) soft iron tying wired with the ends twisted and turned into the body of the concrete. Binders, links and the like shall make close contact with main reinforcement and shall be securely wired to same.

When reinforcement is placed in horizontal or sloping layers whether in beams, slabs or staircases, etc., the distance between each layer shall be carefully maintained by the insertion of sufficient spacer bars to prevent either movement or sagging of the main reinforcement in each layer.

1.4.27 Cover to Concrete

The concrete cover to all reinforcement shall be carefully maintained as shown on the drawings and bending schedules within a tolerance of 3 mm under or over.

Cover to underside of soffits may be obtained by the use of accurately made cement mortar blocks.

1.4.28 Inspection of Reinforcement

No concrete shall be poured until the Project Manager has inspected and approved the reinforcement.

All reinforcement shall be properly fixed in position and every precaution shall be taken to ensure that no movement takes place whilst the concrete is being poured and compacted and that it is properly surrounded by concrete.

Any rods which have worked loose during fixing shall be securely retied and any small pieces of rod or fabric shall be removed from the forms before pouring is commenced.

1.4.29 Formwork

The term formwork shall include for any material or mould required for forming the concrete into the desired shape and upholding it until it is set, together with all necessary temporary supports, stagings, bolts, nuts, wedges, clamps, and other fixing, all cutting and waste and the cost of all labour and material in the construction, erection and removal of such formwork.

Formwork shall be of timber or other approved material and shall be of such strength as will ensure complete rigidity throughout the placing, compaction, vibration and setting of the concrete and so designed and constructed that it can be easily removed without shock, vibration or damage to the finished concrete.

All joints in forms shall be sufficiently tight to prevent leakage of grout and in timber forms, unless otherwise specified, they shall be tongued and grooved.

Timber boards for formwork shall be seasoned to 20% moisture content and shall be in widths not exceeding 150 mm or narrower if the Project Manager so directs.

The use of internal ties shall be avoided as far as possible, but, if used they shall be reduced to the minimum, of metal and capable of easy removal without damage to the face of the concrete. No part of any metal tie or spacer remaining permanently embedded in the concrete shall be nearer the finished surface of the concrete than the thickness of the general cover dimension as shown on the drawings.

When vibrators are used, special care shall be taken to see that all bolts, wedges, clamps, etc. are kept tight so that no distortion of the forms takes place.

1.4.30 Formwork Non-Exposed Concrete

When the surface of the concrete is to be covered with some other finishing material, the forms may be constructed of plain, but jointed sawn timber, unless otherwise instructed by the Project Manager. The boards shall be sufficiently thick to withstand the loading of the concreting operations without deflection so that the finished surface cover specified is maintained.

1.4.31 Formwork for exposed Concrete

When a particular type of finish is required to be produced by formwork on exposed concrete surfaces this will be fully described in the particular Specification of bills of Quantities and the material to be used to achieve it will be specified, i.e. plywood, hardboard, hessian, polythene paper, strips, panels, etc.

When wrot formwork is required the boards shall be tongued and grooved and wrot and free from all cracks and irregularities on the face in contact with the concrete.

1.4.32 Preparation of Formwork before concreting

Unless otherwise directed the inside faces of all formwork shall be coated with lime wash or an approved non-retarding mould oil. Care shall be taken to keep reinforcement free of any coating material.

Temporary windows shall be cut in the sides of vertical surfaces of forms to ensure that concrete is not poured from a height exceeding 1.5 m.

Forms shall be thoroughly scraped and cleaned down between each and before subsequent uses.

Prior to depositing concrete, the forms shall be thoroughly cleaned and freed from all sawdust shavings, mud, dust or other debris by hosing with clean water and draining through temporary openings left for this purpose.

1.4.33 Approval of Formwork

All formwork shall be inspected and approved by the Project Manager before pouring of concrete. Forms is commenced, but such approval will not relieve the contractor of his overall responsibility for the safety and efficiency of the works. Details of special forms and systems of formwork i.e. self lifting or sliding forms etc. shall be submitted to the Project Manager for his approval before they are put into use.

1.4.34 Removal of Formwork

The removal of formwork shall be carried out in such a manner that the concrete will not be subjected to sudden shock or injury, nor shall it be removed before the concrete is sufficiently set hardened.

The minimum time shall elapse between placing and compaction of the concrete and the removal of the formwork for various parts of the structure is indicated in the following table:-

TABLE 4.34.1: MINIMUM TIMES FOR REMOVING FORMWORK

Location	Removal of Forms Only	Removal of Props
Side of beams, Walls and columns	4 days	-
Soffit of Main Slabs	12 days	28 days
Soffit of Secondary Slabs	6 days	24 days
Soffit of Beams	12 days	28 days

The foregoing figures are given as a guide for normal cement concrete for average conditions of setting and hardening. For vibrated concrete or extreme climatic conditions or for special surface finishes the above times may be varied on the instructions of the Project Manager.

Compliance with the requirements of the foregoing shall not relieve the Contractor of his obligations and overall responsibility. Should the removal of the formwork be found to have been carried out prematurely, any damage caused thereby shall be made good entirely at the contractor's own expense.

1.4.35 Composite Concrete/Hollow Clay Block Structures

Composite concrete/hollow clay block construction when specified for floors and roofs shall consist of 305 x 305 mm hollow clay filler blocks placed end to end in rows on formwork as described with an in-situ reinforced concrete rib between each row and a concrete topping or cover over the blocks. The overall thickness of the composite slab, thickness of the filler blocks and the width of the ribs and details of reinforcement and concrete mixes in the ribs and topping will be described in the Particular specification or bills of Quantities.

All hollow clay filler blocks shall be well burnt, of even colour, uniform density free from cracks, distortion and conforming in every respect with the requirements of BS 3921 Part 2.

The hollow clay blocks are to be laid end to end in rows, care being taken that the joints are close and that the specified width between rows is maintained, ends of rows of blocks are to be plugged with a stiff mixture of cement and sand 1:3 before the inset concrete is placed.

The ribs and transverse reinforcement as specified is then to be fixed in position, care being taken to ensure that the filler blocks in each row are not displaced.

Concrete as specified is to be placed in the ribs and topping and compacted as described, care again being taken to see that the reinforcement and filler blocks are not displaced. The topping is to be leveled and smoothed over to receive the finish as specified and carefully covered up and protected as before described for solid reinforced concrete slabs.

Before the placing of the concrete ribs and topping is commenced the spaces between the rows of blocks are to be thoroughly cleaned of any rubbish and the clay blocks and formwork sprayed with clean water.

The contractor shall provide this construction only to the extent indicated on the drawings, any other areas from where this work stops up to the outer edges of the construction being made out with thickness equal to the thickness of the composite slab.

The minimum time for removal of formwork given in Table 6 will apply

for this type of construction.

1.4.36 “Freespan” and “Maxspan” Suspended Structures

The burnt clay beam, rib and filler tiles for “Free span” and “Maxspan” construction or their equivalent shall, be by approved manufacturers.

“Freespan” is a system of clay blocks, concrete and reinforcement assembled into precast beams whilst “Maxspan” uses a system of clay ribs, and reinforcement assembled into precast ribs with hollow filler blocks between and inset concrete rib filling and topping.

All clay blocks are to be as previously specified and any which are cracked, chipped, broken or distorted shall be rejected.

Concrete for filling beams, ribs and topping is to be Mix “C” 12 mm aggregate as described.

Steel reinforcement shall be as previously specified bent or hooked at ends required and accurately and securely positioned in the units.

All units shall bear on perimeter walls or supports a minimum of 115 mm.

The units shall be assembled for precasting on an even, clean concrete bed or timber form provided with a camber of approximately 1/300 of the span.

The precasting of beams and ribs is to be carried out under cover. The units shall be kept covered with wet hessian or other approved means and left to cure for a minimum period of 14 days during which time the hessian etc. shall be kept wet.

When the units are cured and ready for handling they shall be carefully removed from the place where they were cast without undue shock or jarring and transported and hoisted into position where required. Each unit must be handled at each end to ensure that cracking does not take place. When fixed in position the joints between adjacent beams shall not exceed 3 mm.

After placing in position, the ends of all hollow blocks and beams shall be sealed with a stiff mixture of cement and sand (1:3).

Carefully cover up and protect the finished surfaces of all “Freespan” and “Maxspan” slabs as previously described for concrete work.

1.4.37 “Freespan” Units or Beams

The “Freespan” burnt clay blocks 305 mm wide and 30mm long shall be closely assembled end to end in straight lines on the casting bed

to form beams of the required length. The required amount of reinforcement is then placed in the channel, after which the blocks are soaked thoroughly with water and filled with concrete, properly compacted as described.

After curing as before described the units shall be hoisted and fixed in position side by side, the recessed side joints flushed up with cement and sand (1:3) and the whole covered with a layer of fine concrete or cement and sand (1:3) not less than 20 mm thick or as otherwise specified, finished to a level even surface.

1.4.38 “Maxspan” Precast Rib and Filler Block Structures

The “Maxspan” clay rib channel blocks either 75 or 100 mm wide as specified shall be assembled to form rib units as described for “Freespan” beams.

The rib channels are then thoroughly soaked with clean water and four 6 mm diameter mild steel rods inserted into the prepared grooves in the blocks and grouted in place with a stiff mixture of cement and sand (1:3). These units can be precast one on top of the other up to a maximum of 10 in height.

After curing the ribs shall be hoisted and described of the diameters shown in the fixed in position at the appropriate centers following table:-and propped on the underside every 2 m. The hollow filler blocks of the specified size shall be laid end to end between the rib units.

Reinforcement of the specified size is then laid in the rib channel and the transverse distribution reinforcement placed in the topping. The whole of the ribs and filler blocks are to be thoroughly soaked with clean water and the ribs and topping filled up to the specified thickness with well compacted concrete Mix “C” 12 mm aggregate all as previously described. Finish surface level and even ready to receive screeds.

1.4.39 Concrete Lintels

Concrete in lintels to be (1:2:4) as previously described, well tamped around reinforcing rods. The reinforcement and sizes of lintels shall be in accordance with drawings for standard Lintels, copies of which can be obtained from the Project Manager unless otherwise directed by the Project Manager.

Lintels may be cast in-situ or precast. When cast in-situ the general concrete specifications already described shall apply except that the lintel may be built upon after 7 days providing the soffit boards and propping are not removed.

Precast lintels shall be cast in accordance with the clauses governing precast concrete as later described but they shall not be built on for a minimum of 14 days after casting or such other longer period as the Project Manager may direct.

Provide to all buildings where shown on the drawings as an in-situ concrete (1:2:3) ring beam 225 mm deep for the full thickness of the wall, cast in alternate 6 m lengths, with suitable construction joints and reinforced with 4 No. 12 mm diameter twisted steel reinforcing rods with 6 mm diameter stirrups at 300 mm centers.

Unless otherwise indicated on the drawings or other Contract Documents, lintels shall be of the depths and bearings and reinforced with round mild steel reinforcement as described of the diameters shown in the following table:-

Table 4.39.1 – Concrete Lintels for Normal Spans and Loading

Clear span (mm)	Bearing Each End (mm)	Depth (mm)	Diameter of Reinforcement in mm per 115 m thickness of wall
up to 610	115	100	1
610 to 1000	115	150	10
1000 to 1300	115	150	10
1300 to 1600	230	230	12
1600 to 1900	230	230	12
1900 to 2500	230	230	12
2200 to 2500	230	230	16
2500 onwards	As	indicated	on drawings

All reinforcement in lintels is to be embedded in the concrete to have not more than 40 mm cover. Ends of bars are to be hooked.

Where shown cills shall be of rebated, splayed and throated precast concrete to the sizes required and having an outer projection of not less than 40 mm from the finished wall face. They shall be cast in suitable moulds and finished fine on all exposed faces, free from all cracks, crazing, chipped or broken arises, discolouration or other defects.

Reinforcement shall be provided where necessary for handling with a 25 mm minimum cover.

Cills over 1.4 m Long shall be divided into even sections, and butt jointed with joints not more than 1/8' thick grouted up with cement mortar and neatly flush pointed.

Clean cut throatings 12 mm deep shall be formed 25 mm back from the finished outer edge of the cill.

Throating of not less than 50 mm wide shall be formed on cills required to be built in.

Cills to take metal windows shall have holes for fixing lugs formed during casting to the required size, depth and positions.

All concrete not plastered shall be finished fair face unless otherwise stated. Unless otherwise state precast concrete ventilators to be 300 mm or 225 mm wide x 225 mm x 40 mm thick of approved pattern. The ventilators shall be fixed double, one fixed flush with outer face of wall and having approved copper mosquito gauze cut to size and fixed by tucking over top and bottom edges of ventilator before building in, the other ventilator fixed flush with inner face of wall and include for rendering around sides, top and bottom of ventilator opening in cement and sand (1:4).

All concrete floors shall be in concrete (1:3:6) and have a minimum thickness of 100 mm unless otherwise shown on drawings.

Entrance steps as required to suit ground and floor levels shall be formed in concrete (1:3:6), with suitable foundations under as directed by the Project Manager. Treads shall be not less than 300 mm wide and risers not more than 175 mm high. All exposed surfaces shall be finished in cement and sand (1:4) trowel led smooth with a wood float 20 mm thick on treads and 12 mm thick on risers or finished with carborundum dust.

All suspended precast or in situ concrete shelves, pot slabs, etc., shall be reinforced with B.R.C. Weld mesh No. 28 or 210 as ordered by the Project Manager or other equal and approved fabric

reinforcement. Where required these shall be size 600 mm x 600 mm x 50 mm thick of vibrated (1:2:4) concrete finished on top with a wood float, clean cut edges and free from all cracks, chips or broken corners. The slabs shall be laid on a 75 mm consolidated bed of sand or stone dust, laid to falls where necessary and jointed and pointed in cement mortar (1:4). The jointing mortar to be worked well down into the joints and the pointing to be key drawn and all excess mortar cleaned off.

1.4.40 Precast Concrete

All precast concrete work shall be carried out in accordance with the instructions of the Project Manager and as recommended by the Code of Practice BS 8110 except where the Code differs with this specification, this specification shall take precedence.

The concrete and reinforcement shall be as described elsewhere or as indicated on the drawings.

The moulds for precast work shall be of stout timber or steel, strong, properly made true to shape to produce the sections shown on the drawings, finished perfectly true, without twist or deformation of any kind and having clean sharp arises, grooves, sinkings, etc., as required.

When concrete is specified as with "Fair Face Finish" the moulds shall be lined with a smooth surface free from all blemishes, irregularities, honeycombing, joint or gain marks.

Where the concrete is described as "Finished Fine" the moulds are to be made of metal or are to have linings which will produce a smooth dense fine face to the finished concrete free from all shutter marks, protuberances and pittings and suitable to receive a painted surface direct.

Concrete shall be thoroughly tamped in the moulds and if required by the Project Manager shall be vibrated as described.

The precasting shall be carried out under an approved shade and shall remain under same for a minimum period of seven days after which the moulds may be removed and the units stored under shade for a further seven days.

After this the units may be stacked in the open for not less than seven days before fixing. Unless otherwise described, faces are to be left rough from the sawn moulds.

For the whole of the period from casting of the units until the time they are put into use they shall be covered with sacking or approved material which is to be kept wet constantly.

All units shall be cast in convenient lengths for handling and the contractor shall provide all necessary handling reinforcement whether specifically shown on the drawings or not.

1.4.41 Concrete Apron

To all houses of Category D and above and where directed by the Project Manager, the contractor shall provide a 50 mm C 15 concrete apron, 1 m wide around the perimeter of the building, laid on a 100 mm bed of hardcore.

1.4.42 Attendance

Particular care shall be exercised by the contractor to ensure that all pipes, ducts, drains, conduit, junction boxes, anti-static installations, etc are laid before the concrete for the floor and roof slabs is poured, and the Contractor will be held responsible for the cost of any additional cutting etc. and making good which becomes necessary through his failure to make proper arrangements for all sub-contractors work to be done in close cooperation with his own.

1.5 WALLING

1.5.1 General Requirements

I. Cement

The cement used shall be as described in "Concrete Work".

II. Lime

The lime shall be best quality hydrated lime from an approved source and shall conform with BS EN 459-1:2001 or the equivalent BS Standard.

III. Sand

Sand for mortars shall be as described in "Concrete Works" except that it shall be fine sand.

IV. Mortars

The cement mortar shall consist of one part of cement to four parts of sand by volume (1:4). The sand shall be measured in specifically prepared gauge boxes and thoroughly mixed in an approved mechanical mixer or mixed dry on clean and approved mixing platforms, with water added afterwards until all parts are completely incorporated and brought to a proper consistency. The use of retempering of wholly or partially set mortar will not be allowed.

The gauged mortar shall consist of one part of cement to two parts of lime to nine parts of sand by volume (1: 2: 9).

In the case of gauged mortar, the sand and lime shall first be mixed into a coarse mix before addition of cement. All mortar is to be thoroughly mixed to a uniform consistency with only sufficient water to obtain a plastic condition suitable for toweling. No mortar that has commenced to set is to be used or knocked up again for reuse.

V. Protection

All walling shall be properly protected while the mortar is setting as the Project Manager shall direct.

VI. Setting Out

The Contractor shall provide proper setting out rods and set out on the same all work showing opening, heights, cills and lintels and shall build the various walls and piers to the thickness, widths and heights shown upon the drawings. No part of the walling shall be carried up more than 900 mm higher at one time than any other part and in such cases the joining shall be made in long stops so as to prevent cracks arising and all walls shall be leveled round at each floor and roof level.

1.5.2 Brick Walling**I. Bricks**

Bricks are to be kiln burnt bricks from a local source, and samples are to be submitted for the Project Manager's approval. Bricks are to comply with BS EN 772 and BS 6750 as regards size and tolerances, and are to be of good shape, well burnt, of even colour, free from flaws, stones and unburnt lumps and are to emit a clear ringing sound when struck one another. Brittle or badly burnt bricks must not be used and broken bricks or bats may only be used where required for bond. No brick shall absorb more than 20% of its dry weight during 24 hours immersion in water.

Load bearing brickwork shall be constructed in solid bricks and internal non-load bearing walls where specified may be built in bricks having perforations.

Clay bricks for load-bearing construction shall be as manufactured by Uganda Clays limited or any other approved source. The properties of the bricks shall be as shown in Table 1.5.2.1.1

Bricks may also be used in non-load bearing construction as facing or in-fill walling. The various classes of bricks are: -

- a) Non-facing plastered (NFP);
- b) Facing brick standard (FBS);
- c) Facing bricks aesthetic (FBA); and
- d) Engineering brick (EB)

II. Facing Bricks

Table 5.2.1.1: Physical Properties of Bricks

Class of Brick	Crushing Strength (N/mm ²)	Water Absorption	Average Weigh (kg)
NFP	10	10	2.75
FBS	20	6.3	2.75
FBA	22	7.5	2.75
EB	25	7.9	3.00

The facing bricks unless otherwise described shall be bricks specially selected from the common stock for evenness of size shape and colour.

Care is to be taken when selecting and stacking facing bricks to see that all bricks with chipped or damaged faces or arises are rejected.

Facing bricks shall be obtained from an approved manufacturer and conform with BS EN 772 and samples are to be submitted for the Project Manager's approval. Purpose made corner blocks and half blocks shall be used as necessary at angles etc., and for purposes of bond.

III. Concrete Blocks

Concrete blocks shall be machine made, solid or hollow as specified, and comply with BS 6073, work other than internal non-load bearing partitions which may be of blocks in accordance with Type C.

Blocks shall be made with naturally occurring aggregates complying with BS EN 1260 with a binder as listed in BS 4887 except that lime as a sole bind agent will not be allowed.

The density of Type 'A' blocks shall be not less than 1500 kg/m³ and the density of type C may be less than this providing it meets the due requirements regarding strength.

The choice of a suitable mix to produce blocks of the required properties will be left to the discretion of the Contractor but all blocks shall have compressive strengths in accordance with the following Table:-

**TABLE 5.2.3.1: MINIMUM COMPRESSIVE STRENGTH OF CONCRETE
BLOCKS**

Block	Minimum Compressive Strength	
	Average of 10 Blocks N/mm ²	Individual Block N/mm ²
1	3.5	2.8
2	2.8	2.2

As a guide a mix consisting of one part cement, two parts of fine aggregate grade 9mm down but free of fines and dust and seven parts of coarse sand by volume (1:2:7) will produce a block of the required strength but this must not be regarded as infallible and the contractor will be entirely responsible for finding the most suitable mix consistent with the available aggregates which will produce blocks of the requisite properties and strengths.

If suitable materials are not obtainable locally the Contractor shall obtain them from such other sources as he carried out under shelter and after casting the blocks shall be stacked under shelter to protect them from sun and adverse weather. The blocks shall be properly cured by covering them with sand or sacks and spraying daily for not less than 14 days.

All blocks must be left with good sharp edges. The standard face size of blocks for use in the Works shall be 450 x 225 mm and these size blocks shall be used wherever, practicable. Blocks will, however, be required to form proper bonding at corners, round openings, cills, lintels, beams, etc., and the like positions and the Contractor must make or cut blocks to all varying sizes required for these purposes.

Should the Contractor obtain blocks from local manufacturers or suppliers he shall be responsible for ensuring that the blocks are of such quality as to meet the above loading requirements.

IV.Fair faced blocks

Concrete blocks for fair faced walls shall have a perfectly smooth exposed face free of all honeycombing, blemish or other irregularity.

V.Stone

Stone is to be obtained from a local source and samples are to be submitted for the Project Manager's approval.

It is to be free from cracks, fissures, sand and clay holes and is to be dressed to shape on the beds and faces as described in the Particular Specification or as indicated on the Drawings.

VI.Bond and Joints

All brickwork shall be built in English bond except that half brick walls shall be built in Stretcher bond.

All block work shall be properly bonded together and in such a manner that no vertical joint in anyone course shall be within 225 mm of a similar joint in the courses immediately above and below. Alternate courses of walling at all angles and intersections shall be carried through the full thickness of the adjoining walls.

All perpend, reveals, quoins and other angles of the walls etc., shall be built strictly true and square.

VII.Cleaning Facework

All bricks and blocks are to be well wetted before use and tops of walls where left off shall be well wetted before commencing building. All joints are to be flushed up and grouted in solid as the work proceeds.

VIII.Plaster Key

Joints shall not exceed 9 mm or as otherwise indicated on the Drawings.

All faced brickwork and block work is to be kept clean and free of all mortar droppings, splashes, smears, stains etc.

Include for hacking and raking out joints of all walls as required to receive plaster, screeds, or other finishes.

IX.Ant and Damp Proof Courses

Unless otherwise indicated on the drawings the ant proof course shall consist of a bed of cement and sand composed of one part cement to three parts (1:3) by volume and not less than 30 mm thickness laid

over the whole area of walls and piers, finished to a smooth level surface with the edges pointed flush with the faces of the walls. Before laying the ant proof course the top of all walls shall be cleaned and well wetted, and after it is laid it shall be carefully protected until firm and covered with damp soaking.

When the ant proof course is hard it shall be covered with a damp proof course of Hessian based bituminous felt in accordance with BS 743 Part 2 unless otherwise described in the Particular Specification or Bills of Quantities.

Before laying the damp proof course the ant proof course shall be cleaned and brushed and any projections in the surface leveled off. The damp proof course shall then be laid and bedded on a thin bed of cement mortar and neatly pointed on the exposed edges. Joints in the running length shall be made in the damp proof course by horizontal laps of not less than 225mm and at intersections of walls the lap shall be equal to thickness of the interacting wall or partition.

Damp proof course as described shall be laid under all internal walls where these are built off the ground floor slab.

X.Provisions, Allocations for other works

Do all necessary cutting and bonding up to other work and perform all rough and fair cutting required.

Leave or form all chases for edges of concrete floors, roofs, staircases, landings, etc., and provide chases for pipes conduit and the like and make good.

Rake out joint or form grooves for flashings, turn-ups etc., and the like as required and point in cement mortar as described.

Where shown on the drawing, all walls are to be carried up to the underside of the roof sheets and are to be splayed out on top edge to suit roof slope and the corrugations or tiling flushed up solid in gauged mortar as described.

Level all wall plates, bed in gauged mortar and secure with 25 mm x 16 S.W.G. (1.63mm) galvanized hoop iron straps 900 mm long and 1250 mm apart bedded in walls and bent around, drilled and spiked to plates.

Build in or cut and pin in cement mortar ends of cills, thresholds steps lintels and the like and make good.

Leave or form holes for all pipes, conduit and services and make good.

Sills are to be bedded in cement mortar and jambs and heads bedded in gauged mortar and pointed in cement mortar unless otherwise described or indicated on the drawings.

Concrete lintels shall be provided with suitable plugs for the fixing of heads of wood frames.

Form all flues as shown on the drawings and parge with gauged mortar not less than 20 mm thick and core on completion.

Rough render in gauged mortar not less than 12 mm thick to the faces of all flues where passing through timber roof or floor spaces or where passing less than 150 mm from the face of any timbers.

Carefully fill up all putlog holes as scaffolding is dismantled and where required face up to match adjoining work.

Cut away for and attend upon as required and make good after all trades.

Screeds shall be brushed with a stiff brass broom to remove any surface dust or debris before felt laying commences.

1.6. ROOFING

1.6.1 General

Roofing sheets shall generally be fixed in accordance with C.P 143 except where the contract drawings or documents expressly override or modify this.

1.6.2 Steel Sheet

The galvanized corrugated steel roof sheets shall be generally in accordance with BS 3083:1998 having a steel sheet not less than 0.559 mm (24 S.W.G) thick with a coating of zinc on both sides with a total weight of not less than 610 and not more than 763 grammas per square meter of steel surface area.

Sheets shall be laid with 150 mm end laps and side laps of one and half corrugations on the side away from the prevailing wind otherwise lapping shall be to the full extent indicated on the contract drawings or documents. Laps shall be not less than 150 mm long.

When timber purling are employed sheets shall be securely fixed to same on the crown of the corrugations at not less than 300 mm centers with 6 mm diameter galvanized drive screws each not less than 62 mm long with head and galvanized embossed curved washer under.

Sheets shall be fixed to steel purlins with 8 mm diameter galvanized mild steel hook bolts of 50 mm longer in the shank than the depth of the steel purling to which they are fixed each with nut and galvanized embossed curved washer. The sheets shall be fixed at not less than 300 mm centers on the crown of the corrugations.

Where sheets are required to be stitched together they shall be joined at not less than 300 mm centers with 6 mm diameter and finished clean without rags, burrs or damage to the surrounding zinc coating.

Ridges shall have a roll top and plain wings not less than 450 mm girth all in galvanized steel sheet not less than 0.559 mm (24 S.W.G) thick and fixed in similar manner to the sheeting.

At square abutments the last two corrugations of the corrugated iron sheets next to walls shall be flattened and turned up against the wall and covered with 24 S.W.G galvanised iron apron flashing.

Holes for bolts or screws shall be punched from the inside of the sheet and shall be in the ridges of the corrugations as fixed and not in the holes.

Bat proofing shall consist of "Perspex" or similar approved translucent plastic corrugated sheeting.

1.6.3 Aluminum Sheets

The aluminum corrugated roof sheets shall be in accordance with BS 6100 - 1.3.2:1989 having a minimum thickness of 0.559 mm (24 S.W.G.)

The aluminum troughed roof sheets shall be in accordance with BS 6100 - 1.3.2:1989 Type A or B as specified in the Contract Documents having a minimum thickness of 0.9 mm (20 S.W.G.) and 1.2 mm (19 S.W.G.) respectively.

Sheets shall be lapped to the full extent indicated on the contract drawings or documents.

Corrugated roof sheets shall be fixed to timber purlins and corrugated roof sheets and troughed roofs sheets shall be fixed to steel purlins all as before described for galvanized corrugated steel roof sheets unless otherwise specified.

Troughed roof sheets shall be fixed to timber purlins on the crown of the trough at not less than 300 m centers with 6 mm galvanized embossed washer under to give not less than 50 mm penetration of the purlins to which they are attached.

Sheets shall be stitched all as before described for galvanized corrugated steel roof sheets.

All holes in sheets shall be neatly drilled or punched, of the required diameter and finished clean without rages, burrs.

Ridges shall have a tool top and plain wings not less than 450 mm girth having a minimum thickness of 0.71 m (22 S.W.G.) and fixed in a similar manner to the iron sheeting. Laps shall be not less than 150 mm.

1.6.4 Roof Tiling

The roofing tiles shall be first quality local clay tiles of the type as specified in the contract drawings and documents and are to be similar to those obtained from a firm approved by the Project Manager.

All tiles shall be well and evenly burnt, uniform in shape, size and colour and free from cracks, twists and other defects.

Samples shall be submitted to the Project Manager for his approval before the work commences and all tiles used shall be of equal quality to the approved sample.

Ridge and hip tiles shall be saddle back or half round tiles as indicated on the contract drawings of similar quality and manufacture as the roofing tiles.

Tiles shall be carefully graded for size shape and colour upon delivery and again before fixing.

All tiles shall be carefully stacked on edge in the site and rows of tiles shall be separated with a layer of straw, elephant grass etc. between each to prevent damage.

Any chipped, cracked or defective tiles shall not be used.

Nails, when required, shall be stout zinc nails not less than 36 mm long.

Mortar for bedding shall be gauged mortar as before described and if required shall be tinted with an approved colouring compound to match the tiling.

When required, tile battens shall be of sawn pressure impregnated structural timber as described in Carpenter.

Tile battens shall be not less than 50 x 35 mm sectional area or as indicted on the drawings and shall be accurately spaced at the specified gauge and securely fixed at the intersection with each rafter with 75 mm stout round wire nails.

All tiling is to be laid with the specified lap and when laid on battens the head of each tile shall be securely double nailed to the battens in every alternate course unless otherwise described.

An underlining of "Sisalkraft" orange label or other equal and approved reinforced waterproof paper shall be provided under all tiling battens. The paper shall be laid over the rafters with the length of the roll at right angles to same. Laps at heads of adjacent sheets shall be laid over the rafters with the length of the roll at right angles to same. Laps at heads

of adjacent sheets shall be not less than 75 mm and at the ends 300 mm . End laps shall be made at a rafter. Sheets shall be lightly tacked in position to prevent movement whilst tiling battens are being fixed.

Form all verges, eaves, valleys, hips etc. as described, do all cutting, replace all broken or damaged tiles and leave all perfect and watertight on completion.

1.6.5 Bituminous Felt Roofing

Roofing shall be of three layers of bituminous felt all of which must be of Tropical Grade with a softening point temperature of not less than 1040 C, and shall comply with BS 747: 2000 except where this is inconsistent with this temperature requirement.

The three layers shall be of self finished Glass Fibre Felt weighing not less than 18.1 kg/ 10 m².

Oxidized bitumen shall be used for bedding and bonding felt layers and shall be applied hot and shall have a softening point temperature of not less than 1040 C.

The first layer of felt shall be secured on all edges of the roof with hot bitumen in strips 150 mm wide, the surfaces beneath these stripes being primed with a cold cut-back bitumen. The main areas of the felt shall be spot stuck at 1800 mm intervals staggered and in very exposed situations this spacing shall be reduced to 900 mm.

The upper layers shall be continuously bedded and bonded in hot bitumen applied at the rate of 14.65 Kg/ 10 m² and shall be laid with lapped joints at all edges, side laps being not less than 50 mm and end laps not less than 75 mm wide, and each layer shall be laid breaking joint, the felt being laid in the direction of the fall starting from the eaves.

The top layer where so described shall be surface dressed with light coloured quartzite or marble mineral gauged 6 to 12 mm of rounded shape, samples of which must be approved by the Architect, laid shoulder to shoulder at the rate of 16 Kg/ m². Alternatively, and where so described instead of the described in-situ surface finished or Glass Fibre Felt weighing not less than 27.2 Kg/ 10 m² with a factory applied mineral surface dressing to a specification not inferior to the above described in-situ dressing.

Built-up felt roofing shall not be laid under wet, damp or humid conditions and the substructure and screeds shall have been allowed to set thoroughly and dry out for at least seven days before felt laying is commenced and the surface must be completely free from all moisture, dirt and dust.

The Contractor shall satisfy himself that the sub-structure and screeds are in fit condition to receive the felt and that falls are adequate and not less than 1: 80. All flashings, turn-downs at edge, etc., shall be generally in accordance with BS 8217.

Prices for built-up roofing shall include for all straight cutting and waste.

The contractor will be required to guarantee the whole of the bituminous felt roofing against defective workmanship and materials and maintain as required for a period of five years from the date of the Practical Completion of the Works notwithstanding anything to the contrary contained in the Contract Conditions.

1.6.6 Roofing Shingles

Shingles roofing shall have two layers, bituminous felt water proofing layer that complies with BS 747 and shingles that are placed on the bituminous felt. Shingles shall comply with BS 5534.

1.6.7 Proprietary Roofing Systems

When Proprietary or Specialist roofing systems are required to be used as specified in the contract documents they shall be carried out strictly in accordance with the proprietors or specialist manufacturer's instructions. Under no circumstances will any deviation there from be allowed.

1.6.8 Roof Screeds

The lightweight concrete roof screeds shall be mixed strictly in accordance with the specification of the manufacturers.

The surface of the concrete roof on which the screeds are to be laid shall be perfectly dry before laying commences.

The screeds shall be laid to fall of not less than 1 in 80 to give falls and cross falls as indicated on the drawings and the surface floated perfectly smooth and free of all irregularities and projections to receive the felt roofing.

On completion of the screeds they shall be covered with a waterproof cover to prevent too rapid drying or the reabsorption of rainwater before being covered with felt.

Screeds shall be brushed with a stiff brass broom to remove any surface dust or debris before felt laying commences.

1.6.9 Make Good

Carefully inspect all roofing works on completion and make good or replace all defective materials and workmanship, clean out all eaves, gutters, rainwater outlets, etc. and leave all perfectly sound and watertight.

1.7 CARPENTRY

1.7.1 Timber

Timber for carpentry work shall be well seasoned preservative treated timber as later described, graded and free from defects in accordance with The Timber (Export and Grading Rules 1967) and obtained from an approved Uganda sawmill.

Hardwood shall be second or selected grade in accordance with the “Hardwood Timber Grading”, and softwood shall be in accordance with the Second Strength Grade of the “Softwood Strength Grading Rules”.

All timber shall be free of live borer, rot and decay, brittle heart and compression failure and loose unsound or dead knots.

All timber shall be grade marked as specified in the Grading Rules and certificates of Grading shall be produced for verification by the Project Manager.

Timber shall be purchased immediately after the contract is signed to enable it to be adequately seasoned before required for use.

The timber referred to in the previous clause will be referred to in the Particular Specification or Bills of Quantities as “CARPENTRY TIMBER as described” and may consist of any of the following timbers listed on Table 7.1.1

TABLE 7.1.1 – CARPENTRY TIMBER

HARDWOODS	
BOTANICAL NAME	TRADE AND LOCAL NAME
<i>Symphonia globulifera</i>	Muyanja, Munyeya
<i>Piptadeniastrum africanum</i>	Dahoma, Muwere
<i>Chrysophilum</i> spp.	Mululu, Mubakampungu, Munyamata
	Muhumbulya, Mulyanyonyi
<i>Drypetes</i> spp.	Mushabarara
<i>Carapa grandiflora</i>	Mujogo, Mutongana
<i>Celtis</i> spp.	Lufogo, African Celtis
<i>Fagara</i> spp.	Akasinsa, Namamuka, Mukomakoma
<i>Croton</i> spp.	E. Satinwood, Munyene
<i>Trichilia spendida</i>	Musine, Mutundu, Muhote
	Sekoba, Sesambya
<i>Pterygota mildbraedii</i>	Mukoko
<i>Eucalyptus gaudis</i>	Eucalyptus, Kalitunsi
<i>Grevillea robusta</i>	Australina Silky Oak
<i>Markhamia platycalyx</i>	Musaribya
<i>Newtonia buchananii</i>	Muchenche, Mpewere
<i>Albizia</i> (All species except <i>A. Coriaria</i>)	Nongo, Murongo, Mulera
<i>Funtumia</i> spp.	Musanda, Nkago, Wild Rubber
<i>Aningeria</i> spp.	Osan, Mutoke
<i>Bosquiea phoberos</i>	Mugwi, Katomatoma
<i>Maesopsis eminii</i>	Musizi
<i>Antiaris toxicaria</i>	Durundu, Muhehere
SOFTWOODS	
<i>Podocarpus</i> spp.	Podo
<i>Pinus</i> spp.	Pine

1.7.2 Timber for Special Structures

Timbers for designed structural work requiring timber of high strength and quality will be specified by name in the Particular Specification or the Bills of Quantities.

1.7.3 Preventive treatment for Timber

All timber for carpentry work shall be vacuum pressure treated with Celcure or Tamalith or other approved medium, toxic to termites, cryptoterms and other timber pests. All cut ends of timber so impregnated are to be treated with two coats of "B" crystals or other approved method.

A "charge sheet" giving details of treatment shall be supplied to the Project Manager if he so directs.

Pressure treatment shall be carried out by a specialist firm with approved equipment.

1.7.4 Seasoning

Timber shall be seasoned after preservative treatment has been carried out to moisture content as shown in table 7.4.1 below.

Table 7.4.1: Moisture content of timber for various positions in building

Position	Moisture Content of Timber in its Permanent Position%	Moisture Content of Timber at Time of Erection%
Rafters, battens, trusses	15	22
Floor joists	15	22
T and G flooring	12-14	15-22

After delivery to site timber shall be carefully stacked to ensure a free circulation of air throughout the stack and covered with a waterproof cover to prevent excessive drying by the sun or reabsorption of rainwater.

1.7.5 Samples and Testing

The Project Manager may select any samples of timber he may require for the purpose of testing i.e. strength, moisture content penetration of preservative, identification of species etc.

Samples for testing shall consist of cross sections not exceeding 50 mm thick cut at least 500 mm from the end of the piece. They shall be packed in polythene bags with the ends tightly tied, labeled and delivered either to the Government Chemist the Chief Materials Engineer, Central Materials Laboratory, Kampala or any approved laboratory as directed.

1.7.6 Sawn Timber

All timber, except as specified elsewhere, shall be die square clean sawn as left from the saw and shall hold the full dimensions specified.

1.7.7 Wrot Timber

The term "wrot" shall mean finished to a perfectly smooth finish to receive paint or other surface treatment. Pieces which have been machine planed shall be finely smoothed by hand plane and glass paper or sanding machines to remove all planning machine or other marks.

3 mm reduction of specified size will be allowed in respect of each wrot face except in members 25 mm thick or less or where described as finished size "finished" when the members shall hold the full size stated.

1.7.8 Workmanship

All Carpentry work shall be executed by skilled workmen, with workmanship of the best quality, accurately set out in strict accordance with the drawings and be framed together and securely fixed in the best possible manner with properly made joints; all brads, nails and screws etc., shall be provided as necessary, directed and approved, and the Contractor's prices shall allow for all the foregoing.

1.7.9 Jointing

All timber shall be as long as possible and practicable to eliminate joints. Where joints are unavoidable surfaces are to be in good contact over the whole area of the joint before fastenings are applied.

Scarfed joint shall be of a length not less than twice the greatest dimension of the timber member and shall be bolted if required. Whenever practicable scarfed joints are to be placed at a point of support in order to obtain maximum strength.

No nails, screws or bolts are to be placed in any split end. If splitting is likely, or is encountered in the course of the work, holes for nails are to be prebored at diameter not exceeding $\frac{4}{5}$ th of the diameter of the nails. Clenched nails must be bent at right angles to the grain.

Lead holes are to be bored for all screws. When the use of bolts is specified the holes are to be bored from both sides of the timber and are to be of the diameter $D + D/16$, where D is the diameter of the bolt. Nuts must be brought up tight but care is to be taken to avoid crushing of the timber under the washer.

A tolerance of 1 mm will be allowed in positioning of bolt holes.

1.7.10 Connectors

When trusses are required to be bolted together with timber connectors these shall be of the single or double sided toothed type in accordance with relevant standard or as directed by the Project Manager on Connectors for Timber.

1.7.11 Nails, Bolts etc

All nails, bolts and metal fastenings shall be of mild steel, free of all rust and defects and of approved manufacture.

1.7.18 Roofs

The roofs are to be constructed in accordance with the details and scantlings shown on drawings. All ironwork necessary at joints, etc., is to be fitted and bolts, nuts and washers provided and fixed as required. Trusses shall be hoisted into position at the spacings shown and such temporary struttings as may be required are to be provided. Purlins are to be of the size and intervals shown. Rafter feet are to be cut and splayed as shown on the drawings. Plates shall, so far as possible, be in one length between points of change of direction. Joints between continuous lengths or at changes of direction and intersections shall be halved.

1.7.19 Ends of Timber

The exposed ends of all cut timbers, whether exposed, built in or otherwise shall be painted with two coats of “Wykamol” or other equal and approved to prevent rot and entry of borers.

1.7.20 Fixing slips, Plugs, etc

The Contractor shall provide and fix all necessary hardwood plugs and fixing slips to walls and dovetailed blocks costs into concrete soffits, etc., for the purpose of providing fixings for joinery and other Trades.

All hardwood fixings shall be clean and dry and dipped in “Wykamol” or other approved wood preservative before fixing.

Where work is described as “plugged” it shall be fixed with nails to treated hardwood plugs inserted into the brick or block work joints. Plugs shall be of dry hardwood with the end cut on the twist, dipped in “Wykamol” or other approved wood preservation and tightly driven into the raked out joint in the wall.

Where work is described as “plugged and screwed” it shall be fixed with steel screws unless otherwise specified to cylindrical fibre or polyvinyl plastic plugs of approved manufacture let into holes of suitable size drilled in the walls. When the wall is of such a material that it is impossible to drill neat round holes they shall be packed with a suitable plastic plugging compound such as “Rawplastic” or “Philplug” or other similar approved as instructed by the manufacturers.

Plugs shall be inserted in walls to provide fixings not more than 750 mm apart horizontally. The number of plugs at each fixing point will depend on the width, height and thickness of the material to be fixed but a minimum of two will be required with an additional one for each 150 mm width or height in excess of the first 150 mm.

1.7.21 Insect Damage

All timber brought on to the site shall be free of live borer beetle or other insect infestation and it will be the entire responsibility of the Contractor to see that it remains free of infestation until the end of the maintenance period.

If upon inspection any timber is found to have been attacked, the Contractor will be required to execute at his own expense all necessary remedial measures to eradicate it, including the removal and replacement of all infected timber and such other measures as he is directed to take by the Project Manager.

1.7.22 Cleaning

The Contractor is to remove and destroy all cut ends, shavings and other wood waste from all parts of the building and the site generally both whilst the work is in progress and at its completion.

1.8.0 JOINERY AND IRONMONGERY

1.8.1 Timber

Timber for joinery work shall be well seasoned preservative treated timber all as described in Clause 7.1 "Carpentry" with the following exceptions:-

Hardwood shall be First or Prime Grade in accordance with the "Hardwood Timber Grading" and softwood shall be in accordance with the First Appearance Grade of the "Softwood Appearance Grading Rules".

TABLE 8.2.2 HARDWOODS FOR HIGH CLASS JOINERY WORK

BOTANICAL NAMES	TRADE AND LOCAL NAME
Albizia coriaria	Mugavu, Musisi, Murongo
Fagara spp.	E.A. Satinwood, Munyenye
Chlorophora excelsa	Iroko, Muvule
Fagaropsis angolense	Mafu, Muyinja, Mumara
Entandro phragma	
Cyclindricum	Sapele, Muyovu
E. Utile	Utile, Mufumbi
Lavoa spp.	Nkoba, Mukusu
Entandrophragma Engolense	Godu Nohor, Mukusu
Guarea cedrata	Scented guarea
Khaya spp.	African Mahogany Munyama

1.8.2 Species of Timber for Joinery Works

The timber referred to in the previous Clause will be referred to in the Particular Specification or Bills of Quantities as “JOINERY TIMBERS as described” and may consist of any of the following timbers:-

TABLE 8.2.2 - HARDWOODS FOR HIGH CLASS JOINERY WORK

Botanical Name	Trade and Local Name
<i>Symphonia globulifera</i>	Nuyanja, Munyeya
<i>Piptadeniastrum africanum</i>	Dahoma, Muwere
<i>Chrysophilum</i> spp.	Mululu, Mubakampungu, Munyamata Muhumbulya, Mulyanyonyi.
<i>Drypetes</i> spp.	Mushabarara
<i>Carapa grandiflora</i>	Mujogo, Mutongana
<i>Celtis</i> spp.	Lufogo, African Celtis
<i>Fagara</i> spp.	Akasinsa, Namamuka, Mukomakoma
<i>Croton</i> spp,	E. Satinwood, Muynene,
<i>Trichilia spendida</i>	Musine, Mutundu, Muhote Sekoba, Sesambya
<i>Pterygota mildbraedii</i>	Mukoko
<i>Eucalyptus gaudis</i>	Eucalyptus, Kalitunsi
<i>Grevillea robusta</i>	Australian Silky Oak
<i>Markhamia platycalyx</i>	Musaribya
<i>Newtonia buchananii</i>	Muchenche, Mpewere
<i>Albizia</i> (All species except <i>A. Coriaria</i>)	Nongo, Murongo, Mulera
<i>Futumia</i> spp.	Nusanda, Nkago, Wild Rubber
<i>Aningeria</i> spp.	Osan, Mutoke
<i>Bosquiea phoberos</i>	Mugwi, Katomatoma
<i>Maesopsis eminii</i>	Musizi
<i>Antiaris toxicaria</i>	Durundu, Muhehere

1.8.3 Preventive Treatment

Preservative treatment of all timber for joinery work shall be carried out in accordance with Clause 7.3 "Carpentry".

1.8.4 Seasoning

Timber shall be seasoned after preservation treatment has been carried out to moisture content as described with Clause 7.4 "Carpentry".

Seasoned timber shall be stored inside an enclosed building until required for use.

1.8.5 Samples for Testing

The Project Manager may select samples for testing all as described in Clause 7.5 "Carpentry".

1.8.6 All Joinery be wrot

All joinery timber shall, unless specifically so described, be wrot within the definition given in Clause 7.6 "Carpentry"

1.8.7 Selected Timber for Polish etc.

When timber is to be lacquered, varnished or polished this will be specifically described in the Particular Specification or Bills of Quantities as "hardwood/ softwood selected and kept clean for polish".

Such timbers shall be carefully selected and matched for uniformity, symmetry and evenness of both grain and colour.

1.8.8 Plywood

Plywood shall comply with BS 6566, Parts 1 -8 – Plywood manufactured from Tropical Hardwoods, of the first grade. Plywood for external use shall be weatherproof resin bonded, Bonding W.B.P. Quality.

The Project Manager may require samples for testing in accordance with the provisions in the relevant B.S or Uganda Standard and the Contractor shall supply these and he will be reimbursed with the cost as previously described.

1.8.9 Block boards

Block boards shall comply with BS 8701:1987 and shall be of the first grade. Blackboard for external use shall be weatherproof resin bonded, Bonding W.B.P. quality. Tests may be called for as previously described.

1.8.10 Wood chipboards

Chipboard shall comply with BS 5268 Resin Bonded Wood chipboard and unless otherwise specified the faces shall be filled and finished to receive paint. Tests may be called for as previously described in BS EN 181104: 1998.

1.8.11 Veneers

When veneering of blackboards, chipboards, etc. is required, it shall be carried out in an approved manner. The sheets of veneer in adjacent panels shall be carefully matched for uniformity of colour and symmetry in the direction of the grain, laid with tight edges and secured with approved adhesives under pressure to the base.

1.8.12 Adhesives

Organic or casein glues in accordance with BS EN 12765:2001 may be used for all non-load bearing internal work or work where the moisture content will never exceed 15%.

For external work or when the moisture content is likely to exceed 15% only resin type adhesives in accordance with BS EN 12765 shall be used.

1.8.13 Nails, Screws etc

Nails shall be as described in "Carpentry". Screws shall unless otherwise specified shall be steel screws in accordance with US.194-1.2001 PART 1 or BS 1210 "Wood Screws".

Unless elsewhere described, nails shall be of length equal to two and a half times the length of the material which is being fastened and screws shall be not less than No. 8 gauge and of a length not less than twice the thickness of the timber being fixed.

1.8.14 Workmanship

The Joinery work shall be carried out by skilled workmen and in an approved manner exactly in accordance with the Project Manager's detail drawings.

The joiner shall carry out all necessary mortises, tenons, rebates, grooves, notching, tongues and housings and all other labours necessary for correct jointing. He shall also provide all tongues, dowels, metal plates, screws, nails and other fastenings that may be required for the proper carrying out of the work.

The joiner shall carry out all works necessary for the proper construction of all frames, linings, panels, etc. and their support and fixing in the building. All joinery work shall be arranged, jointed and fixed to allow for minimum shrinkage and damage either to its strength or appearance.

Joinery work shall be commenced as soon as practicable and all frames and components shall be loosely framed and assembled, but they shall not be finally glued, pinned and wedged until they are required for fixing on site.

Where joints shall be commenced as soon as practicable and all frames and components shall be loosely framed and assembled, but they shall not be finally glued, pinned and wedged until they are required for fixing on site.

1.8.15 Joints

Where joints are required even though not specifically indicated on the drawings, they shall be the recognized form of joint for such positions and shall be made in accordance with BS 1186- 2: 1988 and BS 1186– 3:1990.

All nails are to be punched and stopped with linseed oil putty.

Loose joints are to be made where provision for shrinkage is required e.g. tongued and grooved in fill or paneling.

Glued joints are to be made when the joint has to be sealed or when shrinkage or other movement in the boards, etc. can be discounted. In glued joints all surfaces in contact shall be sawn or wrot and shall be perfectly clean and free from dirt, dust, sawdust, oil and any other contaminating matter likely to impair the strength of the joint. All joints shall be properly cramped until the wedges and pins are driven or subjected to adequate pressure which shall be maintained until the glue has set.

All glues shall be used in accordance with the manufacturer's instructions.

1.8.16 Moulding

All mouldings shall be accurately worked in accordance with the details and unless otherwise specified shall be worked on the solid.

1.8.17 Fixing or Building Frames

All frames for normal joinery construction shall be built-in as the adjoining walling or masonry is carried out.

Frames which are to receive polish or other clear finish previously referred to are to be carefully stored until the openings to receive them are completed and all plastering or other wet trades are finished and then "built-in"

1.8.18 Fixing Beads etc

Except as otherwise described all beads, fillets and small mouldings, architraves and skirtings which are not required to be removed shall be fixed without stout round or oval pins, brads or nails.

When specifically stated work shall be fixed with steel or brass screws with the heads let in and pelleted with matching wood pellets.

All glazing beads for doors and opening lights and beads for securing mosquito gauze to all types of frames shall be fixed with brass cups and screws.

1.8.19 Scribing

All skirtings, cover fillets, architraves etc. shall be accurately scribed to fit to the contours of any adjacent irregular surfaces to form a close butt joint.

1.8.20 Grounds

Provide and fix where indicated on the drawings, particular specification or bills of quantities all necessary sawn grounds to receive skirtings, linings and other "built-in" fittings, etc.

1.8.21 Flush Doors

Flush doors unless specifically otherwise described, shall consist of hardwood skeleton framing 75 mm wide to all stiles top and bottom rails, 50 mm wide horizontal intermediate rails not more than 150 mm apart, with suitable blocks to receive mortise locks on each long edge and covered on both sides with 6 mm plywood finished for paint and approved hardwood lipping 30 mm thick on each vertical edge.

All flush doors unless otherwise described are to be 45 mm finished thickness and are to be properly framed and put together in accordance with the requirements of BS 459: 1988.

External quality flush doors where so described shall be as described above except that the plywood shall be external quality bonding W.B.P. plywood as previously described and all adhesives used shall be of the resin type.

All flush doors shall be perfectly plane on both faces free of all waves, ripples and distortion of any kind. Any door which after the application of paint or polish shows any of these defects shall be removed

1.8.22 Priming

All joinery work which is prepared for painting shall be knotted and primed as soon as it is prepared and ready for incorporating in the building. The backs of all frames, linings, skirting boards, bottom edges of doors and sashes etc., and other timber likely to come into contact with plaster or masonry shall be similarly primed.

Priming shall consist of one coat of priming paint in accordance with B.S. 2523: 1966.

Touch up priming coat of all members as necessary before finally incorporating in the Works.

1.8.23 Polish or clear finishes

Where Joinery is to be polished or varnished it shall be given the first coat of the selected treatment as soon as it is ready for incorporating into the Works.

1.8.24 Inspection

Facilities shall be given to the Project Manager to inspect work in the course of fabrication in the Contractor's Workshop.

1.8.25 Storage and Delivery

All completed joinery shall be carefully stored in an enclosed building until it is required for use and shall not be prematurely brought on the site.

All joinery in transit shall be carefully protected from damage and kept under a waterproof cover.

1.8.26 Protection of Joinery

All joinery likely to be damaged after being fixed in position shall be adequately cased up and protected by the Contractor until completion of the Works.

1.8.27 Ironmongery

All ironmongery is to be as specified in the Particular Specification or Bills of Quantities with regards to manufacture and finish.

All ironmongery shall be carefully stored, sorted, assembled and fixed in the best manner with matching screws, and shall be left oiled if required and in perfect working order.

All keys shall be stamped with an identity number corresponding to its lock and if directed by the Project Manager it shall have a stamped brass identification tag attached to it by means of a steel split ring.

All ironmongery shall be removed before painting work is carried out and after completion it shall be refixed, adjusted, cleared and left in full working order.

All damaged or defective ironmongery shall be replaced at the Contractor's own expense.

1.8.28 Dowels

The feet of all door frames or other vertical posts or timbers shown on the drawings shall be firmly anchored to the floor with a 9 mm diameter mild steel dowel 100 mm long let into the frame, etc., and the floor for equal amounts. Dowels shall be bedded to the frame in red or white lead.

1.8.29 Mosquito Gauze

Where indicated on the drawings mosquito gauze shall be brass or copper gauze not less than 0.559 mm (24 S.W.G) x 20 mesh.

1.8.30 Making Good

Should any joiners work bend, shrink or warp before the end of the Maintenance period such work shall be removed and replaced entirely at the Contractors own expense together with any other work disturbed in consequence thereof to the entire satisfaction of the Project Manager.

1.9.0 METAL WORK

1.9.1 Materials generally

- (i) All materials shall be the best of their respective kinds, free from defects, and all work shall be carried out in the most workmanlike manner and strictly as directed by the Project Manager.
- (ii) The materials in all stages of transportation, handling and piling shall be kept clean and injury from breaking, bending and distortion prevented.

1.9.2 Structural Steel

Structural steel shall comply with BS 4-1: 1993 Steel of Non-British origin shall comply with the tests enumerated in BS 159: 1992 and samples shall be submitted to the Project Manager for this purpose and for his approval.

All structural steelwork shall be fabricated in accordance with BS 449-2:1969 – The use of Structural Steel in Building.

1.9.3 Welding

Welding of steel shall be carried out strictly in accordance with BS 5950 – General requirements and/or DD ENV 1090 Eurocode.

1.9.4 Bolts

All bolts shall be of the best quality mild steel of lengths and weights approved by the Project Manager. Bolts shall project at least two threads through nuts and all bolts passing through timber shall have washers under heads and nuts.

1.9.5 Metal Windows and Doors

All metal windows and doors shall unless otherwise specifically described be of the domestic type in accordance with BS EN 990: 1996 – Steel Windows generally for Domestic and Similar Buildings.

Windows generally shall be Standard Metal Windows of the type and layout shown on the drawings, constructed from sections rolled from best quality mild steel. Corners shall be electrically welded and glazing bars shall be locked at points of intersection and machine tenoned to frames. All welds shall be ground flush and all frames and casements shall be square and free from deformity of any kind.

1.9.6 Hanging

All casements shall open as indicted on the drawings and shall be fitted with projecting hinges with bronze or gun – metal pins horizontal pivot hung windows shall be fitted with bronze friction centers. All fittings shall be of bronze or gun-metal.

1.9.7 Fittings

All side hung windows are to be fitted with double notched wedge plate casement handle and peg casement stay not less in length than three quarters of the width of the opening light and suitable retaining pin welded to the frame.

Horizontally hung windows shall be fitted with a peg casement stay as above described but pivoted windows shall be fitted with spring loaded catches with either ring handle for pole operation or where specifically so described, gears for remote control operation.

Doors shall be hung on heavy pattern projecting type hinges with bronze or gun – metal pins and fitted with a three lever mortise lock of “Union” or other equal approved manufacture with two keys and bronze handles to each. One leaf of folding doors shall be fitted with two 150 mm bronze concealed bolts.

1.9.8 Glazing Clips

All sections shall be slotted or drilled to receive glazing clips.

1.9.9 Fixing lugs and screws

Adequate mild steel fixing lugs and screws shall be provided at not more than 450 mm centers at jambs, heads or cills and where these are less than 450 mm in length they shall be fitted with not less than one lug per member. Lugs shall be of the adjustable type for building into walls with slotted holes to allow vertical adjustment of the fixing screws.

Frames shall be screwed either to the fixing lugs or direct to wood frames with suitable screws.

Frames fixed direct to masonry brickwork etc., are to be fully bedded in gauged mortar and neatly pointed all round externally in an approved waterproof mastic compound. Frames screwed into wood sub-frames shall be bedded in approved waterproof mastic compound before screwing in position and the surplus mastic neatly dressed off and pointed on both sides.

1.9.10 Composite Windows

Composite windows and doors shall be provided as shown in the contract documents and shall include for all necessary coupling mullions, transoms and cills etc. as indicated.

All mullions and transoms shall be bedded in approved mastic.

1.9.11 Protective Finish

All metal windows shall be given one coat of approved red oxide paint at the works. The metal shall be thoroughly cleaned before the paint is applied.

After delivery to the site the paint coat shall be touched up with similar paint as required before the application of subsequent coats.

1.9.12 Fly screens

Where fly screens are indicated on the drawings unless specifically otherwise shown these are to be manufactured in accordance with the standard Ministry of Works, Transport & Communication's detail drawings (see unallocated Stores Catalogue for these).

The frames, opening lights and mullions, etc. are to be manufactured from good quality mild steel all properly framed and welded together.

Where plate mullions and transoms are required these are to consist of 1.626 mm thick sheet 112 mm girth with one edge bent, drilled and set screwed to the window and the other edge drilled and set screwed to the metal angle frame of the fly screen.

Opening lights shall be provided with one pair of brass hinges and two brass turnbuckles to each and filled in with 20 mesh x 10.274 m (32 S.W.G) brass gauge screwed with mild steel beads fixed to the inside of the angle frame.

All fly screen frames are to be thoroughly cleaned and prepared at the manufacturer's works and painted with one coat of approved red oxide paint.

1.9.13 Aluminum security grilles

Where aluminium security grilles are indicated, these to be folding aluminum closure model "Concept-1212" as supplied by Vrinda Inc. TEL.: 1-877-874-6321 FAX: 1-801-457-0594.

The contractor shall submit the subcontractors shop drawings, installation instructions, operation and maintenance instructions.

The top and bottom of each section to be fitted with an aluminum panel 4" (101mm) high, consisting of an aluminum extrusion 1/16" thick and made of modules with a 15° angle between them to facilitate the operation of the closure. The curtain is to be constructed of modules 1/16" (1.6mm) thick arranged in a checkerboard design of 3" (76mm) C/C. These modules to be linked together by hidden aluminum and steel rods of 5/16" (7.9mm) diameter. The height of the panels to be 12" (305mm).

Lead posts shall be equipped with a hook bolt lock with supplied cylinders each side, and shall engage a full height wall jamb.

Trailing post shall be self-locking at the top and bottom inside the storage pocket. Free floating intermediate posts shall be located at all curves and at intervals not exceeding 10 feet (3M), 6 feet (2M) for counter top units. Intermediate posts shall be equipped with self-adjusting spring loaded drop bolts activated from the inside only. Drop bolts shall engage dust proof stainless steel receptacles.

Curtain shall be hung from an overhead track 1-5/16" (33mm) wide by 1-9/16" (40mm) high. Track shall be aluminum 6351 alloy tempered to T6. Curves where required shall be 14" (355mm) radius standard.

Stacking shall not exceed a depth of 1.15" per foot of closure width plus 3" for each post (lead, end or intermediate). (95mm/lin. M. + 76mm per post). Full egress doors add 7" (176mm).

Finish shall be standard (clear anodized or acrylic paint in white, black, medium bronze #40, light bronze #26.

Closure as per printed instructions from VrindaInc and approved shop drawing. Clean and adjust closure to ensure smooth operation.

Top and bottom lock posts to have key cylinders both sides for either end of the curtain. Sections to be divided by incorporating bipart units as intermediate posts, with second hook bolts on lead, end or biparts. High security lock cylinders to be incorporated.

Bi-part egress door.(Bi-part post with interior thumbturn activation).and 3' (915mm) panels (Royal or Impact) to protect the thumbturn.

1.9.14 General Specification of steel cabinets, drawers and shelves

I. Cabinets:

Cabinets to be made of Cold-rolled steel sheets electrostatically zinc plated.

- a) Front doors and drawers to be made of same steel double layer.
- b) The two sides of cabinets housing to be double layer.
- c) To keep the zinc layer all over the cabinet, toxing (cold joint) to be used instead of hot welding.
- d) All cabinets to be modular to accept changing doors and drawers with different sizes in future.
- e) Finishing to be Electrostatically applied powder paint for all parts of the cabinets and metal preparation prior to application of finish metal parts to go through the following steps to ensure high quality :
 - * Degreasing and cleaning.
 - * Phosphating
 - * Water rinse
 - * Passivation
 - * Drying
- f) Depth of all cabinets not less than 55 cm to allow for sufficient storage area.
- g) Hinges to open 180 degree for easy access to lab-equipment and avoid damage if the door is accidentally pushed. Hinges to be rust proof and of superior quality which qualifies for lab. Standards.
- h) All inner shelves of cupboards designed as such to allow for change of its height inside the cupboard as may be needed to fit for the different sizes of lab. apparatus, chemicals and glass-ware.
- i) All L-shape benches to have corner filler panel for tight connection with cabinets to avoid accumulation of dust or dirt.
- j) All drawers to operate on telescopic rail with self-closing. These rails not t allow for the accidental drop of drawers when fully opened.
- k) Center benches equipped with energy cell above the bench with all outlets needed (electricity, gas, water, etc.) and used as reagent shelf with extra shelf above the energy cell.

II. Fitting and outlets:

To be made of special laboratory quality according to international norms.

- a) Water taps to be supplied with oil bath head valve and tightness in EPDM or with ¼ turn ceramics head valve.
- b) Handles to be in compliance with DIN12920 regulation manufactured in Moplen, acid resistant material.
- c) Threads to be in compliance with ISO228/1 regulation, B tolerance class.

- d) All material processing operations to be carried out with technologically advanced, Machines, numeric controlled lathes, CNC welding centers, transfer, epoxy and epoxy Polyester powder painting cab. static heating furnace, computerized test bench, etc.
- e) The brass used to be completely free from ferrous substances and to be used in the form of drawn bars or hot forged.
- f) The alloy used for the brazing to be free of Cadmium.
- g) Nozzle: olive-type fixed DIN 12898. (for compressor air fittings)
- h) Upper part: with fine regulation, maintenance free. (for compressor air fittings).
- i) Upper part: with normal regulation, maintenance free. (for gas fittings)
- j) Gas fittings to be manufactured in accordance with DIN
- k)** DVGW regulations to conform with DIN 3537 TEIL 1-3.
- l)** Nozzle: olive-type hose screw coupling DIN 12898. (water fittings)
- m) Sound-control during the flow of the water: DIN 4109. (water fittings)
- n) Precautionary measures for the installation DIN 1988. (water fittings)
- o) Technical characteristics:
 - * Heat resistance: from -30 °C to + 150 °C.
 - * Light resistance: very good also U.V.
 - * Chemical resistance: the relations are very rare.
 - * Pea-souper test: according to ASTM no alterations.
 - * Kesternich test: no alteration (DIN 500 1 8).

Valve handles with color code according to international standard. All fittings could be fit directly on bench top or coming from energy cell above the bench and the same energy cell used as storage shelf.

1.9.15 PARTICULAR SPECIFICATIONS FOR LABORATORY CASE WORK

- I. BASE UNITS TO BE WIDTHS OF EITHER 457.2mm, 609.6mm, 736.6mm, 889mm, 1041.4mm & 1193.8mm AS INDICATED ON DRAWINGS. ALL MUST BE ABLE TO BE RECONFIGURED IN THE FIELD BY USE OF HAND TOOLS ONLY. ALL BASE UNITS TO HAVE REMOVABLE BACKS FOR ACCESS TO PLUMBING CHASE.**
- a. Sides to be 18-gauge formed with 25mm flanges on top, bottom and back with 50mm return on 25mm front flange to receive removable pilasters and front of case track.
 - b. Bottom to be 18-gauge formed with 35mm flange and 20mm return on front with 25mm flange down on back and 25mm flanges up for welding to sides. Bottom to also have 20mm access holes, each to receive plastic cap plug, above leveling gusset. Bottom shall be full depth and full width of cabinet.
 - c. Front Crosspiece at top to be 16-gauge, width of opening of cabinet (to create flush surface typical of bottom & side), 35mm high with 20mm return and 32mm deep with 20mm return.
All four pieces above, when spot-welded together, will be gas-welded at each front corner and ground smooth to create smooth integral corners for painting.
 - d. Backs to be 18-gauge with no formation at sides, which are spot-welded to side flanges, and 20mm flange at bottom and top to have 28mm bend with 10mm return to create rear crosspiece. Backs to have cutouts for access to plumbing connections (one cutout on single width cabinets and two cutouts on double width units to accept removable panels). Sink back to be only 340mm high up from bottom of base, with no cutout, and sink unit shipped with removable rear top rail.
 - e. Rear pilasters to be 18-gauge, spot-welded into each corner. Each pilaster to be 11mm high x 59mm wide x full height of cabinet opening. Each pilaster to have 3mm x 8mm slots on 12.7mm centers (typical slottage of front removable pilaster) for adjustable shelves along with provision to accept rear of tracks. Double-wide unit to have center pilaster (between both cutouts) 11mm high x 95mm wide height of opening with provisions as above on right and left side of pilaster.
 - f. Double units to have center upright 25mm wide with two 56mm flanges x height of opening to be welded into place except for open units and units with double-wide drawers. Upright to have typical provisions found on side return. (This piece also to be gas-welded in place at top and bottom, and ground to create seamless joint, typical of corners.)

- g. Integral base located to create 100mm high x 75mm deep toe space. Base constructed of 18gauge with two halves, each being full width of base unit with both sides 247mm long. Height of base to be 100mm with 16mm returns on top and bottom. Both halves to be spot-welded together at each side with 92mm L x 20mm H high splices. (All 4 pieces to be 18-gauge material). Two 14-gauge leveling channels at each side of base with 2 cage nuts in each. Cage nut to receive a 10 mm 16 leveler with 6mm hex head for easy leveling through bottom for approximately 25mm of leveling capability.
 - o Adjustable shelves to be of 18-gauge cold rolled steel and formed with 20mm flanges on all sides with front and back of shelf to have 10mm return. Shelf size to be 500mm front to back. Shelves over 915mm in width to have 18-gauge reinforcing channel spot welded to underside of shelf.
 - o Removable rear panels to be 18-gauge in all base cabinets, except sink unit and model 7000 acid storage units. Panel to be full width and height of cutout in back (two required for double units). Panel to be formed of 18-gauge with sides to be 10mm flanges down, top and bottom to be 12mm offsets with bottom flange to be 10mm and top to be 28mm to allow for movement upwards to remove panel. Panel supplied with 20mm finger hole on center 50mm up from bottom and to be equipped with cup plug.
 - o Drawer to be constructed with four pieces: 20-gauge drawer body, drawer back, inside front, and drawer front. All of which are to be spot-welded into one integral piece, with drawer front to be fastened on using sheet metal screws for easy removal when installing locks. Drawer face to be pre-punched knock out to accept lock.
 - i. *Traditional front overall to be 180mm high (full) or 90mm high (half). Formed with 22mm flanges and 12mm returns with side returns to have provisions to accept inside front and two 3mm holes to align with mounting angles (which are spot-welded on drawer body) and accept sheet metal screws, also to have pre-punched holes on 100mm centers to accept wire pull (two pulls required on double-width fronts). Adhesive mounted honey comb sound deadening material to be placed into drawer front.*
 - ii. *Traditional inside front in height to be 20mm less than outside front and typical width of inside drawer body. Bottom and both sides to be formed with 21mm flanges with top to be formed with 1.5mm offset, 12mm high and 13.5mm flange. Outside front to be 20-gauge and inside front to be 20-gauge.*
 - iii. *Body to be formed out of 20-gauge cold rolled steel with sides form up 65mm on half drawers and up 152 on full drawers with 10mm flange and 8mm return at top of both sides. Sides to be formed up with 90-degree bend and will accept inside front and back.*

- iv. *Back to be formed of 20-gauge cold rolled steel with height 52mm on half drawers and 144mm on full height drawers with width being inside dimension of body. Formation to be with 12mm flanges on all four (4) sides for welding to drawer body with 12mm return on top of back only.*
- v. *Both inside front and back are spot-welded into drawer body with flanges of inside front and flanges of back welded flush to raw edges of front and rear of body.*
- h. Hinged doors to be double pan construction with both inside and outside door formed of 18gauge cold rolled steel. All four sides formed typical with 20mm flange and 6mm return. Two 6mm diameter holes on center 100mm apart and 38mm in from edge of door to receive wire pull: two hinge provisions each typical as follows: 65mm high cutout located from top and/or bottom of door 55mm to center of cutout. Cutout starts 5.5mm: on front of hinge side and wraps around door to end up 4mm from same side on rear of door. Typical 20mm flange on all sides. Hinge brackets (2 per door) are formed of 14-gauge material 16mm wide x 124mm long with two 3.2mm offsets to create 65mm long provision for hinge, which includes 3 holes drilled and tapped for 6.4mm machine screws. Outside door and inside door are welded to create one integral rigid piece with sound deadening.
- i. Sliding doors are similar, less provisions for hinges, wire pull and roller catch. In place of these provisions are provisions for door rollers and finger cup.

II. CORNER BASE UNITS

- a. Unit manufactured with front access to be 457.2mm wide, with two front sides at 571.5mm deep, two rear sides a 435mm deep and back to be 651mm wide.
 - Front to be full height cupboard door for storage or with partial door and louver panel for sink cabinet.
 - Two front sides and rear sides to be formed out of one piece on each side with both portions to be solid formation.
 - Back to be formed typical of base units with one removable back for plumbing and electrical access.
- b. Optional lazy Susan to consist of vertical post with top & bottom mounting provisions for post to be secured into cabinet (independent of countertop) with two full round shelves. Shelves to be adjusting vertically with additional shelves available as option.

III. TABLE APRON & KNEESPACE DRAWERS

- a. Table aprons to be 16-gauge cold rolled steel, 95.3mm high, 571.5mm deep or 723.9mm depth and width as required or specified in drawing. Apron to have 32mm top flange and 25mm bottom flange and formed in two halves with length being width as specified with two bends 285.75mm (571.5 apron) or 361.95mm (723.9mm apron). Unit to be spot-welded together with splices at each side and center support front-to-back when necessary (occasionally, large aprons manufactured in four pieces in-lieu of halves). Leg pockets to be 14-gauge cold rolled steel, spot-welded into each corner, legs to be bolted in place with 6.35mm - 20 bolts.
- b. Standard legs are to be H-leg design, manufactured with 16-gauge 50.8mm x 50.8mm tubing and 16-gauge spreader to weld both legs together. Each leg to have 9.525mm- 16 levelers, adjustable to approximately 150mm in height. The H-legs to be in both cabinet heights and both apron depths
- c. Knee space drawers to be standard half height drawers in both 457.2mm wide and 609.6mm wide sizes according to drawings. Drawer housing to be manufactured of 18-gauge cold rolled steel with two sides 95.25mm high x 571.5mm deep with 25.4mm flanges on top, bottom & back with front to have 25.4mm flange with 55.56mm return for drawer roller. Back to be 18gauge with formation on top to be spot-welded inside of unit between rear of sides. Unit to have top weld strap with 12.7mm flange at front, the width of drawer unit. 914.4mm x 1219.2mm units to be two single units welded together with front bottom stiffener and rear 16gauge stiffener, both to be 914.4mm or 1219.2mm wide to create integral double drawer unit.

Drawer ends to be available to extend the width of drawer unit. (example: 609.6mm unit with 152.4mm end to create a 762mm wide unit). End to be typical of an apron half in formation and gas-welded in place in front and back of drawer unit. Drawer ends also to be available on both ends of drawer unit. (Example: 7200-30 is a 609.6mm unit with two 76.2mm ends). When using H-legs on a drawer end, the smallest end possible to be 101.6mm to accommodate leg pockets.

IV. MOBILE STORAGE UNITS

Mobile units to be constructed in a similar manner as base units and or drawer units as case may be. They are to be 705mm high 623mm deep in either 450mm or 750mm width. They are to either have drawers or shelves with shutters as specified. Each unit is to have 4 swivel castors supported on legs, with the front two castors lockable. The Units should be able to slide and completely fit underneath workbenches.

V. KNEESPACE PANELS, FILLERS & SOFFITS

- a. All panels and fillers to be fabricated out of 20-gauge cold rolled steel. All spring clips used for mounting against cabinets and/or wall to be 18-gauge galvanic material. Mounting flanges on all panels and fillers to be 38.1mm long typical.
- b. Adjustable knee space panels to accommodate the width of the opening and/or knee space drawer with mounting flanges and 19.05mm x 12.7mm box bends at top and bottom. Panels to be fabricated of 20-gauge material in four heights: 901.7mm for 7000 & 7100 series, 809.625mm with knee space drawer/apron frame; 717.55 for 7300 & 7400 lowboy series, 625.475" with knee space drawer/apron frame.
- c. Front base fillers are fabricated of 20-gauge material in two heights: 908.05mm for 7000 & 7100 series and 723.9mm for 7300 & 7400 lowboy series. Each standard with 76.2mm x 101.6mm high toe space at bottom, 19.05mm returns at top and bottom, and mounting flanges.
- d. Rear base fillers to be fabricated in the same two heights with side-mounting flanges by width of void to be closed. Standard width rear base filler for 762mm top to be 165.1mm.
- e. Standard bottom corner toe space fillers to be 101.6mm x 101.6mm high.
- f. Miscellaneous fillers available upon request or as needed (size & configuration).

Sloping tops to be 20-gauge cold rolled steel with 30-degree slope. Tops for 330.2mm deep to have an overall height of 190.5mm; tops for 457.2mm deep to have an overall height of 263.525mm. Tops are cut to width of cabinet and include end caps.

VI. WALL UNITS TO BE IN THE SAME WIDTHS AS THE BASE UNITS i.e. 610mm, 762mm, 914.4mm, & 1219.2mm HEIGHTS. 330.2mm & 406.4mm DEPTHS STANDARD. ALL UNITS TO BE CAPABLE OF BEING RECONFIGURED IN THE FIELD TO ADD DOORS OR REMOVE AS NEEDED WITH THE USE OF HAND TOOLS ONLY.

- a. Wall units to be in four different heights: 609.6mm, 762mm, 914.4mm, and 1219.2mm. Single widths to be in either 457.2mm, 533.4mm, and 2609.6mm; double widths to be either 736.6mm, 889mm, 1041.4mm and 1193.8mm. All units to have standard depth on either 330.2mm or 406.4mm. the dimensions to be determined from drawings

- b. Tops to be 18-gauge cold rolled steel with overall size to be 330.2mm deep. Tops to have 19.05mm flanges on both sides and rear to have 34.925mm flange on front with a 25.4mm return.
- c. Sides to be 18-gauge cold rolled steel. Sides will be formed with a 19.05mm flange at rear, a 25.4mm flange on bottom and front, with 25.4mm flange and 55.56mm return to have provisions for hardware. Sides to have a 9.525mm coved bottom and 22.225mm spotting flanges. Back to be 2.381mm less than the overall width and height of the unit with 11.113mm flanges for spot-welding on all four sides. Back to be provided with slottage for adjustable shelf clips on 12.7mm centers. Outside bottom to be 25.4mm smaller than the depth of the unit and 38.1mm smaller than the width. Outside bottom to have 33.337mm flanges on both sides and 19.05mm pointed up in front, which will be gas-welded in place. Typical 18-gauge construction. Shelves, doors, and hardware provisions typical of base units
- d. Glass doors to be double-panel, reinforced frame construction as hinged doors. Glass to be 6.35mm thick, set and held in place in a resilient glazing channel. Sliding doors to operate on nylon rollers suspended from the extruded aluminum track at the top of the door, with a center guide at the bottom. Sliding doors to have recessed aluminum door pulls and glass stop on inside. Rubber channels used to cushion glass in glazed doors to be a neoprene rubber extrusion.

VII. FREESTANDING UNITS TO BE EITHER 457.2mm, 533.4mm, 609.6mm, 736.6mm, 889mm, 1041.4mm, & 1193.8mm WIDTHS AND 457.2mm OR 609.6mm DEPTHS. ALL UNITS TO BE CAPABLE OF BEING FIELD RECONFIGURED TO ADD OR DELETE DOORS WITH USE OF HAND TOOLS ONLY.

- a. Freestanding units to be 2139.95mm high overall, including flush base. Single widths to be in 457.2mm or 609.6mm; double widths to be either 736.6mm, 889mm, 1041.4mm and 1193.8mm. Depths to be either 457.2mm and 609.6mm. All specifications to be typical of wall units except the following:
 - Sides to be 18-gauge, formed only front to back (no formation on top of bottom). Depth is typical of overall unit with 25.4mm front flange and 55.56mm return.
 - Back to be 18-gauge and has formation only on sides, which are 12.7mm flanges for spot-welding.
 - Two side angles of 14-gauge cold rolled steel 17.46mm x 17.46mm x 22.22 mm smaller than depth of unit are required; one is spot-welded to the inside bottom of each side
 - 14-gauge angle 25.4mm x 8.73mm x 6.35mm less than width of unit to be spot-welded onto bottom of back for rigidity.
 - 14-gauge angle 22.225mm x 22.225mm x 6.35mm less than width of units to be spot welded onto top of back for rigidity

VIII. SPECIALITY CABINETS- ACID STORAGE AND NARCOTICS STORAGE

a. Acid Cabinet

To be supplied in dimensions as specified, constructed in similar manner as base unit or wall unit but with inside lined with approved wesliner material for maximum corrosion resistance in case of spills or accidents. Each hinged doors to be top and bottom vented to prevent buildup of noxious fumes. The wesliner lining to be monolithic, natural white non asbestos fiber/cement panel with a smooth surface on both sides. It should be of strong and rugged material, designed to offer maximum resistant to heat, chemical, impact and moisture. The unit should include a phenolic resin height adjustable shelf. It should have adscription Lebel marked in red on silver.

IX. Narcotic storage cabinets

To be supplied in dimensions as specified, generally constructed in similar manner as base unit or wall unit as case may be but in vermin free double wall construction manner featuring two adjustable shelves, dual locking double door assembly, with lighted alarm for maximum security of floor stock narcotic medications. The dual locking double door assembly to consist of an 18gauge double pan welded door and a full height 3mm plate inside door suspended on a piano hinge welded to the cabinet to eliminate removal of hinge pins. Both doors to have interchangeable removable core locks complemented with electronic security. It is to have a warning light with audible alarm. The light and alarm are to automatically activate if inside door is not locked.

X. ALL UNITS MUST BE IN STANDARD COLORS FOR EASE OF REPLACEMENT TO AT NO EXTRA COST. TONING OF CABINET SHELL AND COMPONENTS TO BE AT NO EXTRA COST.

a. Phosphatizing Process

- The welded, assembled cabinets shall have all exposed spot- or otherwise- welded surfaces ground to a smooth surface suitable for finishing. The units shall be given a pre-paint treatment to ensure excellent paint adhesion and to aid in the prevention of corrosion.
- Complete cleaning of the metal shall be accomplished by the use of an alkaline cleaner to remove oil, grease and soil. The units shall be rinsed, followed by the application of a phosphate coating to transform the metal surface into a new, non-metallic and conductive surface. The phosphate treated parts shall be rinsed in cold water.
- The units shall have all unreacted chemical removed in a chromic acid seal treatment. The completely treated units shall be placed in dry-off oven at high temperature for five (5) minutes to dry the work and stabilize the complete phosphate treatment.

b. Painting Process

Following the phosphate treatment, a full powder coating of specially formulated acrylic finish shall be applied and baked on at high temperature for fifteen (15) minutes, then cooled to produce optimum coating properties. (Film thickness of finish coat to be 32 to 45 microns).

c. Colors

Color to be selected by the client from a Standard color range.

d. Chemical Performance Test

- Chemical performance tests shall be made by applying ten (10) drops (approximately ½ cc) of each reagent to the surface to be tested. The reagent to be covered by a watch to be tested. The reagent to be covered by a watch glass, concave side down, in the center of the puddle to hold the reagent in place. tests for volatile solvents shall be done in such a way that a wet surface shall be maintained for the duration of the test period. A 25.4mm ball of cotton, saturated with solvent, shall be placed on the rest surface. This shall be covered with a small jar to retard evaporation of the solvent. Reagents to remain on the surface for one (1) hour.
- At the end of the test, reagents to be removed and the surface to be washed down with soap and water and dried before examination and evaluation.

e. Performance Test Ratings

- Where the terms "excellent" and "good" are used in the performance test results, the following definitions shall apply:
 - i. Excellent - The test leaves no visible effect on finish other than a slight change of gloss visible only from a grazing angle
 - ii. Good - The test leaves no effect other than slight discoloration, change of gloss or temporary slight softening of film with no loss of film protection.
 - iii. The test results are to be Excellent.
- Results of chemical spot performance tests after one (1) hour:
 - i. Concentration of reagents is percent by weight. All chemicals shall be "reagent grade", in accordance with the requirements of the American Chemical Society.
 - ii. Acids.
37% Hydrochloric; 75% Phosphoric; 25% Sulfuric; 25% Nitric; Glacial Acetic; 88% Formic
 - iii. Bases and salts.
10% Sodium Hydroxide; 25% Sodium Hydroxide; 23% Ammonium Hydroxide; 5% Hydrogen Peroxide,
 - iv. Solvents.

Ethyl Alcohol; Ethyl Acetate; Ethyl Ether; Xylene; Acetone; Methyl Ethyl Ketone; 37% Formaldehyde; Carbon Tetrachloride

- Moisture Resistance Test
 - i. Boiling water shall be trickled over the test panel surface inclined at 45-degree angle for five minutes. At the end of the test, the surface shall be dried and, upon examination, shall show no visible effect on the finish.
 - ii. A cellulose sponge (50.8mm x 76.2mm x 25.4mm) shall be soaked with water and placed on the test surface for a period of 100 hours. (The sponge must be maintained in a wet condition throughout the test period). At the end of the test, the surface shall be dried and upon examination, shall show no visible effect on the finish.
- Bending Test

An 18-gauge metal strip, finished as required, when bent 180 degrees over a 19.05mm diameter mandrel, shall show no peeling of the finish or expose of the base metal.
- Adhesion Test
 - i. Performance Requirement; Ninety (90) or more squares of the test sample shall remain coated after the scratch adhesion test.
 - ii. Test Procedure; Two (2) sets of eleven (11) parallel lines, 1.5875mm apart shall be cut with a razor blade to intersect at right angles, thus forming a grid of 100 squares. The cuts shall be made just deep enough to go through the coating, but not into the substrate. They shall then be brushed lightly with a soft brush and examined under 100-foot candles of illumination.
 - iii. Test Evaluation; Ninety (90) of the squares shall show finish

f. Hardness Test

- Performance Requirement;

The test sample shall have a hardness of 3-H using the pencil hardness test.
- Test Procedure;

Pencils, regardless of their brand, are valued in this way: 8-H is the hardest, and next, in order of diminishing hardness, are 7-H, 6-H, 5-H, 4-H, 3-H, 2-H, H, F, HB, B (soft), 2B, 3-B, 4-B, 5-B (which is the softest). The pencils shall be sharpened on emery paper to a wide sharp edge. Pencils of increasing hardness shall be pushed across the paint film in a chisel-like manner until one is found that will cut or scratch the film. The pencil used before that one, that is, the hardest pencil that will not rupture the film, is then used to express or designate the hardness.
- Test Evaluation;

The paint film shall have a hardness of 3-H minimum.

XI. HARDWARE

- a. Base unit drawer and door pulls to be of clean modern brushed aluminum design pull handle w/radiused edges offering a comfortable hand grip and attached to door or drawer with machine screws. Cast pulls shall have adequate cross section to ensure against breakage under rough usage and a chrome finish. Flush pull handles to be available at no extra charge.
- b. Base unit hinges to be of stainless steel & shall be institutional type with a five-knuckle, bullet-type barrel. Hinges shall be attached to both door and case with three (3) heavy steel screws through each leaf. Welding to doors or case shall not be acceptable. Doors under 914.4mm in height to be hung on two (2) 63.5mm hinges; doors over 914.4mm in height to be hung on three (3) 63.5mm hinges.
- c. Base unit door catches to be nylon roller catch type. Use of an active knob and up-and-down bolt assembly will be acceptable only on such special units as solvent storage cabinets or metal floor cases; doors on such units to be locking type.
- d. Base unit and wall case shelf clips for adjustable shelves to be nickel-plated steel. A channel shall be provided to support the half-depth shelves.
- e. Sink supports to be of the hanger type, suspended from the top side horizontal 38.1mm Unistrut rails of the cabinets by four (4) 6.35mm rods, threaded at the bottom and offset 6.35mm at top to hang from full-length support angles at side rails.
- f. Mobile unit castors to be Self-lubricating precision swivel casters of minimum loading capacity 90Kg, with locking brakes. They are to be 75mm diameter of 110mm loading height. They are to be of High temperature phenolic, nylon, or synthetic rubber designed to be autoclaved. Housing to be Type 304 stainless steel.

XII. TRIM

- a. Leg shoes to be provided on table legs to conceal shims or leveling devices. Shoes shall be coved at bottom, shall be 63.5mm high and shall be black chemical rubber. Use of a leg shoe that does not conceal leveling device will not be acceptable.
- b. Base molding to be black vinyl, sufficiently pliable to permit cementing tightly against cabinet base and floor line to provide a watertight seal. Molding to be coved at bottom, shall be 101.6mm high and to be applied continuously around base of cabinets and cases after installation and leveling to cover any shims and to effect floor seal. Waterproof cement shall be used as an adhesive.

XIII. MECHANICAL SERVICE FIXTURES

Valve bodies to be cast of commercial red brass alloy which conforms to A.S.T.M. standard C85700 or C84400. Flanges, turrets and handles to be of forged brass alloy which conforms to A.S.T.M. standard B124-74-280. Assembly components to be of red brass alloy or stainless-steel alloy. Seals and seat discs to be of materials which are suitable for potable water. All fixtures shall be furnished with a chromium-plated finish, highly polished on all exposed surfaces and chrome plated to specifications which conform to A.S.T.M. standard B456-5 and exceed ANSI A112.18.1.

Corrosion-resistant finishes may only be furnished when specified.

a. Laboratory Water Fixtures

- All water faucets to have an operating cartridge that contains all working parts that are subject to wear, and shall close with the pressure of the water to ease shut off and to provide a tight seal. All moving parts which are in the waterway shall be of stainless steel or Monel with the exception of seal, which shall be of Ethylene propylene diene monomer. The handle broach shall be a four-point tapered broach to allow ease of handle removal. All repair parts shall interchange regardless of fitting type. Faucet shall be capable of converting to manual or self-closing without requiring removal of the body or any special tools. All faucets shall withstand a test of 690,000 Pascals.
- All gooseneck spouts must be attached to faucet body by means of a union connection to allow changing of spouts after installation. Spouts which are threaded directly into faucet body will not be permitted. All gooseneck spouts must be easily converted from rigid to swing or swing to rigid after installation, with no special adapters required. Sealing to be achieved by double O-ring or E.P.D.M. seal. Vacuum breaker spouts to be of atmospheric type which conforms to A.S.S.E. standard 1001. Gooseneck spouts to have a ten-serration hose connector unless otherwise specified.
- All faucets and needle-type valves shall have fore-arm, forged brass handles with plastic screw-type indicator discs signifying -- by color and letters -- the service controlled and shall have threads integral with discs. The disc shall not be held in place with a separate metal retainer. Fixtures having quick-acting valves shall have lever handles with service indicated by a button in the handle.
- Steam cocks to have black molded plastic composition handles and to be constructed so they can be easily repacked under pressure and easily converted to needle-type cocks by changing valve steam and seat. Steam cocks shall be indexed accordingly.

- Distilled water fixtures to be of red brass alloy with a polished chrome-plated finish over nickel and copper with tin-lined interior, or PVC type as specified. All distilled water fixtures to be self-closing type.
- Vacuum Breakers to be chrome-plated brass and shall be either Water-Saver type, as required by the plumbing code. Vacuum breakers shall be installed between the control valve and the outlet of the fixture. When the plumbing code requires vacuum breakers to be installed in an elevated position, the piping necessary to connect valve, vacuum breaker and hose end to be supplied by the plumbing contractor.

b. Gas, Air, and Vacuum Cocks

- All ground key service cocks to have stem and body ground and lapped and shall have stem held in place by spring and locknut that has been staked to prevent removal. Each fixture shall be leak proof at 276,000 Pascals when tested under water.
- All floating needle point valves shall have working parts contained within a removable cartridge. Needle point shall be stainless steel precision finished and shall be held in
- place on stem assembly with a U-clip which is of stainless steel. Needle point shall seat against a brass seat contained within a replaceable sleeve. Micro control type valves shall have same features as needle point and shall have a tapered needle point and shall have a length no less than 19.05mm and shall seat into an orifice no less than 3.175mm diameter. Valve shall have a minimum of 5 and half full turns of the handle from off position to full on position. Each fixture shall be leak-proof at 862,000 Pascals maximum when tested under water.

c. Remote Control Valves

- Remote control valves shall consist of 9.525mm compression disc valves for water and steam fixtures and 9.525mm slow compression true needle valve for gas, air and vacuum fixtures, complete with extension rods having handles with colored button indexes for each service as specified for each fixture.
- Extension rods shall operate valves through an escutcheon-plate bearing mounted on the exterior of the scientific laboratory furniture equipment. Portions of remote-control fixtures exposed within fume hood chamber shall be furnished with a chemical-resistant finish.

d. Mounting Shanks

Mounting shanks shall be furnished with required to anchor fittings to service shelves, ledges and decks for all fixtures except electrical. They shall provide a running pipe thread running into a tapered thread to provide leak-proof joints and a locknut to provide a means of anchoring fixture to the ledge.

e. Serrated Hose Ends

Serrated hose ends shall be provided on all water and steam fixtures. Serrations shall be so designed to hold hoses securely. An aerator, when so specified, shall be furnished in place of the serrated hose ends for water fixtures.

f. Color Index Buttons

Handles of fixtures shall have a screw-on type, color-coded index disc to designate type of service on all mechanical service fixtures. Both color and lettering shall be provided in button (screw-on type) which shall be located in handles of fixtures. Buttons shall not be held in place with a metal retainer. All indexes shall be of colored plastic material, and indented letters shall be filled with enamel in contrasting colors. Color designations shall be as follows:

SERVICE	INDEXING	BUTTON COLORS	LETTER COLORS
Cold Water	CW	Dark green	White
Hot Water	HW	Red	White
Gas	GAS	Dark Blue	White
Air	AIR	Orange	Black
Vacuum	VAC	Yellow	Black
Distilled Water	DW	White	Black
Steam	STM	Black	White
Oxygen	OXY	Light Green	White
Nitrogen	N	Grey	Black
Hydrogen	H	Pink	Black

XIV. ELECTRICAL FIXTURES

- a. Deck mounted electrical fixtures shall be 20-Amp, 110-volt, 3-wire polarized grounded receptacles. Reagent rack mounted and flush mounted receptacles shall be 15-Amp, 125-volt.
- b. The electrical pedestal-type fixtures and electrical flush boxes are to be corrosion-resistant aluminum alloy, polished to a chrome-like finish.
- c. All receptacles shall be designated to permit only plugs having the same current characteristics as the service line to be inserted.
- d. All fixtures and any electrical conduit or fittings to be furnished under these specifications shall be accordance with requirements of the National Electrical Code and the National Fire Prevention Association.

XV. STEEL CASEWORK CONSTRUCTION PERFORMANCE

- a. Base cabinets shall be constructed to support at least a uniformly distributed load 980Kgs. Per square M^2 of cabinet top area, including working surface without objectionable distortion or interference with door and drawer operation.
- b. Base cabinet corner gussets with leveling bolts shall support 230Kgs. Per corner, at 38mm projection of the leveling bolt below the gusset.
- c. Each adjustable and fixed shelf 1220mm shorter in length shall support an evenly distributed load of at least 196 Kgs/ M^2 with nominal temporary deflection, but without permanent set.
- d. Drawer construction and performance shall allow 381mm clear when in an extended position and suspension system shall prevent friction contact with any other drawer or door during opening or closing. All drawers shall operate smoothly, a minimum of 10,000 cycles with an evenly distributed load of 70Kgs.
- e. Swinging doors on floor mounted casework shall support 91Kgs. suspended at a point 305mm from hinged side, with door swung through an arc of 160 degrees. Weight load test shall allow only a temporary deflection, without permanent distortion or twist. Door shall operate freely after test and assume a flat plane in a closed position.

XVI. COUNTERTOPS

a. Epoxy resin countertop tops.

They shall be cast of modified thermosetting epoxy resin, 19.05mm, 25.4mm or 31.75mm thick. Tops shall be a uniform mixture throughout and not depend on a surface coating which is easily removed by physical or chemical abuse. Marine edge to be provided when specified. Backsplash and end splash to be loose 101.6mm high x 25.4mm thick and coved to top during installation. Epoxy tops to be in standard Black Onyx with the option of Platinum Gray at additional charge.

Epoxy resin tops to be blended to provide maximum chemical resistance and physical strength. Finished material to conform to the following physical properties testing:

Compressive strength	(ASTM D-695)	236 Mega Pascals (34,200 PSI)
Tensile Strength (avg)	(ASTM D-638)	69.64 Mega Pascals (10,100 PSI)
Flexural Strength	(ASTM D-790)	112 Mega Pascals (16,200 PSI)
Rockwell "M" Hardness	(ASTM D-785)	111
Density	ASTM D-792)	2.03g./cc
Water Absorption	(ASTM D-570	0.004%
Fire Resistance	(ASTM D-635)	ATB (sec)=0 Samples did not ignite

b. Stainless-steel countertops.

They shall be Type 304 No. 4 satin finish. Tops shall be of 18-gauge stainless steel reinforced on the underside by 16-gauge carbon steel channels, so spaced as to prevent twisting, oil canning or buckling. Exposed edges of top shall be formed into a channel shape 31.75mm high. Tops may be fabricated with a marine edge when specified. Backsplashes and curbs shall be integral and formed from the same sheet as the top. Sink tops shall be pitched to sink bowl for proper drainage. All sink basins shall have bottoms sloped towards drain openings. Entire underside of tops shall be sprayed with sound-deadening material.

c. Laminated plastic tops

They shall be of 0.8mm thick laboratory grade high pressure laminate which shall not crack or splinter and shall be heat resistant. The laminated plastic shall be attached with a water-resistant adhesive to a moisture-resistant particle board core or optional treated plywood, providing a finished overall top thickness of 32mm. Tops shall have a self-edged front edge. Tops with curbs shall have attached 101.6mm high x 19.05mm thick curb with a 90-degree angle at the junction between top and curb. Underside of top is to be sealed with a protective coating.

d. Countertops Characteristics - Tolerances:

- Size:
Length, plus or minus 4.23mm; width and thickness, plus or minus 0.79mm.
- Squareness:
Plus, or minus 0.397mm for each 304.8mm. (A tabletop spanning 1219.2mm will be held to plus or minus 1.587mm).
- Fabrication:
Location of cutouts and drillings -- plus or minus 1.587mm sizes of cutouts and drillings - plus 1.587mm minus 0.
- Flatness (Warpage):
Plus, or minus 1.587mm for each 1219.2mm span.

XVII. SERVICE SHELVES, LEDGES AND DECKS

- a. The ledges and shelves shall be easily altered on site to accommodate existing wall conditions and shall be easily drilled to accommodate service lines. Service ledges and shelves shall provide a raceway behind the base units to house the mechanical service piping. Ledges are available in any of the materials listed above.
- b. Service shelves shall be supported by angular brackets, capable of being mounted on strut supports or directly off wall providing for fine shelf adjustment.
- c. Service ledges shall be supported by a 90-degree wall angle at the rear, and the countertop backsplash at the front.
- d. Service shelf and service ledge fillers, where shown or called for to enclose open spaces at the end of wall and island assemblies, shall be finished in the same material as the service shelving. They shall be provided complete with means for attaching to the service shelving and shall cover the piping from the top of the service shelf to the base cabinets.

XVIII. SINKS, DRAIN TROUGHS AND CUP SINKS

- a. Epoxy resin sinks shall be completely cured during processing. Sinks shall be one-piece, no glazing, black in color (gray or beige optional) with generous covering in all corners and bottom, and a minimum of 1 degree dishing to outlet. Sinks shall possess high resistance to mechanical and thermal shock. Sinks shall be field-bonded to the underside of the countertop or top mounted into rabbeted cutout to become an integral part of the epoxy resin top.

- b. Stainless steel sinks shall utilize Type 304 stainless steel and all exposed surfaces shall be finished in a No. 4 satin finish. Sinks shall be of 18-gauge metal unless heavier gauges are specified or dictated by construction requirements. All sink joints shall be butt-welded by the Heli arc-welding process. Inside radii shall be 28.6mm. bottom shall be pitched to the sink outlet. Where stainless steel countertops occur, sinks shall be welded to form an integral part of the top. No soldering will be permitted in connection with the construction of sink bowls.
- c. Drain troughs shall be constructed of epoxy resin. The troughs shall be cast units with no longitudinal joints, with a generous radius provided in the bottom corners for easy cleaning. A slope of 10.4mm per meter or more per foot shall assure complete drainage.
- d. Cup sinks shall be epoxy resin, stainless steel, or Kimax* brand glass as specified.

XIX. SINK ACCESSORIES

- a. Traps and drain fittings shall be polypropylene or Kimax* brand tempered glass. They shall be included as part of the sink assembly only when material is specifically called for and shall be 38.1mm or 50.8mm in diameter as indicated.
- b. Traps shall be a standard "P" type and shall have a beaded end for connection to the main drain line by use of a coupling or be provided with standard IPS thread.
- c. Kimax* brand or polypropylene traps shall be furnished for all sink assemblies when specified.
- d. Sink strainer and tailpieces shall be furnished as a standard part of each sink assembly. Sink strainer shall be crisscross-type with 38.1mm diameter outlet.
- e. Standing beehive or open-end type overflows shall be provided when specified.

XX. CANOPY HOODS

- a. The canopy hood efficiently collects exhaust heat, steam and odors when mounted over work areas where steam baths, hot plates, and other heat-producing equipment is employed.
- b. The superstructure to be finished with a chemical resistant painted sheet steel. The standard canopy hood to be 762mm deep and 457.2mm high with duct collar of 203.2, 254mm, 304.8mm, 406.4mm or 508mm diameter. Threaded hanging rods to be provided with couplers for additional ceiling height when specified. Stainless steel construction, duct transitions and baffles to be provided where specified.

XXI. FABRICATION

- a. All metal furniture required under the drawings and specifications shall be furnished in strict accordance with the description and details provided. Construction and design shall enable maximum strength and rigidity in each sectional unit.
- b. Each sectional unit shall be fabricated as an integral unit in itself to permit relocation at any subsequent time.
- c. The door- and drawer-heads to be removable for purpose of decontamination and/or cleaning.
- d. Doors and drawers to be sound deadened and readily removable, with easily replaceable door hinges
- e. All hinges to be fixed to case and door bodies as here in specified. Welding of hinges to either door or case will not be permissible.
- f. Where unit are joined together in assemblies, they shall be fastened by bolting through side panels with 6.35mm-20 bolts.
- g. All components' parts shall be die-formed, ensuring uniformity and interchange-ability, and shall be assembled in jigs of accurate alignment.
- h. All cabinet parts shall not only be electrically welded, but shall be notched, keyed and overlapped, forming interlocking joint construction. The electro-welding shall be comprised of spot-welding, arc-welding and Heli arc welding.
- i. Any notching, piercing, bending or framing not specifically called for in the construction specifications and/or drawings will not be permitted.
- j. All construction shall ensure a smooth, cleanable interior of all units.
- k. All die-pierced slots and perforations required for mounting of case channels, hinges, or shelf brackets shall not be visible from the exterior of the assembled cabinet after installation. Screws shall not be used in the construction of the unit proper and shall only be used where backs, pans and panels are required to be removed for accessibility.
- l. Standard cabinet units shall be so constructed that they will permit quick and easy change, after installation, from drawers to doors, or vice versa, or the substitution for two (2) half depth drawers in place of a standard-depth drawer with the purchase of the necessary parts.

- m. All sectional units located on the laboratory floor shall be equipped with leveling devices easily adjustable from within the units, to compensate for unevenness in the laboratory floor.

XXII. SUBMITTALS

a. Shop drawings:

The contractor shall submit shop drawings indicating but not limited to;

- Details of laboratory casework construction with related accessories with dimensions
- Location of each casework unit.
- Location for roughing-in of plumbing, including sinks, faucets, strainers and cocks and electrical services.

b. Duplicate samples of:

- Each countertop material, 300 x 300 mm including external corner.
- Each standard colour of cabinet finish on 300 x 300 mm steel sheet.
- Each item of cabinet hardware. Approved samples to be used for maintenance material.

XXIII. TESTING AND COMMISSIONING

- a. The contractor shall instruct the user how to operation, adjust, clean the casework and general maintenance of the casework.
- b. The contractor shall conduct the testing of the different materials and units to certify that they conform to the specifications and provide certificates. Tests shall be witnessed by a User's representative.

1.10 PAVING

1.10.1 Cement

All cement shall be as described in clause 4.2 "Cement".

1.10.2 Sand

Sand for paving shall be clean well graded sand in accordance with BS 1199: 1976 and BS 1200: 1976 washed if required.

1.10.3 Granolithic Coarse Aggregate

Coarse aggregate for granolithic paving shall be clean properly graded quartzite chippings finely crushed to pass a 6 mm mesh and down but free from dust and organic matter.

1.10.4 Water

Water shall be as previously described.

1.10.5 Granolithic paving

The mix for granolithic paving concrete shall consist of one part cement, one and a quarter parts sand and two and a half parts coarse aggregate as described by volume (1 : 1¼ : 2½).

If the coarse aggregate grading approaches the upper limit of 20% passing a 4.5 mm sieve the proportion of sand should be reduced accordingly.

The provisions of "Concrete" regarding batching and mixing shall apply to granolithic concrete and in all cases the water content shall be kept as low as possible consistent with obtaining full compaction.

The paving may be laid:

- i. monolithic with the concrete base under i.e. within 3 hours of the base being laid, or
- ii. as separate construction i.e. after the concrete base under has been allowed to dry and attain its full strength.

The special conditions applying to laying, thickness and size of bays for each method are fully described hereafter.

All paving shall be thoroughly compacted without segregation or excessive laitance.

After placing, leveling and compaction the topping shall be trowelled at least three times at intervals during the next 6-10 hours so as to produce a uniform, dense and hard surface with as much coarse aggregate just below the surface as possible. During the second subsequent trowellings any laitance shall be removed. The final trowelling should be at such a time that considerable pressure is required to make an impression on the surface. Under no circumstances should cement be sprinkled on the surface and trowelled in to absorb surplus water.

As soon as the surface has been finished it shall be shaded from the sun and breeze to prevent rapid drying. Immediately the surface has hardened sufficiently it shall be covered for at least seven days with damp sand or hessian, building paper, plastic etc., and shall be kept completely and continually damp. After the curing period it shall be allowed to dry out slowly.

1.10.6 Granolithic Paving (Separate Construction)

The area of bays shall be determined by the layout, the structure and the method of construction to be adopted. The position of construction joints, movement joints and day work joints in the base shall be carefully planned in relation to the layout as such joints will necessitate corresponding joints in the paving. The paving to be laid in areas not exceeding 15 sq. metres or in panels the length of which shall not exceed 1½ times their width. Plastic or ebonite strip as described shall be used to define the joints in the paving and over all bans and load bearing walls.

The base shall be thoroughly hacked shortly before the paving is to be laid to provide a good bond. All laitance shall be removed to expose the coarse aggregate and all dust and dirt cleaned out. The base shall be thoroughly wetted but all excess water removed before grouting. If the paving is to be laid less than 24 hours after the base, preparation may be done by wire brushing.

Before paving is placed a thin layer of grout consisting of cement and water mixed to the consistency of thick cream shall be brushed into the surface of the base. The grout shall be followed immediately by the paving as previously described.

The paving, when fully compacted, shall be not less than 36 mm + 6 mm and service pipes or conduit shall not be laid in it.

1.10.7 Granolithic Paving (Monolithic)

Where the thickness of base and paving is 150 mm or greater the area of individual slabs shall not exceed 30 sq. metres.

When the thickness of base and paving is between 100 mm and 150 mm the area of slabs shall not exceed 15 sq. metres.

The area and shape of slabs will depend on the layout of the building but shapes approaching square are to be preferred and in no case shall the longer dimension exceed 8 metres. Plastic or ebonite strip as described shall be used to define the joints in the paving and over all beams and load bearing walls.

The paving when fully compacted shall be average 19 mm thick with a minimum thickness of 12 mm.

1.10.8 Chemical Surface treatment etc

Integral hardeners or surface treatments where specified shall be used strictly in accordance with the manufacturer's instructions.

1.10.9 Screeds

Screeds for in-situ terrazzo and other tile pavings shall consist of cement and sand (1:3) and are to be laid in a similar manner as described for granolithic paving (monolithic or separate) to the specified thickness and finished with wood float or steel trowel to suit the type of finish as specified in the Particular Specification or Bills of Quantities.

1.10.10 Terrazzo Paving

The materials used and method of laying is to be in accordance with BS 8204.

The terrazzo paving is to be of an approved colour as selected by the Project Manager and composed of two parts of white or coloured marble chips to one part tinted white cement laid rolled and trowelled to a dense even surface and rubbed down at completion to a grit finished surface free from holes and blemishes.

Terrazzo paving shall not be less than 15 mm finished thickness and laid in panels 1000 x 1000 mm maximum or to patterns as indicated on the drawings and divided by ebonite or coloured plastic strips securely anchored into the screed and having their top edges finished flush with the surrounding paving.

The paving is to be laid on a cement and sand screed as described of the thickness indicated (but not less than 19 mm) and is to be finally ground and polished to the approval of the Project Manager. The concrete sub-floor shall be thoroughly cleaned and free from dust, grease and other foreign materials and coated with cement slurry before the laying of screeds and paving.

1.10.11 Concrete and Quarry Tile Paving

Concrete floor tiles and fittings shall comply in all respects with BS 1197-2: 1973 and samples shall be submitted to the Project Manager for testing and approval.

Quarry floors tiles and fittings shall comply in all respects with BS 6431 and samples shall be submitted to the Project Manager for testing and approval.

All tiles shall be well soaked in water before use.

Tiles shall be laid to the patterns indicated on the drawings with either close butt joints or wide joints as required.

All tiles shall be laid on a prepared cement and sand screed and bedded and jointed in cement mortar (1:3) as before described and pointed as indicated on the drawings.

1.10.12 Cork Tile Paving

Cork tile paving shall be carried out by an approved specialist firm and shall consist of medium density cork tiles each size 305 x 305 x 6 mm thick with tongued and grooved edges laid with close butt continuous joints in both directions and bedded in an approved adhesive.

Cork tiles shall be of a natural colour approved by the Project Manager.

The tiles shall be laid on a clean dry cement and sand (1:3) screed as before described and after laying shall be surfaced and sealed with three coats of approved polyurethane lacquer buffed down between coats.

1.10.13 Flexible P.V.C Floor Tiling

Flexible P.V.C. floor tiling shall be carried out by an approved specialist firm and shall consist of tiles in accordance with B.S. 3261:1973 of approved manufacture and colour to the sizes and thickness as indicated in the Drawings, Particular Specification or Bills of Quantities. The tiles shall be laid to the patterns as indicated (if any) on the drawings with close butt joints and bedded in approved

mastic on a clean, dry cement and sand (1:3) screed as before described with a stool trowelled finish.

On completion, any surplus mastic which may have squeezed out of the joints shall be removed, the tiles cleaned with an approved cleaner and two coats of approved P.V.C. tile sealer applied.

1.10.14 Dividing Strips

Dividing strips shall be black ebonite or plastic of approved colour to the sizes and positions as indicated on the drawings, Particular Specification or Bills of Quantities. The strips shall extend to the full depth of the pavings in which they are inserted and in the case of terrazzo work shall be let into the screed under for a depth of not less than 6 mm.

1.10.15 Cover up and Protection of Paving

Cover up and protect all pavings and finishes as required to assist slow and even drying and to prevent damage by traffic. Remove all such coverings and leave the work clean and perfect at completion.

1.10.16 Epoxy –Resin Floor Topping

This shall be Resiguard ES and Techni floor SL 20 applied to concrete floors and worktops to provide a seamless, self-leveling surface between 5-25 thick where high chemical and mechanical resistance is required.

The surface must be clean, sound, dry and properly cured. Remove all loose material mechanically, with a wire brush, or by water or sand blasting. Mix to manufacturer's specifications, apply primer to the prepared substrate using a brush, roller or airless spray. Porous floor may require a second coat.

Resiguard ES and Techni Floor SL 20 shall be mixed to manufacturer's specifications and the mortar poured onto the floor or worktop spread using a notched trowel. Immediately use a spiked roller to remove air and ensure an even layer.

Existing expansion joints must be maintained and continued through the floor surface and sealed with sikaflex or similar approved polyurethane joint sealant.

1.11 WALL AND CEILING FINISHES

1.11.1 Cement

All cement shall be as previously described in concrete works.

1.11.2 Lime

The lime for plastering shall comply with BS EN 459-1:2001 or US 61:1999 and US 155:1995 for non-hydraulic lime and be as rich as obtainable and to the approval of the Project Manager. It must be freshly burned and shall be slaked at least one month before being used by drenching with water, well broken up and mixed and the wet mixture shall be passed through a sieve of 10 meshes to 100 square mm. Lime putty shall consist of freshly slaked lime as above described, saturated with water until semi-fluid and passed through a fine sieve, it shall then be allowed to stand until superfluous water has evaporated and it has become of the consistency of thick paste, in no case for a shorter period than one month before using, during which time it must be kept damp and clean and no portion of it allowed to become dry.

Alternatively, approved hydrated lime with average 70% Calcium Oxide CaO content may be used soaked to a putty at least 24 hours before use.

1.11.3 Sand

The sand for plaster work shall be in accordance with BS 1199: 1976 and BS 1200: 1976. It shall be clean and well graded to a suitable fineness in accordance with the nature of the plaster and the finish to be obtained.

1.11.4 Plastering Generally

Where walls are to be rendered or plastered, the joints are to be raked out 12 mm deep and brushed clean to afford a key and joints and walls are to be sprayed with clean water before rendering or plastering. Concrete surfaces shall be hacked to form key in addition.

All surfaces to be plastered must be scored for a key and brushed clean and well wetted before each coat is applied.

All materials shall be properly mixed either by hand or by machine.

Hand mixing shall be carried out on a clean properly prepared platform which shall be thoroughly scraped and cleaned between batches.

Machine mixers shall be thoroughly cleaned out between each batch.

No batch of mixture shall be used after the initial set of the cement has

taken place and no material shall be allowed to stand and be subsequently "knocked" up for reuse.

All cement plaster shall be kept continually damp in the interval between application of coats and for seven days after application of the final coat.

All arrises and angles shall be clean and sharp except where the Drawings indicate otherwise.

The Contractor shall include for filling plaster into chases and working around pipes, conduits, switch boxes and outlets, into rebates, up to metal window frames etc. and the like and for all making good.

1.11.5 Internal Plastering

The internal plastering is to be applied in three coats and to be 16mm minimum thickness as follows:-

1st Coat – Cement and sand (1: 5 by volume), allowed to dry out thoroughly and well scratched to afford a key for the second coat.

2nd Coat – Cement and sand (1: 5 by volume), 6mm thick, finished true and level with a wood float.

3rd Coat – Cement Slurry or if lime is to be used, It shall be neat lime, plus 10% cement, not less than 2mm thick, applied as soon as the second coat can stand trowelling and finished smooth with a steel trowel.

Plastering on expanded metal lathing is to have a preliminary or pricking-up coat in addition.

The setting coat of plaster shall not be applied until all conduits, pipes and the like have been fixed and until all air bricks etc., have been fixed and all chases and catting in the walls have been performed and made good.

1.11.6 External Rendering

External rendering is to consist of one part cement and five parts sand by volume (1: 5).

One coat work is to have a minimum finished thickness of 12 mm and two coats work 19 mm.

Unless otherwise described rendering is to be floated smooth with a wood float.

1.11.7 Tyrolean Finish Rendering

Tyrolean finish rendering shall consist of a base coat of one part cement and five parts sand (1:5) by volume and a finishing coat of one part cement to four parts (1:4) of fine stone chippings 9mm and down applied to the base coat by means of an approved machine to a total finished thickness of not less than 20 mm.

The base coat shall be floated to a smooth even surface and liberally scratched to form a key.

1.11.8 Expanded Metal Lathing

Expanded metal lathing for plastering shall be in accordance with BS 1369: 1987 and unless otherwise described in the Particular Specification or Bills of Quantities shall have a stoved black asphalt paint finish.

The lathing shall be 9 mm mesh x 24 S.W.G (0.559mm). Lathing shall be not less than 25 mm at the sides and end laps which shall be wired together at not more than 75 mm centres with stout iron tying wire. The cut ends of all tying wires shall be bent back through the lathing.

Lathing shall be fixed with the long way of the mesh across the supports and shall be fixed to same with stout galvanized staples at not more than 300 mm centres.

1.11.9 Wall Tiling

Wall tiles shall comply with BS 6431 Glazed Ceramic tiles and Tile Fittings for Internal Walls.

All tiles shall be of the size, colour and quality as described in the Particular Specification of Bills of Quantities and shall be perfectly true to shape and free of all blemishes and flaws.

Samples shall be submitted to the Project Manager for approval.

All wall tiling shall be fixed on a perfectly plane vertical screed of cement and sand (1: 3).

Tiling shall be bedded on the prepared screed in a slurry of cement and sand (1: 4) or in an approved tile adhesive. The surface of each tile shall finish flush with the adjacent tiles. Joints shall be continuous straight joints both horizontally and vertically not exceeding 3 mm wide and shall be flushed up with white cement. Spacers are to be used to ensure that the correct joint width is maintained.

All cutting shall be kept to a minimum and the tiling shall be set out so that only the largest possible pieces of cut tiles are used.

Purpose made tiles with round on one edge shall be fixed to all vertical external angles and to the top edge of dados and the wall face over.

1.11.10 Expanded Polystyrene Tiles

Expanded polystyrene tiles shall be in accordance with BS 2552: 1955 Flameproof Quality.

Tiles shall be to thickness and sizes as indicated in the Drawings, Particular Specification or bills of Quantities.

All tiles shall be chamfered on all edges, close butt jointed with continuous straight joints in both directions and either nailed to timber bearers with approved panel pins with the heads neatly punched in or glued on all edges either to timber bearers or to plaster or concrete soffits with an approved adhesive.

All tiling shall be properly set out so that all cut tiles to border on all sides of a room are of equal width.

1.11.11 Special Note:-

Under no circumstances are these tiles to be painted, decorated or subjected to any surface treatment of any kind so that great care must be exercised during handling and fixing to see that they are kept perfectly clean.

1.11.12 Insulation Board

Insulation board shall be in accordance with BS EN 120:1992 / 310:1993 / 317:1993 / 319:1993 / 320:1993 / 322:1993 / 323:1993 / 324:1993 / 325:1993 / 382:1993 / 022:1997

Sheets shall be set out to provide evenly balanced borders on all edges and shall be fixed to timber ceiling bearers spaced at 600 mm centers in both directions with stout galvanized gimp pins along each at 150 mm centers with their heads punched in and stopped. Joints between sheets shall be 3 mm wide.

Timber cornices shall be provided at the junction of all walls and ceilings as indicated on the drawings. Cornice members shall be plunged to the wall, not to the ceiling boards.

1.11.13 Flat Sheets

Sheets shall be butt jointed and secured to timber bearers at minimum 400 mm centers with 30 mm long stout galvanized flat headed nails not more than 300 mm apart.

All holes shall be drilled (not punched) not less than 12 mm from the edge of the sheet and all nails shall be driven home so that the head finishes flush with the sheet.

Sheets to ceiling shall be set out in the same manner as described for Insulation Board.

1.11.14 Make Good

The contractor shall cut out and make good all cracks, blisters and other defects and leave the whole of the plasterwork perfect on completion. When making good defects the plaster shall be cut out cleanly as directed, with the edges undercut to form a good key with the surrounding work, and the new material shall finish flush with the adjacent plaster.

Tiled and sheeted surfaces shall be left perfectly clean on completion.

1.12 GLASS WORKS

1.12.1 Glass

All glass shall comply with BS EN 12758 and shall be free from spots, bubbles, waves and all other defects. Samples of glass shall be submitted to the Project Manager for approval.

Unless otherwise described in the Particular Specification or Bills of Quantities, sheet glass shall be ordinary glazing quality and polished plate glass shall be glazing quality. The nominal thickness of glass is to be as described in the Contract Documents.

1.12.2 Putty

The putty used in glazing in wood frames is to be whiting ground with linseed oil. That used for metal frames to be composed of whiting, linseed oil and gold size in accordance with current BS 544: 1969.

1.12.3 Glazing

Panes are to be cut with 1.5 mm clearance all round.

Generally glaze all windows with glass carefully puttied and fully back puttied, where glazing is to wood the glass must be sprigged. Carefully trim off all superfluous putty.

Glazing clips are not necessary for small panes of metal windows but should be used for the no-glazing bar types. Where no glazing bars are used the weight of the glass should be thrown on the lower hinge corner by means of small wood edges placed between the glass and the metal frame.

Curtain walling shall be assembled with structural natural anodized aluminum framing.

Curtain walling glass shall be 12mm thick laminated tempered glass bonded together with a plastic layer of polyvinyl butyral .

1.12.4 Bedding Strips

All glazing to wood doors or where otherwise directed shall be bedded in wash leather or other approved plastic shock absorbing material. The bedding material shall be cut to fit exactly the rebate line of the frame and it shall be secured with wood or metal beads fixed with cups and screws.

1.12.5 Cleaning, etc on completion

Remove all broken, scratched or cracked panes and replace with new to the satisfaction of the Project Manager. Clean inside and out with an approved cleaner. On no account shall windows be cleaned by scraping with glass.

1.13 PAINTING

1.13.1 Workmanship

All paintings work shall be carried out by skilled tradesmen and finished in a manner in accordance with the best acceptable trade practice.

1.13.2 Sub-letting Work

The work shall not be sub-let to a specialist firm without the written approval of the Project Manager.

1.13.3 Materials

All materials shall be the best of their respective kinds and shall be in accordance with their respective current Uganda standard.

1.13.4 Paint

All paints, including cement paint, oil paints, emulsion paint and oil bound distemper shall be ready mixed and obtained, unless specifically instructed to the contrary, from approved local manufacturers, and they shall be delivered to the site in sealed cans and shall be thoroughly mixed and applied in accordance with the manufacturer's instructions.

1.13.5 Linseed Oil

The linseed oil to be refined linseed oil, boiled or raw.

1.13.6 Knotting

The knotting is to be in accordance with BS 1336: 1971.

1.13.7 Wax Polish

The wax polish shall be furniture polish of an approved brand.

1.13.8 Lacquer Treatment

Lacquer shall be an approved catalytic polyurethane lacquer and used strictly in accordance with the manufacturer's instructions.

1.13.9 Generally

The contractor shall arrange his programme of work so that all other trades are completed and away from the area to be painted is commenced the contractor must remove all concrete and mortar droppings and the like from all work to be decorated and remove all stains from and obtain uniform colour to work to be oiled and polished.

All materials to be applied externally shall be of exterior quality and/ or recommended by the manufacturers for external use.

Unless specially instructed by the directions and approved by the Project Manager, no paints, distemper etc., are to be used as supplied by the manufacturers and direct from the tins.

If required by the Project Manager the contractor is to provide samples of paints, etc., with containers which shall be forwarded to the Chief Materials Engineer, Central Materials Laboratory, Kampala for testing.

The priming, undercoats and finishing coats shall each be of different tints and the priming and undercoat shall be the correct brands and tints to suit the respective finishing coats, in accordance with the Manufacturer's instructions. All finishing coats shall be of colours and tints selected by the Project Manager.

Each coat shall be properly dry and in the case of oil or enamel paints shall be well rubbed down with fine glass paper before the next coat is applied. The paintwork shall be finished smooth and free from brush marks.

Colour cards of all paints, etc., shall be submitted to and samples prepared for approval of the Project Manager before laying on, and such samples, when approved, shall become the standard for the work.

All paints, emulsion paints, and distempers shall be applied by means of a brush or spray gun or rollers of an approved type, where so agreed by the Project Manager.

No painting is to be done in wet weather or on surfaces which are not thoroughly dry.

1.13.10 Preparation

All surfaces to be painted are to be entirely free from all dirt, grease and dust.

(i) Plaster

Areas of defective plaster are to be cut out and made good with similar plaster finished smooth.

Large cracks are to be cut out, under cut and filled with plaster finished smooth and flush. Small cracks and holes are to be filled with an approved hard filler.

Plastered surfaces to be painted with oil paint are to be treated with one coat of alkali resistant primer.

(ii) Metal

All rust and loose scale is to be removed by means of wire brushing or scraping.

All bare metal is to be primed with a primer conforming to BS 2523: 1966 and all bare patches of works priming are to be touched up and brought forward.

Coated surfaces, such as stack pipes are to be thoroughly brushed down and painted with one coat of knotting.

Galvanised surfaces to be washed down, after drying are to be coated with an approved solution approved by the Project Manager.

(iii) Woodwork

All woodwork shall be rubbed down, all knots covered with a thick coat of good shellac knotting, given one coat of approved ready-mixed proprietary wood primer and all cracks, nail holes, defects and uneven surfaces etc., stopped and faced up with hard stopping rubbed down flush.

(iv) Insulation or Fibres Boards

All holes are to be stopped with an approved plaster compound rubbed down flush and all surfaces treated with one coat of thinned paint or emulsion paint as specified.

1.13.11 Preparation of Existing surfaces

i Plaster, Insulation Board and remove all loose flaking wash down, rub down, paint fill in holes and cracks with an approved filler including cutting out cracks in old plasterwork, bring forward bare patches.

ii Metal

Wash down, rub down, thoroughly scrape down as necessary to remove all loose and flaking paint and rust and prime and bring forward bare patches.

iii Woodwork

Wash down, rub down remove all loose and flaking paints fill in cracks and holes etc. with an approved filler and knot and prime and bring forward bare patches. Alternatively where specified completely remove paint by burning off or other approved means, rub down, fill in cracks and holes etc. with an approved filler and knot and prime as described for new woodwork.

1.13.12 Backs of Frames

Prime backs of all timber frames, skirtings and the like in contact with masonry or plaster with one coat of approved ready mixed proprietary wood priming paint before fixing.

1.13.13 Remove Ironmongery

Metal fittings and fastenings etc., are not to be fixed until painting is completed. Where they have been fixed, they shall be removed and stored until painting is completed and then carefully cleaned and refixed in position. Lugs to metal windows and door handles are to be painted before glazing.

1.13.14 Cover up and Protect

Before painting is commenced, floors must be washed and the buildings thoroughly cleaned out and every precaution taken to keep down dust.

The Contractor shall provide covers to all gauze screens and sashes and elsewhere as may be required to prevent marking and staining by paint.

1.13.15 Cleaning up

Replace any cracked or broken glass. Remove and replace any gauze screens which may be stained with paint. Remove all other paint splashes, spots and stains and clean out and leave the buildings to the requirements and satisfaction of the Project Manager.

1.14 SUBTERRANEAN STORM AND SURFACE WATER DRAINAGE

1.14.1 Site

The drainage of sites and roofs of buildings shall comply with the following:-

(a) The sub-soil of the site of the building shall, where the depress of the site renders it necessary, be effectively drained by means of earthenware field pipes or other suitable pipes properly laid to a suitable outfall, or other manner which the authority may require.

(b) The roof of the building shall be so constructed as to drain effectually to suitable and sufficient gutter on trough, unless a splash apron in concrete or other approved impervious material sufficient to protect the foundations of buildings is provided.

Where gutters or troughs are used they shall be connected to a sufficient number of downpipes constructed so as to carry away all water from the roof without causing dampness to any part of the walls or foundations of buildings and shall cause such water to be carried off in a manner approved by the Authority.

(c) Provision shall be made for carrying off any surface water of a building when desirable and in a manner approved by the Authority.

(d) Rain water pipes or trunks for the purpose of conveying any water from a roof shall not be connected to discharge directly into a closed rain but shall be caused to discharge directly into the open air, into an open channel, pavement drain or over a properly trapped gully, or into such gully above the level of the water in the trap thereof.

1.14.2 Roof

Eaves gutters and down pipes shall be of galvanized iron, steel, cast iron, or other equally suitable materials approved by the Authority and shall conform in all respects to the relevant BS or US Specification.

1.14.3 Surface water

All eaves gutters shall be borne and supported by approved brackets not more than 1m apart, and shall be properly aligned so as to provide continuous and even fall to the point of discharge. Discharge or outlet points shall be spaced at not more than 9.15 m center to center.

PART 2; SPECIFICATION FOR MECHANICAL INSTALLATIONS MATERIALS AND WORKS

2.1 GENERAL REQUIREMENTS FOR MECHANICAL AND DRAINAGE INSTALLATIONS

2.1.1 General

This section specifies the general requirement for plant, equipment and materials forming part of the mechanical and drainage Works and shall apply except where specifically stated elsewhere in the Specification or on the Contract Drawings.

2.1.2 Quality Of Materials

All plant, equipment and materials supplied as part of the the Works shall be new and of first class commercial quality, shall be free from defects and imperfections and where indicated shall be of grades and classifications designated herein.

All products or materials not manufactured by the Sub-contractor shall be products of reputable manufacturers and so far as the provisions of the Specification is concerned shall be as if they had been manufactured by the Sub-contractor.

Materials and apparatus required for the complete installation as called for by the Specification and Contract Drawings shall be supplied by the Sub-contractor unless mention is made otherwise.

Materials and apparatus supplied by others for installation and connection by the Sub-contractor shall be carefully examined on receipt. Should any defects be noted, the Sub-contractor shall immediately notify the Engineer.

Defective equipment or that damaged in the course of installation or tests shall be replaced as required to the approval of the Engineer.

2.1.3 Regulations And Standards

The Sub-contract Works shall comply with the current editions of the following:

- a) The Uganda Government Regulations.

The United Kingdom Institution of Electrical Engineers (IEE) Regulations for the Electrical Equipment of Buildings.

The United Kingdom Chartered Institute of Building Services Engineers (CIBSE) Guides.

- b) British Standard and Codes of Practice as published by the British Standards Institution (BSI)
- c) The Local Council By-laws.
- d) The Electricity Supply Authority By-laws.
- e) Local Authority By-laws.
- f) The Uganda Bureau of Standards

2.1.4 Electrical Requirements

Plant and equipment supplied under this Sub-contract shall be complete with all necessary motor starters, control boards, and other control apparatus. Where control panels incorporating several starters are supplied they shall be complete with a main isolator.

The supply power up to and including local isolators shall be provided and installed by the Electrical Sub-contractor. All other wiring and connections to equipment shall form part of this Sub-contract and be the responsibility of the Sub-contractor.

The Sub-contractor shall supply three copies of all schematic, cabling and wiring diagrams for the Engineer's approval.

The starting current of all electric motors and equipment shall not exceed the maximum permissible starting currents.

All electrical plant and equipment supplied by the Sub-contractor shall be rated for the supply voltage and frequency obtained in Uganda, that is 415 Volts, 50Hz, 3-Phase or 240Volts, 50Hz, 1-phase.

Any equipment that is not rated for the above voltages and frequencies shall be rejected by the Engineer.

2.1.5 Transport And Storage

All plant and equipment shall, during transportation be suitably packed, crated and protected to minimise the possibility of damage and to prevent corrosion or other deterioration.

On arrival at site all plant and equipment shall be examined and any damage to parts and protective priming coats made good before storage or installation.

Adequate measures shall be taken by the Sub-contractor to ensure that plant and equipment do not suffer any deterioration during storage.

Prior to installation all piping and equipment shall be thoroughly cleaned.

If, in the opinion of the Engineer any equipment has deteriorated or been damaged to such an extent that it is not suitable for installation, the Sub-contractor shall replace this equipment at his own cost.

2.1.6 Site Supervision

The Sub-contractor shall ensure that there is an English-speaking supervisor on the site at all times during normal working hours.

2.1.7 Installation

Installation of all special plant and equipment shall be carried out by the Sub-contractor under adequate supervision from skilled staff provided by the plant and equipment manufacturer or his appointed agent in accordance with the best standards of modern practice and to the relevant regulations and standards described under Clause 3.0.

2.1.8 Material Tests

All material for plant and equipment to be installed under this Sub-contract shall be tested, unless otherwise directed, in accordance with the relevant B.S Specification concerned.

For materials where no B.S. Specification exists, tests are to be made in accordance with the best modern commercial methods to the approval of the Engineer, having regard to the particular type of the materials concerned.

The Sub-contractor shall prepare specimens and performance tests and analyses to demonstrate conformance of the various materials with the applicable standards.

If stock material, which has not been specially manufactured for the plant and equipment specified is used, then the Sub-contractor shall submit satisfactory evidence to the Engineer that such materials conform to the requirements stated herein in which case tests of material may be partially or completely waived.

Certified mill test reports of plates, piping and other materials shall be deemed acceptable.

2.1.9 Manufactured Plant And Equipment- Work Tests

The rights of the Engineer relating to the inspection, examination and testing of plant and equipment during manufacture shall be applicable to the Insurance Companies or Inspection Authorities so nominated by the Engineer.

The Sub-contractor shall give two week's notice to the Engineer of the manufacturer's intention to carry out such tests and inspections.

The Engineer or his representative shall be entitled to witness such tests and inspections. The cost of such tests and inspections shall be borne by the Sub-contractor.

Six copies of all test and inspection certificates and performance graphs shall be submitted to the Engineer for his approval as soon as possible after the completion of such tests and inspections.

Plant and equipment which is shipped before the relevant test certificate has been approved by the Engineer shall be shipped at the Sub-contractor's own risk and should the test and inspection certificates not be approved, new tests may be ordered by the Engineer at the Sub-contractor's expense.

2.1.10 Pressure Testing

All pipe work installations shall be pressure tested in accordance with the requirements of the various sections of this Specification. The installations may be tested in sections to suit the progress of the works but all tests must be carried out before the work is buried or concealed behind building finishes. All tests must be witnessed by the Engineer or his representative and the Sub-contractor shall give 48 hours notice to the Engineer of his intention to carry out such tests.

Any pipework that is buried or concealed before witnessed pressure tests have been carried out shall be exposed at the expense of the Sub-contractor and the specified tests shall then be applied.

The Sub-contractor shall prepare test certificates for signature by the Engineer and shall keep a progressive and up-to-date record of the section of the work that has been tested.

2.1.11 Colour Coding

Unless stated otherwise in the Particular Specification all pipework shall be colour coded in accordance with the latest edition of B.S 1710 and to the approval of the Engineer or Architect.

2.1.12 Welding

Joints to be made by welding shall be accurately cut to size with edges sheared, flame cut or machined to suit the required type of joint. The prepared surface shall be free from all visible defects such as lamination, surface imperfection due to shearing or flame cutting operation, etc., and shall be free from rust scale, grease and other foreign matter.

All welding shall be carried out by the electric arc processing using covered electrodes in accordance with B.S. 639.

Gas welding may be employed in certain circumstances provided that prior approval is obtained from the Engineer.

2.1.13 Welding Code And Construction

All welded joints shall be carried out in accordance with the following Specifications:

I. Pipe Welding

All pipe welds shall be carried out in accordance with the requirements of B.S.806.

II. General Welding

All welding of mild steel components other than pipe work shall comply with the general requirements of B.S. 1856.

2.1.14 Welders Qualifications

Any welder employed shall have passed the trade tests as laid down by the Government of Uganda.

The Engineer may require to see the appropriate certificate obtained by any welder and should it be proved that the welder does not have the necessary qualifications the Engineer may instruct the Sub- contractor to replace him by a qualified welder.

2.2 PLUMBING AND DRAINAGE

2.2.1 General

This section specifies the general requirements for plant, equipment, and materials forming part of the following:

- I. Plumbing and Drainage
- II. Cold water Supply and Storage

2.2.2 Approval

Not with standing regulations and standards, the Contract works must be carried out strictly in accordance with the following documents:-

- I. The Performance Specification.
- II. Any working drawings produced by the Contractor and approved by the Engineer.
- III. The Engineer's instructions, drawings and details.

The Contractor shall undertake all modifications demanded by the authorities in order to comply with the regulations, and produce all certificates, if any, from the authorities without extra charge.

After the Contract works are handed over to the Client, the contractor will submit as built drawings to be approved by the Engineer after which the contractor will submit to the Client a set of as built drawings in hard and soft copies.

2.2.3 Materials

I. Copper Tubing

All copper tubing shall be manufactured in accordance with B.S. 659 from C.106 'Phosphorus De-oxide Non-Arsenical Copper' in accordance with B.S 6071.

Pipe joints shall be made with soldered capillary fittings and connection to equipment shall be with compression fittings manufactured in accordance with B.S.864.

Copper tubing is to be used as connection tubes between steel pipe work and sanitary or laboratory fittings. In order to avoid direct contact a brass straight connector shall be positioned between the steel pipe and the copper tube.

II. Galvanised Steel Pipework

Galvanized steel pipe work up to 65mm nominal bore shall be manufactured in accordance with B.S. 1387 Medium Grade, with tapered pipe threads in accordance with B.S. 21. All fittings shall be malleable iron and manufactured in accordance with B.S. 143.

Pipe joints shall be screwed and socketed and sufficient coupling unions shall be allowed so that fittings can be disconnected without cutting the pipe. Running nipples and long screws shall not be permitted unless exceptionally approved by the Engineer.

Galvanized steel pipe work, 80mm nominal bore up to 150mm nominal bore shall be manufactured to comply in all respects with the specification for 65mm pipe, except that screwed and bolted flanges shall replace unions and couplings for the jointing of pipes to valves and other items of plant. All flanges shall comply with the requirements of B.S. 10 to the relevant classifications contained hereinafter under Section 'C' of the Specification.

Galvanizing shall be carried out in accordance with the requirements of B.S. 1387 and B.S. 143 respectively.

Short copper connection tubes between galvanized pipe work and sanitary fittings shall not be used because of the risk of galvanic action.

If, as may occur in certain circumstances, it is not possible to make the connection in any way than the use of copper tubing, then a brass straight connector shall be positioned between the galvanized pipe and the copper tube in order to prevent direct contact.

III. PPR pipes and fittings

The PPR pipes and fittings shall be produced from polypropylene Random type PN25 material or equivalent which has high molecular weight and excellent creep resistance and will be used for hot and cold water installations.

The installation shall be in accordance with the manufacturers recommendation with provision for expansion, including all necessary fittings and accessories. The pipe shall be tested at 15 bars for one hour, immediately after the preliminary test, the main test shall be carried out at 10bars for 24 Hours. There shall be no leakage of any kind not even in the form of moisture in either of the tests. The installation must be perfectly tight.

IV. PVC pressure pipework

All P.V.C pipes for cold water services shall comply with the requirements of BS 3505 and all fittings shall comply with BS4346.

V. uPVC SOIL SYSTEM

The Sub-contractor shall supply and fix uPVC soil pipes and fittings as indicated on the Drawings and Schedules.

Pipes and fittings shall be in accordance with relevant British Standards, including B.S. 4514 and fixed to the manufacturer's instructions and B.S. 5572, and shall where appropriate bear the British Standard Kite Mark as Terrain Manufacture or equal and approved.

The soil system shall incorporate synthetic rubber gaskets as provided by the manufacturer whose fixing instructions shall be strictly adhere to.

Connections to WC pans shall be effected by the use of a WC connector, gasket and cover, fixed to suit pan outlet.

Suitable supporting brackets and pipe clips shall be provided at maximum of one metre centres.

The Sub-contractor shall be responsible for the joint into the Gully Trap on Drain as indicated on the Drawings.

VI. Vulcathene piping

The vulcathene pipe and fittings shall be supplied and fixed as indicated on the drawings and Schedules. These pipes shall be used in all laboratory areas with chemical waste drainage.

2.2.4 Valves

I. Stop-Cocks , Taps and Stop Valves

Stop cocks for underground use shall be plug cock pattern or screw down pattern complying with requirements of B.S.2580.

Taps and stop valves shall be screw down pattern and shall comply with the requirements of B.S. 1010 fitted with washers complying with B.S.3457. Hose taps and hose connections shall have outlet nosels screwed in accordance with the requirements of B.S.1010.

II. Gate Valves

All gate valves 50mm nominal bore and above, other than those required for fitting to buried water mains shall be of cast iron construction in accordance with the requirements of B.S. 5150. All gate valves required for fitting to buried water mains shall be of cast iron construction in accordance with the requirements of B.S. 5163.

All gate valves up to and including 50mm nominal bore shall be of bronze construction in accordance with the requirements of B.S. 1952.

The pressure classification of all gate valves shall depend upon the pressure conditions pertaining to the site of works.

III. Globe Valves

All globe valves up to and including 50mm nominal bore shall be of bronze construction in accordance with the requirements of B.S. 3061. The pressure classification of all globe valves shall depend upon the pressure conditions pertaining to the site of works.

IV. Gas Valves

To be globe valves in accordance with B.S. 5154.

V. Check or Non-return Valves

All check or non-return valves up to and including 50mm nominal bore shall be of the swing check type of bronze construction in accordance with B.S. 5154.

All check or non-return valves 50mm nominal bore and above shall be of the swing check type of cast iron construction in accordance with the requirements of B.S. 5153.

The pressure classification of all check non-return valves shall depend on the pressure conditions pertaining to site of the works.

VI. Ball Valves

All ball valves for use in connection with hot and cold water services shall be of portmouth type in accordance with the requirements of B.S 1212 and construction of bronze or other non-corrosive material

2.2.5 Waste Fitment Traps

I. Standard and Deep Seal P & S Traps

Where standard or deep seal traps are specified they shall be manufactured in suitable non-ferrous materials in accordance with the full requirements of B.S. 1184.

II. Anti-Syphon Traps

Where anti-syphon traps are specified, these shall be similar or equal to the range of traps manufactured by Greenwood and Hughes Ltd., Deacon Works, Littlehampton, Sussex, England. The trade name for traps manufactured by this Company is 'Grevak'.

2.2.6 Workmanship

I. Water Services Installation

All work shall be carried out in accordance with C.P.342 and C.P.310 and to the approval of the Engineers

All water systems shall be provided with sufficient drain points and automatic air vents to enable them to function correctly. Valves and other user equipment shall be installed with adequate access for operation and maintenance. Where valves and other operational equipment are unavoidably installed beyond normal reach from a short step ladder, extension spindles with floor or wall pedestals shall be provided.

Screwed piping shall be installed with sufficient number of unions to facilitate easy removal of valves and fittings and to enable alterations of pipe work to be carried out without the need to cut the pipe.

Full allowance shall be made for the expansion and contraction of the pipework, precautions being taken to ensure that any forces produced by pipe movements are not transmitted to valves, equipment or plant. All screwed joints to piping and fittings shall be made with P.T.F.E. tape.

II. Sanitary Services

Soil, waste and vent pipe systems shall be installed in accordance with the best standard of modern practice as described in B.S. 5572:1978 to the approval of the Engineer.

It shall be ensured that all ground floor waste fittings are discharged to a gully trap before passing to the sewer via a manhole.

All necessary roding and inspection facilities shall be provided within the draining system in positions where easy accessibility is available.

Where a branch requires roding facilities in a position to which normal access is unobtainable, then that branch shall be extended so as to provide a suitable purpose made roding eye in the nearest adjacent wall or floor to which easy access is available.

The vent stacks shall terminate above roof level and where a stack passes through the roof, a weather skirt shall be provided. The roof shall be sealed after installation of the stacks.

The open of each stack shall be fitted with a plastic coated, or galvanised steel, wire guard.

Access for roding and testing shall be provided at the foot of each stack. All sanitary appliances associated with the works shall be installed in accordance with CP 305 to the approval of the Engineer.

2.2.7 Pipe Supports For Suspended Pipework

I. General

This sub-clause deals with pipe supports securing pipes to the structure of buildings for above ground application.

The variety and type of support shall be kept to a minimum and their design shall be such as to facilitate quick and secure fixings to metal, concrete, masonry or wood.

Consideration shall be given, when designing supports, to the maintenance of desired pipe falls and the restraining of pipe movements to a longitudinal axial direction only.

The Sub-contractor shall supply and install all steelwork forming part of the pipe support assemblies and shall be responsible for making good damage to builders work associated with the pipe support installation.

The Sub-contractor shall submit all his proposals for pipe supports to the Engineer for approval before any erection works commence.

II. Securing of Pipes

Pipe runs shall be secured by pipe clips connected to pipe hangers, wall brackets, or trapeze type supports. 'U' bolts shall not be used as a substitute for pipe clips without the prior approval of the Engineer.

The support spacing for vertical runs shall not exceed one and a half times the distances given for horizontal runs.

An approximate guide to the maximum permissible supports spacing in metres for steel and copper pipe and tube is given in the following table for horizontal runs:

Size Nominal Bores	Copper Tube to B.S. 659	Steel Tube to B.S. 1387
15mm	1.25m	2.0m
20mm	2.0m	2.5m
25mm	2.0m	2.5m
32mm	2.5m	3.0m
40mm	2.5m	3.0m
50mm	2.5m	3.0m
65mm	3.0m	3.5m
80mm	3.0m	3.5m
100mm	3.0m	4.0m
125mm	3.5m	4.5m
150mm	4.5m	5.5m

III. Expansion Joints and Anchors

Where practicable, cold pipework systems shall be arranged with sufficient bends and changes of direction to absorb pipe expansion providing that the pipe stresses are contained within the working limits prescribed in the relevant B.S. specification.

Where piping anchors are supplied, they shall be fixed to the main structure only. Details of all anchor design proposals shall be submitted to the Engineer for approval before erection commences.

The Sub-contractor when arranging his piping shall ensure that no expansion movements are transmitted directly to connections and flanges on pumps or other items of plant.

The Sub-contractor shall supply flexible joints to prevent vibrations and other movements being transmitted from pumps to piping systems or vice versa.

2.2.8 Underground Pipe Lines

I. General

All underground water and drainage service installations shall be according to modern practice as described in C.P. 301 and C.P. 310 respectively.

The following sequence shall be followed for operation for Underground Service Installation:

a) Setting Out

As described in B.S. Code of Practice 301 Clause 502

b) Breaking up Surface (if in roads)

As described in B.S. Code of Practice 301 Clause 503

c) Excavation for Water Main

As described in B.S. Code of Practice 301 Clause 503 and the following:-

The contractor shall excavate the pipe trenches in the line and to the depths indicated on the drawings or directed by the Engineer, all pipes must have a minimum cover of 50mm over top of the barrel of the B49 pipe when laid, plus or minus, and a tolerance of 75mm either way. All trenches shall be excavated in open cuttings.

Where the trench passes through grassland, arable land or garden, whether enclosed or otherwise, the turf, if any, shall be pared off and stacked, and the productive soil shall be carefully removed for a width of 600mm greater than the normal trench width, or equal to the overall width of track of the excavating machine whichever is greater, and laid aside to be subsequently used in reinstating the surface of the ground after the trench has been refilled.

The bottom of the trench shall be properly trimmed off, and all low places or irregularities shall be levelled up with fine material. Where rock or large stones are encountered, they shall be cut down to a depth of at least 75mm below the level at which the bottoms of the barrel of the pipes are to be laid, and covered to a like depth with fine material, so as to form a fine and even bed for the pipes.

Joint holes shall be excavated to such minimum dimensions as will allow the joints to be well and properly jointed.

The pipe trench shall be kept clear of water at all times.

The Contractor shall, whenever necessary, by means of timbering or otherwise, support the sides of the trench so as to make them thoroughly

secure, and afford adequate support to adjoining roads, lands, building and property, during the whole time the trench remains open and shall remove such timbering when the trench has been backfilled. The cost of such timbering or other work shall be deemed to be included in the rates for excavation. In case the Contractor is instructed by the Engineer to leave any portion of such timber in position, the contractor will pay for it accordingly.

The clear width inside the timbering, in the case of single pipes, shall be at least 320mm in excess of the external diameter of the pipe being laid, in order to allow it to be freely lowered into position in the trench without damage to the external protection.

Where more than one pipe is to be laid parallel, then the clear width inside the timbering shall be at least 520mm in excess of the combined external diameters of the pipes.

Any excavation below the specified depth, in error or without the instruction of the Engineer as the case may be, shall be refilled to the correct levels, at no extra cost, with mix 1:3:6 concrete or other approved material.

If a mechanical excavator is used by the Contractor, he shall indemnify the Employer against all claims for damage which, in the opinion of the Engineer, may have been caused by the use of this point. When a mechanical excavator is used the bottom 230mm of excavation shall be excavated by hand to ensure an even bed for the pipes.

II. Excavation for Drainage pipes

Excavation shall be made to such depths and dimensions as may be required by the Engineer to obtain proper falls and firm foundations. No permanent construction shall be commenced on any bottom until the excavation has been examined and approved by the Engineer.

Prices shall include for excavating in all materials met with, for trimming bottoms to the necessary falls and for excavation required for planking and strutting and working space.

All prices shall include for keeping the whole of the trenches or other excavations free from water and for execution of such works and install such pumps as may be necessary to keep the excavations dry at all times. No sub-soil water shall be discharged into the sewage systems without written permission of the Engineer.

III. Laying of Concrete Beds or other Supports for Pipes (if required)

As described in B.S. Code of Practice 301 Clause 504 and the following:

All drains below buildings shall be encased in concrete 150mm thick. Drains below roads shall be protected by a reinforced concrete slab, 300mm below surface. 150mm thick and with same width as the trench.

Concrete beds and supports shall be concrete of mix 1:3:6 to 25mm maximum aggregate size.

IV. Pipe Laying and Jointing

Drain pipes shall be laid and jointed as described under B.S. Code of Practice 301 Clause 505.

Water pipes shall be laid and jointed as described under B.S. Code of Practice 310, Clause 401, 402, 403, and 404.

V. Protection of Underground Steel Pipes

Where laid underground, mild steel piping shall be protected by 'Denso' tape, or similar, wound on at least two layers thick or given two coats of approved bitumen.

VI. Manholes and Inspection Chambers

Manholes and inspection chambers shall be constructed in accordance with the drawings and in the position shown on the drawings or directed by the Engineer. Foundation slabs and benching shall consist of concrete of the appropriate grades.

Benching to manhole floors shall have a minimum fall of 1 in 12 from the manhole walls and shall be finished tangentially vertical to the bore of the channel diameter. The intersection of the channel sides and the benching shall be finished in a sharp curve not greater than 30mm in diameter.

The benching shall be formed of concrete, as specified, floated to a hard smooth surface with a coat of cement mortar (1:1).

If required half channel pipes, bends and junctions shall be laid and bedded in cement mortar (1:3) to the required lines and levels, and both sides of the channel pipes shall be benched up with concrete of the appropriate grade and finished smooth to the slopes and levels as shown on the drawings or directed by the Engineer. The ends of all pipes shall be neatly built in and finished flush with cement mortar (1:3).

Walls of manholes and access shafts shall be constructed of concrete block work as specified in accordance with the drawings.

Walls shall be rendered internally for the full height with a cement and mortar (1:3) of at least 12mm thickness finished with a completely smooth surface.

Cast iron manhole covers and frames as specified shall be provided and the frames shall be bedded in cement mortar (1:3) and so set that the tops of the covers shall be flush at all points with the surrounding surface of the footway, verge or carriageway, as the case may be. Any slight adjustment of the cover level which may be necessary to accomplish this shall be effected by topping the sidewalls with concrete integral with the slab.

Where the depth of the invert exceeds 1 metre below the finished surface of the carriageway or the adjacent ground, step irons of heavy galvanised cast iron or galvanised mild steel round bar shall be built in 300mm apart with alternate steps in line vertically and with such additional hand irons as the Engineer may direct. Step irons must be set into the walls when these are built and not subsequently.

All manholes when completed shall be watertight and to the satisfaction of the Engineer.

Vertical backdrops shall be positioned inside the manholes or tanks and be constructed in cast iron or PVC drain pipes and fittings.

VII. Gulley Connections

Connection from gullies to sewers and surface water drains or ditches shall consist of PVC pipes and fittings as specified jointed with push-fit joints. All pipes, bends and junctions shall be laid to the lines and levels shown in the drawings or as directed by the Engineer.

VIII. Surface Boxes, covers, etc.

Surface boxes, manhole and other covers lying within the site of the works, shall be raised, lowered, altered or removed as directed by the Engineer.

IX. Testing of Pipelines

After pipelines are connected up and joints have been sealed, the pipeline shall be tested before pipes are, if required, haunched or surrounded in concrete. Methods of testing and inspection shall be in accordance with the requirements of the appropriate section in this Specification.

X. Concrete bedding, Haunching and Surround

Concrete bedding, haunching and surround shall be provided as necessary or where called for by the Engineer in accordance with the requirements laid down in B.S. Code of Practice 301, Clause 310.

XI. Backfilling

Backfilling of trenches, headings and around manholes shall be carried out in accordance with the methods described in B.S. Code of Practice 301, Clause 508.

XII. Reinstatement of Surfaces

Following the final backfilling of all trenches, headings and manhole surrounds, the surface of the excavated areas shall be fully reinstated to the approval of the Engineer.

Where excavations have been carried out in public highways or other areas not forming part of the site, prices will be deemed to allow for all charges associated with the temporary and final reinstatement requirements of the Local Highway Authority.

XIII. Sanitary Appliances

All sanitary appliances associated with the works shall be installed in accordance with CP 305 to the approval of the Engineer.

2.2.9 Cold Water Booster Pumps

Cold water pumps shall boost water between the Underground Tank and the distribution tanks on the roof. The pump shall start and stop automatically by pressure contactor to meet the demand. The cold water pump booster set shall comprise the following:- submersible pumps, pressure vessels, valves and accessories complete with a control panel.

2.2.10 Testing And Inspection

The following site tests for the pipe-work systems shall be carried out as part of the installation and shall be deemed to have been allowed for in the price.

I. Underground Water Mains

After laying, jointing and anchoring, the main shall be slowly and carefully charged with water, so that all air is expelled and allowed to stand full for three days before testing under pressure.

Tests shall be applied to sections of pipelines not exceeding 1000 metres in length or such lesser lengths as may be required, and pipe joints shall be left uncovered.

The open end of the main may be temporarily closed for testing under moderate pressure by fitting a water pipe expanding plug, of which several types are available. The end of the main and the plug should be secured by struts or otherwise, to resist the end of thrust of the water pressure in the main. If the section of the main tested terminates with a sluice valve, the wedge of the valve shall not be used to retain the water, with a plug and the wedge shall be placed in the open position while testing. Suitable end supports shall be provided to withstand the end thrust of the water pressure in the main.

The test pressure shall be applied by means of a manually operated test pump or, in case of a long mains of large diameter, by a power driven test pump that shall be taken to ensure that required pressure is not exceeded. Pressure gauges should be recalibrated before the tests.

Prices shall be deemed to include for all test pumps and other equipment required under this clause of the specification.

The test pressure shall be one and half times the maximum working pressure except where a pipe is manufactured from a material for which the relevant BS specification designates differently, otherwise the maximum test pressure should not exceed 120, 180 and 240 metre head for class B,C or D pipes respectively.

The pipeline or pipe-work shall be filled with water in such a manner as to prevent any shock or water hammer and allow for the complete evacuation of air, and kept under observation for leakages at static head for twenty four hours. If there are no leakages the pressure shall be raised slowly to the required test pressure for that pipeline and maintained at that pressure for a period long enough for the Engineer to examine the whole section under test, or not less than 4 hours which ever is the longer period. Thereafter, for a period of 2 hours the leakage of water, as measured by

the amount drawn into the pump to maintain the pressure must not exceed a rate of 0.1 litre per millimetre nominal internal diameter per kilometre length of main per 30 metres head for each 24 hours.

All pipes or joints which are proved to be in any way defective shall be cut out, remade and retested as often as may be necessary until a satisfactory test is obtained and any work which fails or is proved by test to be unsatisfactory in any way shall be cut out and redone by the contractor at his own expense.

In addition to the tests in separate sections, on completion the main shall be tested in whole or in parts to the same pressure and by the same procedure as that outlined for individual sections.

During pipe laying the gauge shall remain in the pipeline and shall be pulled by a stout rope or chain which shall be threaded through each successive pipe or tube so that the gauge is never more than one pipe length behind the laying. Any debris collected in front of the gauge shall be regularly cleaned out before the next pipe is placed in position.

II. Above ground internal water service installation

All water service pipe systems installed above ground shall be tested hydraulically for a period of one hour to not less than one and a half times the design working pressure.

If preferred, the pipe line may be tested in sections. Any such section found to be satisfactory need not be the subject of a further test when the system has been completed, unless specifically requested by the Engineer.

During the test, each branch and joint shall be examined carefully for leaks. Any defects revealed shall be made good and the section re-tested. All necessary precautions shall be taken to prevent damage occurring to special valves and fittings during the tests.

Any item damaged shall be replaced or repaired.

III. Underground Drainage System

A site test shall be carried out on all drainage pipes before concrete haunchings or surrounds are applied. These tests shall be carried out preferably from manhole to manhole.

Short branch drains connected to a main drain between manholes shall be tested as one system with the main drain. In long branches a testing junction shall be inserted next to the junction with the main drain and the branch tested separately. After the test has been passed, the testing junction shall be effectively sealed.

All tests on underground drains shall be water tests. Smoke test shall not be permitted.

In certain circumstances, air tests may be permitted on cast iron drains at the discretion and to the approval of the Engineer.

Water tests shall be carried out in accordance with the methods described under B.S. Code of Practice 301, Clause 601 (b) and (c) and the test pressure shall not be less than 1.52m head at the highest point in the pipe section and not more than 10.36 m head at any point in the section.

The test pressure shall be maintained for a period of one hour during which time the pipes and joints shall be inspected for sweating and leakage. Any leaks discovered during the test shall be made good and the section re-tested.

In addition to pressure tests, drain pipe runs shall also be tested for straightness where applicable. The test shall be carried out in accordance with one of the two methods described in B.S. Code of Practice 8301, Clause 602.

IV. Above Ground Soil, Waste and Ventilating Pipe System

All soil, waste and ventilating pipe system forming part of the above ground installation, shall be given a smoke test to a pressure of 39mm of water gauge and this pressure shall remain constant for a period of not less than 3 minutes.

Water tests on above ground soil, waste and ventilating pipe systems shall not be permitted.

Pressure tests shall be carried out before any work which is to be concealed is finally enclosed.

Any defects revealed by the tests shall be made good and the test repeated to the approval of the Engineer. In all other respects, tests shall comply with the BS58 requirements of B.S. Code of Practice 5572.

Following satisfactory pressure tests on the pipe-work systems, operational tests shall be carried out in accordance with the relevant B.S. Code of Practice on the system as a whole to establish that special valves, gauges, controls, fittings, equipment and plant are functioning correctly to the satisfaction of the Engineer.

2.2.11 Colour Coding In General

All pipe-work shall be colour coded in accordance with the latest edition of B.S. 1710.

2.2.12 Sterilization Of Hot And Cold Water Supply System

The sterilisation procedure shall be carried out in accordance with the requirements of the BS Code of Practice 310, Clause 409 to the approval of the Engineer. The pipelines after testing shall be thoroughly flushed out and cleaned.

After the Engineer has approved the cleaning, the Contractor shall completely fill the pipelines with water to which he shall have added chloride of lime or other approved chemical to give a concentration of free chlorine of 50mg per litre.

Chlorine gas must not be injected directly into the main from a cylinder other than through an approved chlorinator and care must be taken to ensure that there is no flow back into the preceding sections of the main.

The method used for sterilisation shall be approved by the engineer and solution allowed to remain in the pipelines for not less than 6 hours, nor more than 24 hours. Chlorine residual test shall then be taken at the end of the main furthest from the dosing point. The sterilisation process shall be repeated until the free chlorine residual is less than 5mg per litre. The chlorine residual tests shall be carried out on site in order to obtain an accurate reading of free chlorine present.

2.2.13 Chambers And Manholes

Chambers and manholes shall be constructed to the dimensions and general arrangement detailed on the drawings and in the Contract. Chamber covers shall be constructed as for manholes.

2.2.14 Testing Of Manholes

Manholes and other chambers shall be tested by filling with water after completion of backfilling.

The first 1.0 metre of depth may be filled as quickly as supply permits. Between this end and top water level the rate of filling must not exceed 1.0 metre in 24 hours. After filling to top water level, no further water shall be introduced for 2 days. At the end of this period the tanks shall be topped up to water level and allowed to stand satisfactory if the fall in water in 24 hours does not exceed 15mm.

In the event of a fall exceeding the above tank will be emptied and any defects made good prior to re-test as before, all at the Contractors expense.

2.2.15 Cold Water Storage Tanks

There shall be uPVC tanks of various capacities complete with provisions for overflow, mains supply connection float valve.

2.2.16 Sanitary Fittings

All sanitary appliances supplied and installed as part of the Sub-contract works shall comply with the general requirements of B.S. Code of Practice 305 and the particular requirements of the latest B.S. Specifications.

2.3 FIRE FIGHTING

2.3.1 Hose Reel System

I. System description

This General Specification details the requirements for the supply, installation and commissioning of the hose reel installation. The hose reel installation shall comply in all respects to the requirements set out in C.O.P 5306 Part 1: 1976, B.S 5041 and B.S 5274. The System shall comprise of a pumped system.

The source of water for the hose reel system will be a PVC tank in the roof of the building. A hose reel pump set complete with control panel and pressure switches will be installed in the roof next to the tank. The pump set shall boost water to hose reels on all the floors of the building as indicated on the drawing. The Sub-Contractor will be required to connect his hose reel booster pumps from the water reserve in the tank.

II. Hose reels

Swinging type of hose reels, recessed models as Angus Fire Swing Model or equal and approved will be supplied and installed having their centre line at 1 metre above finished floor level in the recesses provided. They will be supplied complete with pre-painted steel swinging drum, 560mm diameter fitted with wall mounting bracket and 20mm diameter; reinforced non-kink rubber hoses 45 metres long unless otherwise specified. Terminal jet/spray nozzles, 5mm diameter will be fitted to the hoses and each hose will be required to discharge a minimum of 0.4 litres per second. Hose guide brackets made of plated steel with nylon rollers will also be installed in appropriate positions adjacent to the reel. A screw down chrome - plated globe valve to B.S 1010 to the inlet to the reel is to be supplied.

The hose reel shall comply with B.S EN 671-1:1995 and EN 694 and is to be installed to the requirements of C.P. 5306 Part 1: 1976.

III. Hose reel pumps

The fire hose reel pumps shall consist of a duplicate set of multi-line centrifugal pumps from approved manufacturers. The pumps shall be capable of delivering 2.5 litres/sec at a running pressure of 2.25 bar.

The pump casing shall be of cast iron construction with the impeller shaft of stainless steel with mechanical seal.

The duplicate pump set will be constructed by the manufacturer in the manner described above complete with all the necessary valves, fittings and control panel and therefore installation work on site will be minimum.

The pumps for this system will be required to operate automatically 'on' and 'off' maintaining the system under pressure. The automatic 'on' and 'off' operations will be by means of appropriately set low and high pressure switches. A change- over switch from duty to stand-by pump will be incorporated in the control panel. In addition, a flow switch will be fitted in the system control to ensure continuous pumping so long as water flows in the system

IV. Control panel

The control panel shall be constructed of mild steel 1.0mm thick sheet, be moisture, insect and rodent proof and shall be provided complete with circuit breakers and a wiring diagram enclosed in plastic laminate.

The pump shall be controlled by a flow switch therefore; the control panel shall include the following facilities:

- a) 'On' push button for setting the control panel to live.
- b) Green indicator light for indicating control panel live.
- c) Duty / Stand-by pump auto change over.
- d) Duty pump run green indicator light.
- e) Stand-by pump run green indicator light.
- f) Duty pump fail red indicator light.
- g) Stand-by pump fail red indicator light.
- h) Low water condition pump cut-out with red indicator light.

The pumps are to be protected by a low level cut-out switch to prevent dry pump run when low level water conditions occur in the water storage tank.

V. Pipework

In this system, galvanized steel pipes Class "B" shall be installed in accordance with B.S 1387: 1967 with pipe threads to B.S 21

VI. Pipe fittings

The pipe fittings shall be wrought steel pipe fittings, welded or seamless fittings conforming to B.S. 1740 or malleable iron fittings to B.S 143. All changes in direction will be with standard bends or long radius fittings. No elbows will be provided.

VII. Non-return valves

The non-return valves up to and including 80mm diameter shall be to B.S. 5153: 1974. The valves shall be of cast iron construction with gunmetal seat and bronze hinge pin.

VIII. Gate valves

The gate valves up to and including 80mm diameter shall be non-rising stem and wedge disc to B.S 5154: 1974 with screwed threads to B.S. 21 tapes thread

IX. Sleeves

Where pipe work passes through walls, floors or ceilings, a sleeve shall be provided one diameter larger than the diameter of the pipe, the space between them to be packed with mineral wool, to the Engineer's approval.

X. Earthing

The hose reel installation shall be electrically earthed by a direct earth connection. The installation of the earthing shall be carried out by the Electrical Sub- contractor.

XI. Finish painting

Upon completion of testing and commissioning the hose reel installation, the pipe work shall be primed and finish painted with 2 No. coats of paints to Engineer's requirements.

XII. Testing and commissioning

The hose reel installation shall be flushed out before testing to ensure that no builder's debris has entered the system. The installation is to be then tested to

one and half times the working pressure of the installation to the approval of the Engineer. Simulated fault conditions of the pumping equipment are to be carried out before acceptance of the System by the Engineer.

XIII. Instruction period

The Sub-contractor shall allow in his contract sum for instructing of the use of the equipment to the Client's maintenance staff. The period of instruction may be within the contract period but may also be required after the contract period has expired.

The period of time required shall be stipulated by the Client but will not exceed two days in which time the Client's staff shall be instructed on the operation and maintenance of the equipment.

2.3.2 Fire Extinguishers

I. General

This specification details the requirements for the supply, installation and commissioning of the Portable Fire Extinguishers which shall conform to B.S. 5423:1977. The Sub-contractor shall include for all appurtenances and appliances not necessarily called for in this specification or shown on the contract drawings but which are necessary for the completion and satisfactory functioning of the works.

If in the opinion of the Sub-contractor there is a discrepancy between the requirements of the Specifications and the Contract Drawings, he shall clarify these discrepancies with the Engineer before tendering.

II. Scope of works

The Sub-contractor shall supply, deliver, install, test and commission all the portable fire extinguishers which are called for in these Specifications and shown on the Contract Drawings. Generally, two portable extinguishers shall be supplied and installed against each hose reel. On all general office floors one water type and one carbon dioxide gas fire extinguisher shall be installed against each hose reel. In the basements dry powder and carbon dioxide gas extinguishers will be installed as shown on the drawings. Fire blankets will be installed in the kitchen at the locations indicated on the drawing.

III. Water/Co2 extinguishers

These shall be 9-litre water filled CO2 cartridge operated portable fire extinguishers and shall comply with B.S. 1382: 1948 and to the requirements of B.S.4523: 1977. Unless manufactured with stainless steel, bodies shall have all internal surfaces completely coated with either a lead tin, lead alloy or zinc applied by hot dipping. There shall be no visibly uncoated areas.

The extinguishers shall be clearly marked with the following:

- a) Method of operation.
- b) The words 'WATER TYPE' (GAS PRESSURE) in prominent letters.
- c) Name and address of the manufacturer or responsible vendor.
- d) The nominal charge of the liquid in imperial gallons and litres.
- e) The liquid level to which the extinguisher is to be charged.
- f) The year of manufacture.
- g) A declaration to the effect that the extinguisher has been tested to a pressure of 24.1 bar (350 p.s.i.).
- h) The number of British Standard 'B.S' 1382 or B.S. 5423: 1977.

IV. Portable carbon dioxide fire extinguishers

These shall be portable carbon dioxide fire extinguishers and shall comply with B.S. 3326: 1960 and B.S. 5423: 1977.

The body of extinguisher shall be a seamless steel cylinder manufactured to one of the following British Standards; B.S. 401 or B.S. 1288.

The filling ratio shall comply with B.S. 5355 with valves fittings for compressed gas cylinders to B.S.341. Where a hose is fitted it shall be flexible and have a minimum working pressure of 206.85 bar (3000 p.s.i.). The hose is not to be under internal pressure until the extinguisher is operated.

The nozzle shall be manufactured of brass gunmetal, aluminium or stainless steel and may be fitted with a suitable valve for temporarily stopping the discharge if such means are not incorporated in the operating head.

The discharge horn shall be designed and constructed so as to direct the discharge and limit the entrainment of air. It shall be constructed of electrically non-conductive material.

The following markings shall be applied to the extinguishers:-

- a) The words "Carbon Dioxide Fire Extinguisher" and to include the appropriate nominal gas content.
- b) Method of operation.
- c) The words "Re-charge immediately after use".
- d) Instructions for periodic checking.
- e) The number of the British Standard B.S. 3326: 1960 or B.S. 5423.
- f) The manufacturer's name or identification markings.

V. Dry chemical powder portable fire extinguishers

The portable dry powder fire extinguishers shall comply with BS EN 3/BS 1449 and BS 1004. The body shall be constructed in steel to not less than the requirements of BS 1449 or aluminium to BS 1470 : 1972 and shall be suitably protected against corrosion.

The dry powder charge shall be not-toxic and retain its free flowing properties under normal storage conditions. Any pressurizing agent used as an expellant shall be in dry state; in particular compressed air.

The discharge tube and gas tube if either is fitted shall be made of steel, brass, copper or other not less suitable material. Where a hose is provided it shall not exceed 1,060mm and shall be acid and alkali resistant. Provision shall be made for securing the nozzle when not in use.

The extinguisher shall be clearly marked with the following information:

- a) The word "Dry Powder Fire Extinguisher"
- b) Method of operation in prominent letters.
- c) The working pressure and the weight of the powder charge in Kilogramme.
- d) Manufacturer's name or identification mark
- e) The words "RECHARGE AFTER USE" if rechargeable type.
- f) Instructions to regularly check the weight of the pressure container (gas Cartridge) or inspect the pressure indicator on stored pressure types when fitted, and remedy any loss indicated by either.
- g) The year of manufacture.

- h) The Pressure to which the extinguisher was tested.
- i) The number of this British Standard BS 3465 or BS 5423: 1977.
- j) When appropriate complete instructions for charging the extinguisher shall be clearly marked on the extinguisher or otherwise be supplied with the refill.

VI. Air foam fire extinguisher

These shall be of 9 litres capacity complete with refills cartridges and wall fixing brackets and complying with B.S. EN 3/BS 1449 and BS 1004 with the following specifications:-

- a) Cylinder: to B.S. 1449
- b) Necking: to be 76mm outside diameter steel EN 3A 23/4 X 8TPI female thread.
- c) Headcap: to be plastic moulding acetyl resin.
- d) CO2 Cylinder: to be 75gm P.V.C coated.
- e) Internal Finish: to be polythene lining on phosphate coating.
- f) External finish: to be phosphated - One coat primer paint and one coat stove
- g) Enamel: to B.S. 381 C.

VII. Fire blanket

The fire blanket shall be made from cloth woven with pre-asbestos yarn or any other fire proof material and to measure 1800 x 1210 mm and shall be fitted with special tapes folded so as to offer instantaneous single action to release blanket from storing jacket to BS 1721.

2.4 SPECIFICATIONS FOR REFUSE CHUTE SYSTEM

2.4.1 Equipment

The provided equipment shall meet the requirements of BS1703:2005 and BS5906:2005 Design and components currently used in Hardall Refuse Chutes (Hardall International Ltd Unit 2 Fairway Works Southfields Road Dunstable LU6 3EP) shall be considered the standard for quality, performance and appearance

2.4.2 Service And Parts

The manufacturer shall maintain the ability to supply spare parts and components, for a period of three years from the date of manufacture.

2.4.3 Submittals

The contractor will be required to provide the manufacturer's fully dimensioned shop drawings for approval prior to manufacture.

2.4.4 Supply

As detailed on drawing a 450mm internal diameter Refuse Chute System as manufactured by Hardall International Limited or equal approved.

2.4.5 Material Trunking

All vertical chute trunking, chute entry sections and vent pipes shall be manufactured from 2mm stainless steel type 430 S.D. to BS1449 .

2.4.6 Spc Hoppers

Shall be provided to the Refuse Chute and manufactured as follows:

The hopper door face will have maximum size as specified in the BOQ and be designed to ensure that refuse inserted into the hopper cannot cause a blockage in the chute. The hopper shall be self-closing and sealing, have a 1 hour fire rating and a smoke seal to BS476 Part 22 Sections 6 and 31.1.

2.4.7 Floor Support Frames

The manufacturer shall provide 16 No. 40 x 40 x 6mm R.S.A. frames with welded clamp bands, the clamp band to have a 3mm rubber insert as a sound isolator. All fixing nuts and bolts to be provided. The frame shall be rustproofed after manufacture.

2.4.8 Discharge

The manufacturer shall provide a stainless steel discharge to be connected to the underside of a fire shutter door. (Discharge shall be 3mm for chutes up to 11 storeys, and 4mm for chutes 12 storeys and over). Fire shutter shall be automatic in operation and be capable of cutting off the chute and its shaft from the refuse room. A 6mm thick manually operated cut-off plate shall be fitted to the discharge section.

2.4.9 Chute Cleaning

The manufacturer shall provide a factory fitted electrically powered automatic chute cleaning system. The chute cleaning system, to be fitted above the topmost entry section, shall have its own separate housing and side-hung, stainless steel faced lockable access door. The cleaning system shall consist of a cylindrical housing with two bands of stiff nylon brushes firmly attached, a geared electric motor, cable, stabilising weight, flushing head spray and the manufacturers standard electric logic control installed to ensure efficient cleaning of the internal surfaces of the chute.

2.4.10 Disinfectant And Sanitising Unit

A factory fitted disinfectant and sanitising unit shall be provided. The unit shall be automatic in operation and capable of injecting odour counteractant into the water supply of the automatic brush cleaning system.

2.4.11 Ventilation

The chute shall extend through the roof, terminating 1.2m above roof level complete with a weathering terminal.

2.4.12 Exhaust Fan

The manufacturer shall provide a factory fitted foul air exhaust fan, the fan to be fitted internally in the refuse chute vent pipe. An access door will be provided for servicing the fan. The fan shall be protected above and below by lightweight mesh screens, which are to be removable for cleaning. The fan motor shall be 1/5 HP, class F, continuously rated, capable of a 200m³/hour air displacement. Electric supply 220/240V, 50Hz, 0.8A.

2.4.13 Sound Damping

The total vertical length of all exterior surfaces of the refuse chute shall have a factory applied coating of Revac DC1010 Sound Deadening Compound. The coating shall be applied at the rate of 1.8kgs/m², or to give a coating of not less than the thickness of the substrate.

2.4.14 Chute Construction

The chute shall be fully factory assembled and all joints except those required to separate the sections for shipment and installation, shall be lock seamed or welded. The hopper doors shall be bolted in place on the entry sections and checked to ensure proper alignment with the inner baffle plate. Sections shall fit inside the section below and there shall be no bolts, rivets or other projections inside the chute, to impede the free flow of falling refuse. A minimum of one slip or telescopic joint per storey shall be allowed to give working tolerance. The manufacturer shall provide

sealant to ensure all joints are watertight and further provide all other equipment necessary to execute the contract.

2.4.15 Equipment

Shall be protected at all times from physical damage.

2.4.16 Construction Waste

Under no circumstances shall the chute be used for construction waste.

2.4.17 Inspection Prior To Installation

The manufacturer shall inspect the area of installation, verify any dimensions and advise of conditions detrimental to the proper and timely completion of the work.

2.4.18 Installation

The manufacturer shall where instructed, provide experienced technicians from his own staff to install the chute. The chute shall be installed in compliance with the manufacturer's standard instructions and shop drawings.

2.4.19 Testing And Commissioning

The manufacturer's technician shall test and commission the refuse chute system after repairing or replacing any damaged parts.

2.4.20 Acceptance

The manufacturer's certificate of acceptance shall be signed by the main contractor or client, on successful completion of this work.

2.5 VENTILATION AND AIR CONDITIONING

2.5.1 General

The Sub contractor shall supply and install ventilation and air conditioning (VAC) systems according to these specifications and the HVAC drawings, All the necessary elements and details for complete systems are to be included.

2.5.2 Scope Of Work

The Sub Contractor shall supply, transport to site, erect, connect and commission to full working condition all the plant and equipment. .

The Sub Contractor shall configure control equipment to achieve the sequence of operations specified for the different VAC systems.

Excluded from the Sub-Contract are:-

- a) All concrete works
- b) All block work
- c) Electrical wiring, isolators and switch boards, except internal wiring for control systems from a local isolator.

2.5.3 Drawings

The VAC drawings show the main layout and principles for the VAC systems The Sub-Contractor shall produce working drawings and details to the Engineer's approval before the work is executed.

It will be the Sub-Contractors duty to coordinate working drawings with other services involved and avoid any interference with them.

If some of the Sub-Contractor's installations require other contractors assistance such as foundations, etc. details of these items shall be submitted immediately after the tender process.

2.5.4 Materials And Workmanship

In the specifications and Bills of Quantities, materials are described according a given standard. In addition, equipment is described according to capacity and a particular make. In order to give each contractor a chance to offer her specific materials and equipment due to the various makes and qualities existing on the market, the contractor shall enclose with the tender documents details (leaf lets and brochures) of the materials and equipment offered.

The Engineer shall reject any makes which he finds to be of unsatisfactory quality. If the Architect or the Engineer finds it necessary, the Sub-Contractor shall submit samples of the materials for approval before placing an order or before the Sub-Contractor is appointed.

When the Sub-Contractor is appointed his work shall be carried out by competent workmen under experienced supervision. All plant and equipment installed shall be the equipment specified in the tender documents; alternative makes will not be considered.

In case of poor quality work or unsatisfactory equipment performance, the Engineer shall have the authority to have any work re-done and equipment replaced with adequate equipment.

The Sub Contractor shall ensure the protection of equipment, particularly sensitive or fragile items, from the activities of other trades during construction and from dirt.

2.5.5 Climatic Conditions

The following climatic conditions apply at the site of the Contract Works and all plant, equipment, apparatus, materials and installations shall be suitable for these conditions.

a)	Max. Highest Temp.	35 degrees Celsius
b)	Min. Lowest Temp.	13.3 degrees Celsius
c)	Mean Temp.	28 degrees Celsius
d)	Relative Humidity	50% - 92%
e)	Altitude	1312 meter A.S.L.
f)	Longitude	32 degrees 36' E
g)	Latitude	00 degrees 20' N

2.5.6 Design Conditions For Air Conditioning

I. Inside design temperature will be 23 degrees Celsius, dry bulb, 50% Relative Humidity

II. Outside conditions:

Temperature = 35 degrees Celsius, dry bulb; 24.4 degrees Celsius, wet bulb.

2.5.7 Ductwork

I. General

The Sub Contractor shall supply and install ductwork runs and sizes as shown on the Tender Drawings. Alterations will be permissible only after Engineer's approval.

The Sub Contractor shall be required to check all Architect's, Civil Engineer's, Structural Engineer's and other Contractor's drawings to ensure that the ductwork shall be accommodated within the structure and does not foul pipework, light fittings, electric trunking and all other services.

The Sub-Contractor shall check the building dimension and positions of plant on site before the fabrication of ductwork is started.

The Sub Contractor shall be responsible for taking all measurements on site that are necessary for the manufacture of and installing of the ductwork. The Sub Contractor shall make the arrangements, where necessary, for walls, doors, etc. to be down so that he can install the plant.

The Sub Contractor shall ensure maintenance of cleanliness of all plant and air supply and extraction systems during construction.

The Sub Contractor shall supervise the positioning of ducting deliveries and off-loading of the plant.

Duct runs shall be erected on the supports provided and aligned, prior to connections to items of equipment, to present a neat and workmanlike appearance with allowance made for all clearance for insulation and other adjacent services. Transverse joints for rectangular and circular ducts shall be made on site in a manner similar to that already detailed.

Transformation and taper pieces shall, wherever possible, be constructed so that the included angle does not exceed 30 degrees.

II. Material

a) Rectangular ducts

Ductwork shall be made from galvanised, cold rolled, close annealed patent flattened sheet steel. For any other type of duct material the Sub Contractor shall get its prior approval from the Engineer.

For ducts with the longer side equal to or less than 599mm, the thickness shall be 0.6mm.

For ducts with the longer side equal to or less than 1000mm, the thickness shall be 0.8mm.

For ducts with the longer side equal to or less than 2500mm, the thickness shall be 1.0mm.

b) Circular Ducts

Diameter (mm)	Thickness (mm)
160	0.6
510	0.7
630	0.8
1,020	1.0

III. Construction and Erection

All ductwork shall be constructed and installed in accordance with the Heating and Ventilating Contractors Association, specification for Sheet Metal Ductwork, DW 142.

All seams, joints and connections to plant shall be made so as to reduce air leakage to a minimum. Internal roughness and obstructions to airflow (other than from dampers, vanes) will not be accepted. Sharp edges on corners or on the inside and outside of ductwork, flanges, supports, etc shall be rounded off. Any part of galvanised ductwork where the galvanising is damaged during manufacture or erection shall be painted with two coats of aluminum zinc rich or other corrosion – resisting paint to the approval of the Engineer.

Where ducts pass through roofs (and external walls where applicable) shall be fitted with an angle flange and a weather cravat to ensure a weather-proof fitting to the building structure.

Connections to equipment shall be made with angle flanged joints. Ductwork which may have to be moved to enable plant to be removed or accessed for maintenance shall incorporate flanged joints. For long duct runs, angle flanged joints shall be included at intervals to facilitate any subsequent alterations.

Bends and offsets shall have a minimum throat radius equal to the width of the duct. Where short radius elbows are indicated or agreed by the Engineer as necessary due to site limitations the dimensions and internal vane(s) shall be in accordance with HVAC publication DW/121.

All openings for branches shall be cut before the ducting is erected and shall not be less than the connection dimensions.

When ductwork is run in false ceilings, bulkheads etc. the Sub Contractor shall ensure that adequate clearance is available for ceiling supports, light fittings and other services and equipment

III. Duct Jointing

The ductwork shall be installed with all joints air tight and adequately stiffened and braced where necessary to prevent vibration or drumming. All bends shall have the largest radius possible with a minimum throat radius of one diameter if possible. Square or mitre elbows will only be allowed where shown on the drawings. Turning vanes shall be fitted in square or miter elbows.

Branch ducts shall enter main ducts in expansion sections where possible. Where branch ducts occur, at taper or transformation pieces, the length of such pieces in the main duct shall be symmetrical about the axis of the branch.

Duct jointing shall be arranged with the following:-

- a) Longitudinal joints up to and including 1.2mm duct thickness with Pittsburgh lock, riveted at a maximum of 65mm centers.
- b) Joints between ducts riveted, flanged or bolted according to sheet metal gauge, and location.
- c) Slip joints with a minimum of 75mm slip and be taped with Arbol No. 1291 or equal and approved.
- d) Loose flanges fitted where the position of the ducts cannot be determined during planning.
- e) Jointing compound for sealing joints of the slip type. Sealing strips according to application between flanges. Particular attention shall be paid to the air extract duct joints where no leakage of air what so ever shall be permitted.
- f) Flanged drilled for 10mm diameter bolts at a maximum of 100mm centres, for duct sizes up to 760mm longest side, over 760mm longest side drilled for 10mm diameter bolts at 150mm centres except for holes in flanged connections to plant which shall be made with the plant flanges. All bolts, nuts, washers etc. shall be cadmium plated.

The use of Imes 'Pop' rivets and huck bolts will under normal circumstances not be allowed. The ductwork Contractor shall make specific reference in his tender to any constructional details on which his price is based which are not generally accepted practices, and written approval of such items must be obtained prior to manufacture.

- g) Air tight access doors shall be provided on the ductwork wherever indicated on the drawings. The access doors, of sufficiently heavy construction to avoid distortion, complete with handles, shall be secured by brass wing nuts screwed into studs provided, on galvanised mild steel stiffening frames riveted, or bolted to the ductwork. The access doors shall be provided with felt or rubber gaskets to ensure that when closed they are perfectly tight.

V. Brackets and supports

Supports and brackets for ductworks shall be made adjustable for height, spaced to ensure support and where practicable shall be fitted at each joint of the ductwork. Vertical ductwork shall be supported at each floor level, horizontal ducts at intervals not exceeding 2280mm and adjacent to fans, canvas joints and other equipment. All support members in close contact with metal ductwork shall be galvanised after fabrication.

Socketed joints shall have a minimum overlap of 50mm in the direction of flow. The joints shall be made with an approved type of jointing compound with bolts or rivets at centres not exceeding 50mm. Wherever access cannot be made for riveting or bolting self tapping screw of the shortest length which will give a satisfactory joint shall be used in lieu of the rivets or bolts, on size or diameters up to 530mm. All slip joints on circular ductwork are to have a spigot carefully swaged circumferentially to act as a stiffener and a register for the socket and control damper leaves shall be multileaf type. The quadrants shall be of robust construction and securely fixed to the ductwork.

The supports shall be:

- a) Fixed from a structurally sound part of the building by mild steel straps, hanging brackets on rolled steel angle.
- b) Spaced at not more than 3m centers and beneath vertical risers. Branches shall not be used as supports.
- c) For timber or heavy duty cork spacer between duct and the support where thermal insulation is specified; elsewhere felt inserts shall be provided.
- d) No drilling or burning holes and welding to the roof trusses and other building structural steel members shall be permitted without written permission from the Engineer.
- e) The corners of rolled steel sections shall be neatly trimmed off. Screwed rods used for duct hangers shall not project below the bolts.
- f) Equipment such as fans where fitted in ductwork shall be fitted with their own supports. The Sub contractor shall ensure wherever fans or similar equipment are connected to the ductwork system, the connections are made with a heavy duty rot or vermin proof neoprene or similar material, flexible connection to prevent vibration transmission to the duct work or building fabric. Flexible connection shall be secured by a pre-drilled mating flange, or when fixing to a spigot, the spigot should be beaded and a jubilee clip or split flat iron ring should be used.
- g) Where ductwork passes through the structure which is not a fire barrier, fireproof packing shall be provided between the duct and masonry with a mastic sealant.

h) Where ductwork passes through floors and walls, galvanised sheet steel sleeves or builders' work timber frames shall be provided. The space between duct and sleeve or frame shall be packed with asbestos rope or mastic to prevent air movement or noise transmission from one space to another. Ducts must not come into direct contact with the building fabric.

i) All supports and brackets shall be wire brushed and painted one coat of red oxide paint prior to and after erection. All nuts and bolts shall be sheradized. The fastening of electrical cables to ductwork will not be permitted.

VI. Flexible joints

Flexible joints shall be provided on fan inlet and outlet connections and elsewhere on the ductwork where indicated. They shall be over the full cross-sectional area of the mating fan inlet or outlet section. The ends of the duct and fan connections shall be in line.

Flexible joints shall consist of, or be protected by, material having a fire penetrating time of at least fifteen minutes when tested in accordance with BS 476 Part 1 Section 3. The material shall be of the glass fibre cloth type; canvas will not be permitted. The width of joints from metal edge to metal edge shall not be less than 80mm and more than 250mm.

All flexible joints other than fan inlet connections shall be between flanged ends. The flexible material flange shall be backed by an angle or flat iron flange and the flexible joint flat iron bar used with fan inlets shall not be less than 5mm thick.

VII. Flexible connections

Generally, flexible connections shall be fitted between rigid duct work and fans, air handling units, and grilles/diffuser in ceiling grids.

Where flexible connections are indicated or required, the internal diameter of the flexible duct shall be equal to the external diameter of the rigid ductwork and of the spigot type. The use of flexible duct between rigid sections of sheet metal ductwork to change direction or plane will not be permitted except where indicated or expressly authorised by the Engineer.

The flexible duct shall have a liner and a cover of tough tear-resistant fabric equal in durability and flexibility to glass fibre fabric and shall be impregnated and coated with plastics. It shall be reinforced with a bonded galvanised spring steel wire helix between the liner and the cover and an outer helix of glass fibre cord or equal shall be bonded to cover to ensure regular convolutions.

Alternatively the flexible duct shall consist of flexible corrugated metal tubing of stainless steel, aluminium, tinplated steel or aluminium coated steel. The metal may be lined on the inside or the outside or both with plastics materials

The joints to rigid spigots shall be sealed with a brush coat of pipe jointing paste or mastic compound. Ducts up to 150mm diameter shall be secured with a worm drive type hose clip complying with BS 3628. Ducts over 150mm diameter shall be secured with band clip.

The frictional resistance to air flow per unit length of the flexible duct shall not be exceed 50% more than the frictional resistance per unit length of galvanised steel ducts of equivalent diameter. The radius ratio R/D for bends shall not be less than 2, where R is the centre line radius and D is the diameter of the flexible duct.

The leakage from any section of flexible duct shall not exceed 1% of the design airflow rate at the static operating pressure. Flexible ducts shall be suitable for an operating temperature range of 180 degrees Centigrade to 1200 degrees Centigrade and shall comply with BS 476 Part 1, Section 2, Clause 7 (class1; surface of very low flame spread).

VIII. Test Holes and Access Doors

At least three test holes shall be provided adjacent to all plant, inlet and outlet louvres, at branches, after volume control dampers and elsewhere as required by the Sub Contractor for balancing the system. Test holes after dampers shall be positioned clear of the damper and at a position where the air stream is flowing evenly along the duct. Air tight swivel type metal covers shall be fitted over the test holes in such a manner that they shall be readily removed as required.

The contractor shall provide sufficient access doors for the purpose of maintenance and inspection. Access doors shall be of the hinged. Door openings in the ductwork shall be adequately stiffened and made airtight with purpose made rubber gaskets around the door perimeter.

IX. Duct insulation

Air conditioning ducts shall be insulated with 25 mm thick Armaflex thermal insulation covered with aluminum foil. Where the duct is exposed to the outside weather conditions, aluminum cladding shall be applied instead of aluminum foil.

2.5.8 Instruments

I. General

The instruments such as gauges etc, detailed in this section shall be provided in addition to those associated with specific items of plant and detailed elsewhere. They shall be mounted in accessible positions and shall be easily read.

II. Differential Pressure Gauges

Differential pressure gauges shall be of the Magnehelic type such as DWYER Instruments or approved equivalent

The differential pressure gauges shall be bi-directional to determine the proper direction of pressure with a range of -50Pa to +50 Pa and with a minimum diameter of 100 mm.

The pressure gauges shall be supplied complete with transducers. The transducers shall be bi-directional and shall incorporate low voltage cabling and step down transformer to 24 Volts).

IV. Filter Pressure Gauges

Diaphragm photohelic gauges shall be used to monitor the pressure differential of the HEPA and pre-filters. The gauges shall comprise a dial and pointer in metal case, vent valves and black figures on white background and a provision for a high static pressure signal to the Programmable Logic Controllers or Building Management System for alarm. The gauges shall be of DWYER Instruments manufacture or approved equivalent. Filter gauge static pressure tips shall be installed upstream and downstream of filters. Filter gauges shall be mounted on the outside of the filter housing in an accessible position.

2.5.9 Filters

I. General

The filter systems shall be manufactured under a Quality Assurance program that meets the basic requirements for ASME NQA-1, Quality Assurance Program Requirements for nuclear facilities. The manufacturers shall submit documented evidence that they have been independently audited by relevant approved authorities in the last three years to ASME NQA-1 requirements and that they passed all the three audits.

Temporary filters shall be used during construction testing. The temporary filters shall be replaced with new clean filters.

II. High Efficiency Particulate Air (HEPA) Filters

The HEPA filter shall have the capacity to remove at least 99.97% of all particles greater than 0.3micron meter in diameter with low initial and final pressure drop. The filter shall be made out of fiber glass media packs pleated in one piece and assembled to give lowest pressure drop. Each filter shall be sized and rated for the system airflow rate. The filter shall be tested and packed in accordance with American Standard IEST-RP-CC001.3 (HEPA and ULPA Filters) or in accordance with the European Standard EN 1822-1, 4&5 (Testing filter elements HEPA and ULPA efficiency and sacn method). A differential pressure gauge shall be fitted down stream of the filter and pressure transducers shall be fitted to monitor the pressure drop and communicate with the Programmable Logic Controller so that automatic adjustment of airflow is done when required to compensate for filter loading. The HEPA filter shall be housed together with a pre-filter in a steel housing and provision will be made for safe changing of the filters.

III. Pre-Filters

Pre-filters shall have a minimum efficiency of 60% with low initial and final pressure drop, high dust holding capacity and maximum burst pressures (greater than 3000 Pa). The filter shall be made out of fiber glass media packs pleated into one piece. The filters shall be sized and rated for the system airflow rate. The filter shall be tested according to European Standard EN 779 based on ASHRAE 52.1 guideline (Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices used in general ventilation removing particulate matter).

IV. Filter Housing

The filter housing shall accommodate the prefilter and HEPA filter. The filter housing shall be made out of Type 304 stainless steel. The filter housing shall be adequately reinforced to withstand a negative or positive pressure of 30 Pa. The filter housing shall incorporate a sealing surface that mates with the face of the filters. Access to the filters shall be on the side of the housing. Each tier of the filters shall be fitted with a filter clamping mechanism that is operated from inside the housing. The filter housings shall be equipped with filter removal rods to draw the filters to the change-out position. The removal rods shall be operated from inside the change-out bag and shall remove the filter by pulling against the top and/or bottom of the filter frame. All change out operations shall be within the bag so that there is a barrier between the worker and the filter at all times. The housing shall have a bagging ring around each filter access port. The housing shall be tested for filter fit, operation of the filter clamping

mechanism, sealing surface and leak tightness before leaving the factory. Both the filter sealing surface and the complete assembly pressure boundary shall be leak tested by the "Pressure Decay Method" in accordance with ASME N510-1995 "Testing of air cleaning systems". A positive sealing gasket material shall be incorporated on channels to seal top and bottom of filter cartridge frames to prevent by pass of unfiltered air. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1. The filter locking mechanism shall be tested at the factory to ensure that the system functions properly.

2.5.10 Dampers

I. Volume Control Dampers

Volume Control Dampers (VCD) shall be provided to regulate and balance the system. The VCDs shall be fitted in all branch ducts and on diffusers. The VCDs shall be of multi leaf opposed blade construction. All dampers shall be sufficiently rigid to prevent fluttering. Unless otherwise indicated the air leakage past dampers in the fully closed position shall not exceed 5% of the maximum design air flow in the duct. VCDs on diffusers shall be used for fine or secondary control. Manual dampers shall be worm geared, with a hand wheel, self locking in any position and equipped with a visual indicator to show the position of the damper position. The damper leaves shall be linked with a connecting rod and the ends of the spindle shall be housed in bearings. Dampers are to indicate the full and closed positions and are to be marked and then locked after air Volume has been set.

Where indicated, motorized dampers (damper with electric actuator) shall be installed. Electric rotary actuators shall be rugged, high torque, integral, single phase capacitor motors, equipped with factory set limit switches. The actuator will be equipped with a motor brake, a spring return to close upon loss of power, a manual wheel override and a digital damper position transmitter. The damper shall shut off volume flow in an air tight manner and should withstand duct pressure of 1500 Pa. Actuators shall be of Trox make or equivalent approved by the Engineer.

II. Fire Dampers

Each fire damper shall have at least the same standard of fire resistance as the wall or floor through which the duct passes, unless otherwise indicated it shall have a fire resistance rating of 2 hours (BS 476 Part 1). When a fire resistance of 4 hours is required either two dampers one on each side of the wall or a single damper having a fire resistance rating of 4 hours certified by recognized authority shall be provided.

In a horizontal duct the fire damper may be of either the single bladed or the multi-bladed pivoted type, in a vertical duct a multi-bladed damper shall not be fitted. Alternatively the folded continuous interlocked blade type of

damper may be provided; if this type is fitted in a vertical duct the closing force shall be provided by a stainless steel spring. A multi-bladed damper longer than 1000mm shall be controlled by two linkage tie rods.

Each fire damper shall be held in the open position by a releasing device consisting of a fusible link and either a stranded wire or steel strap. Alternatively the damper blade may be released by a fusible pin in cartridge housing. The fusible element shall operate at 700 degrees Centigrade. A door giving access to the damper blade (s) and the fusible element shall be provided in the damper casing or in the adjoining ducting.

2.5.11 Grilles, Diffusers And Louvres

I. General

The grilles, diffusers and louvers shall be of the type specified in the Bills of Quantities, positively and firmly located within the ductwork system. The Sub Contractor shall provide the necessary air seal between grille and structure in all cases. The Sub Contractor shall provide all accessories for connecting/adapting the diffusers/grilles to the ductwork.

All diffusers connected to ducting shall be provided with integral volume dampers of multi leaf opposed blade construction.

Fixing screws that are visible shall be of a non rusting type, the colour and type to be agreed with the Architect.

II. Louvres

The contractor shall supply and install at the termination of fresh air and exhaust air ducting at the external walls fixed louvred inlets and outlets with insect proof screens.

The louvres shall be of robust extruded aluminium alloy section or hot dipped galvanized mild steel construction.

The louvres shall have specially designed water shedding blades and shall be fitted with a galvanized steel wire mesh screen of 20mm diamond mesh and at least 2mm diameter wire, mounted in a frame of galvanized steel rod with securing lugs or flat galvanized mild steel.

Flanges shall be fitted with a returned edge, drilled for screw fixing.

III. Grilles

All supply and extract grilles shall be constructed from aluminium alloy or mild steel, with a finish of approved colour. Flanges shall be fitted with a return edge, complete with plastic foam or sponge rubber sealing gasket. The grilles shall be suitable for fixing to timber grounds, mild steel or plastic ducting. All grilles shall incorporate an aluminium alloy or mild steel

opposed blade, volume control damper adjustable from within the ventilated space without grille removal. Two sets of volume and pattern adjustment keys shall be handed to the Engineer.

IV. Diffusers

All air diffusers shall be constructed from aluminium alloy or mild steel and shall be of the sizes and suitable for the operating conditions indicated in the Bills of Quantities.

All diffusers shall incorporate an aluminium alloy or mild steel volume control damper adjustable from within the ventilated space without the removal of any part of the diffuser.

Two sets of volume control damper keys shall be handed to the Engineer.

V. Laminar Flow Panels

Laminar flow panels shall be perforated and made of stainless steel. The panels shall be supplied complete with plenum box and entry spigot.

VI. Transfer grilles

Transfer grilles shall be of the sizes and suitable for the operating conditions indicated in the Bills of Quantities. The grilles shall be manufactured from aluminium or mild steel with an approved finish.

The grilles shall be sight proof and rattle free with a flange auxiliary frame for the reverse side.

2.5.12 Fans

I. General

Fans shall be capable of the specified performance when tested in accordance with BS 848. Although the value of the resistance to airflow is indicated for the systems, this does not relieve the Sub Contractor of the responsibility for providing fans capable of delivering the required air volume through the system. Air supply fans shall have the specified filter assembly, anti vibration mountings and shall be supplied with specified starters of suitable rating incorporating over current and under voltage protection. The fans shall have an enclosure of IP 55.

The make and design of the fans shall be as indicated in the Bills of Quantities. If no particular make of fan is indicated, the Contractor shall submit full details of the fan including the drive and motor together with supporting evidence from the manufacturers of noise levels and efficiencies for Engineer's approval.

Belt driven fans shall be fitted with pulleys suitable for V-belts; pulleys of the taper lock type may be used for drives up to 30KW output. Alternatively, and in any case above 30KW output, pulleys shall be secured to the fan and the motor shafts by keys fitted into machined keyways. Pulleys shall be keyed to the fan shaft in the overhung position. Keys shall be easily accessible so that they can be withdrawn or tightened and they shall be accurately fitted so that the gib head does not protrude beyond the end of the shaft.

Machine bolts, nuts and washers only shall be used, for assembly of fans. All bearing surfaces for the heads of bolts or washers shall be counter faced.

Holding-down bolts for fans and motors shall be square section under the head or be fitted with snugs to prevent them turning in the base plate when the nuts are tightened.

Any fan which is too large or too heavy for safe handling shall be fitted with lifting eyes or other lifting facilities to enable mechanical lifting equipment to be used.

II. Noise level

The Sub contractor shall provide noise level information for fans based on octave analysis data. The reference level and the testing technique shall be stated.

The maximum sound pressure level measured at any point 3 m from the fan (extract fan, AHU fan and condenser fans) shall not exceed 60 decibels.

The noise criteria level (NC) shall not exceed 40 decibels for Laboratories and 35 decibels for offices and training areas.

2.5.13 Air Cooled Liquid Chillers

The chillers shall be of the air cooled type and shall be installed outdoors in the open. The chillers shall therefore be capable of withstanding exposure to weather conditions at the site location and shall be capable of operating satisfactorily at the specified site outdoor conditions, and at part load. The chillers shall use ozone-friendly refrigerant [chloro fluoro carbon (CFC) free refrigerant] and the refrigerant circuit shall be leak tight. The liquid to be chilled shall be water. A hydronic module unit (pump, expansion tank, a vent valve and automatic water fill, pressure gauge) shall be integrated in the unit chassis. The chiller shall use inverter technology and rotary or scroll compressors and shall be highly energy efficient, rated Class A with an Energy Efficiency Ratio (EER) of greater than 3.2 in the cooling mode. The control system shall be micro processor

based integrating features such as fault diagnosis, incident history recording capability, a night mode limiting capacity and fan speed, an operator interface and a Building Management System (BMS) interface.

The condenser fans shall be of either variable speed or twin speed.

The chillers shall be supplied already charged with refrigerant and ready for connecting to power and water supply and return piping. The electrical supply at the site location is 415 V, 3 Phase 50 Hz. The chillers shall incorporate anti vibration mountings. The make of the chillers shall be CARRIER or an equivalent approved by the Engineer.

2.5.14 Air Handling Units

The Air Handling Unit (AHU) shall be installed outdoors in the open. The AHUs shall therefore be capable of withstanding exposure to weather conditions at the site location. The make of the AHU shall be CARRIER or an equivalent approved by the Engineer.

The design of the AHU shall be based on the use of modular panels and extruded aluminium perimeter frames. Units shall be of horizontal draw through type and shall consist of a primary filter section, a coil section, a fan section and final filter section. Some AHUs shall have a mixing box section. The unit shall be supplied with a welded unit base with holes for rigging located to suit optimum hoisting stability.

The section panels shall comprise two layers of steel with injected in situ 25 mm CFC free Polyurethane insulation of thermal conductivity of 0.017 W/mK and density of 40 kg/cu meter. Removable panels shall be provided on all sides of the unit with hexagonal socket compression type latch assembly and large non conductive handles. All external panels shall be pre painted zinc-alum. Internal panels shall be galvanized steel sheet.

The fan shall be of the forward curved centrifugal type. The blade of the curved lades shall be galvanized steel. The fan assembly shall be statically balanced to the 80% of the maximum fan speed. Factory or field furnished and installed fan motors shall be mounted inside the fan section on the mounting base. The fan drive package shall consist of foxed pitch fan and motor pulleys and V-belts. The fan and motor assembly shall be mounted on an adjustable common base with factory supplied internally mounted spring isolators or rubber isolators. The fan discharge shall be square in area and flanged and isolated from the casing by a fire retardant grade flexible connection.

The motor shall be of the totally enclosed fan cooled (TEFC) suitable for use with 415 V, 3 Phase 50 Hz electrical supply. The motor speed shall controlled by a variable frequency drive (VFD). Provision shall be made to automatically adjust airflow to compensate for filter loading.

The AHU shall have primary and secondary filter sections. The filters shall be removable and shall be capable of achieving efficiencies of a minimum 60%, with low initial and final pressure drop, high dust holding capacity and maximum burst pressures (greater than 3000 Pa). The filter shall be tested according to European Standard EN 779 based on ASHRAE 52.1 guideline (Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices used in general ventilation removing particulate matter). Provision shall be made for monitoring the pressure drop.

The mixing boxes shall be parallel bladed, interconnected outside and return air dampers. Damper blades shall be brake formed for stiffness and shall be mechanically secured to steel rods rotating in nylon bushings and mounted in rigid powder painted steel damper frames.

Chilled water coils shall be of the cartridge type, mounted over the condensate drain pan. Coils shall be tested to 2760 kPag air pressure while submerged in water. Coil performance shall be rated in accordance with ARI Standard 410. Chilled water coils shall have aluminium/copper fins and a galvanized steel casing. Coils shall be drainable and have non air trapping circuits and counter flow arrangements. The coils shall be removable via coil tracks.

The condensate drain pan shall be constructed in 16 gauge powder painted galvanized steel and it shall be constructed in slope with a pipe connection routed through the bottom for drainage, in accordance with ASHRAE 62-89 Standard. The drain pan shall be accessible for inspection and cleaning.

2.5.15 Variable Refrigerant Volume (Vrv) Systems

VRV systems shall comprise outdoor units (ODUs), refrigerant circuits and indoor units (fan coils). The VRV systems shall use ozone-friendly refrigerant [chloro fluoro carbon (CFC) free refrigerant] and the refrigerant circuits shall be leak tight. The make of the ODUs and fan coils shall be TOSHIBA or an equivalent approved by the Engineer. The control system shall be micro processor based integrating features such as fault diagnosis, incident history recording capability, an operator interface and a Building Management System (BMS) interface.

The Sub Contractor shall be required to supply all the accessories required for a complete VRV system including the refrigerant, insulated refrigerant interlocking copper pipes, insulated branch liquid/gas sets and insulated headers and, pvc drain pipes. The refrigerant pipe insulation shall be 18 mm thick and of Armaflex make or approved equivalent. The Sub Contractor shall ensure that the manufacturer's specified height differences between indoor units, and, the maximum refrigerant piping lengths are not exceeded.

The ODUs shall be of the air cooled type and are to be installed outdoors in the open. The ODUs shall therefore be capable of withstanding

exposure to weather conditions at the site location and shall be capable of operating satisfactorily at the specified site outdoor conditions, and at part load. The ODUs shall incorporate inverter technology and rotary compressors and shall be highly energy efficient, with Class A rating and an Energy Efficiency Ratio (EER) of greater than 3.2 in the cooling mode..

The fan coils shall be located in the locations shown on the tender drawings and shall be supplied with the necessary brackets and fixtures. The fan coils shall fit flush into ceilings and shall match standard architectural modules without cutting ceiling tiles. The fan coils shall incorporate drain up pumps and fresh air knockouts. The fan coil units shall be controlled by wall mounted 3 speed control units. The fan coils shall be for "cooling mode" application.

2.5.16 Variable Frequency Drive / Controllers (Vfd)

The VFD shall provide variable speed to 3-phase, 415 Volts, 50Hz induction motors by adjusting output voltage and frequency and shall incorporate line harmonic filters. The VFD shall be suitable for the specified loads and shall have 100% of rated torque throughout the voltage range and an operational range of 5 to 55 Hz. The VFD shall be complete with protection devices, providing protection against under and overvoltage, inverter overtemperature, overcurrent, motor overload, loss of phase, reverse phase and short circuit (as a minimum). The VFD shall be supplied complete with electrical control accessories. The VFD shall be of SIEMENS make or an equivalent approved by the Engineer.

2.5.17 Programmable Logic Controllers (Plc)

Programmable Logic Controllers (PLC) shall monitor, control and sequence activities to match the design operational parameters. The PLC shall be pre-programmed and with enough digital and analogue input and output ports. Through the input ports, the PLC will interpret logical states from sensors/transducers, and through output ports, the PLC will send signals to controlled equipment/devices. The PLC shall have a selector switch to enable selection of one of three programmed operating positions of Off, Occupied and Unoccupied/Night. In the 'Off' position, the ventilation equipment will be completely switched off including supply and exhaust fans. The 'Occupied' setting position will be for normal operations with all fans at set point as programmed. The 'Unoccupied/Night' setting, shall be used when the Laboratory is not in use and for night set back. The PLC shall incorporate a human interface in form of an LCD screen, displaying the status of controlled parameters. The PLC shall be programmed under the IEC 61131-3 Standard, Standards based programming languages such as ladder diagram. The PLC shall operate under the electrical supply conditions at the site. The PLC shall have an integral Human Machine Interface (HMI) which allows monitoring and changing of internal parameters. The PLC and HMI shall be of SIEMENS make or an equivalent approved by the Engineer.

2.5.18 Room Pressure Monitor

The Sub Contractor shall provide room pressure monitors to display pressure in the Laboratories. The room pressure monitor shall have a digital display indicating the measured pressure in Pa with a range of -50 Pa to +50 Pa. The room pressure monitor shall be supplied with pressure transducers which will also be linked to the overall controller for a given Laboratory. The room pressure monitor shall be factory fabricated with an industrial grade metal case for mounting on a snap on bracket provided by the manufacturer. The controller shall mount to the bracket attached to a wall inside the controlled space. Two indicator lights shall be shown on the front of the controller indicating the following conditions RED for alarm conditions and Green for normal conditions. The room monitor shall incorporate an audible alarm that is triggered by alarm conditions, and an alarm mute switch.

2.5.19 Split Units

The split units shall comprise a condensing unit, refrigerant circuits and indoor units (fan coils). The fan coils shall be for cooling mode only. The split unit shall be protected against voltage fluctuations by an automatic voltage switch. The split units shall use ozone-friendly refrigerant [chloro fluoro carbon (CFC) free refrigerant] and the refrigerant circuits shall be leak tight. The split units shall be highly energy efficient, rated Class A with an Energy Efficiency Ratio (EER) of greater than 3.2 in the cooling mode. The make of the split units shall be DAIKIN or an equivalent approved by the Engineer.

2.5.20 Electrical Installations

I. General

The Sub Contractor shall be responsible for the accuracy of all wiring diagrams provided by him and for the correct internal wiring of all pre-wired equipment supplied for the contract. The Sub Contractor shall ensure that the Programmable Logic Controllers provide the coordination of the specified operations for the different Laboratories.

Unless otherwise indicated all electrical equipment and installation shall be suitable for use in ambient temperatures up to 40 degrees Centigrade and relative humidity of up to 90%. The electrical equipment shall be proofed against atmospheric corrosion, and electrical materials shall not be susceptible to mould growth or attack by termite and similar hazards.

The electrical installations shall be in accordance with the Regulations for Electrical Installations in Buildings of the Institution of Electrical Engineers. The installations shall comprise power supply to all power consuming units of the VAC systems, signal and control wiring. The supply shall include

cables, temperature and pressure control devices, switchgear, control panels with all safety devices, circuit components and all accessories. The electricity supply is 415 Volts(3 phase) and 240 Volts (1 phase), 50 Hz. The control voltage shall be 24 Volts. The electrical equipment shall be rated for continuous operation and capable of driving full load without derating under the site conditions.

The Sub Contractor shall provide protection to electrical equipment from damp during construction and commissioning.

II. Control panels

As far as is practicable, all controls, indicator lamps shall be grouped and mounted together in a floor or wall mounted panel.

Control panels shall be constructed of folded mild steel sheet of minimum thickness 2.5mm or of mild steel angle frame which supports sheets of mild steel or of a proprietary system of construction, as approved by the Engineer.

No sharp edges or corners will be allowed, and all exposed screws, bolts or other fittings shall have rounded heads with protective and decorative plating. Panels shall be adequately stiffened and reinforced as necessary to ensure rigidity. A metal plinth shall be provided with provision for bolting down the floor mounted cubicle. Lifting eyes shall be provided for convenience of handling.

Panels shall be painted internally and shall also be finished externally with a semi gloss sprayed or cellulose enamel finish as approved by the Engineer. All surfaces shall be properly prepared before final finishing and the external appearance shall be of a high standard.

All indicating lamps, instruments and controls shall be, as far as is practicable, of the same manufacture and style to provide uniformity of appearance and to facilitate maintenance. Externally visible equipment shall be flush mounted, with minimum projection and fixed securely to the front panels or other members. Internal equipment shall be secured to purpose made rails or mounting bars. All fixing shall incorporate shake proof washers or other vibration resistant fastenings.

Indicator lamps shall be clear. Glasses of not less than 25mm diameter shall be fitted. Where indicator lamps are not immediately adjacent to their associated switches they shall be clearly labeled.

The precise sitting of the control panels shall be agreed with the Engineer and whilst providing good visibility of the plant shall not interfere with the facilities for maintenance and cleaning of plant.

Internal wiring shall be coded and in general shall be bunched and run on trays or in purpose-made slotted plastic cable trunking. Positive fixing of

cable ends shall be ensured by purpose made clamps, or pinch type terminals, or by the use of crimped cable tags or other approved termination devices. All cable ends shall be permanently identified.

Grouped terminal blocks of adequate capacity with permanent labels shall be provided for all wires leading to equipment outside the cubicle or panel. Removable covers or other facilities shall be provided for the entry of incoming cables, conduits, trunking, etc., with means of effective earthing to the panel chassis.

If main power terminals are incorporated within the control panel, soldered socket type terminals shall be provided.

Fuses shall be grouped and mounted so as to be readily accessible without danger. Fuses, terminal blocks and all items of equipment shall be readily identified by means of clearly visible labels secured to them by screws or by other approved methods.

All items on the outside face of the panel shall be identified by means of attached white laminated plastic labels engraved with black cyphers.

The layout of the control panel shall be agreed with the Engineer before manufacture. A neat and orderly arrangement is required. Equipment shall not be fixed to panels removable for maintenance and not, as far as is practicable, to opening doors.

The control cubicle panel, as far as is practicable, shall be manufactured, equipped, wired and tested before delivery to site.

III. Electric Motors

Electric motors shall comply with BS 170 and BS 2048 or with BS 2613 and BS 3979 as appropriate. All motors shall have Class E insulation (BS 2757) and be continuously rated.

The motors shall be screen protected (BS 2817) unless otherwise indicated. Each motor shall be adequately rated to drive the fan, pump, compressor etc. under all normal conditions without being overloaded. All motors larger than 0.75kw output shall be three phase, for motors above 15kw output the type of motor and method of starting shall be such as to limit the starting and run-up currents to three times the rated full load current unless otherwise indicated.

2.5.21 Commissioning

Each VAC system shall be tested, adjusted, balanced and fully commissioned to confirm that the system functions as per design specification and objectives. The Sub Contractor shall provide for testing, balancing and measuring equipment/instruments. The Sub Contractor shall engage a certified testing, adjusting and balancing agent, and an

authorised manufacturer's representative trained and approved for installation of system control equipment. In general, the following aspects shall be checked:

- a) Air systems,
- b) Hydronic piping systems,
- c) VAC quantitative performance settings,
- d) Space pressurisation,
- e) Indoor air quality,
- f) Proper setting and functioning of control devices including the safety interlocking systems, and noise levels.

In the case of the BSL3 Laboratory, particular attention shall be paid to:

- g) Room integrity test to identify leakages that require sealing.
- h) Directional flow test to confirm that there is no turbulence at the face of the bio safety cabinets when the laboratory is in normal use.
- i) Average room air velocity which shall not exceed 0.50 m/s
- j) Air supply and exhaust volumes
- k) Shut down test to verify performance of the PLC controller and the supply and exhaust fans to confirm that if the exhasust fan fails or is switched off, the Laboratory will not become positive
- l) HEPA filter integrity to ensure that there are no leakages or excessive pressure.

2.5.22 Operating And Maintenance Instructions

The Sub Contractor shall provide training to such staff as the Client shall nominate, on all installed VAC equipment. The training shall include operation and maintenance of the equipment and the VAC Systems.

The Sub Contractor shall provide three sets of operating and maintenance instructions which shall be enclosed in durable covers. The operating and maintenance instructions shall include;-

- I. A brief outline of the operation of the plant.
- II. Instructions on how to start and stop the plant, noting any safety and/or sequencing arrangements.

- III. Details of required maintenance with suggested frequency of action
- IV. Details of all lubricants and gases required and filter replacement.
- V. Details of each item of plant including the name and address of the manufacturer, type and model, serial number, duty and rating.

2.5.23 Spare Parts

The Sub-Contractor shall submit with the tender a priced list of any recommended extras which are not supplied as standard and the recommended running stock of spare parts for the maintenance of the equipment.

2.5.24 Documentation And As Built Drawings

The Sub Contractor shall provide, in the English language, full documentation including installation, startup, testing and operation verification and commissioning reports for all VAC equipment and plant installed.

The Sub Contractor shall provide technical and operation manuals of the various VAC equipment, including, fans, air handling units, VRV equipment, chillers and all electronic control equipment

After completion of the Contract works, the Contractor shall submit as built drawings to be approved by the Engineer after which the Contractor shall submit to the Engineer two soft copies on CD, and two complete sets of prints of as built drawings showing the complete installation.

2.5.25 Design Review Meeting

The Sub Contractor shall provide for a meeting between the Client's representative, the Architect and the Engineer, prior to making shop drawings and confirming orders for equipment. The objective of the meeting is to ensure that all parties develop a mutual understanding of the project requirements including the design and operating parameters and the specifications.

Part 3
General Specifications for Electrical Services

3.1 GENERAL SPECIFICATIONS FOR ELECTRICAL WORKS

3.1.1 Introduction

This section of the Specification deals with the general standards of materials and workmanship and approved methods in connection with the design, manufacture and installation of the electrical services. This section must be read in conjunction with other sections of the Specifications and Drawings and schedules issued herewith.

Except for materials or items or equipment which are specified as being supplied and/or fixed for the works by others, these works shall include the supply, testing and delivery to site, erection, connection, finishing and putting into service of the whole of the materials, fittings and all cables and conduits necessary for the electrical installation works as specified and scheduled herein and/or indicated on the drawings issued herewith.

Materials and products shall comply with the following:

- a) This Specification
- b) Appropriate British Standard (BS) Specifications and Codes of Practice (CP). Particular mention is made to BS7671: 1992 "Requirements for Electrical Installations" (IEE Wiring Regulations Sixteenth Edition) including all current amendments and the Standards of the International Electro-technical Commission (IEC) Publication 364 "Electrical Installations in buildings".
- c) Government Rules
- d) Local Authority's Bye-laws and Regulations
- e) Electricity Supply Authority's requirements
- f) Fire Prevention Officer's requirements
- g) Health and Safety at Work regulations

The Contractor shall notify the Engineer of any revisions or additions to the foregoing as they are published during the installation of the Works for the Engineer's decision and instructions.

The Contractor shall pay all charges necessary for any Authority's approval of any part of the works.

I. Suitability of Materials

Materials and products shall be supplied to suit the temperature and other conditions of use normally expected to apply after the installation is completed, and also to withstand any test specified herein or in any document referred to herein.

II. Definitions

For the purpose of this Specification:

a) The definitions given in BS 7671:1992 Requirements for Electrical Installations (IEE Wiring Regulations 16th Edition) referred to hereinafter interchangeably as the IEE Wiring Regulations or BS 7671 shall apply.

b) The words "weatherproof" and "dust protected" shall have the meanings ascribed to them in BS 2817, definitions 13 and 178 respectively.

c) As applied to steel conduits and fittings, the words "protection against corrosion according to class 2" (or to class 4) shall have the following meaning:

Class 2 - Medium protection both inside and outside (e.g. stoved enamel, air drying paint).

Class 4 - Heavy protection both inside and outside (e.g. hot dip zinc coating, shearadizing).

d) As applied in cable trunking (steel surface) the words "protection against corrosion according to class 3" shall have the meaning:

Class 3 - Heavy protection both inside and outside (e.g. galvanized steel complying with BS 2989, Class 2A or 2B).

III. Standardization

For the purpose of this Specification, the following equipment shall be standardized throughout the installation:

- a) LV distribution and sub-distribution cabling.
- b) Distribution boards.
- c) Wall mounted switch fuses and isolators.
- d) Socket outlets, spur units, lighting switches etc.

Every item of equipment shall in each of the above groups be of the same make and type unless otherwise specified.

IV. Methods of Fixing

The size of bolt or screw used must be the nearest permitted by the diameter of the hole in the equipment to be used.

All bolt or screw holes provided in equipment shall be used and in each, fixing must be secure.

All screws and bolts shall be sheradized. For fixing in block, brick or concrete, holes of the correct size for screws or bolts shall be neatly drilled with tungsten carbide tipped twist drill to a depth (excluding plaster thickness) equal to the length of plug to be used. The plug length must be correct for the screw. Fixings shall not be made between joints in blockwork or brickwork.

All fixings required to pre-cast concrete wall planks shall be drilled and plugged. Under no circumstances shall "shot fired fixings" be used.

Conduit boxes shall be fixed by two roundhead screws.

Countersunk screws shall only be used where countersunk holes are provided, otherwise the wood screws shall be roundhead and setscrews shall be cheese head. Where holes have to be drilled for fixing, No.10 wood screws shall be the minimum size used. Fixing screws used in conjunction with Class 3 and 4 conduit and trunking shall be stainless steel.

V. Lightweight Accessories

Fixing to hollow partitions etc. where the hole is bottomless shall be by means of rawlplug screw anchors.

Fixing to supporting metalwork shall be made where possible, by means of setscrews or bolts and nuts of appropriate size for the equipment, holes being drilled to correct size. Each bolt and setscrew shall be fitted with a plain washer and shakeproof washer under the nut. Where it is not possible to fit a nut, a tapped hole shall be provided.

Fixings to structural steelwork shall be to the approval of the Engineer.

3.1.2 Polyvinyl Chloride (Pvc) Or Cross Linked Polyethylene (Xlpe) Insulated, Single Wire Armoured And Pvc Sheathed Cables

This section of the Specification deals with all main, sub-main and sub-circuit wiring specified to be carried out in PVC or XLPE insulated PVC bedded, single wire armoured and PVC sheathed overall cable with copper conductors.

I. British standard

The cables and associated materials shall comply with the following British Standard Specifications, unless otherwise stated:

- a) BS 1442 - Galvanized mild steel wire for armouring cables.
- b) BS 5467 - Specification for cables with thermosetting insulation for electricity supply.
- c) BS 6346 - Specification for PVC Insulated cables for electricity supply.
- d) BS 6360 - Specification for copper conductors in insulated cables and cords.
- e) BS 6746 - Specification for PVC Insulation and sheath of electric cables.

II. Cable Type

PVC or XLPE insulated power cables shall have copper conductors, PVC sheath, single steel wire armour and PVC sheath overall.

III. Cable Support System

The cable support system shall be constructed from galvanized cold rolled steel sections. No section shall be smaller than 41mm x 41mm or manufactured in a material of thickness less than 2.7 mm. The support system shall be capable of accepting the cable cleat fixing bolts or studs.

Unless stated otherwise, racks shall be designed to accommodate additional cables to the extent of 20% of those to be installed under this Contract.

The spacing of the racks shall not be greater than that set out in the IEE Wiring Regulations or specified elsewhere in the contract documents.

IV. Method of Installation - General

Except where special structures such as cable bridges are required, the whole of the supporting steelwork, racks, trays, cleats, clips etc. shall be supplied by the Contractor.

All cables shall be run with particular regard to neatness of appearance, multiple runs shall be marshaled so that cables entering or leaving the crossover shall be kept to a minimum.

a) **Cable Glands**

All cable glands shall be of the correct type and size for the specific application and location.

Cable glands for PVC or XLPE insulated cables shall be of the two-stage type, which grip both the cable sheath and the armouring independently and incorporate an external earthing lug. A PVC shroud shall be used with all cable glands.

b) **Straight Through Joints**

Each cable shall be run in one continuous length. No joints will be permitted unless otherwise agreed by the Engineer.

c) **Bending Radii of Cables**

Bends in cables shall be as large as possible and in no case shall the bending radii of any cable be such that the cable may suffer damage.

d) **Cleats and Saddles**

Cable cleats shall be manufactured in pressure diecast silicon aluminium grade LM6 to BS 1490. Cable cleats shall be manufactured in two identical halves and secured to the support system by two studs or bolts suitable for fixing to the support system. These shall be provided in vertical and horizontal runs of cables at intervals of not more than 1.2 metres.

Single core cables carrying alternating current for three phase working shall, as far as possible, be arranged in trefoil formation with the cables touching and where departures from the trefoil arrangement cannot be avoided, approved arrangements shall be employed to minimize sheath currents or other undesirable effects.

The cleating arrangements for single core cables shall be of sufficient strength to withstand the forces setup during short circuit conditions.

Where installed on trays, cables not provided with cleats shall be secured by heavy gauge copper or plastic coated clips or saddles at intervals of not more than 1.2m, not more than six cables shall be embraced by one clip, and not more than two layers of cables shall be run on one way.

Where installed on flat surfaces, cables shall be secured by cable cleats at intervals of not more than 1.2 metres.

Every cable shall be securely supported throughout its length and at a point not more than one metre from its termination, and on vertical routes passing through a floor, immediately above the floor.

e) **Cable Identification**

Each end of cable shall be provided with an identification label, which shall be lettered to the Engineer's instruction.

Labels shall be permanently attached to the cables in an approved manner; loose tags will not be accepted.

The materials of the labels and fastenings shall be such as to avoid corrosion due to incompatibility of materials and to ensure permanent legibility.

f) **Cables Installed in Service Ducts. Cable Tunnels and Fire Ducts**

Where installed in service ducts, cables shall be installed at least 25mm clear of walls and ceilings on cable cleats. Cable cleats shall be fixed to the galvanised rolled steel cable support system at distances in accordance with IEE Wiring Regulation.

Where cables emerge from a service duct and rise up a wall, a length of suitable sized galvanised steel pipe, bushed at each end shall be threaded over the cable to 450mm above floor level and so positioned as to protect the cable from mechanical damage.

Where cables are detailed to be drawn into ducts, cable pulling eyes shall be used and the cable shall be supported on rollers without sharp edges during drawing operation. All cable ducts shall first be cleared and proved by drawing mandrel of slightly less diameter than the duct immediately before pulling in the cables. Any lubricant used shall have no deleterious effect on the cables.

Where draw-in pits are inserted in the route, they will be of such size that no undue strain caused by bending radii is placed upon the cables. Minimum bending shall be as specified.

Cable rollers shall be used when drawing cables into a pit to ensure that no undue strain is placed on the cables.

After the cable is taken off the drum and flaked, the bending radii shall not be less than those stated for the installation.

After the cable is installed in a duct, the Contractor shall supply and install a suitable purpose made sealing gland assembly within each duct to prevent the ingress of water and fire to ensure that a complete watertight seal is provided.

g) **Termination of PVC and XLPE Insulated Cables**

The method of stripping the sheath, filler and insulation, shall be as recommended by the cable manufacturer, and shall be such that no damage is caused to the insulation or conductor.

Each cable gland shall be fitted in accordance with the manufacturer's recommendations.

3.1.3 Elastomer And Polyvinyl Chloride Insulated Cables Enclosed In Heavy Gauge Conduit And Metal Trunking

I. General

This section of the Specification deals with main, sub-main and sub-circuit wiring specified to be carried out in VR, EPR, BR, SR and PVC insulated cables drawn into heavy gauge conduit or installed in cable trunking.

Recognised good engineering practice shall be adopted for all conduit runs and no conduit shall be run in such a way as to provide a trap for moisture condensation.

Precautions shall be taken to prevent the ingress of moisture, silt, brick and concrete chippings etc. into the conduit system during and after the installation of same. Hexagonal headed stopping plugs shall be fitted to the ends of all conduits not connected to fixing and outlet boxes. Where condensation has occurred, the conduits shall be thoroughly dried by drawing swabs through it. The inside of all conduits shall be free from burrs or other obstructions.

Where conduits enter the building from outside or in other positions and where in the opinion of the Engineer there may be substantial difference in temperature between different parts of the conduit system, junction boxes shall be inserted into the conduit system and filled with plastic compound to impede the free movement of air in the conduits.

II. Cables

Cables shall be single core, insulated but non-sheathed and shall comply with the following:

a) BS 6004: Specification for PVC Insulated Cables (None Armoured) for Electric Power and Lighting.

b) BS 6007: Specification for Rubber -Insulated Cables for Electric Power and Lighting.

The rated voltage of all cables shall be 600/1000 volts.

Cable joints shall only be made at main switches, distribution boards, ceiling boxes and fixed accessories. No joints shall be made in joint boxes unless the special permission of the Engineer is first obtained.

All phase cables shall be red, yellow or blue, neutral cables black and circuit protective conductors yellow and green. All single pole switches shall be connected in phase cable.

Conduit and cable trunking capacity as set out in the IEE Wiring Regulations shall not be exceeded.

III. Conduits and Fittings

a) Steel Conduits and Fittings

Steel conduits shall be new, heavy gauge, welded and screwed, enamelled or galvanised as specified and shall comply with BS 4568: Part 1. Each length of conduit shall bear a stamp guaranteeing it to be to this standard. The use of conduit less than 20mm diameter shall not be permitted.

All conduit fittings and accessories, including couplers, ordinary clips, saddles, pipe hooks, screwed reducers, stopping plugs, nuts and male and female bushes shall comply with BS 4568 Parts 1 and 2 where applicable.

All screwed couplers, reducers, unions and lock nuts shall be made of malleable iron and all stopping plugs, male and female bushes made of brass. Round locknuts only shall be used on surface work.

b) PVC Conduits and Fittings

PVC conduits shall be new, heavy gauge, super high impact as specified and shall comply with BS 4607 and BS 6099. Each length of conduit shall bear a stamp guaranteeing it to be to this standard. The use of conduit less than 20mm diameter shall not be permitted.

All conduit fittings and accessories, including couplers, ordinary clips, saddles, reducers, stopping plugs, male and female bushes, etc. shall comply with BS 4607 and BS 6099 where applicable.

All couplers, reducers, unions, lock nuts, stopping plugs, male and female bushes shall be made of uPVC. Round lock nuts shall be used on surface work.

Solid or Inspection Elbow, Bends, Tee and Inspection Couplings shall not be used.

For wiring purposes all draw-in and inspection boxes must be installed in readily accessible positions as agreed with the Engineer.

Where cables under 6mm² are being drawn-in, through boxes shall be used to minimise bending of cables. The heavy duty type fitted with neoprene gaskets shall be used for external work. The inside surface of erected conduit and fittings shall be smooth and free from burrs and other defects.

Where boxes are flush with the ceilings or wall surfaces approved break joint rings shall be provided where necessary to hide the joint.

c) Conduit Joints

Joints in steel conduits shall be made tight by painting the threads just before jointing with an approved aluminium paint to help prevent corrosion and to ensure a high conductivity joint.

Joints in PVC conduits shall be made with specially prepared waterproof adhesives of appropriate types for the joint.

Running joints shall be used only where absolutely necessary; they shall be painted with two coats of the above aluminium paint as soon as they have been tightened.

Conduits crossing expansion joints in the concrete shall be jointed by means of an expansion coupler. The coupler shall be wrapped with waterproof building paper for a distance of 300mm on either side. An inspection box shall be fitted as close as possible on each side of the expansion coupler and a copper protective conductor complying with the IEE Wiring Regulations installed in the conduit between the boxes. The protective conductor shall terminate at each box by means of a M4 brass roundhead tapped onto the bottom of the box and 2 No. flat brass washers.

d) Inspection Boxes

Small standard circular conduit boxes shall be provided and fixed at all junctions and the necessary angles and bends of the conduits.

For surface work, boxes of the raised back pattern shall be used.

Conduit boxes mounted outside a building shall have external fixing lugs. Boxes shall be fitted with light steel covers when used internally, overlapping type on flush work, and recessed covers when used externally and in damp situations.

To ensure adequate earth continuity and fitting it is essential that the correct size hole is cut. Holes shall be formed using a hole cutter of approved design. A ring saw cutter must not be used.

No more than two right angle bends or equivalent sets must be made in conduit runs between inspection boxes. On straight runs inspection boxes must be fitted after each second conduit length.

Corners shall be turned by easy bends or sets made cold without altering the section or opening the seams of the conduit. No bend shall have an outside radius of less than three times the external diameter of the conduit. All bends must be machine made.

Where conduits are installed side by side, all off-sets shall be similar and where off-sets are necessary at switch boxes, distribution boards etc. they shall be as short as possible.

Where bending of the conduit causes damage to the paint finish, it shall be made good immediately with high quality matching paint.

Sheet steel adaptable inspection boxes shall be provided and fixed in inspection positions where more than two conduits cross. These boxes shall be 150mm x 150mm x 50mm deep. Where the boxes are fully recessed they shall be provided with 2mm mild steel lids overlapping the boxes 5mm all round.

In damp and external situations, malleable cast iron adaptable boxes shall be used. The boxes shall be provided with neoprene gaskets and malleable cast iron lids secured by four M4 brass roundhead screws. The boxes shall have external fixing lugs.

Boxes shall be fixed with a minimum number of two No.10 round brass screws in plastic wall plugs.

No more than three conduits up to 25mm diameter will be allowed per side on the above adaptable boxes. Where more than three conduits per side occur, proportionally larger boxes shall be used. Deeper boxes shall be provided for conduits larger than 25mm diameter.

Conduits shall be terminated to adaptable boxes, distribution boards, consumer units, switches etc. by means of smooth bore male brass bushes and couplers.

Spanner or purpose made tools shall be used to tighten all conduit fittings. Pliers or toothed wrenches shall not be used.

Where boxes are flush with the ceiling or wall surface approved break joint rings shall be provided where necessary to hide the joint.

IV. Flexible Conduit

Where specified, final connection to machines and other items of apparatus shall be with flexible conduit.

The flexible conduit shall consist of a single layer of leaded steel, sheathed with PVC. The flexible conduit shall terminate in couplings with threaded internal sleeve and plastic male bush.

The interconnection between the solid and flexible conduit shall be via a small circular conduit box.

A separate copper protective conductor complying with IEE Wiring Regulations must be included within the conduit and be connected to a brass earthing terminal at each end. Brass washers must be placed above and below the earth wire on the terminals. On no account must a screw securing box lids be used for earthing purposes.

V. Painting Conduits

Conduit and fittings installed behind plaster shall be given one coat of red lead primer immediately after erection.

On concealed installations, in concrete floors and screed where the finish of the conduit fittings is damaged during erection, it shall be made good in the same colour.

Where installed in roof spaces, specified to be in a damp situation, the conduit and fittings shall be given one coat of red primer immediately after fixing.

Galvanised conduit and fittings shall be given one coat of aluminium paint after the installed runs have been inspected by the Engineer.

VI. Installation of Conduits

All conduits must be run vertically or horizontally; diagonal runs will not be permitted on walls. Conduits, conduit fittings and equipment shall be fixed by heavy distance saddles fixed not more than 1000mm apart secured by means of 1.75" x No.8 brass countersunk screws, in a plastic wall plug of the correct size.

Conduit installed in concealed positions such as ceiling or floor spaces, shall be fixed by spacer bar saddles, fixed not more than 1000mm apart to the fabric of the building as specified above.

Conduit buried in concrete shall have 40mm depth of cover over its entire length. Conduit buried in plaster shall have 6mm depth of cover over its entire length.

Conduits which are to be cast in concrete slab shall be laid directly on the upper surface of the shuttering before the concrete is poured. Fixing holes shall not be drilled or otherwise made in the back of the conduit boxes.

A space of 75mm shall be left between adjacent and the like conduits where they are to be covered with concrete.

Conduits installed in chases shall be fixed with corrugated steel clips secured with hardened steel pins at 1200 mm centres.

Conduits laid on concrete floor slab or floor and roof beams shall be fixed by means of corrugated steel saddles secured by hardened steel pins at 1200 mm centres.

On pre-stressed beams fixings must be into the joints between the beams unless instructed otherwise by the Engineer.

Where conduits, boxes or other fittings are fitted to girders, wrought iron girder clips of approved pattern shall be employed and in no circumstances shall holes be drilled in girders without written instructions from the Engineer.

All conduit outlets installed in concrete or other in-situ construction must be plugged with extreme care to prevent the ingress of foreign matter and the conduit system from becoming blocked during building construction. The Contractor will be held entirely responsible for any additional cost resulting from blockage of conduits due to neglect or lack of attendance.

Female brass bushes shall be screwed on to all free ends of conduit.

Conduit systems shall be electrically and mechanically continuous and watertight after installation. All conduit systems shall be arranged wherever possible to be self-drained to conduit boxes and outlet points. Where necessary, provision shall be made to counteract condensation as directed by the Engineer.

Immediately before wiring, all conduit systems shall be thoroughly swabbed out until dry and clean.

All spare ways in junction boxes etc. left for possible future extensions shall be fitted with brass stopping plugs.

At connection between trunking and apparatus a 4mm paxolin fillet shall be fixed between the two to prevent chafing of cables on metalwork. The cables slot cut in the fillet shall be 5mm smaller all round than the slot cut in the metalwork. As an alternative a standard flanged adaptor or flanged assembly shall be used. Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with smooth bore bushes or grommets and the return edge of the trunking lid is left intact.

Where trunking is used to enclose cables leaving a distribution board the trunking shall be sized to accommodate all cables connected to the board and to leave room for cables that may be connected to spare ways at a future date.

Holes in trunking shall be drilled, cut or punched and all cut edges painted.

Individual pieces of trunking shall be independently supported. On straight runs, fixing shall be at regular intervals not exceeding 1200mm and shall

consist of 1.75" X No.10 roundhead black japanned steel screws. Where weatherproof trunking is used, fixing screws shall be brass.

Trunking systems erected outside shall be weatherproof. When installed in damp situations the trunking must be spaced from the wall by means of short tube collars.

Cable supports shall be provided at 900 mm intervals in vertical runs. Where a fire barrier is required between floors, a cable support shall be provided at floor level and fibre-glass insulation packed between the pins.

Where extra low voltage circuits are contained in the same trunking as mains voltage circuits, cable insulation shall be to mains voltage standards. The cables for each different system shall be laced together to denote the different service and voltage ranges and shall be installed on cable separators fixed at 900mm intervals.

Cable separators shall also be provided when it is specified on the plan that circuits are to be separated and when the space factor exceeds 20%. Cable retaining straps shall be provided above each cover fixing button on a horizontal run of trunking when the cover is on the underside.

The trunking shall be adequately bonded throughout its entire length to comply with IEE Wiring Regulations.

3.1.4 Cable Trays And Racks

I. Perforated Cable Trays

Perforated cable trays shall be formed from plain sheet steel complying with BS 1449: Part 1b, classifications CR4/GP. Cable trays shall not exceed 600mm in width and be of the heavy duty return flange pattern and shall be hot dipped galvanised.

Bends shall be of the same material, thickness and finish as the cable tray and shall have an inner radius of 50mm and a straight length of 100mm at each end.

Tees shall be of the same material, thickness and finish as the cable tray. The distance between a point of intersection and the end of the fitting shall be 100mm.

Mushroom-head steel roofing bolts and nuts complying with BS 1494: Part 1 shall be used to fix together adjacent sections of cable tray and/or accessories.

Cable trays shall only be cut along a line of plain metal, i.e. not through the perforations.

All cut edges of galvanised cable tray shall be prepared and treated with a zinc rich paint.

Site fabrications of accessories shall be kept to a minimum and manufacturer's standard items shall be used. Where special sections are required, the materials, thickness and finish shall be as specified for standard items. Approval of the Engineer shall be sought before such fabrications are carried out.

Where welding has to be employed in the fabrication of cable tray and/or accessories, the area around the joint shall be mechanically prepared and thereafter treated with Zinc Chromate primer or zinc rich paint according to the original finish of the metal.

Holes cut in the cable tray for the passage of cables shall be provided with grommets complying with BS 1767. Alternatively, they shall be bushed or lined.

A minimum clear space of 120 mm shall be left behind all cable trays for securing cable trays. Fixing for cable tray shall be disposed at regular intervals not exceeding 1.2 m and at 225 mm from bends and intersections.

Fixings shall be fabricated from mild steel flat bar complying with BS 4360. When used with galvanised cable tray, fixings shall be hot-dip galvanised, unless only bending and drilling is required in the manufacture, when galvanised mild steel flat bar may be used. Hot-dip galvanising shall comply with BS 729: Part 1.

Coach screws shall comply with BS 1449 and wood screws with BS 1210. Where used with galvanised fixings, screws shall be steel zinc plated (electro- galvanised) to comply with BS 1706.

All sections of the cable tray shall be thoroughly bonded to each other and to all fittings and accessories to maintain complete electrical and mechanical continuity.

II. Cable Racks

Generally, Cable racks shall be of 2.0 mm thickness. All racks, accessories, screws, nuts, bolts etc. shall be hot dipped galvanised.

The Contractor shall prepare detailed layout drawings and obtain the Engineer's written consent before the installation work proceeds.

3.1.6 Wiring Systems

I. General

This section of the specification deals with various types of wiring systems that may be specified in the Project Specification or on the drawings relating to the installation of main, sub-main and sub-circuit cables.

II. Cables and Flexible Cords

All cables and flexible cords shall be manufactured in accordance with the latest relevant British Standard as detailed in the sections of this Specification.

The names of the proposed cable manufacturers shall be submitted at the time of tendering and detailed on the Schedule of Equipment in the Project Specification for approval by the Engineer.

The approved makes of each particular cable type shall be used throughout the installation.

No coil of cable or flexible cord manufactured more than one year prior to delivery on site shall be used in the installation. Every coil of cable and flexible cord shall bear the manufacturer's label being retained for inspection by the Engineer.

Cable runs between items of switch gear and accessories shall be continuous lengths, no through joint being allowed without the written permission of the Engineer.

The Contractor shall be responsible for the correct measurement of the lengths.

III. Installation of Cables

The specific installation requirements for the various types of cable and cabling systems shall be detailed in the following sub-sections.

3.1.6 Elastomer And Polyvinyl Chloride Insulated Cables Enclosed In Heavy Gauge Conduit And Metal Switchgear And Distribution Boards

I. General

This section of the Specification deals with switchgear and distribution boards to be supplied and installed throughout the installation.

All fuse switchgear, circuit breakers and contactors etc. shall be of the types outlined, suitable for the fault currents of the system and in accordance with the following British Standard Specifications, unless otherwise specified.

- a) BS 89 Direct acting electrical indicating instruments.
- b) BS 142 Electrical protective relays.
- c) BS 158 Markings and arrangement of switchgear busbars, main connections and small wiring.
- d) BS 159 Bus-bars and Bus-bar connections.
- e) BS 162 Electric Power Switchgear.
- f) BS 1598 Ceramic insulating material for electrical purposes.
- g) BS 1858 Bitumen based filling compounds for electrical purposes.
- h) BS 3858 Binding and identification sleeves for use on electric cables and wires.
- i) BS 3871 Miniature air-break circuit breakers for AC circuits.
- j) BS 3938 Current transformers.
- k) BS 3941 Voltage transformers.
- l) BS 4752 Switchgear and control gear for voltage up to and including 1000 V AC and 1200 V DC.
- m) BS 4794 Control switches (switching devices including contactor relays, for control and auxiliary circuits up to and including 1000 V AC and 1200 V DC).
- n) BS 4800 Paint colours for building purposes.
- o) BS 5227 AC metal enclosed switchgear and control gear of rated voltage above 1 kV and up to and including 72.5 kV.
- p) BS 5331 Specification for AC circuit breakers of rated voltage above 1 kV.
- q) BS 5419 Air-break switches, air-break disconnectors, air-break switch disconnectors and fuse-combination units for voltages up to and including 1000 V AC and 1200 V DC.
- r) BS 5424 Control gear for voltages up to and including 1000 V AC and 1200 V DC.
- s) BS 5486 Factory built assemblies of switch gear and control gear for voltages up to and including 1000 V AC and 1200 V DC.
- t) BS 5559 Identification of apparatus terminals and general rules for a uniform system of marking using an alphanumeric notation.
- u) BS 6004 PVC-insulated cables (non-armoured) for electric power and lighting.
- v) BS 6321 PVC-insulated cables for switch gear and control gear wiring.

II. Fault Levels

The switchboards and switchgear shall be designed for the system fault levels to be checked and confirmed by the Contractor throughout the main and sub- distribution networks.

Circuit breakers, switch gear, isolators, contactors, busbars and cable connections shall be suitable for operating at the calculated fault levels.

III. Fused Switches

All fuses and links shall be accessible from the front. Switches and isolators shall operate on all poles, i.e. the neutral link shall be switched, and shall be arranged to break last and make first.

All switchgear shall be capable of making, carrying and breaking the calculated fault level. Switch gear shall be of utilization category reference AC23 and be capable of carrying a maximum prospective short time withstand peak current of twice the rated fault current.

The rated making, carrying and breaking capacity of switch gear, is expressed as the rms value of AC component.

All switch gear shall be suitable for uninterrupted duty and contacts shall be silver plated.

Provision shall be made for locking isolators and switches in the off position with a standard padlock.

IV. Fuses

All fuses shall be rated in accordance with BS 88 and shall be to BS rating 415AC80.

V. Contactors

Contactors shall be of the air-break type and shall comply with BS 5424 : Part 1. They shall be of the uninterrupted rating and contacts shall either be silver contacts or derated to allow for this duty. The contactors shall be category AC3 and have a no-load operating cycle of 1 million operations. All contactors shall be of the block type. Contacts shall be of the self-cleaning type and easily renewable. The design shall be such as to prevent welding in.

All operating coils of contactors shall be designed to operate on the control system voltage of the main low voltage switch gear.

Each contactor shall be so screened from adjacent units and current carrying parts that it is possible to carry out, in complete safety, work on its outgoing cable whilst other equipment in the panel remain live and on load.

Means of isolation shall be provided to isolate all primary and secondary circuits to contactors, but means shall be provided to temporarily reinstate interlocks or other circuit interconnections with equipment which is required in service whilst the contactor is isolated.

If the fault level for the main voltage switch gear is higher than that specified for the making and breaking conditions in Table 2 BS 5424 co-ordination of short circuit protective devices and contactors must be achieved. The manufacturer shall indicate the method and characteristics of achieving this co-ordination.

VI. Switch gear

Switch fuses, fuse switches, and isolating switches shall be complete with suitable fuses or solid copper links as applicable. All the fuses shall be of the HRC type.

Moulded case circuit breakers which are not mounted within a distribution board shall be complete with suitable metal enclosures.

Cable spreader boxes shall be provided for mounting directly on to switch and fusegear assemblies, to provide adequate space for spreading cable cores before entering equipment, where this is necessary. The box shall be of the same manufacturer as the equipment to which it is related. The spreader box shall be complete with a hardwood or paxolin fillet for fitting between the box and the assembly.

Where switch and distribution equipment is to be fixed to the Bus-bar Chamber or cable trunking a 4 mm paxolin or hardwood fillet shall be fixed between the items to prevent the chaffing of cables on metal works. The slot cut in the fillet shall be 5 mm smaller all round than the slot in the associated metalwork.

Top and/or bottom end plate fixing screws shall be utilised where possible to secure the equipment to the Bus-bar Chamber or Distribution Board.

VII. Cable Glands

All cable boxes and glands for the termination of all cabling shall be supplied as necessary by the Contractor.

All cable glands shall be in accordance with this Specification and be suitable for the cables specified.

All cable glands shall be complete with locknut, earth tag and shroud. Terminals shall be marked in a clear and permanent manner. Entry holes, suitable for the reception of XLPE or PVC/SWA and MICC cables shall be provided in the gland plates.

VIII. Labelling

Each outgoing and incoming circuit shall be clearly labelled to indicate the circuit controlled.

Labels shall include black lettering, minimum height 5 mm on a white background for general use, and 5mm red letters on a white background for warning labels.

All labels shall be screwed, not glued or fixed by the use of rivets.

Any labelling required inside the panel shall not be by the use of self adhesive PVC strip.

3.1.7 Fuses And Miniature Circuit Breakers

I. Fuses Generally

All fuses shall comply with the requirements of BS88 and shall be supplied to suit the rating of the circuits protected in accordance with the requirements of the IEE Wiring Regulations.

II. Power Fuses

All fuses in distribution switch and fuse gear and fused distribution boards shall be HRC Cartridge Fuses type and category 414AC80 and DC4, arranged vertically and barriers shall be provided between phases. Unless protected by interlocked covers, all live parts shall be fully shrouded.

Type test certificate shall be provided, if required by the Engineer. All cartridge fuses shall be fitted with a device to indicate a blown element. Fuses shall be of the make and type specified and only one make and type shall be used through the installation to ensure discrimination between fuses.

For contactor control gear, the main circuit fuses shall be connected between the isolator and contactor. Each fuse switch and contactor unit shall be supplied with a spare set of fuses and the design of the equipment shall be such that means shall be provided for retaining the spare set of fuses within the fused switch or contactor cubicle compartment.

III. Control Fuses

Where a control circuit is supplied directly from main power conductors, it shall be protected by HRC power fuses as in power fuses above.

In general, control fuse bases and carriers, of the fully shrouded type having cartridge fuses will be accepted subject to the approval of the Engineer.

The fuse bases and carriers shall be coloured as follows, in accordance with clause 42 of BS 162:-

- a) 5 amp Black
- b) 15 amp Light Green
- c) Link White

Fuses of ratings other than 5 or 15 Amp shall have the rating inscribed on the fuse carrier or label. Such fuses shall be distinguished by approved colourings. Thermo setting self-adhesive labels shall be fitted adjacent to all control fuses and links.

IV. Fuses for Plugs and Spur Units

Fuses for plugs and spur units shall be of the rating of the equipment they protect and shall be to BS 1362 for the 13 amp and ring final circuit accessories or to BS 196 for fuses for industrial ring final circuit accessories.

V. Miniature Circuit Breakers

All miniature circuit breakers shall be rated to withstand the prospective short circuit currents of the circuits they protect without causing any interference in any other protective devices associated with the distribution system.

At the same time, the design of the circuit breaker shall be such that it will protect the circuit for which it is intended and not cause or allow other protective devices to operate when overload current conditions apply.

Miniature circuit breakers shall be in accordance with BS 3871 : Part 1 and comply with the IEE Wiring Regulations. They shall be capable of interrupting 415 volts, three phase symmetrical faults.

Miniature circuit breakers shall be type C unless otherwise stated.

3.1.8 Distribution Boards

All distribution boards shall be of the sizes and types specified and shall be in accordance with BS 5486 Part 12 and shall be fitted with miniature circuit breakers. Miniature circuit breakers shall be in accordance with BS 3871 Part 1 except where modified by this Specification. Where distribution boards are specified to be complete with an isolator or switch, the isolator or switch shall be double pole for SP&N distribution boards and four pole for TP&N distribution boards. The isolator or switch shall be integral with the distribution board enclosure.

The enclosure shall comprise a case and door(s) of sheet metal. The type of construction shall be damp and dust protected as specified to BS 5420 classification IP31 as a minimum standard.

Surface mounting shall be office pattern, fitted with cylinder lock. Doors shall be provided with quick release hinges.

Sheet steel used in the construction of the distribution boards shall have a quality of surface finish equal to that of sheet steel to BS 1440 Part 1A HRP or BS 1449 Part 28 GR4/GP.

Sheet steel shall be electro-zinc coated to minimum thickness of 0.009mm and chromate washed.

All door furniture, e.g. locks, handles, fasteners etc. shall be chromium plated.

Painted finishes for all steel for use indoors shall have two coats of rust proof primer, then filled as necessary to a smooth finish, then two undercoats applied and the final finish being two coats of epoxy resin paint, the final coat drying to a hard semi-gloss surface.

All bright machined parts shall have a protective treatment applied by the manufacturer before dispatch and this treatment is to be kept intact up to the time of handover unless it has to be removed for installation. If the surface is then exposed after installation the Contractor shall apply a further protective coating in accordance with the manufacturer's requirements.

Bus-bars shall be rigidly mounted in the same position on all poles relative to their banks of fuses or MCB's and fully shrouded to enable spare ways to be wired whilst the board is live. Busbars shall be copper to BS159.

All incoming terminals shall be fully shrouded and of the pressure clamp or socket type.

Renewable labels in the form of cards in a transparent envelope shall be provided within the enclosure for recording the following information of each circuit:-

- Circuit designation and location served
- Cable size
- Circuit rating

The sequence of identification shall be stated on the label card. The make and type of fuse that discriminates and/or protects the miniature circuit breakers shall be indicated.

If installation of fuses other than the manufacturer stated would not discriminate or protect the miniature circuit breakers, then a label to this effect shall be installed in the distribution board.

External labels shall be fitted in accordance with "nameplates and labels" and shall be brass plates with engraved black letters.

Neutral terminals shall be provided, one for each outgoing phase way, i.e. three neutral terminals for each TP way in positions respective to their phase terminals.

3.1.9 Lighting Installation

I. General

The lighting installation shall comply with the previous sections of this Specification in so far as they are applicable.

II. Wiring for Lighting Circuits

Wiring for lighting circuits shall be carried out on the "loop-in" principle. The "feed" and "neutral" shall be looped at the lighting point using the "three plate" system.

The wiring shall be in cable of the appropriate rating, type and grade in accordance with the IEE Wiring Regulations. The sub-circuits shall be installed and numbered as shown on the design drawings.

The conduit box at each lighting and ceiling switch point shall be provided with an earthing terminal consisting of a 12mm M4 roundhead brass screw and two flat washers fitted to a tapped hole in the box.

To facilitate the connection of the protective conductors a length of 1.5 mm² yellow/green PVC flexible cord fitted to a 5 amp porcelain shrouded brass connector shall be secured to the earthing terminal.

III. Concealed Conduit Installation

Small circular metal conduit boxes or equivalent "loop-in" boxes shall be provided at each lighting point in which to terminate hard wiring.

Such boxes shall be securely fixed to the structure of the buildings in order to support the weight of the luminaire. Two boxes shall be used for supporting fluorescent luminaires.

Where boxes finish behind surface level the correct size extension ring shall be used to finish level with the ceiling finish.

IV. Surface Conduit Installation

Small circular raised back metal boxes shall be provided and securely fixed at all lighting points. The hard wiring shall be terminated in fixed based porcelain connectors. Heat resisting cables shall be used or heat resisting sleeving applied to PVC sheathed cables and taken into the luminaire from the hard wiring.

V. Trunking Installation

Where fluorescent luminaires are fixed to channel or trunking they shall be fixed direct on using the trunking manufacturer's fittings/attachments. Hard wiring shall be taken into the luminaires. PVC sheathed cables shall be sheathed with heat resistant sleeving where they are installed within the luminaires.

Runs of trunking shall be supported at equally spaced intervals of not more than 3000 mm apart. The two outer suspension points shall be not more than 450mm from the ends to the run.

Where more than one length of trunking is required to make up a run, splice plates shall be used at the joint. Joints shall not be made in the centre half portion of a span between suspension points.

An earthing terminal shall be provided in each run of trunking comprising an M4 screw, with two brass flat washers, screwed into a tapped hole in the trunking.

VI. Luminaires

At every lighting point the Contractor shall supply and fix the luminaire complete with all metal work and glassware etc.

Spare cartridge fuses and lamp starters (where switch start fittings are provided) shall be supplied for 10% of the fluorescent luminaires installed in the Contract with a minimum of 10 each. The spare fuses and starters

shall be handed to the Employer at the time of Practical Completion and a signature obtained.

VII. Recessed Luminaires in Suspended Ceillings

Where recessed luminaires are specified to be fitted in suspended ceilings the conduit box shall be fitted with a captive 5 Amp 3 pin socket outlet and plug of the luminaire support coupler (LSC) type.

The socket outlet shall be fixed adjacent to the lighting fitting and connected to it by a length of 3 core 1.5mm² E.P.R. sheathed flexible cord. The length of flexible cord shall be such that the luminaire can be moved to any of the adjacent ceiling tiles without strain.

VIII. Surface Installation of Luminaires

Where luminaires are installed directly onto a conduit box, white break joint rings shall be provided between the luminaires and conduit box. Except where otherwise specified, the luminaires shall be connected to the sub-circuit wiring using 5 Amp porcelain shrouded brass connectors and 1.5 mm² E.P.R. insulated, taped and glazed cotton braided flexible cord.

IX. Lamps and Tubes

Every luminaire shall be complete with the number of and size of lamps shown in the detailed Schedule of Luminaires and shall be suitable for the mains voltage or other voltage applicable.

Unless otherwise stated~ the incandescent lamps shall be pearl finish and to BS 161. Up to and including 150 watts the lamps shall have bayonet caps, larger sizes having the appropriate E.S. cap. For 240 volt supplies all lamps shall be rated at 250 volts.

Where fluorescent lamps are indicated they shall be manufactured to BS 1270, type MCF/U. The lamp colour shall be white at a colour temperature of approximately 3500K; unless specified otherwise for areas requiring special colour rendering or appearances.

At the Practical Completion of the Contract the Contractor shall allow for replacing all defective and burnt out lamps and shall supply 5% of each type and rating of lamp and tube installed.

A minimum of two of each type and rating shall be supplied and all are to be left with the Employer from whom a signature must be obtained.

X. Cleaning of Luminaires

At completion of the Contract the Contractor shall thoroughly clean all luminaires to ensure all dust, grit, building rubbish, etc. is removed from each luminaire.

XI. Switches

Switch boxes shall comply with BS 4662 and shall be fixed by means of two No. 8 roundhead screws in plastic wall plugs. In external and damp situations brass screws shall be used.

3.1.10 General Power Installation

I. General

II.

The general power installation shall comply with other sections of this Specifications in so far as they are applicable.

II. Makes of Accessories and Equipment

The make and finish of accessories and equipment shall be as indicated in the detailed schedule of equipment.

III. 13 Amp Outlets and Spur Units

The socket outlets are generally to be wired in ring circuits. Where radial circuits are to be installed, these shall be indicated on the drawings.

IV. Fixed Equipment

Items of equipment that essentially stand in one position but are moved for cleaning may be specified to be supplied from flush fitting controls. Where this is the case, the control shall be fitted at the height specified and a flush fitting box shall be fixed below the control to allow the flexible cables to be taken to the equipment. The accessories to be used to enable flexible cables to be taken to these boxes shall either be flex outlet plates or a fixed connector block in a conduit box fitted with a strain relief grip.

3.1.11 Luminaires

I. British Standards

Components used in the construction of luminaires and the luminaires themselves shall conform to the following British Standards:-

- a) BS 52: 1963: Bayonet lampcaps, lampholders and BC adapters
- b) BS 2782: 1975: Methods of testing plastics
- c) BS 2818: 1973: Ballasts for the operation of tubular fluorescent lamps on AC 50 Hz and 60 Hz supplies
- d) BS 4533: Electric luminaires (lighting fittings)
- e) BS 4800: 1972: Paint colours for building purposes

3.1.12 Emergency Lighting Installation

I. General

The emergency lighting and exit sign installation shall conform to other sections of this Specification in so far as they are applicable and BS 5266 Part 1 and to the requirements of the Local Fire Officer.

The system shall comprise either self contained non-maintained luminaires or maintained general purpose luminaires.

Self contained emergency lighting units shall comply with BS 764, GLC and ICEL 1001 specifications.

The units shall be complete with tube and control gear and be suitable for a minimum three hour operation without significant loss of output.

II. Mains Supply

The emergency lighting units shall be provided with a permanent (unswitched) supply which shall originate from the local sub-circuit fuse or MCB.

III. Emergency Lighting Test Certificate

On completion of the installation the Contractor shall submit to the Engineer an Emergency Lighting Test Certificate, as referred to in BS 5266 Part 1.

3.1.13 Main Equipotential Earthing And Bonding

I. Materials General

All materials used in the earthing network shall be of high conductivity annealed copper of type size and with protective covering manufactured to the appropriate British Standard.

II. Method of Installation

Non-current-carrying metalwork shall be bonded to extraneous fixed metalwork and the whole of the non-current-carrying metalwork shall be bonded together in accordance with the 16th Edition of the IEE Wiring Regulations.

III. Bonding of Protective Conductors

All metal pipes or conduits in which the cables have been installed shall be bonded to the main earth point. The joints, metal sheath and armour, if any, of the cable shall not increase the resistance of the protective conductor. Where cables are more than 365 metres in length, the metal sheaths and armour of such cables shall be bonded to earth at intervals of 350 metres.

IV. Earth Tapes

All connections to earth tapes shall be made by means of tinning, sweating and bolting. All connection to fixings of earth tapes to the building shall be by means of 3.5mm thick phosphor bronze or gunmetal saddles and brass screws.

V. Bonding to Extraneous Metalwork

Metal sinks waste pipes, hot and cold pipes shall be bonded to the nearest socket outlet and/or spur unit by means of a 2.5 mm² PVC insulated cable, coloured green/yellow, enclosed within heavy gauge conduit terminating at a low level in a BS 1363 box fitted with a flex outlet plate complete with a solidly mounted earth stud.

From the flex outlet plate a 4 mm² FVC insulated cable coloured green and yellow shall be installed in a neat and tidy manner and be securely bonded to the extraneous metalwork.

VI. Protective Conductors Associated with Flexible Conduits

Where flexible conduits are installed, each shall be provided with a separate earth conductor of 4.0 mm² minimum size and shall be connected to the nearest conduit box and the apparatus served by means of tinned copper lugs, brass screws and washers. The protective conductor

shall not be installed within the flexible conduit unless otherwise specifically agreed in writing by the Engineer.

3.1.14 Lightning Protection

I. General

The lightning protection system shall comply with BS 6651.

II. Aluminium Tape

Aluminium tape used for roof termination networks and down conductors shall be bare to BS 2898- 1350 and shall have a minimum cross sectional area of 50 mm².

III. Copper Tape

Copper tape used for earthing shall be bare and made from high conductivity copper to BS 1432- C101/C103 and shall have a minimum cross sectional area of 50mm².

IV. Fixing of Tape Conductors

Conductor tapes shall be fixed to the background using metallic tape clips of the spacer bar type using 1 x no.10 countersunk wood screws and wall plug.

When straight through, cross or tee joints are formed in the tape, square tape clamps shall be used and these shall be fixed to the background as described above for tape conductor clips.

Copper conductor fixing accessories shall be made from high quality copper alloys and aluminium accessories shall be made from high quality aluminium alloys.

No accessory meant for copper conductors shall be used on aluminium conductor and vice-versa.

When aluminium fittings are installed an approved oxide inhibiting compound shall be applied to the connection after it has been made.

At the junction between aluminium down conductors and copper earthing conductors, a bimetallic connector shall be used. The connector shall be firmly fixed to the background using 1 x no.10 countersunk wood screw and wall plug.

V. Air Termination Network

The air termination network shall be arranged so that no part of the roof is more than 5 metres from an air termination conductor.

VI. Down Conductors

There shall be one down conductor for every 20 metres of the building perimeter at ground level.

Down conductors shall be as evenly spaced, and shall be routed as directly from the air termination network to the earth termination, as the building contour will permit.

The existence of re-entrant loops in the down conductors shall not be permitted, except as allowed by BS 6651.

VII. Earth Termination Network

The earth termination network shall be executed in copper tape and copper clad earth electrodes only.

The connection between tape and earth rod shall be made with a proprietary rod to tape clamp of high strength copper alloy body and screw. Commercial brass shall not be used for this purpose. This connection shall be made at least 150 mm above the immediate surrounding ground and enclosed in an earth inspection chamber.

The inspection pit and cover shall be made of concrete of internal dimensions 160 x 160 mm and minimum depth of 210 mm. The top of the pit shall not be below the general surrounding ground.

VIII. Earth Resistance

The resistance to earth of the complete lightning protection system measured at any point shall not exceed 10 ohms.

The resistance of each individual earth shall not exceed ten times the number of down conductors in the complete system.

IX. Testing and Commissioning

As the installation proceeds and on completion of the installation and at the expiration of the maintenance period, the Contractor shall carry out tests in the presence of the Engineer on all sections of the Electrical Services Installation and shall submit six signed copies of the results of the tests to the Engineer, together with six copies of a Completion and Inspection Certificate as required by the IEE Wiring Regulations, Part 7.

Site testing of all systems and components comprising the Contract works shall be carried out in the presence of and to the complete satisfaction of the Engineer, after the Contractor has first satisfied himself that the systems are operating correctly.

The Contractor shall prepare and submit for approval comprehensive commissioning documents prior to commencement of testing. No section of the installation shall be energised until these tests have been completed.

The Contractor shall provide all certified instruments, equipment, plant, labour and materials necessary for conducting specified site tests and shall be responsible for and prepared to demonstrate the accuracy of all test instruments supplied by him.

All installations, plant and tests must satisfy the requirements of the Factories Act and the requirements of all other interested Authorities and the Contractor shall include for all safety devices, etc. required by such Act or Authority.

Observations shall be made of the operation and performance of the installations and subsequent readjustments made as necessary.

Accurate records of all commissioning and testing shall be kept and results comprehensively reported to the Engineer when the installed system(s) are functioning correctly.

Where it is not possible at the particular time of commissioning and/or demonstration of the plant for full load conditions to be obtained or assimilated, the Contractor shall repeat the requisite operations of the commissioning and demonstrations under such full load conditions (or the reasonable approximation or simulation of such conditions acceptable to the Engineer) at the first opportunity.

The Contractor shall ensure that all equipment and plant under his supply shall be tested at the makers works before dispatch and six copies of test certificates in respect of each test shall be forwarded to the Engineer.

All works tests shall comply with the relevant British Standard Specification or IEC Standard Specification and shall be sufficient to show that

equipment will function correctly when installed as part of the Sub-Contract works.

Each item of electrical plant or equipment so tested shall be fitted with a plate giving at least the following information:

- Date of Test
- Individual equipment serial number
- BSS number if any
- Test Voltage
- Operating voltage (if different from test voltage)
- Test current
- Full load current (if different from test current)
- Loading (expressed in kVA) and power factor Phase
- Frequency (expressed in Hz)

The above information shall be included on the test certificate for each item of plant or equipment. This shall also include a description of any particular method of wiring and/or connection with the location of the test and signature of the witness.

The following test results shall be submitted:

- a) Continuity of ring final circuit conductors
- b) Continuity of protective conductors, including main and supplementary equipotential bonding
- c) Earth electrode resistance
- d) Insulation resistance
- e) Insulation of site-built assemblies
- f) Protection by electrical separation
- g) Protection by barriers or enclosures during erection
- h) Polarity
- i) Earth fault loop impedance
- j) Operation of residual current devices and fault voltage operated protective devices
- k) Each circuit breaker shall be operated manually or electrically 50 times to the satisfaction of the Engineer. Where the circuit breaker is designed for electrical operation at least 10 of these operations shall be made with 80% normal voltage applied to the trip coil in accordance with BS 116: 1952. During this test the trip free feature shall be demonstrated.

3.2 SCOPE OF ELECTRICAL WORKS AND DESIGN CONSIDERATIONS

3.2.1 Scope Of Works

The Contractor shall supply, deliver, install, set to work, test, commission and hand over to the Employer the complete Electrical Services installation inclusive of the following:

- I. Power and lighting installation in all areas including supply to services to be installed by others, such as lifts, parking entrance shutters, parking control barriers, cooking equipment etc.
- II. Installation of lightning protection system.
- III. Liaison with the Power Supply Authority for power connection to the building.
- IV. Liaison with the Telecommunications Authority for installation of incoming telephone cables into the building.
- V. Testing, certification and commissioning of the services.
- VI. Preparation of co-ordinated working drawings, record drawings and operating and maintenance manuals.

The foregoing is an outline description only and reference to the other Specification Clauses and site inspection must be made to assess the full extent of the works.

Should any portion of the work which would reasonably and obviously be inferred as necessary for the complete, safe, efficient and satisfactory operation of the installation as a whole, not be expressly described or specified then such works shall be executed as part of the Contract at no additional cost.

In addition to the above the Contractor shall quote a further extra over cost for the maintenance of the above systems for the first twelve months of operation.

3.2.2 Description Of The Building

I. General

The project comprises modification and refurbishment of part of an existing building.

II. Structure

The structure is in-situ cast concrete columns with in-fills of concrete blockwork.

III. Internal Finishes

Details of internal finishes are shown on the architectural drawings and can be inspected at the Architect's offices.

3.2.3 Fire Ratings

Where trunkings, conduits, cable trays, cables etc. pass through fire rated walls, floors, etc. from half hour or greater, the Contractor shall include for fire barriers, seals, etc. to maintain fire integrity and rating of the construction in accordance with Fire Officer's Committee requirements.

In addition, the Contractor shall assume that all floor slab constructions are 1 hour fire rated.

All materials used in connection with or as part of the installation shall be incapable of spontaneous combustion once ignited and they shall ideally be self-extinguishing.

The Contractor shall achieve this fire rating by utilising a proprietary brand of fire barrier penetration sealing system in accordance with the manufacturer's instructions so as to achieve the fire rating as outlined above through any penetration.

The Contractor shall ensure that holes formed by others through which the relevant services shall pass are so executed that compliance with the above requirements is achievable utilising a suitable system.

3.2.4 Supports And Fixings

The Contractor shall include for all supports necessary to supply and install his services. All supports shall be to an approved pattern and surface finish.

The Contractors "shall also include for the supply and installation of any mounting brackets, mounting flanges sealing glands or any special fittings necessary for the installation of the services.

All supports shall take due account of the limitations of the proposed structure. In selecting the method of support and fixing, the Contractor shall make due allowance for the suitability of the fixing against the structural elements to the satisfaction and approval of the Architect. In particular, the Contractor shall take into account:

I. That all fixings from the underside of the floors can be bolted with approved expansion bolts into the concrete units.

II. The Contractor shall allow for the fixing of any bolts required and should note that these should be fixed in the downstand sections of the

concrete floor slabs. The Contractor shall include for any secondary steelwork necessary to give support in the space between fixing centres.

III. The false ceiling generally will be supplied capable of supporting luminaires but not necessarily emergency lighting luminaire packs which may be independently supported by the Contractor.

3.2.5 Clearance For The Removal Of Items

Adequate clearance space must be left during the installation for both the removal of all demountable items and for normal inspection, testing and maintenance access without removal.

3.2.6 Maintenance Access

The Contractor shall at all time give proper consideration to the future maintenance of all plant and shall include for such component parts as are provided by the manufacturer or equipment and plant for this purpose.

Under this clause the Contractor shall include for the installation of equipment to give ease of subsequent removal of electric motors, circuit breakers or any other item to which it would reasonably be anticipated that maintenance accessibility would be required.

The Contractor shall take due account in his design and installation of the limited accessibility of the ceiling voids and shall ensure that all items requiring access for maintenance, adjustments etc. within these areas are installed in accessible locations.

Any item requiring checking/resetting on a regular basis shall be grouped to easily accessible areas such as riser ducts etc. to minimise access through the ceiling voids.

3.2.7 Climatic Conditions

The following climatic conditions are outlined as a guidance for the site, i.e. Kampala.

Average peak temperature is 32° C but this temperature may be exceeded. Therefore it is suggested that an external temperature of 400 C is allowed for.

The altitude is 1200 metres above mean sea level.

3.2.8 Supply Characteristics

The high voltage (HV) supply in this area is 11/33 kV.

The low voltage (LV) supply to be distributed throughout the building is 415 volts three phase / 240 volts single phase at 50 Hz.

3.3 PARTICULAR SPECIFICATIONS FOR ELECTRICAL SERVICES

3.3.1 General

The electrical materials and works will be selected, erected, inspected and tested in accordance with the following:-

I. This Specification

II. Appropriate British Standard (BS) Specifications and Codes of Practice (CP). Particular mention is made to BS 7671 : 1992 "Requirements for Electrical Installations" (IEE Wiring Regulations Sixteenth Edition) including all current amendments and the standards of International Electrotechnical Commission (IEC) Publication 364 "Electrical Installations in buildings".

III. Government Rules

IV. Local Authority's Bye-laws and Regulations

V. Electricity Supply Authority's requirements (vi) Fire Prevention Officer's requirements

VI. Health and Safety at work regulations

The Contractor shall notify the Engineer of any revisions or additions to the foregoing as they are published during the installation of the Works for the Engineer's decision and instructions.

The Contractor shall pay all charges necessary for any Authority's approval of any part of the Works.

The Contractor shall include everything required for the completion of the Works within the installation to ensure continuous operation of all equipment and plant.

The Contractor shall ensure that the installation is compatible with Architectural and Structural details.

The Contractor shall note the requirement for detailed co-ordinated working drawings showing the location or layout of wiring accessories or particular method of installation.

In the event that the tenderer is not sure that any preference for a particular material, design or type of construction given in this document or implied by the Contract Drawings will satisfy the requirements of this document, then he must make alternative proposals and give his reasons for them when submitting his tender. If the tenderer makes no alternative proposals to any given material or method then they will be deemed to form part of his proposals and to satisfy the requirements of this document.

3.3.2 Suitability Of Materials And Products

Materials and products shall be supplied to suit all conditions of use normally expected to apply after completion of the installation. They should also withstand any tests specified in this Specification or any other documents referred to herein.

Unless otherwise explicitly stated in the contract documents, all materials and equipment incorporated in the Works shall be new and for the purpose intended.

3.3.3 Lighting Installation

I. General

The Contractor shall supply, install and connect the complete lighting installation as described herein and indicated on the drawings. The description of each luminaire type is indicated in the Schedule of Luminaires within this Specification.

All recessed luminaires within suspended ceiling tiles may be supported independently by the ceilings. However, the Contractor must ensure that the arrangements for fixing of the luminaires to be ordered is completely compatible with the ceiling grid type.

Final connection to all luminaires shall be carried out using 1.5 mm² heat resisting flexible plug-in lighting Luminaire Support Coupler (LSC) system. In the case of luminaires within the suspended ceiling areas, ample lengths of flexible cable shall be provided so that the luminaire can be moved horizontally a distance of 600mm in any direction from the position shown on the drawing without straining the cable.

The lighting installation shall be carried out using PVC insulated, stranded copper conductor cables, drawn within heavy gauge, high impact PVC conduit.

Separate circuit protective conductors of the same cross sectional area as the phase conductors shall be provided.

Lighting circuits shall be wired in 1.5 mm² or 2.5 mm² cables as indicated on the drawings.

No cable size smaller than 1.5 mm² shall be used for the lighting installation.

The lighting installation shall be flush / concealed with conduits concealed within suspended ceiling voids or buried as necessary within walls, floors and other building finishes.

The Contractor shall ensure that all conduits, cables etc. installed are clear of any thermal or other insulation which may be provided within ceiling voids, etc.

Wiring shall be carried out in loop-in system and no cable junctions or terminations will be permitted in inaccessible locations.

Lighting cables shall be drawn within conduits specifically provided for the purpose and shall not be drawn within conduits provided for other services or vice versa.

The Contractor shall prepare detailed working drawings of the installation indicating the exact positioning and routing of all conduits, trunkings, luminaires etc. and submitted to the Architect for approval prior to commencement of installation.

The Contractor shall ensure that the transformer and associated cabling are installed to the manufacturer's specifications.

The modular luminaires in the meeting room on the first floor shall be suspended at 500mm below ceiling level by methods recommended by the manufacturer.

II. Emergency Lighting

The Contractor shall install the emergency lighting in the positions shown on the drawings.

Where emergency lighting is indicated, self contained units or remote box versions as specified shall be provided as an integral part of these luminaires and will be complete with the luminaires and supplied by the manufacturer. The units will automatically change over from mains to emergency operation in the event of mains failure and revert to mains operation upon mains return. The units will operate the lamp within the luminaire in emergency operation for a duration of 3 hours without significant loss of output.

An L.E.D indicator shall indicate that both the main lamp filament and mains supply are healthy and the battery is being charged. Individual self-contained emergency lighting luminaires will also be provided as indicated on the drawings and Schedule of Luminaires.

Operation of these luminaires will be similar to that outlined above for emergency lighting units contained within the general lighting luminaires.

A suitable label shall be provided and fitted in a conspicuous position within each luminaire incorporating emergency lighting by the Contractor to indicate the presence of unswitched live feed stating "WARNING: UNSWITCHED LIVE FEED" .

The emergency lighting installations shall be carried out as previously described for the general lighting installation.

The Contractor's attention is drawn to the requirement for a certificate to be submitted on completion of the installation indicating the results of tests associated with the emergency lighting installation.

III. Lighting Switches

Lighting switches for the control of luminaires shall be suitable for flush mounting with overlapping white plastic front plates, single or multi-gang as indicated on the drawings.

Key switches shall be of the grid switch type, 20 amperes single pole and each shall be provided with a secret key.

3.3.4 13 Amp Socket Outlets

General purpose socket outlets, unless otherwise specified, shall be of 13 ampere capacity, single pole and of rectangular pin type to BS 1363/1947 with a white plastic front plate and integral switches. They shall be mounted in rectangular galvanised steel boxes single or multi-gang as necessary with at least one adjustable lug.

Socket outlets for mounting onto the skirting trunking shall be of a type suitable for that purpose and shall be provided with all necessary proprietary accessories. No local improvisation shall be accepted.

I. Wiring

The installation shall be carried out using PVC insulated single core cables having stranded copper conductors enclosed in heavy gauge high impact PVC conduit and steel cable trunking. Separate circuit protective conductors (c.p.c.) of the same cross sectional area as phase conductors shall also be provided and installed for each circuit. Where the phase conductors are wired in a ring, the c.p.c. conductors shall also be wired in a ring.

All 13 amp socket circuits shall be wired using 2.5 mm² cables or other size as indicated on the drawings.

No cable size smaller than 2.5 mm² shall be used for any power installation.

The power circuits shall be a flush or concealed installation with conduits concealed within suspended ceiling voids or buried as necessary within walls, floors and other building finishes.

The Contractor shall ensure that all cabling, conduits, trunking etc. installed are clear of any thermal or other insulation which may be provided within the ceiling and floor voids, risers etc.

Power circuits shall be contained within the conduits or trunking compartment specifically provided for the purpose and shall not be installed within conduits or trunking compartments provided for other services or vice versa.

Detailed working installation drawings shall be prepared by the Contractor indicating the exact positioning and routing of all conduits, trunking etc.

These drawings shall be submitted by the Contractor to the Architect for approval prior to commencement of the installation.

II. Communication Provisions

A third compartment is provided within the skirting trunking for the wiring of other communication facilities such as computer networks.

Detailed working installation drawings shall be prepared by the Contractor indicating the exact positioning and routing of all conduits, trunking etc. These drawings shall be submitted by the Contractor to the Architect for approval prior to commencement of installation.

3.3.5 Earthing And Bonding

The entire cable, trunking, conduit and cable tray installation, together with the sheathed and earthing conductors of cables shall be electrically bonded to earth.

All main, sub-main and final distribution boards, plant and equipment shall be bonded to earth in an approved manner by solid copper conductors secured by means of substantial bonding clamps.

The Contractor shall bond, in all locations, all extraneous conductive parts of the installation including sinks, basins, waste pipes, hot and cold water pipes and all general items of mechanical services plant. The bonding shall be carried out using green/yellow PVC insulated single core conductors.

All steel accessories boxes for light switches, socket outlets etc. shall be bonded to earth by connecting the brass earth terminal at the back of the box solidly to the circuit protective conductor.

All bonding installations shall be carried out in a neat and unobtrusive manner to the satisfaction of the Engineer.

3.3.6 Lightning Protection

The lightning protection system shall consist of an air terminal network, down conductors, earth termination network and bonding to prevent side flashing.

I. Air Termination Network

The air termination network shall consist of bare aluminium conductor tape which forms a network mesh of not more than 20 m by 10 m as shown on the drawing. The tape shall be 30 mm x 3 mm thick.

All tape intersections or connections shall be carried out with connectors which are compatible with the tape material. All fixings of tapes to the building shall be by means of tape clips of cast gun metal upper and lower sections with countersunk brass screws.

II. Down Conductors

Down conductors shall be installed to provide a low impedance path from the air termination network to the earth termination network, to allow the lightning current to be safely conducted to earth.

The down conductors shall be of bare aluminium conductor tape of dimensions 30mm x 3mm and shall be fixed in like manner as the air termination network conductors.

The aluminium conductor tapes shall terminate onto a test clamp at a height of 1.5 m from ground level from where a copper tape will lead into the ground termination.

Down conductors systems shall take the most direct route from the air termination network to the earth termination network. The routes chosen shall be such as to avoid side-flashing.

Re-entrant loops shall not be permitted in the conductor except where the length of the conductor forming the loop does not exceed eight times the width of the open side of the loop as recommended in BS 6651. The routing of conductors inside the structure shall not be permitted.

III. Earth Termination Network

The earth termination network shall consist of high conductivity annealed bare copper conductor tape of dimensions 30 mm x 3 mm from the test clamps installed at 1.5 m above ground level and terminating onto earth rods driven into the ground.

The copper tape to earth rod connection shall be via a rod to tape clamp of cast gun metal body and phosphor bronze bolt. The connection shall be

made above the surrounding soil in the inspection chamber to facilitate visual inspection.

The earth rods shall be of the extensible type made from pure electrolytic copper of minimum thickness 0.25 m, molecularly bonded onto low carbon steel cores with high tensile strength. The threads shall be rolled onto the rod with a uniform layer of copper. The coupling shall be of silicon and aluminium bronze, counter bored and shall completely cover the threads on the rods. The rods shall be 1500mm x 16mm diameter and driven to a depth of 4.5 m.

The whole earthing assembly shall be enclosed in a concrete earth inspection chamber of 300mm x 300mm external dimensions complete with a concrete cover.

IV. Bonding

The Contractor shall bond all exposed metal work on or around the structure to the lightning protection system to avoid side-flashing. All such bonding shall be carried out using factory made accessories.

3.4 INFORMATION AND COMMUNICATION TECHNOLOGY

3.41 Generally

This document provides specifications for an ICT network system, including required network cabling and components and required network devices. The contractor shall furnish all labor, materials, tools, equipment, and reasonable incidental services necessary to complete an acceptable installation of the data and voice communications network, access control and CCTV network system. This is to include, but is not necessarily limited to, switches, faceplates, modular jacks, connectors, patch panels, equipment racks, cable, fiber optics, access control components, CCTV cameras and monitoring and recording system.

3.4.2 Scope

Work shall include all components for both a backbone cable plant and data cabling from workstation outlet termination to rack mount equipment and patch panel terminations. All cable-plant components, such as outlets, wiring-termination blocks, racks, patch cables, intelligent-hub equipment, etc., will be furnished, installed, and tested by the contractor. The data cable plant is designed to support 100Mbps Ethernet and 1000Mbps Ethernet. The data cabling plant and components shall carry a manufacturer-supported 10-year performance warranty for data rates up to 1000Mbps. The bidder must provide such manufacturer guarantee for the above requirements as part of the bid submission.

The scope of work includes all activities needed to complete the wiring described in this document and the drawings that will be made available during the mandatory walk-through.

Any and all overtime or off-hours work required to complete the scope of work within the time frame specified is to be included in the contractor's bid. No additional overtime will be paid.

The contractor must instruct the owner's representative in all the necessary procedures for satisfactory operation and maintenance of the plant relating to the work described in their specifications and provide complete maintenance manuals for all systems, components, and equipment specified. Maintenance manuals shall include complete wiring diagrams, parts lists, etc. to enable the owner's representative to perform any and all servicing, maintenance, troubleshooting, inspection, testing, etc. as may be necessary and/or requested.

All basic electronic equipment shall be listed by Underwriters Laboratories, Inc. The contractor shall have supplied similar apparatuses to comparable installations, rendering satisfactory service for at least three years where applicable.

3.4.3 Intent

This ICT network system will provide the connectivity of multiple PCs, printers, and/or terminals through a local area network environment. Each designated network interface outlet will have a capacity to support voice and asynchronous 10, 100 and 1000 Mbps Ethernet through the network cabling and topology specified.

3.4.4 Cable Plant

The following section covers the installation of horizontal cabling, backbone cabling, cable pathways, fire-code compliance, wire identification, and cross-connects.

I. Horizontal Cable

The following requirements apply for horizontal cabling:

- a. Office rooms shall have double-outlet wall plates installed. Each of the two information outlets shall be terminated with eight-pin modular jacks (RJ-45). The wall plates will be placed on opposite walls. The locations of the wall plates will be marked on the blueprints supplied during the walk-through.
- b. Horizontal cable shall be installed in trunking.
- c. No 4-pair UTP cable may exceed 90 metres. The installer must satisfy himself that all cables must be within length prior to the installation. If he believes any run may be over-length, he must inform NHL/NTRL and the Consultant.
- d. The Contractor is responsible for pulling, terminating, and testing all circuits being installed.
- e. The horizontal cable for the data network shall be twisted-pair wire that meets or exceeds the transmission performance requirements for Category 6 UTP cable as specified by the ANSI/TIA/EIA-568-B Standard and any addendums, and shall be UL-listed and verified.
- f. Connection points should be installed such as to prevent damage and ingress of dust or fluids.
- g. All four pairs of the UTP cable shall be terminated at either end via Insulation Displacement Connection (IDC) techniques. To ensure the transmission performance requirements of Category 6 system are maintained, the amount of untwisting in a cable pair to achieve a termination shall be no greater than 13mm. In addition, the stripping back of the outer sheath shall be limited to the minimum amount required to achieve successful termination.

h. The outlet faceplate to be provided shall meet or exceed the Category 6 standard. Compliance with this standard must be met on all pair combinations. In addition to the performance specifications, the faceplate shall also meet the following requirements:

- All outlets shall be provided with shutters that automatically close when device leads are removed
- All IDC connector blocks shall be permanently fixed to the faceplate.
- All unused faceplate apertures shall be provided with blanking plates.

i. Cables shall be terminated at the rear of the patch panel within the equipment rooms and at the wall plates only. There shall be no splicing of any of the cables installed. Intermediate cross-connects and transition points are not allowed.

j. Testing for the distribution components will comply with the TIA/EIA Commercial Building Telecommunications Wiring Standard for Category 6 specifications and will certify 100 percent functionality of all conductors. All circuits must be tested and found to be in compliance. All testing results will be provided to customer in a hard copy and electronic Excel format.

k. The data-cable specifications are intended to describe the minimum standard for use in the “NHL/NTRL Network System.” The use of higher-grade data cabling is recommended if such can be provided in a cost-effective manner.

l. Each cable shall be assigned a unique cable number.

m. Cable management shall be employed in all equipment rooms.

n. Holes drilled through walls and floors for the routing of cables shall

be suitably sleeved to prevent damage to the installed cables. Where cables pass through floors, such protection shall be extended to at least skirting height. Where cables, trunking, traywork or conduit pass through floors or walls, suitable fire sealing shall be provided in accordance with IEE 16th edition wiring regulations.

o. Notwithstanding the compliance with the issues of segregation, additional care shall be taken to ensure that UTP cables are not routed adjacent to other services where electro-magnetic emissions may be generated. Minimum segregation distances shall also comply with the standards laid down by the cable manufacturer. UTP Data cable must never be run in the same containment as mains voltage cables or fire alarm circuits. Where data cables are run in trunking containing mains cables and outlets the data cable must be segregated in a separate part of the trunking.

II. Data Backbone Cabling

The following specifications apply to the data backbone cabling:

- a) An ANSI/TIA/EIA-568-B-compliant single mode or multimode fiber-optic cable network is to be the backbone between the server room (the Main Cross-connect) and any equipment (wiring) rooms.
- b) Where fibre cables are run or are exposed or via an underground pathway, then the cable shall be of a type suitable for outdoor installation (e.g. Gel filled cables) and for routing on tray work within buildings. The outer sheath shall meet fire regulations for installation within buildings.
- c) Cable routes shall be as shown on the blue prints. If any modifications have to be done, they will be agreed upon with NHL/NTRL or their representative prior to commencement of the installation.
- d) The optic fibre cabling system shall be installed in strict accordance with the manufacturer's specifications and recommendations. Care shall be taken to ensure that maximum bending radius not exceeded.
- e) All cables shall be complete between termination points; no cable joints will be permitted. Fibres may only be spliced within termination points. All optical fibre cables shall be terminated within purpose provided patch panels mounted within the equipment racks.
- f) It is possible that fibres will need to be re-terminated on a patch panel or re-spliced. In terminating a fibre the Installers shall ensure that enough slack is left to enable at least two re-terminations to be achieved. In the case of fibres left un-terminated initially the amount of slack shall be sufficient for a first termination or splice and then at least two subsequent terminations or splices. Installers shall indicate how much slack will be left to achieve this. It is mandatory that re-termination or splicing of individual fibres can be undertaken without taking any other fibres out of service.
- g) Holes drilled through walls or floor for the routing of cables shall be suitably sleeved to prevent damage to installed cables. Where cables pass through floors, such protection shall be extended to at least a height of 2 metres.
- h) All equipment rooms shall have at least 6 strands of singlemode or multimode fiber-optic cable between the server room and the equipment room.
- i) All fiber must be FDDI- and 1000Base-FX-compatible.

- j) All fibers are to be terminated using SC-type connectors. However, installers may propose the use of an alternative connector at the patch panel. Reasons must be given for offering any alternative and NHL/NTRL must approve any alternative termination.
- k) The fiber-optic patch panels are to be configured to the amount of strands terminated at each location. Fiber-optic panels shall be metallic, are to have a lockable slack storage drawer that can pull out, and shall occupy one rack position.
- l) Suitable trained individuals utilizing state of the art precision fibre splicing equipment shall perform all splicing.
- m) Testing of fibers will be done using a power meter. The tests will be conducted at 850nm and 1300nm, bi-directionally. All test results will be submitted in hard-copy format.
- n) Laser Hazard Warning labels shall be provided at all fibre terminations.

III. Cable Labelling and Identification

A circuit identification system shall be used in order to ensure each UTP circuit has a unique identifier. This shall be agreed upon with NHL/NTRL.

- a) All RJ45 outlets shall be clearly marked with a securely fixed label showing the circuit number. The labels should be printed, with a self-adhesive backing.
- b) Patch panels should be clearly labelled with a securely attached label showing the patch panel identifier. Each socket on the patch panel should also be labelled with the full circuit identifier.
- c) All UTP cables should be labelled at each end with a wrap-around label printed with the circuit identifier. The label should be located near the termination point at either end, such that the circuit can still be identified if the termination is removed.

IV. Fire-Code Compliance

All cabling installed in the riser and horizontal distribution shall meet or exceed all local fire codes.

V. Wiring Pathways

The following are related to the installation of cable in plenum and other cable pathways:

- a) Cable pathway design should follow the ANSI/TIA/EIA-569 (Commercial Buildings Standards for Telecommunications Pathways and Spaces) Standard.
- b) The methods used to run cable through walls, ceilings, and floor shall be subject to safety code and fire regulations. The contractor will assume all responsibility for ensuring that these regulations are observed.
- c) Cables shall be routed behind walls wherever possible. Surface-mount trunking shall be used where necessary.
- d) System layout shall restrict excessive cable lengths; therefore, routing of horizontal cables shall be in a manner as not to exceed 90 meters from device plate to patch panel located in the assigned wiring room. Each cable shall be home-run directly from its cross-connect to the wall plate.

VI. Equipment Rooms

The following are related to the installation of the equipment (wiring) rooms:

- a) The rooms to be used as the originating points for network cables that home-run to the room outlets are referred to as equipment rooms. All racks and their locations are specified on the blueprints that will be provided during the initial walk-through; their exact locations will be confirmed during the mandatory walk-through.
- b) Rack layout should provide enough space to accommodate the cabling, equipment racks, patch panels, and network-control equipment, as required. Additionally, the locations should provide for convenient access by operational personnel. A minimum of 500mm should be allowed between the side and back of cabinets. Front access should allow for a minimum of 1m clearance. It should be dust free, have suitable ventilation, lighting and security.
- c) All racks, panels, and enclosures for mounting equipment shall meet 19-inch EIA mounting-width specifications. Each equipment rack should include two 19-inch rack shelves that can support the weight of a 25kg uninterruptible power supply.

- d) Equipment racks shall be properly grounded to nearest building ground and must be properly attached to the floor and supporting wall by means of horizontal-rack bracket mount. All equipment racks must have a five-outlet 20-amp power strip with surge protection installed inside.
- e) The room shall be suitably air conditioned to maintain equipment temperature not exceeding 23 degrees and shall operate 24x7x365. The room design and cooling is to create positive pressure to assist with the prevention of dust ingress. The room should never exceed temperatures of 28°C even when fully populated with racks and network equipment.
- f) The room's general illumination level shall be 400 lux and it shall be equipped with additional emergency light fittings
- g) Dedicated cable trays shall radiate out from the communications room to access all sections of the building to allow for future additions. The width of the cable trays shall be agreed on consultation with the Manager, ITS, in any case, shall not be less than 150mm.
- h) Upon completion, and prior to hand over to the Client, the room and equipment racks are to be fully cleaned and free from construction dust and debris associated with installation.

VII. Patch Panels

Patch panels are used as intrabuilding interconnects or main crossconnects. They provide a central location for patching, testing, monitoring and restoring service to UTP cable/fiber optic transmission lines. The patch panel receives the UTP cable/fiber optic patch cords or jumpers from the splice panel or from equipment, and properly routes them to other pieces of equipment

The UTP cable patch panels provided shall meet or exceed the Category 6 specifications. Patch panels must either be 1U high 24 port or 2U high 48 port types. Sockets should be arranged in a single row on 1U panels and two rows on 2U panels. All positions on the patch panel must be fully loaded to allow additional circuits to be added later.

For voice, telephone cabling within a building linking the MDF to a communications rack shall terminate within the rack using Krone Voice Patch Panel or approved equivalent.

VIII. MC/IC Cable Management

The following relates to cable management for the main cross-connect (MC) and intermediate cross-connect (IC) in the equipment room, and horizontal cross-connects (HC) in telecommunications rooms:

- a) The contractor is required to install cable management on all racks installed. Cable management is to consist of horizontal management between each panel and vertical management on the sides of the rack.

- b) All cable management is to be of the “base-and-cover” style. Cable management is to be provided for the front of the rack only.

IX. Commissioning Test Results

The results must include 100% of total installation and provide full electronic data files for each cable run indicating the name of the person doing the testing, date, building, cable identification, cable length, Insertion Loss, NEXT, PSNEXT, ACR, PSACR, Propagation Delay, Delay Skew, ELFEXT, PSELFEXT, and Return Loss.

3.4.5 As-Built Diagrams

The Contractor shall provide as-built documentation within 15 days of completion of the project. These prints will include outlet locations, outlet numbers, MC/IC/HC locations, all main cable runs, trunk-cable routing, and legends for all symbols.

Provision Of Training

Prior to Practical Completion, the Contractor and Specialist Sub-contractors shall provide the services of competent personnel to instruct the appropriate Client personnel in the operation and maintenance of the installed systems.

3.4.6 Cctv For Security And Monitoring

I. Cameras

Among other features, the offered cameras shall;

- a) Support H.264, MPEG-4 and JPEG image compression standards with operational flexibility so that the user can select the desired compression format.
- b) Have the pan, tilt and zoom (PTZ) function which can be remotely controlled to provide many views from within its panning, tilting and zooming range, to enable the user to get a close, detailed look at certain parts of the image being monitored. The maximum zoom range shall be indicated but shall not be less than 30px to enable monitoring of areas that have considerable depth.
- c) If IP Cameras are used, they should be able to send images securely over an IP network using a built-in web server.
- d) Have a colour night mode such that when the subject darkens, the camera shall automatically adjust the brightness so that one can see clear, easy-to-view images even in the dark. The minimum light intensity in lux under which the camera can work shall be indicated.

- e) Have a sensor that detects the presence of people by picking up the infrared light (heat) naturally emitted from people and animals.
- f) Give alerts when changes occur, so that when full-time monitoring or long-term video recording is not required, the camera can be set up to come on automatically whenever it senses a change in its field of view.
- g) Outdoor cameras should have a weatherproof enclosure and be able to work well under light conditions that are constantly changing.
- h) Support versatile interfaces such as support for an analogue composite video signal for outputting images to a local recording device or monitor.
- i) Support file export to removable media such as SD card, CF card, etc.
- j) Support two-way audio to allow users not only to listen in but also to verbally communicate with people at the camera end.
- k) Provide video resolution of 640x480 and frame rate of up to 30 frames per second.
- l) Be compatible with the PAL system.

II. Monitoring and Recording system

The offered system shall be a versatile monitoring and recording system that shall, among other things,

- a) Provide for manual recording, motion detection recording, alarm activated recording and timer recording.
- b) Provide for recording in JPEG format, as well as MPEG-4 with simultaneous audio recording.
- c) Provide for multi-camera monitoring and allow the user to customise the operating screens, and be able to convert recorded data to other formats, like Windows Media Player, for easier, and more flexible monitoring and data exchange. It shall be possible to view multiple images and monitor several areas simultaneously with the multi-camera capability.
- d) Control the basic camera functions (pan/tilt/zoom, brightness, resolution, image quality, sound level).
- e) Have search functions
- f) Have recording time display (time stamp function): - it shall be possible to display the date and time on all monitored still or moving images to ensure that even when video is recorded for later viewing, the

exact time of the recording will always be in view. This feature is useful for security checks.

- g) Provide Log analysis

3.4.7 Access Control System

The Security Management System should be a modular and networkable access control system, capable of providing alarm monitoring, video imaging and badging, and CCTV switcher control, that allow for easy expansion or modification of inputs, outputs and the management of remote control stations.

The system should support both manual and automatic response to alarms / events entering the system. Each event will be capable of number of different actions, such as: camera switching, door control, card or PIN validation, and be able to send alert messages to different groups of people (supervisors or security guards) by SMS, E-mail or screen display messages.

Access Control functions should include validation based on time of day and day of week, holiday scheduling site code verification, video image storage and retrieval of cardholder photographs, and access validation based on positive verification of card, biometric and other identification means.

I. Physical Access Control Systems

The integrated Security Management System should provide and integrate the following functions:

- a) Elevator/Door Access Control
- b) Authorization groups
- c) Events alarm Monitoring and Processing
- d) Equipment Control
- e) Management Reporting
- f) CCTV Switching and Control

The System should deploy the latest contactless smart card technology / DESFire, with secure access to premises providing strong authentication methods and avoiding forgery of the identity cards, while minimizing the risk of unauthorized access.

The System should include Biometrics authentication methods (fingerprint and face recognition), and a direct contact between the controller and the badge, in order to prevent “bypass”.

The infrastructure should contain a number of elements that can be used for:

- g) Access control management software, responsible for overall control
- h) Control access stations
- i) Biometric readers (Fingerprint and/or face recognition)
- j) Card reader – DESFire smart card readers
- k) Electromagnetic Yale lock 300kgF,
- l) Electromagnetic Yale lock 500kgF,
- m) Adapter Z+L electromagnet 300kgF
- n) Adapter Z+L electromagnet 500kgF
- o) Electromagnetic Yale lock Fail Safe, 12Vcc,
- p) Door tamper
- q) Magnetic contact
- r) Door open button
- s) Emergency open button
- t) CCTV + DVR System

II. The solution should be able to:

- a) Configure system security objects such as:
 - Controllers
 - Readers
 - Doors
 - Holidays
 - Time specifications
 - System events, intrusion zones and keypad commands
- b) Configure personnel records, user and user privileges
- c) Display, import and export personnel records
- d) Configure events to respond to:
 - inputs
 - alarms
 - communication failures
- e) Configure events to initiate actions such as:
 - Sending SMS / e-mail / page messages
 - Design and print badges
- f) Configure intrusion zones and keypad commands
- g) Emergency door control –user can open/lock all doors
- h) User defined alarms and actions taken based on these events

III. Monitoring station should provide the following functionalities:

- a) View general activity and events
- b) View the status of objects
- c) Acknowledge/verify events
- d) Perform manual actions
- e) Multiple read-only console available for guards

- f) Audio/visual indication during the events

IV. General functionality:

- a) Unlimited number of recordings
- b) Unlimited number of clearances
- c) The possibility of importing recordings from a given list
- d) Analysis of all the recording “from” fields
- e) Analysis of inactivity, expired cards, blocked cards
- f) Unlimited (time & volume) events memorizing
- g) Generation of a variety of reports by date / time / security group / employee / card number etc.
- h) Automatic reports about expiring cards
- i) Audit report regarding all the changes done in the access control system for the specified periods
- j) Reports regarding all kind of permitted messages (user login/logout, card admitted, card rejected, log message, state change, manual action, system activity (non error), system error, device activity (non error), intrusion zone activity, intrusion zone error, area activity), and the possibility of selecting the right type of message
- k) Reports regarding all kind of permitted security equipments (ex administration privilege, clearance, door, controller etc)
- l) Counting the persons within a restricted area: the system keeps strict documentation of the persons situated in a specified zone. This information may be related with the lightening, environmental control, deactivating the alarm at the entrance by the first person to enter. A reversed sequence can be set up when the last person is leaving the zone.
- m) Alert to one-before-last employee about the presence of another employee in the building
- n) Emergency outlet: closing a contact (fire central or evacuation button) all the doors are opening automatically.

V. The solution should be able to manage, from one single point, all administrative functions including:

- a) issuing ID card/smartcard for new users
- b) Fingerprint Enrolment
- c) write digital credential on smartcards
- d) print smartcards
- e) assign/modify/revoke user access rights
- f) real-time track of user activity
- g) generate reports covering user activity for a specific period of time
- h) real time alerting based on specific threshold defined by user

3.4.9 Authorization

The system should have an integrated security layer, allowing users to be assigned to a security group. Security groups are assigned privileges to access different parts of the application. This includes all screens, reports, interfaces and other key business functions.

The system should provide the capability to further add or restrict menu and submenu options for individual users. Ideally, it should be based on a policy where by default no one is allowed to access anything, unless explicitly permitted so.

Ability to protect resources based on: user's ID, time, machine location, state of any additional data (dynamic access based on business rules and dynamic data).

All administrative tasks (including those relevant from the security point of view) should be performed through specific accounts. Their names should not give any clue about their special rights.

The system should provide the ability to delegate limited administration functions to a local administrator. For example, access to a particular local system could be delegated to that system's local administrator.

The system should provide an access control mechanism to be able to show who has been granted access to any particular area, and to show which data entities / transactions any particular individuals may read, modify or execute (given a user ID).

3.4.10 Audit

All events relevant for security (successful or unsuccessful) - that is authentication, authorization or object access events - have to be logged. If the system/application is made up of several components/modules, centralized audit trail functionality should exist, allowing managing the logs on each component.

The audit trail functionality will be highly configurable, allowing for setting on/off of each individual event type of logging. The audit trail functionality will provide the capability to export audit logs into a database, TXT or CSV formats.

The audit trail functionality will provide the capability to select events that took place within a specific range of dates and times. Access to the logging system and data will be restricted to privileged accounts and user profiles (e.g. root, system administrator).

The types of events are (but not limited to):

- a) An intact and permissible card swipe
- b) Card not listed in the database
- c) Swiped at incorrect time
- d) Refused because of anti-pass back check
- e) The reader tamper control has been activated
- f) The door remained open for longer than the defined time
- g) The PIN code was not entered within the time set for time-out
- h) A wrong PIN code has been entered 3 times
- i) The card has used up all its passes. No more countdown
- j) The card is set as Not Permitted
- k) The connection between the controller and the reader has been disconnected (due to electricity, cable problems or cut cables)
- l) The connection between the controller and the reader returned
- m) No more memory space available for new cards. Collecting data from terminal will free up memory space
- n) Blocked keys have been pressed
- o) No input arrived from the keyboard during the time set for time-out
- p) The door was opened using a duress code instead of the PIN code. Using the duress code indicates the holder opened the door under threat
- q) The power returned after working on backup battery of power on/off
- r) The door closed after being open for more than the allowed time
- s) The card is not listed in the database
- t) The card has been suspended
- u) The card is listed but has expired in the security group
- v) The card is not allowed to swipe at this time
- w) The card appears in the data base but is not active
- x) The card does not appear in the card list
- y) A wrong PIN code has been entered

3.4.11 Schedule Of Unit Rates

The Contractor shall price the unit rates of the following materials:

Item No.	Description	Unit	Rate
1	Galvanised steel conduit with all fittings fixed to background, 20mm	LM	
2	Ditto, 25mm	LM	
3	Ditto, 32mm	LM	
4	Ditto, 38mm	LM	
5	Ditto, 50mm	LM	
6	Black enamelled steel conduit with all fittings fixed to the background, 20mm	LM	
7	Ditto, 25mm	LM	
8	Ditto, 32mm	LM	
9	Ditto, 38mm	LM	
10	Ditto, 50mm	LM	
11	PVC conduit, super high impact, heavy gauge, fixed to background, 20mm	LM	
12	Ditto, 25mm	LM	
13	Ditto, 32mm	LM	
14	Ditto, 38mm	LM	
15	Ditto, 50mm	LM	
16	Cable PVC/SWA/PVC 4 core copper in a trench and backfilled, 6mm ² .	LM	
17	Ditto, 10mm ²	LM	
18	Ditto, 16mm ²	LM	
19	Ditto, 25mm ²	LM	
20	Ditto, 35mm ²	LM	
21	Ditto, 50mm ²	LM	
22	Ditto, 70mm ²	LM	
23	Ditto, 95mm ²	LM	
24	Ditto, 120mm ²	LM	
25	Ditto, 150mm ²	LM	
26	Ditto, 180mm ²	LM	
27	Ditto, 240mm ²	LM	
28	Ditto, 300mm ²	LM	
29	Cable PVC/SWA/PVC 4 core copper laid in a duct, 6mm ²	LM	
30	Ditto, 10mm ²	LM	

Item No.	Description	Unit	Rate
31	Cable PVC/SWA/PVC 4 core copper laid in a duct,6mm2	LM	
32	Ditto, 10mm2	LM	
33	Ditto, 16mm2	LM	
34	Ditto, 25mm2	LM	
35	Ditto, 35mm2	LM	
36	Ditto, 50mm2	LM	
37	Ditto, 70mm2	LM	
38	Ditto, 95mm2	LM	
39	Ditto, 120mm2	LM	
40	Ditto, 150mm2	LM	
41	Ditto, 180mm2	LM	
42	Ditto, 240mm2	LM	
43	Ditto, 300mm2	LM	
44	Cable PVC/SWA/PVC 4 core copper fixed to background, 6mm2	LM	
45	Ditto, 10mm2	LM	
46	Ditto, 16mm2	LM	
47	Ditto, 25mm2	LM	
48	Ditto, 35mm2	LM	
49	Ditto, 50mm2	LM	
50	Ditto, 70mm2	LM	
51	Ditto, 95mm2	LM	
52	Ditto, 120mm2	LM	
53	Ditto, 150mm2	LM	
54	Ditto, 180mm2	LM	
55	Ditto, 240mm2	LM	
56	Ditto, 300mm2	LM	
57	Cable, single core, drawn in conduit, 1.5mm2	LM	
58	Ditto, 2.5mm2	LM	
59	Ditto, 4mm2	LM	
60	Ditto, 6mm2	LM	
61	Ditto, 10mm2	LM	
62	Ditto, 16mm2	LM	
63	Ditto, 25mm2	LM	
64	Cable, single core, laid in trunking, 1.5mm2	LM	
65	Ditto, 2.5mm2	LM	