



ITB No.:

Project Name: Constructing Medical Waste Treatment Facility in Gaza Governorate

Technical Specifications

Electronic copy of the BOQ shall be submitted along with the signed hard copy thereof. In case of any discrepancy between the soft and the hard copies, the hard copy shall prevail.

August, 2020

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<u>Constructing Medical Waste Treatment Facility in</u> <u>Gaza and North Governorates</u>

Civil Works Specifications

July 2020

Table of Content

1	EXCAV	ATION AND EARTHWORK	6
	1.1 Clea	aring and Grubbing	6
	1.1.1	Description	6
	1.1.2	Construction Requirements	6
	1.1.3	Method of Measurement	6
	1.2 Gen	eral Excavation	6
	1.2.1	Classification of Excavation	6
	1.2.2	Construction Requirements	7
	1.2.3	Method Of Measurement	7
	1.2.4	Basis Of Payment	8
	1.3 Tren	nch Excavation	8
	1.3.1	General	8
	1.3.2	Obstructions	9
	1.3.3	Trench Width	9
	1.3.4	Supporting Trench Excavations	9
	1.3.5	Undisturbed Ground	10
	1.3.6	Trenches not to be Left Open	10
	1.3.7	Trench Foundation (Bedding)	10
	1.4 Eart	h Filling	11
	1.4.1	Construction Requirements	13
	1.4.2	Method of Measurement and Payment	14
	1.5 Con	paction of Earthwork	14
	1.5.1	Testing Methods	14
	1.5.2	Equipment	15
	1.5.3	Construction Requirements	15
	1.5.4	Existing Foundation For Earth Fill	15
	1.5.5	Earth Fill	16
	1.5.6	Moisture Control Requirements	16
	1.5.7	Tamping	16
	1.5.8	Special Provisions For Other Rollers	16
	1.6 Con	praction Trials	17
2	CONCR	ETE WORK	18
-	2.1 Gen	eral	18
	2.2 For	nwork For Concrete	19
	2.2 Poin 2.3 Reir	forcement For Concrete	21
	2.4 Con	creting	22
	241	Cement	22
	2.4.2	Aggregates	23
	2.1.2	Water	25
	244	<i>Quality of Concrete</i>	25
	245	Batching and Mixing of Concrete	28
	2.4.6	Work in Cold or Hot Weather	29
	2.4.7	Placing	29
	2.4.8	Admixtures	30
	2.1.0	Curing	31
	2.1.9	Formed Finishes	31
	2.7.10 2 <u>4</u> 11	Quality Control Testing	32
	2.7.11 2 4 12	Position of Reinforcement	32
	2.1.12	Ready mixed concrete	33
	2.1.13		55

	2.4.	14 Concrete Surface Hardener	.34
3	BLC	OCK WORK	.35
	3.1	General	.35
	3.2	Manufacture	.35
	3.3	Mortars	.36
	3.4	Construction	.37
	3.5	Workmanship	.38
	3.6	Expansion Joints	.38
	3.7	Steel Channels, Cramps, Ties and Dowels	.38
4	PLA	ASTER WORK	.40
	4.1	General	.40
	4.2	Materials	.40
	4.3	Mixing	.40
	4.4	Plastering And Similar In-Situ Finishing And Backings	.41
	4.5	Preparation for Plaster etc.	.42
	4.6	Curing of Plaster, etc	.42
	4.7	Uses of Plaster	.42
	4.8	Application of Plaster	.43
	4.9	Application Of Tyrolean	.44
	4.10	Steel Mesh Lathing, Stops and Beads	.45
	4.11	Protection	.46
5	PAI	INTING AND DECORATING	.47
	5.1	General	.47
	5.2	Materials	.48
	5.3	Preparation Process	.50
	5.3.	1 Internal Plaster, Fair Faced Concrete and Block Work	.50
	5.3.	2 Steelwork, Internally And Externally	.50
	5.3.	3 Woodwork Required To Be Painted	.51
	5.3.	4 Woodwork Required To Be Stained	.51
	5.4	Finishing Processes	.51
	5.4.	1 Internal Plaster	.51
	5.4.	2 Un plastered Block work or Concrete	.52
	5.4.	3 Woodwork Required To Be Painted	.52
	5.5	Protection of Factory Finished Work	.52
6	WA	ALL AND FLOOR TILING	.53
	6.1	General	.53
	6.2	Materials	.53
	6.3	Terrazzo Tiles	.53
	6.4	Marble	.54
	6.4.	1 Marble Lining	.55
	6.5	Ceramic and Glazed Tiling	.55
	6.5.	1 Unglazed Ceramic Floor Tiling	.55
	6.5.	2 Glazed Ceramic Wall Tiling	.56
	6.6	Protection	.58
7	GLA	AZING	.59
	7.1	General	.59
	7.2	Type of Glass	.59
	7.2.	1 Sheet Glass	.59
	7.2.	2 Plate Glass	.59
	7.2.	3 Wired Glass	.59
	7.2.	4 Mirror Glass	.60

7.3	Installation	60
7.4	Cleaning	60
8 CA	RPENTRY AND JOINERY	61
8.1	General	61
8.2	Timber	61
8.2.	1 Moisture Content of Timber	
8.2.	2 Plywood	
8.2.	3 Timber Face Veneers	
8.2.	4 Fixing And Jointing	
8.2.	5 Spacing And Additional Supports	
8.3	Doors	
8.4	Frames	64
8.5	Fittings	
8.6	Finish	
8./	Protection	
8.8	Sign Board	
9 IRC	ONMONGER Y	
9.1		
9.2	Finish	
9.3	Fitting And Testing	
9.4	Standard Ironmongery for Internal Doors	
10 ME	Canada Cana	
10.1	Clearliness	
10.2	A huminoum Windows	
10.5	Aluminum windows	
10.2	2.2 Sida Hung Windows	
10.	3.2 Sldt Hung Windows	
10.	3.1 Sealing Loints	
10.	3.5 Expansion Joint Trims	70
10.	Steel Doors And Gates	70
10.4	4.1 Execution	70
10	4.7 Frection	
10.	4.3 Sliding Gate	72
10.5	Handrails	
10.6	Raised Floor Slabs	73
10.0	6.1 System Description.	
10.0	6.2 Shop Drawings and Product Data	
10.0	6.3 Samples	
10.0	6.4 <i>Quality Assurance</i>	74
10.0	6.5 Acceptable Manufacturers	74
10.0	6.6 Type Of Understructure	74
10.0	6.7 Pedestal Assembly	74
10.0	6.8 Floor Surface Covering	75
10.0	6.9 Accessories	75
10.0	6.10 Installation	75
10.0	6.11 Step By Step Installation Of Field Area	76
11 RO	OFING AND INSULATING	79
11.1	General	79
11.2	Corrugated Steel Roofs	79
11.3	Screeds	79

11.4	Insulation	.80
11.5	Expansion Joints	.80
11.6	Black Bitumen Paint	.81
11.7	Polyethylene Sheet	.81
11.8	Epoxy Risin Coating	.81
11.9	Waterproofing	.81
11.10	Water Stopper	.81
11.11	Completion	.82
12 STEE	L STRUCTURES	.83
12.1	General	.83
12.1.1	Technical Codes of Practice	.83
12.1.2	Climatic Conditions	.83
12.1.3	State And Quality of Steel	.83
12.1.4	Drawings	.84
12.2	Execution Of The Steel Structures	.84
12.2.1	Selling out and Tolerance	.84
12.2.2	Manufacture in Workshops	.85
12.2.3	Welding	.86
12.2.4	Bolted Assemblies	.87
12.3	Works On Site	.88
12.3.1	Transport and Handling	.88
12.3.2	Erection	.88
12.4	Surface Treatment	.88
12.4.1	Painted Steel Structures	.88
12.4.2	Hot Galvanized steel Structures	.89
12.5	Gangways - Stairs – Ladders - Guard	.89
12.6	Steel Panels	.90
12.7	Monorail and Lifting Device	.90
13 MANI	HOLES AND CHAMBERS	.91
13.1	GENERAL	.91
13.2	CLEANING	.91
13.3	CONSTRUCTION OF MANHOLES AND VALVE CHAMBERS	.91
13.4	FORMWORK OF VALVE CHAMBERS	.91
13.5	PRECAST ELEMENTS	.91
13.5.1	Materials	.91
13.5.2	Mortar	.92
13.5.3	Fabrication	.92
13 5 4	Workmanshin	92
14 INTER	RLOCK TILING WORKS	93
14.1	General	.93
14.1.1	Scope Of Work	.93
14 2	Suborade	93
14.3	Sub-Base	93
1431	General	93
14.3.2	Class A Sub-Base	.94
1433	Class B Sub-Base	.94
1434	Class C Sub-Base	94
1435	Construction	94
14.4	Base $-Course$	95
1441	General	95
1447	Aggregate Base Course - Type A	95
1 7.7.4	1-56 Sale Dube Course 1, per l	

14.4.3 Aggregate Base Course - Type B	96
14.4.4 Construction	97
14.5 Interlock Tiling	97
14.5.1 Construction	

1 EXCAVATION AND EARTHWORK

1.1 Clearing and Grubbing

1.1.1 Description

This work shall consist of clearing, grubbing the top layer (about 15 cm at least) and disposing of all vegetation and debris within the limits of the construction site, except such objects as designated to remain or is to be removed in accordance with other sections of the specifications.

1.1.2 Construction Requirements

The Contractor shall establish construction limits and where applicable, the Engineer or his Representative will designate all tree shrubs, plants, and other things to remain. The Contractor shall preserve all things designated to remain.

All surface objects and all trees, stumps, roots and other protruding obstructions, not designated to remain shall be cleared and/or grubbed.

Except in areas to be excavated, stump holes and other holes from which trees are removed, shall be backfilled with clean sand, moisture and compacted to 95% of the Modified Maximum Dry Density according to specification.

1.1.3 Method of Measurement

This work (clearing & grubbing) will be measured by m^3 or as indicated in the BOQ. The depth will be measured from the existing natural level to the level reached after carrying out the work.

The Contractor has to perform grid survey after completing the clearing and grubbing. The new levels will be adopted as Datum Levels for all measurements to be carried out afterward for the coming excavations.

1.2 General Excavation

This Work shall consist of excavating the earthwork platforms removing and satisfactorily disposing of all materials taken from within the limits of the work, and shall include all excavation, preparation and completion of all platforms, *embankments and slopes*, as directed, and in conformity to the grades, and cross-section shown on the plans or established by the Engineer or his Representative.

1.2.1 Classification of Excavation

General Excavation

The Contractor shall visit the Site prior to making his tender and shall examine the nature of the earth and rock, its quantity, location and suitability to meet the specified requirements and base his bid prices solely on his own determination of soil conditions.

After Award of Contract, no claim based on source of soil information will be entertained for revision of bid prices.

The preliminary classification of general excavation as "Common Excavation" or will be shown on the plans. The Engineering geological information shown on the plans, form which the quantities of "Common Excavation" are estimated, is based on studies made in the field and represents the best information available to the Employer. Final adjustment of the preliminary classification for embankment excavation as "Common Excavation" shall be determined by the Engineer or his Representative as the Work is opened up and performed.

Common Excavations

Common excavation shall consist of the removal and satisfactory disposal of all unclean, agricultural soil and residual materials. Within the Contract limits all Cut Material from the site, after deduction for material declared unsuitable by the Engineer or his Representative shall be considered to be available for use in filling.

1.2.2 Construction Requirements

All materials removed from the excavation shall be used in the filling in other places as directed, unless it is declared unsuitable and ordered to be wasted by the Engineer or his Representative. No excavation material shall be wasted without written permission from the Engineer or his Representative, and when such material is to be wasted, it shall be so placed, in the positions agreed by the Engineer or his Representative.

Excavated materials wasted by the Contractor, without written permission of the Engineer or his Representative, shall be replaced by the Contractor at his expense.

Where excavation to the finished graded platform level results in areas of unsuitable soil, the Engineer or his Representative may require the Contractor to remove the unstable materials and backfill to the finished graded section with approved material. The Contractor shall conduct his operations in such a way that the necessary cross-sectional measurements can to take before the backfill is placed.

The Engineer or his Representative may designate as unsuitable those soils that cannot be properly compacted.

When the Contractor is required or directed to excavate unsuitable material below the surface of the original ground in fill areas, other than those required for clearing and grubbing, the depth to which these unsuitable materials are to be removed will be determined by the Engineer or his Representative. The Contractor shall schedule the work so that authorized cross-sections can be taken before and after the material has been removed.

1.2.3 Method Of Measurement

When payment is specified on a volume basis in the Bill of Quantities, quantities of various classes of Excavation shall be computed by the Contractor and checked by the Engineer or his Representative Quantity computations shall base on the original cross-sections taken by the contractor, which were observed by and attested to by the Engineer or his Representative, and final cross-sections developed from were checked and attested to by the Engineer or his Representative.

Datum Levels reached after carrying out the Clearing and Grubbing will be the bases for computing the depth of excavation.

Any materials removed or excavated before these measurements have been taken and approved by the Engineer or his Representative will not be paid for.

The Engineer or his Representative will check all or part of the work, as he deems necessary, to determine conformance to the lines, grades, elevations and cross-sections submitted by the contractor. The contractor shall at his own expense, provide the equipment and labour, including filed parties, to assist the Engineer or his Representative in checking the work.

Measurement will be made for unsuitable materials actually excavated and removed to obtain proper compaction in cut sections and in foundations for fill sections.

Where it is impractical to measure material by the cross section methods due to the erratic location of isolated deposits, acceptable methods involving three-dimensional measurements may be used, when approved by the Engineer or his Representative.

1.2.4 Basis Of Payment

The amount of completed and accepted works, measured by cubic meter, will be paid for at the unit price(s) per cubic meter for "Common Excavation", as shown in the Bill of Quantities, which price(s) shall be fill compensation for all excavation, hauling of the excavated material to any distance required by the Engineer or his Representative where the material will be dumped and properly leveled, trimming of slopes, clean up, preparation of platforms and for all other items necessary for the proper completion of the works.

1.3 Trench Excavation

1.3.1 General

Trench excavation means excavation in all materials of whatever nature encountered for trenches into which pipes and ducts etc. are to be laid, or appurtenances constructed. The term pipe shall mean pipe of all kinds and for whatever purposes.

The line and level of trenches shall be as shown on the drawings or as may be directed by the Engineer or his Representative. Before commencing trench excavations, the route of the trench shall be pegged out accurately, adjusted if found necessary before final route of trench is approved by the Engineer or his Representative. The natural ground level along the route shall be checked by the Contractor against drawings and its levels shall be agreed with the Engineer or his Representative.

Strong sight rails shall then be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary. On these rails shall be marked the Centerline and the level to which the excavation is to be carried out, such rails being not more than 20m apart. Alternate methods to maintain line and level of pipelines shall be to the approval of the Engineer or his Representative.

Trench excavation shall be carried out by such methods and to such lines dimension and depths as shall allow for the proper construction of the works, or as indicated on drawings or other parts of these documents. Notwithstanding the foregoing, any rock in trench excavation shall be so excavated that the clearance between the pipe, when laid, and the rock sides and bottom of the trench is kept to the minimum limits necessary to provide for the specified thickness of bedding and eventual concrete protection of the pipe.

Bell holes and holes and depressions for couplings, valves and the like shall be excavated the same distance below these installations. The materials excavated shall be used in the backfill or removed and disposed of by the Contractor, as required by the Engineer or his Representative. The trench shall be dug only so far in advance of pipe lying as the Engineer or his Representative shall permit.

The Contractor shall submit typical cross-sections of trenches for the Engineer or his Representative's approval according to specification and as directed by the Engineer or his Representative. No length of trench excavation shall be started until the pipes and fittings to be laid in that length are available on the Site.

1.3.2 Obstructions

Where the grade or alignment of the pipes is obstructed by existing utilities (either shown or not shown on the drawings) such as conduits, ducts, pipes, branch connections etc. the obstructions shall be supported, relocated, removed, or reconstructed by the Contractor at his own cost unless opposite item has been included in the Bill of Quantity.

Whenever it is necessary to determine the location of existing underground utilities, the Contractor, after an examination of available records, shall make all explorations, excavation and survey as may be directed by the Engineer or his Representative to determine these locations. Only such tools and equipment as have been approved by the Engineer or his Representative shall be used by the Contractor to execute the work in a safe and efficient manner. If the obstructions encountered require alterations to the drawings, the Contractor shall, in accordance to the above investigations and in accordance with the indications received by the Engineer or his Representative, change the plan and profiles as necessary and submit the drawings to the Engineer or his Representative for approval.

The Contractor shall not make any deviation from the specified line and/or grade without approval by the Engineer or his Representative Should any deviations in line and/or grade be permitted by the Engineer or his Representative for convenience to the Contractor, any additional costs for the thrust blocks, valves, air and vacuum assemblies, blow-off assemblies, extra pipe footage, manholes or other appurtenances shall be borne by the Contractor.

1.3.3 Trench Width

Unless otherwise specified or instructed the minimum trench width shall be 500 away from the pipe from each side at the specified level (depth).

1.3.4 Supporting Trench Excavations

An excavation must be properly supported or the sides adequately battered to a safe angle as soon as the excavation reaches 1.5 m.

The Contractor shall well and effectively support the sides of all trench excavation. This support shall include the use of steel sheet piles, where necessary, to prevent any fall or run from any portion of the ground outside the excavation into the trench and to prevent settlement of or damage to structures adjacent to the excavation. The Contractor shall be deemed to have made his own allowance for shoring up the sides of trenches, any extra excavation necessary to provide space for such support and for any other working space. If for any reason any portion of trench excavation shall give way, the Contractor shall at his own expense take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed.

The Contractor shall not remove temporary works supporting the excavations until in the opinion of the Engineer or his Representative the permanent work is sufficiently advanced to permit such removal, which shall be executed under the personal supervision of a competent foreman.

Any advice, permission, approval or instruction given by the Engineer or his Representative relative to such support or the removal thereof shall not relieve the Contractor from his responsibilities under the Contract. All temporary works supporting the excavation shall be removed during backfilling unless previous approval has been obtained from the Engineer or his Representative Where temporary supports have been used in the excavation any such supports left in because it is impracticable to remove them shall be left in at the expense of the Contractor.

1.3.5 Undisturbed Ground

When excavating to specified levels for trench excavation or to specified limits for the face of any structure therein required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing construction work except where the Engineer or his Representative permits otherwise.

Should the Contractor has excavated to within 150 mm above these specified levels or to within 150 mm of these specified limits before he is ready or able to commence the construction work he shall where required by the Engineer or his Representative excavate further so as to remove not less than 150 mm of material immediately before commencing the constructional work and any such further excavation and additional foundation material ordered by the Engineer or his Representative shall be at the cost of the Contractor.

1.3.6 Trenches not to be Left Open

Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of trench excavations shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and jointed.

Pipe lying shall follow closely upon the progress of trench excavation, and the Contractor shall not be permitted to leave unreasonably excessive lengths of trench excavation to remain open while waiting testing of the pipes but in any case not more than 200m ahead of the pipe laying operation or greater lengths if approved by the Engineer or his Representative.

The Contractor shall take precautions to prevent flotation of pipes in locations where open trench excavations may become flooded, and these precautions may include the partial refilling of the trench leaving pipe joints exposed for tests of the joints.

If the Engineer or his Representative considers that the Contractor is not complying with any of the foregoing requirements he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trench excavation.

The Contractor will not be permitted to excavate trenches in more than one location in any one road at a given time without the Engineer or his Representative's permission.

1.3.7 Trench Foundation (Bedding)

Bedding material shall be clean natural sand unless not specified otherwise on drawings. All shattered and loose material shall be removed from the bottom of the trench excavations so that the bedding material rests on a solid and clean foundation.

Before bedding material is placed, any unsound material or soft spots naturally occurring in the bottom of any excavation shall be filled with selected material as directed by the Engineer or his Representative.

Where the Contractor is laying a pipe into a port in an existing structure, manhole chamber or thrust blocks, and where the backfill material to previous excavation beneath

the pipe formation, is not concrete, the backfill material shall be removed over its full depth and for the full width of the pipe trench shown on the Drawings. The resulting void shall be filled solid with selected material.

If in the opinion of the Engineer or his Representative a formation is unsound as a result of the Contractor failing to keep the excavation free from water or other materials the Engineer or his Representative will order the removal and disposal of the unsound material and the filling of the resulting void. The Contractor shall execute the work as directed and bear the costs of the same.

1.4 Earth Filling

This work shall consist of approved earth filling in layers not exceeding 300 mm loose material to grades and levels as shown in the drawings and as directed by the Engineer or his Representative, including preparation of the areas upon which they are to be placed, the compaction of approved materials with the limit of construction and where the unsuitable materials has been removed and the placing and compacting of approved materials in holes and pits and other depressions within the lines, grades, thickness as per the cross sections prepared by the contractor and approved by the Engineer or his Representative.

Filling to make up levels under building shall be executed with approved suitable material from existing ground levels up to underside of ground floor slab, and shall be placed in successive layers each having a finished thickness not exceeding 250 mm, watered and compacted prior to the placement of the succeeding layer.

The ground surrounding the building and pavements shall be filled with approved material, fine sand and coarse materials, free of foreign material, debris, clay lumps, organic and vegetation.

Coarse materials:

Such as sandy gravel, gravelly sand, etc. which is the material retained on sieve no. 4, and consists of crushed rock. It shall be clean, hard, tough and free from deleterious substance.

Crushed stone and crushed gravel shall consist of hard, durable and sound particles or fragments of stone, free from other deleterious substances not mention below, other requirements are gypsum, or flaky particles. Other requirements:

Gypsum content (expressed as S03)	2 % max.
Clay Lumps and friable particles	8 % max.
Elongated and flaky particles for crushed	rock (Determined in accordance
with BS 812 Part 1:1975)	
Graint and Basalt	40 % max. each,
Lime Stone	35 % max. each.
Maximum Dry density (g/cm ³)	2.1 mm.

Chert content determined as percentage by weight insoluble in hydrochloric acid to be specified in special technical specification.

Methods used in production of crushed rock shall ensure that the finished product will be as uniform as practicable. Crushing shall result in a product such that, for particles retained on 4.75 mm (No. 4) sieve at least 80 % by weight shall have at least two fractured faces.

Any material passing 4.75 mm (No. 4) sieve and produced in the crushing process shall be incorporated in the base material up to the gradation limits for the particular class of aggregate involved. Crushed aggregate for base course delivered to road site shall meet the requirements of class A or class B gradations as shown in Table 3.1, when tested in accordance with specification after dry mixing and just before spreading and prior to compacting. The class of aggregate to be used shall be as shown on the Drawings or otherwise as selected by the Engineer or his Representative. The actual gradation shall, in all cases, be continuous and smooth within the specified limits for each Class. Gap graded aggregate will not be accepted. If gradation is tested after compaction a tolerance of 3 % is allowed in upper limit for percentage of material passing sieve 200.

Table 3.1 Gradation of Base Course Aggregate by Class

Sieve Designation		
(Square Openings)		
	<u>Class A</u>	<u>Class B</u>
50 mm (2 in.) 100		
37.5 mm (1-1/2 in.)	100	70-100
25 mm (tin.)	75-100	55-85
19.0 mm (3/4 in.)	60-90	50-80
12.5 mm (1/2 in.)	45-80	
9.5 mm (3/8 in.)	40-70	40-70
4.75 mm (No. 4)	30-65	30-60
2.00 mm (No. 10)	20-40	20-50
0. (No. 40)	8-20	10-30
0,075 mm (No. 200)	5-10	5-15

Percent by Weight Passing

The material shall contain a minimum of 35% sand equivalent at any stage of construction.

The loss in weight shall not exceed 45 % after 500 revolutions, when tested in accordance with AASHTO T96 (Los Angeles Abrasion Test).

The ratio of wear loss = $\frac{\text{Abrasion after 100 Rev.}}{\text{Abrasion after 500 Rev.}}$ should not be more than twenty percent of the maximum allowed abrasion after 500 revolution.

The crushed aggregate base course material shall have a 4-thy soaked CUR of not less than 80 when compacted at 100% of modified proctor BS 1377: Pan 4 and tested in accordance with BS 1377: Part 4. When tested for soundness in accordance with **AASHTO T 104**. The material shall not shown signs of disintegration and the loss by weight shall not exceed 12% in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.

The portion of aggregate, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (L.L.) of not more than 25 and plasticity index (P.I.) of not more than 6 when tested in accordance with BS 1377: Part 2, In case of using

cohsionless base course material the exposed surface shall exhibit intact and coherent surface to resist water erosion and fretting, the contractor at his own expense shall ensure such property any solution should not applied unless approved in writing by Engineer or his Representative, such solution may include single bituminous surface treatment, bonding material and other necessary treatment all as directed and approved by the Engineer or his Representative. Provided that angularity test should be more than 8.

b) Fine Sand Materials

Shall consist of that portion of the total aggregate/fines passes no.4 sieve, such as sand, and silty sand.

The fill materials shall consists of the combination of coarse and fine sand and conform to the following grading:

Sieve Size	1/2"	3/8"	#4	#10	#30	#60	#200
0/	90-100	80-90	58-72	42-50	28-38	8-18	2-5
70 Dogg	70-100	60-85	50-75	30-60	20-40	10-25	0-10
rass	100	90-100	65-85	35-45	20-30	15-30	3-8

The fine sand shall conform to the following grading:

Sieve Size	#4	#30	#60	#200
%	100	80-100	30-50	4-8
	90-100	80-90	20-30	0-10
Pass	100	90-100	40-90	5-15

In addition, shall conform to the following physical requirements:

- Minimum CBR	35 % Coarse materials, Kurkar
	25 % Fine sand, sand

1.4.1 Construction Requirements

When layers of fill are to be placed and where new layers are to be compacted against existing, such layers shall be of sufficient width to permit operations of placing and compacting equipment and / or as directed by the Engineer or his Representative.

Earth fill required by the plans to be compacted shall be constructed as hereinafter described under the following Section "Compaction of Earthwork".

The Contractor shall have in operation a sufficient earth equipment to properly smooth and maintain the surface of each layer of freshly placed fill materials prior to and during rolling and compacting operations.

The Engineer or his Representative shall have frill authority to require at any time the suspension of delivery of material to the site until previously delivered materials are properly placed and preceding layers are satisfactorily smooth and uniform and tested.

The contractor shall be responsible for the stability of all fill layers and shall replace all sections of same which, in the opinion of the Engineer or his Representative, have been damaged or displaced due to carelessness or neglect on the part of the contractor, or due

to natural causes, such as storms, and not attributable to the unavoidable movement of the natural ground upon which the fill layer is made. During construction, when unsuitable material has been placed in site, its removal shall be at the expense of the contractor.

All material derived from excavation (common excavation) earth fill shall be used in the construction provided that theft CBR after 4 days soaking is not less than 10% as tested according to BS 1377 test 16, when compacted to not less than 98%MDD, that they shall not contain more than 5% of water soluble salts and that shall not contain deleterious substances.

1.4.2 Method of Measurement and Payment

No separate or additional payment or measurement shall be made for the selection of materials for the earth fill as described above, and the unite price for approved fill materials from and compaction of fill materials only shall be applied, i.e. full compensation for the supply of material, shaping moisture correction and compaction to the required density.

The quantities to be paid for shall be the number of cubic meters after the execution of clearing and grubbing in the volume of compacted earth fill accepted by the Engineer or his Representative formed with materials resulting from Excavation.

Any shrinkage and/or change or reduction in volume due to mechanical compaction of materials from all sources for forming and grading of the surface in accordance with the drawings shall not be paid for directly but shall be considered subsidiary to all other pay items listed in the Bill of Quantities.

The quantities determined as provided above shall be for at the contract unit price bid per cubic meter of material in place. The price and payments shall be full compensation for the compaction in layers at the prescribed density, including the shaping of the slopes and the compaction trials if required and the furnishing of all equipment, labour, and all other items necessary for the proper execution of the work.

1.5 Compaction of Earthwork

This work includes compaction of earthwork by rolling or tamping or any type of combination in accordance with the requirements specified for on the plans, in the Special Specifications or requested by the Engineer or his Representative.

1.5.1 Testing Methods

Moisture — Density Test

A Moisture — density test (BS 1377: Part 4) and preliminary study will be made for each type of soil to be used in the construction of the work to determine the Maximum Density, the Optimum Moisture Content and the Moisture Range required of the soil for satisfactory compaction

The filled density and actual moisture content of the compacted earthworks shall be determined by field tests according to BS 1377: Part 4.

Relative Density Test

For cohesionless free — draining soils for which impact compaction will not produce a well — defined moisture density relationship curve and the maximum density, the test for the relative density of cohesionless Soils (ASTM D 2049) shall be used to determine the relative density.

Relative density is defined as the state of compactness of a soil with respect to the loosest and densest states at which it can be placed by the laboratory procedures described in ASTM D 2049. The field density and actual moisture content of the compacted earthwork shall be determined by field tests according to BS 1377: Part 4.

Borderline Materials

In cases where borderline materials are encountered, both methods will be utilized and the method which results in the higher laboratory maximum density shall be used as the standard to which the field density is compared.

1.5.2 Equipment

Compaction equipment shall conform to the number and type outlined in the contractor's detailed programme of work as approved by the Engineer or his Representative.

Other types of rollers may be used if approved by the Engineer or his Representative and satisfactory performance shall be the basis for such approval.

1.5.3 Construction Requirements

The number of blades and rollers in use shall be sufficient to blade and compact adequately all material being delivered to the site. The Engineer or his Representative shall have full authority to suspend the delivery of material to the earth fill until previously delivered materials are properly placed and satisfactorily compacted.

1.5.4 Existing Foundation For Earth Fill

All vegetable matter shall be removing from the surface upon which the earth fill is to be placed and the cleared surface shall be completely broken up by ploughing, scarifying or stepping to a minimum depth of twenty (20) centimeters.

The materials of within the moisture range and compacted to an average density of not less than ninety—eight (98) percent of M.D.D. Specified by the curve of Modified Proctor Density, with no single density value below ninety —two (92) percent where the depth of fill is less than seventy —five (75) centimeter below sub-grade elevation and compacted to an average density of not less than ninety (90) percent, where the depth of fill is more than seventy five (75) centimeters below the sub-grade elevation, when the material of which the foundation is composed is cohesionless the same shall be compacted to an average relative density (ASTM D2049) of 70% with no single density value below 67% During the preparation of the earth fill foundation, in fill and in cut the area to be treated will be subject to at least ten (10) passes of heavy duty roller of at least 15 tons operating weight , to ascertain the presence of underground cavities, The passes will be executed at minimum speed and maximum vibration frequency.

No direct payment shall be made for earth fill foundation but their cost shall be considered subsidiary to the various Earthworks pay items.

1.5.5 Earth Fill

The compacted density of the soil forming the earth fill shall be equal to or greater than an average value of ninety eight (98) percent of M.D.D specified by the curve of Modified Proctor density with no single value below ninety two (92) percent. When cohesion less sand to construct the earth fill layers, the avenge relative density (ASTM D2049) of 70% shall be achieved with no single value below 67%.

Should the earth fill material consist of sand is not well graded, so there are difficulties in obtaining the required compaction the Engineer or his Representative may permit the thickness of the layer to be increased in order to obtain the specified compaction in the lower 30 cm.

1.5.6 Moisture Control Requirements

When the moisture content of the earth fill soil does not fall within the required moisture range, water shall be added and thoroughly mixed into the soil, by approved methods or the material shall be aerated, whichever is needed to adjust the soil to the proper moisture content.

The amount of water to be added shall be only that amount that will, as determined by the Engineer or his Representative by field testes, provide moisture content in the soil within the required range plus a reasonable amount to compensate for evaporation and other unavoidable losses.

Water added in excess of this amount shall be considered as excess water and must be removed by aeration or other suitable means directed by the Engineer or his Representative. Satisfactory methods and sufficient equipment shall be used for the finishing and handling of the water so that there will be no undue loss due to evaporating or waste. If water is added to cut areas or borrow pits, the surface of the areas or pits shall be maintained in such a manner that will prevent undue loss of moisture. Contractor shall be responsible to provide clean water for watering, including pumping, watering, erecting water net work and constructing a temporally water tanks.

No extra amounts will be made for watering or re- watering several times until rate of compaction is reached.

1.5.7 Tamping

Whenever earth fill is placed adjacent to structures or at locations where it is not practicable to use a roller, the fill materials shall be tamped by use of mechanical reamers or tampers. Each layer shall be compacted to a density equal to or greater than obtained under the above rolling procedure for the type of compaction designated Each successive layer shall contain only that amount of material, which will insure proper compaction, but in no instance shall any layer be greater than thirty (30) centimeters (loose measurement) in depth.

The Engineer or his Representative must approve each layer before the next layer is placed.

1.5.8 Special Provisions For Other Rollers

When special heavy rollers are used, the compacted thickness of the layer may be increased when approved by the Engineer or his Representative as long as satisfactory compaction is obtained, satisfactory compaction is defined as compaction which results in a uniform density throughout the entire depth of the layer equal to or in excess of the specified density. The maximum compacted thickness of the layer shall be established by the Engineer or his Representative of each type of heavy roller used and for the various types of soil encountered.

The Engineer or his Representative reserves the right to vary the compacted thickness of the layer as the work progresses to insure adequate compaction or to rescind approval of the heavy rollers.

1.6 Compaction Trials

Prior to the commencement of earth works the contractor shall construct trial compaction lengths as directed by the Engineer or his Representative. The soils used in the trials shall be those that will be used for the construction of earth fill and the compaction equipment to be used shall be that specified in the contractor's detailed programme of work and approved by the Engineer or his Representative.

The object of these trials is to determine the field moisture content of the material and the relationship between the numbers of compaction.

2 CONCRETE WORK

2.1 General

British Standards (BS) Documents referred to in this section are:

BS EN 197-1:2000	Composition, specification and conformity criteria for
	common cements.
BS 410	Test Sieves. Technical requirements and testing.
BS 410-1:2000	Test sieves of metal wire cloth.
BS 410-2:2000	Test sieves of perforated metal plate.
BS812-101:1984 (2000)	Guide to sampling and testing aggregates.
BS 812-2: 19951 BS EN	1097-3:1998
BS 812-100:1990(1995)	
BS 812-2:1995/BS EN	1097-3:1998
BS 812-100:1990(1995)	
BS 812-102:1989	
BS 812-103.1:1985 (2000)	
BS 812-103.2:1989(2000)	
BS 812-103'4:1994 (2000)	
BS 812-105.1:1989 (2000)	
BS 812-105.2:1990(2000)	
BS 812-106:1985 (2000)	
BS 812-109:1990 (2000)	
BS 812-110:1990(2000)	
BS 812-111:1990 (2000)	
BS 812-112: 1990 (1995)	
BS 812-11:1990(1995)	
BS 812-113:1990(1995)	
BS 812-114:1989 (2000)	
85812-117:1988(2000)	
BS 812-118:1988 (2000)	
BS 812-119:1985(2000)	
BS 812-120:1989 (1995)	
BS 812-121:1989 (2000)	
BS 812-123:1999	
BS 812-124:1989	
BS 882:1992	Specification for aggregates from natural sources for
	concrete.
BS EN 1097-5:1999	Determination of the water content By Drying In A
	ventilated Oven
BS EN 1097-2:1998	Methods of the determination of resistance to Fragmentation
BS EN 1097-8:2000	Determination of the Polished Stone Value.
BS 4449 :1997	Specification for carbon steel bars for the reinforcement of
	concrete.
BS EN 12350-1:2000	Testing Fresh Concrete.
BS EN 12350-2:2000	Testing Fresh Concrete.
BS EN 12390-1:2000	Shape, Dimension and Other Requirements for Speciament and Moulds

BS EN 12390-2:2000	Marking and Curing Specimens for Strength Test
BS EN 12390-3:2002	Compressive Strength of test Specimens.
BS EN 12504-1:2000	Cored Specimens. Taking , Examining and Testing in compression
BS EN 12504-2:2001	Non Destructive Testing . Determination of Rebound
	Number

The All materials shall be subject to such tests as the Engineer or his Representative may direct and provision for such tests shall be included in the price for such materials inserted in the Bill of Quantities or Schedule of Rates unless otherwise provided for.

Properly representative samples of all materials to be used in the works shall be submitted by the Contractor for the Engineer or his Representatives approval when required.

Where tests are required by the Engineer or his Representative, the Contractor shall take samples and send to a firm experienced in analysis of the material. Reports shall be submitted to the Engineer or his Representative.

Contractor shall bear all expenses consequent to the provision, taking and cartage, etc. of samples, in addition to the costs of performing the tests and reporting the results.

The Engineer or his Representative reserves the right to reject any material which, in his opinion is objectionable in any respect, not withstanding its apparent compliance with the relevant Standards. Any such rejected material shall be removed from the site at the Contractor's expense at once.

2.2 Formwork For Concrete

The Contractor shall supply, design, erect, strike and remove the formwork and be entirely responsible for its stability and safety so that it will carry the fresh concrete and all incidental loadings and preserve it from damage and distortion during its placing, vibration, ramming, setting and curing. It shall be so constructed as to leave the finished concrete to the dimensions shown on the Drawings and of a material capable of providing the surface finish specified. In any event, the maximum permissible deflection under all loads shall not exceed 2 mm or 1/600 of the free span, whichever is less.

Formwork shall be of new timber and / or metal and shall include all temporary concrete moulds and their supports. Bolts to be used for fixing the formwork shall be approved by the Engineer or his Representative before staring the work.

For concrete surfaces which are to remain exposed wrought formwork shall be used. Wrought formwork shall be of timber or steel framing lined with 12 mm thick smooth-faced plywood or an equal lining approved by the Engineer or his Representative, or of metal, suitable to obtain a fair face finish on the concrete. All external angles or fair faced in-situ concrete shall have chamfers formed with 15x15 mm (5/8"x5/8") wrought hardwood angle fillets planted in the angles of the formwork, unless larger chamfers are shown on the drawings.

Formwork ready to receive concrete shall be thoroughly clean and the internal faces properly painted with approved shutter oil or other preparation. Joints shall be tight to prevent leakage.

Wherever required and prior to placing of the reinforcement the internal surfaces of all formwork shall be treated with an approved mould oil.

All formwork shall be inspected and approved by the Engineer or his Representative prior to concreting. This approval, however, does not relieve the Contractor of any of his responsibilities.

The striking of all formwork shall be carried out with the greatest of care to avoid damage to concrete.

The formwork to vertical surfaces such as walls, columns and sides of beams may be removed in accordance with the table below although care must be taken to avoid damage to the concrete, especially to arrases and features.

Minimum periods for striking other formwork should be in accordance with the following table, or as directed by the Engineer or his Representative.

	Ordinary Portland Cement Concrete
Slabs (roof slab - dome)	20 days
Vertical Walls	7 days
Beam soffits (props left under)	7 days
Props to slabs	14 days
Props to beams	14 days
Vertical surfaces as walls, columns and sides of	of beams 3 day

Formwork, shuttering, props, or any other means of temporary or semi-permanent support shall not be removed from the concrete until the concrete is sufficiently strong to carry safely the load (dead and temporary).

The Contractor shall inform the Engineer or his Representative when he is ready to strike the formwork, or remove any form of temporary support, and shall obtain his written consent before proceeding.

The times given for the removal of props are based on the assumption that the total live plus dead weight to be supported at the time of removal is not more than one half of the total design load.

For horizontal members where the loading is to be a higher proportion of the total design load these times may need to be increased.

The Contractor shall be responsible for any damage to the concrete work caused by or arising from the removal and striking of the forms and supports any advice, permission or approval by the Engineer or his Representative relative to the removal and striking of forms and supports shall not relieve the Contractor from this responsibility.

Any work showing signs of damage through premature loading is to be entirely reconstructed at the Contractor's expense.

The Contractor shall confirm positions and details of all

- (a) permanent fixings
- (b) pipes and conduit
- (c) holes and chases

to ensure that alterations are not made without the knowledge and approval of the Engineer or his Representative.

The Contractor shall fix inserts or box out as required to correct positions before placing concrete, and shall form all holes and chases. He shall not cut hardened concrete without approval.

2.3 Reinforcement For Concrete

Steel reinforcement shall generally be hot rolled mild, medium or high yield steel smooth round or deformed bars complying with BS 4449 or similar approved standard.

In case any other type of reinforcement is required, it shall comply with the requirements of the BOQ and drawings.

All reinforcement shall be free from rust and mill scale and any coating such as oil, clay, paint etc. that might impair the bond with the concrete.

Manufacturer's test certificates for all classes of reinforcement shall be supplied when required. *Specimens sufficient for three tensile tests and three cold-bending tests per ten tons of bars* or fraction thereof and for each different size of bar shall be sampled under the supervision of the Engineer or his Representative. Testing shall be in accordance with BS 4449 or other approved standard and batches shall be rejected if the average results for each batch are not in accordance with the specification. *All tests should be made on the Contractor's expense.*

All steel is to be totally free from dirt, paint, loose rust or scale when in position ready for concreting.

The Contractor shall cut and bend bars to 135 4466 and to schedule provided unless otherwise instructed by the Engineer or his Representative.

Straight sections of bars must be kept out of winding. *The internal radius of bends shall in no case be less than four times the diameter of the bar*, except for stirrups, column binders, and wall shear bars which are to be bent to fit closely around the main bars.

Great care is to be taken to bend stirrups and columns binders separately and to the sizes shown.

All bars will be cut and bent cold using approved machines.

Lengthening of bars by welding, and rebinding of incorrectly bent bars will not be permitted, except where requested by the Engineer or his Representative.

The Contractor shall provide on site facilities for hand bending to deal with minor adjustments.

Splices in reinforcing bars shall be formed by lapping, and shall be staggered. Except as otherwise indicated on the drawings the minimum overlap of lapped splices shall be 40 bar diameters or 400 mm whichever is greater.

The steel is to be fixed in position exactly as indicated, and the bars are to be securely wired together with 1.6 or 1.4 mm soft galvanized iron wire or approved spring galvanized steel clips wherever necessary to prevent any displacement during concreting.

Spacers, chairs and the like, temporary or permanent, are to be used as required to ensure that the steel has the exact amount of cover indicated. No permanent spacers may show on a surface where a fair faced concrete finish or a brushed aggregate finish is required. Type of spacers shall be approved by the Engineer or his Representative before starting the work.

Unless otherwise indicated, the minimum cover to the reinforcing bars is to be as listed below or equal to the diameter of the bar, whichever is greater.

Position	Minimum cover - mm
Main bars in internal faces of walls,	40
Main bars in external faces of walls	40
Main bars in raft foundation (base slab) slabs	50
Main bars in top of roof slab or dome)	30
Main bars in columns and beams	40
Main bars in floor slabs and soffits of roof slabs	25
Main bars in top of roof slabs	25
Bars in top of ground slabs	30
Bars (walls, beams, columns, slabs and foundation	ns)

Near faces wetted or contact with soil

The placing of all reinforcement will be checked by the Engineer or his Representative and in no case is concrete to be poured around any steel that has not been passed by him. The Contractor is to ensure that no steel is displaced from its position during the placement of concrete and until the concrete is set.

75

The insertion of bars into or removal of bars from concrete already placed will not be permitted. Reinforcement temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer or his Representative.

Secondary reinforced concrete members for which no reinforcement details are given in the drawings or the BOQ shall have a minimum ratio of reinforcement area to concrete area of 0.35%

2.4 Concreting

2.4.1 Cement

The cement used shall be Portland Cement conforming in all respects to BS EN 197-1:2000, unless otherwise required, bags shall contain 50 kg net \pm 1%.

The Contractor shall at all times furnish the Manufacturer's statement of the above Standard Specifications together with the date of manufacture, certified by an independent agency in the country of origin approved by the Engineer or his Representative.

The cement shall be delivered to the site by the Contractor in the original sealed and branded bags or containers of the manufacturer in batches not exceeding 100 tons and shall be stored in a proper manner oft the ground to prevent deterioration. Each batch shall be stacked separately and used in the order of delivery. No cement shall be used which has been manufactured more than twelve months prior to its proposed use on site.

All cements whether stored in bulk, bags, or containers in warehouses or on site shall be sampled for testing according to ASTM C183 (Methods of Sampling Hydraulic Cements). Test samples over and above those specified shall be taken at any time if so requested by the Engineer or his Representative. Testing of cement shall be in accordance with the methods required by BS EN 197-1:2000 or any other accepted by the Engineer or his Representative.

2.4.2 Aggregates

This specification covers fine and coarse aggregates other than lightweight aggregates for use in the production of concrete.

When lightweight aggregates are required, they will be defined in the BOQ.

The aggregates shall be crushed gravel or stone and shall comply with BS 882 for graded or single size aggregate and shall be obtained from any quarry approved by the Engineer or his Representative. For convenience part of Clause 5 of BS 882 (grading) including Tables 1, 2 and 3 are reproduced herein.

Coarse aggregate: the grading of coarse aggregate, when analysed by the method given for sieve analysis in BS EN 1097 shall be within the limits given in Table 4.1.

Fine aggregate: the grading of a fine aggregate, when analysed by the method of sieve analysis described in BS EN 1097, shall be within the limits of one of the grading zones given in Table 4.2, except that a total tolerance of up to 5 per cent may be applied to the percentages under-lined. This tolerance may be split up; for example, it could be 1 per cent on each of three sieves and 2 per cent on another, or 4 per cent on one sieve and 1 per cent on another.

The fine aggregate shall be described as fine aggregate of the grading zone into which it falls, e.g. BS 882, Grading Zone I.

NOTE: It is intended that individual zones should not be specified in contract documents relating to concrete but that the concrete mixes should be modified to make the best use of the materials readily available.

If approved by the Engineer or his Representative, Single-sized aggregate to BS 882 Table 4.1 may only he used for reinforced concrete when combined in two or more sizes to provide a well-graded mixture approved by the Engineer or his Representative.

Sampling and testing of aggregates shall be as required by BS 882 and in accordance with BS 812 'Methods for Sampling and Testing of Mineral Aggregates, Sands and

Fillers'. All sampling shall be done by or under the supervision of the Engineer or his Representative.

The combined percentage of sulphates and chlorides by weight in coarse and fine aggregates shall not exceed 0.05 per cent (500ppm) of the combined weight of total aggregates.

Just before use the aggregate will be washed down with potable water to reduce the content of sulphates chlorides and other extraneous material.

BS 410		Percentage by weight passing BS sieves						
Test	Nomina	al Size of	N	ominal siz	ze of Single	e – Sized a	ıggregat	e
Sieve	Graded	Aggregate						
mm	400 mm	200 mm	14 mm	63 mm	40 mm	20 mm	14	14 mm
	to 5 mm	to 5 mm	to 5 mm				mm	
75.5	100	-	-	100	-	-	-	-
63.0	-	-	-	85-100	100	-	-	-
37.5	95-100	100	-	0-30	85-100	100	-	
20	35-70	95-100	100	0-5	0-25	85-100	100	-
14	-	-	90-100	-	-	0	85-	100
							100	
10	10-40	30-60	50-85	-	0-5	0-25	0-50	85-100
5	0-5	0-10	0-10	-	-	0-5	0-10	0-25
2.36	-	_	-	-	-	-	-	0-25

Table 4.1: Coarse Aggregate

Table 4.2: Fine Aggregate

BS 410 Test	Percentage by Weight passing Bs Sieves					
Sieve		Γ	Γ			
	Grading Zone 1	Grading Zone 2	Grading Zone 3	Grading Zone 4		
mm						
10.00	100	100	100	100		
5	90-100	90-100	90-100	95-100		
2.36	60-95	75-100	85-100	95-100		
1.18	30-70	55-90	75-100	90-100		
Microns						
600	15-34	35-59	60-79	80-100		
300	5-20	8-30	12-40	15-50		
150	0-10	0-10	0-10	0-15		

The choice and preparation of sites for stockpiling of aggregates, the number and sizes of stockpiles and the methods adopted to prevent segregation of component sizes shall be agreed with the Engineer or his Representative.

Coarse aggregate shall be stockpiled in three separate gradings: 38-19mm, 19-10mm, 10-5mm when aggregates of different gradings are stockpiled close together the stockpiles shall be separated by bulkheads.

Stockpiles are to be on concrete or other hard surface sufficiently sloped so that water is not retained in the base of the stockpiles.

All aggregates are to be handled from the stockpile in such a manner as to secure a typical grading of the material, care being taken to avoid crushing the aggregates and contamination with extraneous matter.

Aggregates need not be stockpiled when a crushing-screening plant is used in tandem with a batching plant properly equipped with several bins for different sized aggregates having the appropriate weighing scales at such bin such that a mix of the desired gradation is obtained consistently and the whole operation is conducted to the satisfaction of the Engineer or his Representative.

2.4.3 Water

Unless otherwise authorized in writing by the Engineer or his Representative only water from potable supply system may be used for mixing concrete and other products containing cement.

Similarly only potable water may be used for curing concrete and cement products during the first 24 hours after pouring. Later, fresh water, or other water containing not more than 4750 ppm dissolved solids of which not more than 1000 ppm may be chlorides, may be used for curing.

No additives of any kind shall be used in the concrete without the express approval in writing of the Engineer or his Representative.

2.4.4 Quality of Concrete

Concrete shall be a mixture of cement, aggregates and water as covered respectively by aforementioned Sections. The mix proportions, workability and strengths of the various types of concrete shall conform to Tables 4.3 to 4.5.

The terms contained in Tables 4.3 to 4.5 are defined as follows: WATER/CEMENT RATIO (W/C): the term water/cement ratio means the ratio by weight of the water to the cement in the mix, expressed as a decimal fraction. The water is that which is free to combine with the cement in the mix.

This includes free water in the aggregate but excludes water absorbed or to be absorbed by the aggregate. The aggregate for this purpose shall be taken in a saturated surface-dry condition.

The absorption of the aggregates shall be determined in accordance with BS EN 1097 or any other method approved by the Engineer or his Representative.

The strengths specified are for ordinary Portland cement to BS EN 197-1:2000; if other types of cement are specified, the required strength shall be as defined in the Bills of Quantities.

Table 4.3: Grades of Concrete

	Grade	Minimum works cube strength	Max Agg.	Limits of agg/ Cement	Use of concert if not otherwise specified
-					

	k	g/cm ²	mm	ratio by weight		
	At 7 days	At 28 days		Max.	Min.	Plain concrete foundation
P 150	100	150	20	10:1	8:1	As specified
D- 150	100	150	37	10:1	8:1	As specified
D 200	150	200	20	7:1	5:1	As specified
D-200	150	200	37	8:1	6:1	As specified
D 250	175	250	20	5.5:1	4:1	As specified
D-230	175	250	37	6.5:1	4.5:1	As specified
D 200	200	300	20	5:1	3:1	As specified
D-300	200	300	37	5:1	3:1	As specified
D 250*	250	350				As specified
D-330.	250	350				As specified

<u>*Note: for grade of concrete B-350, trail mix shall be applied and approved by the engineer or his representative.</u>

Table 4.4: Standard Mixes

Grade of concrete	Min work Stre kg/	imum s Cube ength 'cm2	Weight of dry sand per 50 kg of cement	Weig	ht of d	ry coar kg of c	se aggi cement	regate j	per 50	Max design W/C ratio
	7 days	28 days		Low	Med.	High	Low	Med.	High	
			Kg	Kg	Kg	Kg	Kg	Kg	Kg	
B-150	110	150	100	200	180	150	245	210	200	0.60
B-200	150	200	91	193	159	136	226	193	170	0.55
B-250	175	250	80	170	136	113	204	170	147	0.50
B-300	200	300	68	147	113	91	170	136	113	0.45
B-350*	300	400								

<u>*Note: for grade of concrete B-350, trail mix shall be applied and approved by the engineer or his representative.</u>

Table 4.5: Workability

Degree of	20 mm	Max. size	37 mm	Max Size	Use fo	or which
workability	aggi	regate	aggi	regate	Concrete	is suitable
	Slump mm	Compacting Factor	Slump mm	Compacting Factor		
Low	13-25	0.82	13-50	0-82-0.88	Simply sections vibration	reinforced with
Medium	25-50	0.88-0.94	50-101	0.88-0.94	Heavily sections vibration	reinforced with
High	50-127	0.94-0.97	101-117	0.94-0.97	Sections v congested	with heavily

		reinforcement	where
		vibration is diff	ficult

The cubes used for the compression tests shall be 150x150x150 mm as specified in BS 1881. In case cylinders are used for determination of concrete compressive strength in accordance with ASTM C 39, the corresponding cube strength shall be obtained by using a multiplication factor of 1.2.

AGGREGATE/CEMENT RATIO: the term aggregate/cement ratio means the ratio by weight of aggregate to cement in the mix. For this purpose the aggregate is taken in a saturated surface-dry condition as for the water/cement ratio above.

FINE/TOTAL AGGREGATE RATIO: the term fine/total aggregate ratio means the ratio by weight of the fine aggregate to the total aggregate in the mix expressed as a percentage. For this purpose the aggregate is also taken in a saturated surface-dry condition as for the water/cement ratio above.

VOLUME OF AIR ENTRAINED: the air content expressed as a percentage by volume of concrete shall be determined by ASTM C23 1, 'Air Content of Freshly Mixed Concrete by the Pressure Method'. At least one test for each 120 cubic meters of concrete shall be made.

SLUMP: the slump of the freshly mixed concrete shall be determined in accordance with BS EN 12350-2:2000. At least one morning and one afternoon test shall be made and whenever directed by the Engineer or his Representative.

STRENGTH OF CONCRETE: Preliminary Test Cubes shall be taken from the trial mixes designed to select the job mix and shall be made and tested in accordance with BS EN 12390-3:2002.

SAMPLING FOR COMPLIANCE TEST: Works Test Cubes shall be those used for control during construction and shall be made and tested in accordance with BS EN 12350-1:2000 and BS EN 12390- 2:2000.

Average Rate of Sampling One Sample (6 cubes) per	Maximum quantity of concrete at risk under any one decision
$10 \text{ m}^3 \text{ or}$ 10 batches	40 m ³
20 m ³ or 20 batches	80 m ³
50 m ³ or 50 batches	200 m ³

Recommended Minimum Rates Sampling

The Contractor when tendering having knowledge of the source and types of cement, aggregate, plant and method of placing he intends to use shall allow for the aggregate/cement ratio and water/cement ratio which he considers will achieve the strength requirements specified and will produce a workability which will enable the

concrete to be properly compacted to its full depth and finished to the dimensions and within the tolerances shown on the Drawings. In any event the aggregate/cement ratio and the water/cement ratio shall not exceed the upper limits specified in Table 4.3 for each type of concrete. Furthermore, the quantity of cement per cubic meter of concrete shall in no case be less than the minimum specified in Table 4.6.

Grade of Concrete	Minimum Cement Content
	(kg/m3)
B-150	200
B-200	225
B-250	250
B-300	275
B-400	325

Table 4.6: Minimum Cement Content

As soon as possible after signature of the Contract, the Contractor shall prepare such trial mixes as required to satisfy the Engineer or his Representative that the specified concrete strengths will be obtained using the materials and mix proportions in accordance with the above clauses. The proportion of cement shall be increased if necessary to obtain the strengths required.

From each trail mix, six Preliminary Test Cubes shall be made and tested at 7 days and four at 28 days, the test at 7 days being intended to give and early indication of possible variation from the required strength. If the difference between the highest and lowest test results from any one trial mix is more than 15 per cent of the avenge of the strength test results, the test is to be discarded and a further trial mix made, unless all test results so obtained are above the required strength. Separate trail mixes are required for each type of concrete. The trial mix or mixes agreed by the Engineer or his Representative shall be designated job mixes and used as a basis for actual concrete production.

2.4.5 Batching and Mixing of Concrete

All concrete shall be batched by weight and mixed mechanically. Hand mixing shall not be allowed except only upon the written permission of the Engineer or his Representative.

Concrete may either be batched and mixed on site or outside the site and transported thereto.

When mixed outside the site and transported to it, batching and mixing shall be in accordance with ASTM Specification C94, 'Standard Specification for Ready-Mixed Concrete'.

When mixed on site, batching and mixing shall be as follows:

BATCHING BY WEIGHT: The cement and each size of aggregate shall be measured by weight. The water may be measured by weight or volume. The weight-batching machines used shall be of a type approved by the Engineer or his Representative and shall be kept in good condition while in use on the Works. Checks are to be made as

required by the Engineer or his Representative to determine that the weighing devices are registering correctly.

BATCHING AGGREGATE BY VOLUME: When batching aggregates by volume is allowed as and when required, the cement shall be batched by weight and the water by weight or volume - Each size of aggregate shall be measured in metallic containers the depth of which is at least equal to their greatest width. The containers shall be of such shape that their volume can be easily checked by measurement.

MIXING CONCRETE: the location of the batching and mixing plant shall be agreed with the Engineer or his Representative.

The amount of concrete mixed in any one batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enter the drum.

On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean mixing water. If old concrete deposits remain in the mixer drum, they shall be rotated with clean aggregate and water prior to production of new concrete.

Concrete mixed as above is not to be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

2.4.6 Work in Cold or Hot Weather

Concrete is not to be mixed or placed at a shade air temperature below 2 deg. C on a rising thermometer or at a shade air temperature below 3 deg.C on a falling thermometer.

When the shade air temperature is 25 deg .C and rising, special precautions shall be taken during concerting operations, such as shading of the aggregates and plant, cooling of the mixing water or other methods approved by the Engineer or his Representative. So that the temperatures of the concrete when placed shall not be in excess of 32 deg .C

Fresh concrete placed at these temperatures shall be shaded from the direct rays of the sun to the satisfaction of the Engineer or his Representative for a period of at least 24 hours.

2.4.7 Placing

Concrete shall be conveyed from the mixer to its final position in any suitable manner, provided there is no segregation, loss of ingredients or contamination.

It shall be placed in its final position before initial setting takes place and within 20 minutes of the addition of the water to the mixer without using any additives. In case additives will be used, the manufacturer specifications of such additives must be handed over to the Engineer or his Representative to be approved before using it.

The order of placing concrete shall be such as to prevent water from collecting at the ends, corners and along the faces of forms. It shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance in the form.

Whenever possible concrete shall be placed and compacted in even layers with each batch adjoining the previous one.

The thickness of the layers shall be between 150 and 300 mm for reinforced concrete and up to 450 mm for plain (non-reinforced) concrete, the thickness depending on the width of forms, the amount of reinforcement and the need to place each layer before the previous one stiffens.

Concrete shall not be allowed to drop freely for more than 2 meters. To convey the concrete as near as possible to its final position, drop chutes of rubber or metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections.

Concrete shall be carefully compacted when placed to ensure a dense and uniform mass free from air holes and cavities. All concrete types shall be compacted by vibration. Vibration shall be performed by mechanical or electro - mechanical vibrators. The vibrators shall be of the plunger (poker) type for insertion in the concrete except that plate type vibrators (external) shall be used if requested by the Engineer or his Representative.

The plunger (poker) type vibratos shall have a diameter compatible with the lowest spacing of reinforcement, a sufficiently high frequency and be properly handled by experienced personnel. They hall be immersed at regular intervals close enough to vibrate all of the concrete, but not too close to affect previously vibrated and partially set concrete. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually and vertically to ensure that no air pockets are formed.

When external vibrators are used as directed by the Engineer or his Representative, they shall be clamped to the forms whenever possible to avoid large impact during handling, and the forms shall be so constructed as to withstand the additional vibrations.

All vibrations, compaction and finishing operations shall be completed within 15 minutes from the time of placing the concrete in its final position. Until it has hardened sufficiently to carry weight without distortion, workers shall not be allowed to walk over freshly placed concrete.

Concreting of any one part or section of the work shall be carried out in one continuous operation, and no interruption of concreting work will be allowed without the approval of the Engineer or his Representative. Where beams and slabs together form an integral pan of the structure they shall be poured in one operation.

A record is to be kept by the Contractor on site of the time and date of placing the concrete in each portion of the works and the number and identification of the Works Test Cubes, corresponding to these portions. Such records are to be handed to the Engineer or his Representative weekly during the progress of the work.

2.4.8 Admixtures

No admixtures of any type shall be used in the preparation of concrete or concrete products unless so required or directed by the Engineer or his Representative. In case any such admixtures are used the rates and methods of application shall be strictly in accordance with the manufacturer's instructions, which must be approved by the Engineer or his Representative before using it.

2.4.9 Curing

Freshly placed concrete shall be protected from rain, dust storms, chemical attack and the harmful effects of heat, wind, flowing water, vibrations and shocks. This protection shall continue until the concrete is sufficiently set such that it is no longer damaged by these factors.

The Engineer or his Representative shall determine when the protection is no longer required, but in any case this shall not be less than 24 hours after the time of placing.

Concrete shall be cured for at least seven days and as required by the Engineer or his Representative. Curing shall be effected by the direct application of water to the surface of the concrete or by other approved curing methods or curing compounds applied in accordance with the manufacturer's specifications.

In case the application of such curing compounds is delayed for any reason, the concrete shall be kept moist until the application is made.

Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.

2.4.10 Formed Finishes

Basic finish

General requirements

- (a) Produce an even finish with a sheet material.
- (b) Arrange panels in a regular pattern.
- (c) Blowholes not more than about 10 mm in diameter will be permitted but otherwise surface is to be free from voids honey combing and other large defects.
- (d) Variation in colour resulting from the use of a from discoloration due to contamination or grout leakage.

The finish will be left as struck, making good or small defects will normally be permitted but only after inspection by the Engineer or his Representative. All blowholes shall be filled with a matching mortar to an approved sample unless otherwise instructed by the Engineer or his Representative. All faces shall be protected from damage, especially arises.

All faces shall be protected from rust marks and other surface disfigurements. Form tie holes shall be filled with a matching mortar to an approved sample accepted by the Engineer or his Representative.

2. Fine finishes (Fair Face)

General Requirements:

- a) Produce a smooth even finish with an impervious sheet metal
- b) Make panels as large as is practicable and arrange to approval.
- c) Blowhole not more than about 5mm in diameter will be permitted but otherwise surface is to be free from voids, honey combing and other defects.
- d) Variation in colour resulting from the use of an impervious form lining will be permitted, but the surface is to be free from discoloration due to contamination or grout leakage.
- e) Concrete cover spacers shall be used only if approved.

The finish is to be left as struck. Making good will not normally be permitted. All form tie holes are to be filled with a matching mortar to an approved sample. Wire form ties shall not be used. Approval of the Engineer or his Representative for the position of tie holes is to be obtained before use.

2.4.11 Quality Control Testing

Prior to commencing the work the contractor shall make available on site the following minimum approved equipment kept in good condition at all times

- Six Cube moulds.
- Slump cones.
- Thermometer.
- Any other accessories as required by the Engineer or his Representative.

All samples and testing shall be done in the presence of the Engineer or his Representative or his authorized representative either on site or in an approved testing laboratory in the area.

The frequency of testing shall be as noted in the clauses of this section and whenever required by the Engineer or his Representative.

The works Test Cubes shall be made as follows for types of concrete (A), (B) & (C):

- (a) At least three times weekly per mixing plant.
- (b) At least once for three individual parts of the structure.
- (c) At least once per 100 cubic meters of Concrete or fraction thereof.

At least six cubes shall be made at one time. Two of the six cubes are to be tested at seven (7) days. The remaining four cubes are to be tested at 28 days, and their avenge strength must not fall below the minimum strength specified for each type of concrete and the lowest test result shall not be more than 20% below the average of the four cubes.

When the result of 7-day test is unsatisfactory, the Contractor should be remove and replace the defective concrete without waiting for the 28-day test, If the result of the 28-day test is unsatisfactory all concreting shall be stopped at the Contractors expense and shall not proceed further without the written permission of the Engineer or his Representative.

The Contractor shall then, in accordance with the instructions of the Engineer or his Representative, remove cores and test same or conduct in- institutes in accordance with CP 144 from or on suspect portions of the works, under the supervision of the Engineer or his Representative.

Concrete judged by the Engineer or his Representative to be defective shall be forthwith cut out, removed and replaced at the Contractors own expense.

In the event of strengths consistently higher than those specified being obtained, a reduction in the number of tests may be authorized by the Engineer or his Representative.

2.4.12 Position of Reinforcement

The actual concrete cover to all steel at any point should not be smaller than the required nominal cover by more than 5 mm.

The effective depth of fully or nearly fully stressed tensile reinforcement should not be less than that given on the drawings by an amount exceeding 5 per cent of the effective depth of the section being considered or 5 mm whichever is the greater.

2.4.13 Ready mixed concrete

Ready- mixed concrete as defined in BS 1926, batched off the site will be used with agreement of the Engineer or his Representative and shall comply with all requirements of the Contract. The quality and strength of cements shall be determined by site tests. No test results supplied by Ready-Mix Supplier shall be accepted as proof of the quality and strength of the concrete.

The concrete shall be carried in purpose made agitators operating continuously, or in truck mixers. The concrete shall be compacted and in its final position within 1 hour of the introduction of cement to the aggregate or as agreed by the Engineer or his Representative. The time of such introduction shall be recorded on the Delivery Note together with the weight of the constituents of each mix.

When truck mixed concrete is used, water shall be added under supervision either at the site or at the central batching plant as agreed by the Engineer or his Representative but in no circumstances shall water be added in transit.

Unless otherwise agreed by the Engineer or his Representative truck mixer units and their mixing and discharge performance shall comply with the requirements of BS 4251. Mixing shall continue for the number and at the rate of revolutions recommended in accordance with BS 4251 or, in the absence of the manufacturer's instructions, mixing shall continue for not less than 100 revolutions at a rate of not less than 7 revolutions per minute.

Prior to any ready mixed concrete being ordered, the Contractor shall submit to the Engineer or his Representative details of the supplier and shall arrange for the Engineer or his Representative to inspect the supplier's works if required.

Truck—mixer units shall be maintained and operated strictly in accordance with the manufacturer's recommendations.

2.4.14 Concrete Surface Hardener

Monolithic surface hardening compound to provide a highly abrasion resistance surface with a dry shake method.

The abrasion resistance of the hardening compound shall comply, and the compressive strength not less that 70N/mm after 28 days, tested according to the BS EN 12390.

The hardening compound shall be applied in rate of 7 kg/m² on the floor surface at the time when the concrete has stiffened to the point when light foot traffic leaves an imprint of about 3 mm.

The hardening compound shall be applied in two application stages:

- <u>Stage 1</u>: using 1/2 to 2/3 of the required material. When the material becomes uniformly dark by the absorption of moisture from concrete then the floating can be applied.
- <u>Stage 2</u>: spreading the remaining material on the surface, and apply floating to the surface after the moisture being absorbed.

Final finishing of the floor shall be done using mechanical trowelling machine when the floor has stiffened sufficiently.

Curing for the surface shall be applied as clarified above.
3 BLOCK WORK

3.1 General

British Standards (BS) Documents referred to in this section are: BS 410Test sieves. Technical requirements and testing. BS 410-1:2000 Test sieves of metal wire cloth. BS 4 10-2:2000 Test sieves of perforated metal plate. Specification for bitumen damp-proof courses for masonry BS 6398:1983, Specification for polyethylene damp-proof courses for masonry BS6515:1984 BS 8215:1991 Code of practice for design and installation of damp-proof courses in masonry construction Defamations, specifications and conformity criteria BS EN 459-1:20001 BS 1014:1998 BS 1243:1978

3.2 Manufacture

Generally, the blocks used shall be of local manufacture made with concrete in approved vibrated pressure machines. The fine aggregate to be used for blocks shall be clean and sharp approved sand. It shall be chemically and structurally stable and shall comply with the Table of Grading given hereunder. The cement, coarse aggregate and water to be used for blocks shall comply with the requirements given for Concrete Works, and the methods of measuring and mixing the material shall be the same. The following Mixing Table shall be strictly adhered to in all cases. Water/cement ratio shall be strictly governed to produce a mix of nil - slump.

Blocks of walls and slabs shall be tested according to the BS 6073 for the following:

- Compression Strength
- Absorption Test
- Dimension Test

Mixing Table

Nominal Mix (all by volume)

1 part Cement, 2 parts Fine Aggregate and 5 parts Coarse Aggregate. The quantity of cement shall not less than 225 kg/m^3 of concrete.

Table of Grading

BS 410 Sieve No.	Approximate size: mm	Percentage(by weight) Passing BS sieve
-	10.00	100
-	5.00	90-100
7	2.36	75-100
14	1.18	55-90

25	0.60	35-59
52	0.30	8-30
100	0.15	0-10

b) Coarse aggregate 10 mm single size aggregate.

The blocks shall be hard, sound, square and clean with sharp well defined anises and shall, unless previously approved by the Engineer or his Representative, be a work size of $(400 \times 200 \times 200 \text{ mm})$ with properly formed half blocks for bonding.

Hollow blocks, where required, shall be similar quality and overall size to solid blocks, and shall be of local manufacture made with concrete as described above in approved vibrated pressure machines. The design of the cavities and webs shall be submitted to the Engineer or his Representative for approval before manufacture. The thickness of the membranes or solid portions of hollow blocks shall be not less than (25 mm) each and the combined thickness of the solid portion shall exceed one forth of the total thickness in either horizontal direction.

Light weight lime - blocks can be used according to drawings, bills of quantities and the Engineer or his Representative approval.

Arises shall be sharp and true; blocks which have damaged arises are not to be used in the works and shall be discarded at the expense of the Contractor.

Immediately after moulding the blocks shall be placed on clean, level, non-absorbent pallets. Blocks shall not be removed from the pallets until inspected and approved by the Engineer or his Representative Blocks shall be cured by being kept thoroughly wet by means of water sprinklers or other approved means for a period determined by the Engineer or his Representative but in all cases for not less than three days. Blocks must not be left on earth or sand during the curing process. Blocks shall be stacked in honeycomb fashion. Solid stacking will not be permitted.

Blocks for roofs slabs shall be of the shape and dimensions shown in drawings. The average crushing strength of solid or hollow blocks shall be not less than 35 kg/cm² of gross area (average of 12 blocks)

3.3 Mortars

The sand to be used for mortar shall be clean and sharp. It shall be chemically and structurally stable and shall comply with the Table of Grading below. The lime if used for mortar shall be hydrated lime complying with BS EN 459-1:2001.

Where coloured mortars are required these shall be obtained either by the use of coloured cement or by addition of pigments complying with BS 1014.

The cement and water to be used for mortar shall comply with the requirements given under Concrete Works Section, and the methods of measuring and mixing shall be the same. The following Mixing Table shall be strictly adhered to in all cases.

Mixing Table

Normal Mix Cemer	t Kilos Sand m ³	Lime
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			(Dry Hydrate) Kilos
1:4	360	1:00	Approved by the Engineer or his Representative

Table of Grading

BS 410 Sieve No.	Approximate	Sand passing Through
		Sieve. Tercentage
-	3	95-100
7	2.4	80-100
14	0.2	60-100
25	0.6	30-100
52	0.3	5-65
100	0.15	0-15
200	0.08	0-5

Note: the above figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

The mortar generally shall be cement and sand (1:4) mix.

Where plasticizer is added to the mortar the following mixes shall be used:

(a) Building mortar - cement and sand (1:6) and

(b) Mortar for pointing - cement and sand (according to plasticizer manufacturer recommendation)

The plasticizer shall be used strictly in accordance with the manufacturer's instructions, and subject to the Engineer or his Representative approval.

All mortars shall be used before the initial set has begun. Mortar shall not be remixed after the initial set has taken place. The full description given under Plaster Work Section, shall apply also to the measuring, mixing etc. of mortar for block work.

3.4 Construction

All block work shall be set out and built to the dimensions shown on the Drawings or by the Engineer or his Representative approval.

Walls shall be carried up regularly without leaving any part more than one meter lower than another unless the permission of the Engineer or his Representative is first obtained. Work which is left at different levels shall be racked back. In the case of cavity walls, both thicknesses shall not be carried up more than about 400 mm.

The courses of block work shall be properly leveled .me perpendicular joints shall be properly lined and quoins, jambs and other angles plumbed as the work proceeds.

All walls shall be thoroughly bonded in accordance with the best constructional practice and as directed by the Engineer or his Representative. Broken blocks shall not be used except where required for bond (if approved by the Engineer or his Representative.). All concrete blocks shall be soaked with water before being used and the tops of walls left off shall be wetted before work is resumed. The faces of walls shall be kept clean and free from mortar droppings and splashes

All blocks shall be properly spread with mortar before being laid and all joints shall be thoroughly flushed up solid through the full thickness of the wall at each course as the work proceeds.

Walls to be left un-plastered shall have a fair face consisting of selected blocks pointed with a neat weathered or flush joint as the work proceeds using the same mortar mix as for jointing.

Walls to be plastered shall have the horizontal joints raked out to depth of 15 mm to form a key.

Block work shall be bonded to concrete columns and the like with one tie every two courses made of electro galvanized steel ties 2 mm thick, 10 cm length along the column and 15 cm along the course, forming a right angle with fish-tailing at end of 15 cm length, and fixed to column by an expansive bolt of suitable length but not less than 4 cm. Gunning ties to concrete will not be permitted (other ways of bond must be approved by the Engineer or his Representative).

Allowance shall be made for the temporary leaving of open courses immediately under all structural members built into the walls. These open courses shall be left in suitable positions to permit the structural members to take up their full deflection, me open courses shall be made good and pointed up after the structural members have been fully loaded and before completion of the works.

3.5 Workmanship

The contractor shall cut and fit block work around steel work, etc., leave of form chases for edges of concrete slabs, staircases, end of partitions, etc., cut chases for pipes, conduits, etc., and make good.

The contractor shall build all over sailing courses, corbles, etc., where shown and build in the cut and pin ends of sills, steps, lintels, etc., as required.

Wooden plates and doors and window frames shall be bedded and exposed edges pointed in a sealent and fixing cramps shall be built in.

The contractor shall perform all cutting away and making good for all trades.

3.6 Expansion Joints

Expansion joints shall be formed with 20 mm impregnared fiberboard.

3.7 Steel Channels, Cramps, Ties and Dowels

Cramps and angles shall be electra-galvanized (zinc-plated) as described in this item.

Galvanized of the metal shall be zinc by electroplating, so as ro provide a thin, uniform and ductile protective coating. Small holes and threads shall be satisfactorily coated. The ductility of the zinc coating shall be such as to allow for bending of the components without causing any damage. The galvanized gauge and process shall be in compliance with BS 1707-1960.

Block to columns ties shall be of electro-galvanized steel ties 3 mm thick, 10 cm length along the column and 15 cm along the course, forming a right angle with fish-tailing at end of 15 cm length, and a hole for expanding bolt fixation to column.

4 PLASTER WORK

4.1 General

The British Standards (BS)govern the work covered in this section.MS EN ISO 1461:1999Hot dip galvanized coatings on fabricated iron and steel
articles.
Specifications and test methods MS 729MS EN 459-1:2001Definitions, specifications and conformity criteria 890MS EN 197-1:200002
BS 4449:1997Second Second Secon

4.2 Materials

Portland cement, fine aggregate and water shall be as previously specified in Concrete Work section.

The sand for plastering shall be clean fine sand and shall be chemically and structurally stable. The sand shall be sieved and graded in accordance with the Table of Grading given below.

Table of Grading

BS 410 Sieve No	Approximate Size mm	Sand Passing Through Sieve Percentage	
	mm	UNDERCOAT	FINISH COAT
7	2.4	95-100	100
14	1.2	80-95	95-100
25	0.6	30-55	30-85
52	0.3	5-50	5-50
100	0.15	0-10	0-10

Note: the above table represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

Imported lime shall be of the hydrate type complying with MS EN 459-1:2001

Bonding agents where required shall be of a type approved by the Engineer or his Representative, and shall be used as recommended by the manufacturer.

4.3 Mixing

The methods of measuring and mixing shall be as laid down under Concrete Work section, and the proportions shall be in accordance with the following table.

Mixing Table

Nominal Mix	Ratio	Cement Kg	Fine aggregate or	(1) (Dry
		115	Sand m3	hydrate) kg
1:5 cement		289	1.00	-
1:4 cement		361	1.00	-
1:3 cement		476	1.00	-
1:21/2 cement		577	1.00	-
1:2 cement		721	1.00	-
1:1 cement		1442	1.00	-
1:5 cement with 20%	1:5:1	289	1.00	124
(1)				
1:4 (1) with 10%	1:10:21/	145	1.00	161
cement	2			

With regard to the lime mortars gauged with cement, the addition just before use of the cement to small quantities of the lime/sand mix shall preferably take place in a mechanical mixer and mixing shall continue for such time as will ensure uniform distribution of materials and uniform colour and consistency. It is important to note that quantity of water used shall be carefully controlled.

4.4 Plastering And Similar In-Situ Finishing And Backings

All plastering shall be executed in a neat workmanlike manner. All faces except circular work shall be true and flat and angles shall be straight and level or plumb.

Plastering shall be neatly made good up to metal or wooden frames and skirting and around pipes or fittings.

Angles shall be rounded to 5 mm radius.

Surfaces of undercoats shall be well scratched to provide a key for finishing coats. Screed marks or making good on undercoats shall not show through the finishing coats.

Surfaces described as trowelled smooth shall be finished with a steel trowel to a smooth flat surface free from trowel marks.

Surfaces described as floated shall be finished with a wooden or felt float to a flat surface free from trowel marks.

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

Coating work shall not be started until all:

a) Required openings, chases or other apertures have been cut

- b) Pipes, fixtures, fixing pads and plugs have been fixed
- c) Making good has been completed.

The Contractor shall protect all existing work and approaches, with boards, dust sheets etc. All droppings onto finished work shall be cleaned off immediately

The Contractor shall ensure that all plant and tools are kept clean and free from previous mixes.

The Contractor shall make good defective or damaged coatings before starting decoration works.

4.5 **Preparation for Plaster etc.**

All surfaces to be plastered shall be clean and free from dust, loose mortar and all traces of salts. Projections and concrete fins shall be hacked off. Traces of mould oil, paint, grease, dust and other incompatible materials shall be removed by scrubbing with water containing detergent.

Where cement plaster is to be applied the surfaces shall first be wetted and dashed with a mixture of Portland cement and sand (1:2) mix to form a key. This should be kept wet with a fine water spray until set, and allowed to harden before applying undercoat for a minimum of 3 days.

All surfaces shall be thoroughly sprayed with water and all free water allowed disappearing before plaster is applied.

Bonding agents where required shall be applied in accordance with the manufacturer's instructions and must be approved by the Engineer or his Representative.

Before plastering is commenced all junctions between differing materials shall be reinforced in accordance with clause 6.9 of this section.

4.6 Curing of Plaster, etc.

Each coat of plaster should be kept damp for the first three days. Care must be taken to prevent too rapid drying out during hot weather and in drying winds.

Any cracking, discoloration or other defects caused by inadequate curing shall be remedied at the Contractor's expense.

4.7 Uses of Plaster

Slurry Coat

Before starting the actual plasterwork, all concrete surfaces shall receive a slurry coat evenly dashed on the surface with a steel trowel to provide a key for the first coat of plaster. The slurry coat shall be composed of 400kg of cement to one m of clean coarse sand.

At least one day shall elapse after the application of the slurry before the succeeding coat is started.

Internal Plaster

Internal plaster shall consist of two coats (other than the slurry coat mentioned above) having a total thickness of approximately 12 mm as follows:

The first coat shall be 8 mm thick, made of 1:4 mix (one part of cement to four parts of uniformly graded coarse sand) and shall be done between screeds not more than 2m apart and shall be floated and trowelled true, even and plumb with no hollows, ridges or irregularities.

This coat shall be scarred to form key and shall be allowed to set for three days, during which period it shall be cured and kept continuously wet.

• The second and final coat shall be approximately 4 mm thick and of 1:4 mixes (one part of cement to four parts of fine sand) with as approval plasticizers to be used as per the manufacturers instructions, and shall have a wood or felt floated finish.

External Plaster

External plaster shall consist of two coats (other than the slurry coat mentioned above) having a total thickness of approximately 20 mm as follows:

- The first coat shall be the same as for the first coat of internal plaster, but 14-16 mm thick.
- The second and final coat shall be 4-6 mm thick and of 1:3 mix (one part of cement to three parts of fine sand) with as approval pa to be used as per the manufacturers instructions.

Tyrolean Plaster for External Walls

Cement and aggregate for each batch shall be accurately measured and mixed dry until evenly distributed and the mass is uniform in color. All vertices shall be of such size that they can be entirely used within half an hour.

Mechanical mixer of an approved type shall be used for mixing Tyrolean plaster, except when hand mixing of small batches is specifically approved by the Engineer or his Representative.

Mechanical mixers, mixing boxes and tools shall be cleaned after mixing each batch and kept free of Tyrolean mortar from previous mixes.

Water content shall be maintained at a minimum. Mixing shall be continued until plasticity is obtained.

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

Scratch Coat: 1 part of ordinary Portland cement to 2 parts of fine aggregate Finish Coat: 1 part of ordinary Portland cement to 2 parts of fine selected aggregate For coloured finish coats, the contractor has to submit his mix proportions and carry out trial mixes to the approval of the Engineer or his Representative.

No lime shall be allowed in either scratched or finishing coat, scratch coat shall be set on spatter dash.

4.8 Application of Plaster

After preparation of the surfaces the undercoat shall be applied to the required thickness between screeds laid, ruled and plumbed as necessary 'When nearly set the surface of the undercoat shall be scratched. The undercoat shall be allowed to set hard and shall be cured. Where plastering is applied in one coat or where roughcast is to be applied the scratching should be omitted.

The finishing coat shall be applied to the required thickness by means of a laying - on trowel and finished to give the required surface.

The surfaces shall be finished to a true plane to correct line and level , with all angles and corners to a right angle unless otherwise specified , and with walls and reveals plumb and square The surfaces shall be finished to within \pm 3 mm of a straight edge 1 .80m long placed on face of plaster.

If necessary to correct inaccuracies, dubbing out shall be done in thickness of not more than 10 mm in same mix as the first coat. It shall be allowed to dry out before the next coat is applied, and the surface cross- scratched on each coat immediately after set.

Dubbing out shall not be permitted on smooth dense concrete surfaces, which shall be thoroughly hacked before dubbing out is commenced.

The undercoat shall be worked well into the interstices of metal work to obtain maximum key.

Each coat shall be applied firmly to achieve good adhesion, and ruled to an even surface.

Each coat shall be applied to each wall and ceiling surface in one continuous operation.

Each coat shall be applied at full thickness down to floor level or skirting lath All undercoats shall be cross scratched to provide key for next coat.

Subsequent coats of plaster shall be applied as soon as the undercoat has set firmly, bonded to the background and has developed reasonable suction.

Cement based undercoats shall be allowed to dry out thoroughly to ensure that drying shrinkage is substantially complete before applying subsequent coat.

50 mm each side of angle bead to be finished with neat Keene's cement before plaster finishing coat is applied. Where angle beads are not specified, angles shall be formed with pencil round arise.

A smooth Finish shall be achieved by finishing with a steel laying trowel to an even surface.

4.9 Application Of Tyrolean

All surfaces shall be clean, free from dust, dirt, oil or other particles that might interfere with a satisfactory bond. Surfaces to receive Tyrolean shall be evenly spots, the dry areas shall be dampened again to restore uniform suction. Tyrolean coats shall be applied continuously in one general direction without allowing mortar by dry edges. Edges to be jointed shall be dampened slightly to produce a smooth confluence. Tyrolean plaster shall be three coats and not less than 20 mm thick (spatter dash, scratch coat and one finish Tyrolean coat).

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

Finish coat shall be 6 thick approximately. Before applying this coat, the scratch coat must be damped by fog spraying. Dampening by brush will not be permitted.

When measured with a 2.0m long, straight-edge applied in all directions, the finish surface shall not vary from a true plane by more than 1.5 mm. The finishing coat shall be applied by means of a proper spaying machine.

Where a presses Tyrolean finish is required, this should be obtained by mechanically flattening the surface of the sprayed final or finish coat.

The degree of flattens shall be determined by the Engineer or his Representative based on the set up samples of different degrees on fineness and colours for the Tyrolean finish set up by the Contractor.

As soon as the finish coat has taken its initial set, the Tyrolean shall be protected against direct rays of the such or rapid draying for at least 10 days. During this period the Tyrolean shall be kept moist by frequent fog or spraying. Care shall be taken to prevent staining of the Tyrolean.

Tyrolean with cracks, blisters, pits, checks or discolorations will not be accepted. Tyrolean shall be clean and sound and in accordance with the requirements of the specifications.

4.10 Steel Mesh Lathing, Stops and Beads

Steel mesh lathing shall be galvanized type weighing 1.6 kg/m^2 .

Steel rods for distancing shall be hot rolled mild steel round bars to BS 4449, diameter to approval galvanized to BS EN ISO 1461:1999 or bitumen coated.

Steel clout nails shall be to US EN 197-1:200002: Part I, Table 3, galvanized to BS EN ISO 1461:1999.

Galvanized steel angle bead with 50 mm galvanized expanded metal mesh on both sides of bead.

Mesh lathing shall be fixed with the long way of the mesh at right angles to supports. In horizontal work it shall be fixed with all mesh strands sloping in the same direction, while in vertical work it shall be fixed with all mesh strands sloping inwards and downwards from face of coating.

Lathing shall be fixed from the center outwards so that it is taut. Lathing shall not be lapped within 100 mm of angles or curves.

Side edges of lathing shall be lapped not less than 25 mm, and secure with tying wire at not more than 100 mm centers. Ends of lathing shall be lapped 540 mm at supports and 50 mm between supports, and secured with tying wire at not more than 100m centers.

Junctions of lathing shall be reinforced at corners with 75 x 75 mm angled plain mesh, fixed to rails with tying wire at not more than 100 mm centers.

Ends of wire shall be bent away from face of coating.

At junctions between dissimilar solid backgrounds in the same plane and with the same coating, steel lathing shall be fixed with 38 mm clout nails or with staples. They shall be driven into drilled and plugged holes or into fixing bricks or plugs built in or cast in:

- (a) At single junctions, lathing to be not less than 450 mm wide, fixed each edge at 100 mm centers.
- (b) At columns, lathing to extend not less than 150 mm beyond each junction, fixed each edge and centrally at 100 mm centers.

Lathing fixed to metal supports shall be fixed with hair-pin shaped tying wire ties at not more than 100 mm centers , passed over the support with both ends through mesh, twisted tight, ends cut off and bent flat.

Concrete, block work or masonry backgrounds shall be drilled and plugged at not more than 100x400 mm centers and the lathing shall be fixed with 38 mm clout nails or wire staples driven at an angle to tauten the mesh.

Beads and stops shall be fixed plumb, square and true to line and level.

Metal angle beads shall be fixed to solid backgrounds with plaster dabs, and shall be fixed to timber supports with 28 mm clout nails. Both types of fixing shall be on each side of angle at not more than 600 mm centers

4.11 Protection

All floor, wall and ceiling finishes shall be protected from damage during subsequent work, and shall be thoroughly cleaned before handing over the works.

5 PAINTING AND DECORATING

5.1 General

British Standards (BS) Documents referred to in this section are: BS 245:2000 BS 544:2000 BS EN 197-1:200012 BS 1336:2002 BS 3698:2000

All wood and steel surfaces sand sections shall be thoroughly cleaned and rubbed smooth before painting.

No painting on exterior surfaces shall be carried out during wet or dusty weather, or on surfaces that are not thoroughly dry.

All coats of emulsion shall be thoroughly dry before subsequent coats are applied.

Each coat of paint shall be thoroughly rubbed down with fine sandpaper and where required, filled with an approved putty or filler before the succeeding coat id applied.

The tints of undercoats shall approximately that of the finishing coat, but there shall be sufficient contrast between the succeeding coats to clearly indicate missing (unpainted) areas.

The priming of all wood and metal works shall be done before installation. Priming paints on copper and galvanized steel are to incorporate a suitable etching agent.

All paints and primers shall be used in strict accordance with the specifications and instruction of manufacturers.

Every possible precaution shall be taken to keep down dust before and during painting processes. No paint shall be applied to surfaces structurally or superficially damp and all surfaces must be ascertained to be free from condensation, efflorescence etc. before the application of each coat.

Primed or undercoated woodwork and metalwork should not be left in an exposed or unsuitable situation for an undue period before completing the painting process. No exterior or exposed painting shall be carried out under adverse weather conditions, such as rain, extreme humidity, dust storms etc.

Metal fittings such as ironmongery etc. not required to be painted shall first be fitted and then removed before the preparatory processes are commenced. When all painting is completed the fittings shall be cleaned and refixed in position.

The contractor will be required to repaint at his own expense any work on which the paint is found to be incorrectly applied. The contractor shall be responsible for protecting from damage the paint work and all other work during and after painting operations including the provision of all necessary dust sheets, coven etc.

Brushes, pails, bottles etc., used in carrying out the work shall be clean and free from foreign matter. They shall be thoroughly cleaned before being used for different types or classes of material.

The number of coats stated in this specification or in BOQ is the minimum, and the Contractor must apply sufficient coats to achieve a proper even finish to the approval of the Engineer or his Representative.

5.2 Materials

All paints and paint treatments, including wood and steel primers and fillers and all varnishes, *shall be European Type of good quality* according to the requirements of BS 4800-1972 and BS 3483.

Material shall be obtained from approved manufacturers and shall be supplied in the manufacturer's sealed and branded container. All materials must be thoroughly stirred before use unless recommended otherwise by the manufacturer.

Details of mixing and application shall be in accordance with the specifications of the manufacturers concerned and to the approval of the Engineer or his Representative. The mixing paints of different brands before or during the application shall not be permitted. No dilution of painting materials shall be allowed only as detailed by the manufacturers and approved by the Engineer or his Representative.

Mordant solution shall be of approved manufacture.

Rust inhibitors shall be of approved manufacture.

Stopping for woodwork to receive clear finish shall be tinted to match surrounding woodwork, to the approval of the Engineer or his Representative.

Stopping for internal woodwork, plywood, hardboard, and fiberboard shall be linseed oil putty to BS 544, tinted to match the colour of the undercoat. Stopping for external woodwork shall be white lead paste and gold size well mixed.

Thinners shall be approved turpentine or white spirit to BS 245.

Priming paints shall be:

- (a) For wood work : Leadless grey priming paint in accordance with the recommendations of the decorative coating manufacturer
- (b) For steel work: red oxide priming paint.
- (c) For galvanized, zinc or aluminum alloy surfaces: grey zinc chromate priming paint in accordance with BS 3698.
- (d) For plaster, concrete and brickwork, ceiling boards etc.: alkali resisting priming paint in accordance with the recommendations of the decorative coating manufacturer.

Knotting shall be in accordance with BS 1336.

Primer paints shall be tested according to the following standards: Percentage of non-volatile matter ISO 325 1/1993 Percentage of pigments ISO 325 1/1993 ISO 1524-1983 Grinding Viscosity by Ford cup No.4 ISO 2431/1993 Flexibility 3mm ISO 15 19/1973 Scratch by effect of 800 gm ISO 1518/1992 (for red oxide) Scratch by effect of 1200gm ISO 15 18/1992 (for zinc chromate) Water immersing resistance ASTM D50/1981, ASTM D444-1981

Undercoating shall be:

- (a) Zinc oxide Alkali Resisting based undercoating paint.
- (b) White non lead undercoating paint.
- (c) Synthetic alkyd based undercoating in accordance with the recommendations of the decorative coating manufacturer.

Undercoating shall be tested according to the following standards:

ISO 325 1/1993
ISO 325 1/1993
SO 325 1/1993
ASTM 1
ISO 7724/2-1982
ISO 6504/1681
ISO 15 19/1973

Finishing paints shall be:

- (a) Zinc oxide based oil paint:
- (b) White non lead oil gloss finishing paint.
- (c) Synthetic alkyd based finishing paint as approved by the Engineer or his Representative.

Petrifying liquid shall be used undiluted as supplied by the manufacturer a small quantity of water paint of the finishing colour may be mixed with the petrifying liquid.

Water paint shall be an approved brand of washable oil-bound water paint. Thinning shall be done with petrifying liquid or fresh water only.

Water paint shall be tested according to the following standards:

Percentage of non-volatile matter	ISO 3251/1993
Wash ability	ISO 809/1995
Contrast ration	ISO 7724/2-1982
Flexibility	ISO 1519/1973
Viscosity	ASTM D93/1997

Emulsion paint shall be of the Polyvinyl Acetate (PVA) type obtained from an approved manufacturer. The precise specification shall comply with the manufacturer's normal

practice. In all cases thinning shall be done with thinners supplied by the manufacturer or fresh water only.

Emulsion paint shall be tested according to the following standards:			
Percentage of non-volatile matter	ISO 325 1/1993		
Percentage of pigments	ISO 3251/1993		
Wash ability	ISO 809/1995		
Contrast ration	ISO 7724/2-1982		
Viscosity	ASTM D93/1997		
Grinding	ISO 1524-1983		

Stain for woodwork shall be an approved brand of oil stain complying with BS EN 197-1:200015.

Polyurethane lacquer for woodwork shall be of an approved manufacture.

5.3 Preparation Process

5.3.1 Internal Plaster, Fair Faced Concrete and Block Work

Surfaces shall be allowed to dry out completely and cracks shall be cut out and made good with suitable hard plaster or cement and sand mix as appropriate, such repaired portions shall be allowed to dry out. *No painting shall be carried out on plastering less than five weeks old or by approval from the Engineer or his Representative.*

Efflorescence shall be completely removed by rubbing down with dry coarse cloths followed by wiping down with damp cloths and allowed to dry. All surfaces shall be rubbed down with fine glass paper and brushed free of dust before applying any form of decoration.

Surfaces which are to receive water paint shall be treated with one coat of petrifying liquid applied by brush and allowed to dry for at least 24 hours before the application of water paint. A period of 24 hours, or longer if necessary, shall be allowed between subsequent coats.

Fair faced concrete and/or cement and sand plastered surfaces which are to receive oil paint shall be given one thin coat of oil putty and allowed to dry for at least two days.

The surfaces shall then be rubbed down with fine glass paper and given a second thin coat of oil putty and when completely set The surfaces shall then be rubbed down with fine glass paper and given a second thin coat of oil putty and when completely set.

All surfaces which are to receive oil paint shall be treated with one coat of alkali resisting priming paint applied by brush and allowed to completely harden.

5.3.2 Steelwork, Internally And Externally

If delivered galvanized, the surfaces shall be cleaned to remove grease and dirt before priming. Where rusting has occurred through damage to the galvanizing, such rust shall be removed by wire brushing back to clean metal and the galvanizing made good with a rust inhibiting agent.

The surface shall then be treated with one coat of mordant solution and one coat of zinc chromate priming paint.

If delivered primed, the surfaces shall be examined to ascertain that the priming paint is hard, firmly adhering and in good condition. If not satisfactory, the priming paint shall be removed and the surfaces cleaned to remove rust, and reprimed. If the condition of the priming paint is satisfactory, the surfaces shall be cleaned to remove grease and dirt, minor damage to the priming paint being made good with red oxide priming paint after removal of rust.

If delivered unprimed and not galvanized, the surfaces shall be cleaned to remove grease and dirt, and wire brushed and scraped to remove all rust and scale before applying a red oxide priming paint.

Priming paint shall be brushed well into the surface and shall be allowed to dry and harden thoroughly before the application of subsequent coats.

Items of steelwork such as frames to roller shutters, covers to expansion joints etc., which are to be built into walls, shall first be primed.

5.3.3 Woodwork Required To Be Painted

Surfaces shall be cleaned to remove grease and dirt. The surface of teak shall be cleaned with white spirit to remove free oil. The preparation process shall then be:

- (a) **KNOT:** all knots shall be treated with shellac knotting
- (b) **PRIME:** one coat of primer shall be thoroughly applied by brush to all surfaces and when dry a further coat to be applied to end-grain surfaces.
- (c) **STOP:** when priming paint is hard, all cracks, holes, open joints etc. shall be made good with hard stopping and all open grain surfaces filled smooth with linseed oil putty or an approved filler and rubbed down with fine glass paper.

No joinery shall be primed until it has been approved by the Engineer or his Representative Priming shall be carried out on the site and not in the factory.

Items of carpentry work which are to be built into walls etc. shall be first treated by twice coating with creosote or other approved preservative.

5.3.4 Woodwork Required To Be Stained

Surfaces shall be cleaned to remove grease and dirt. The wood shall then be stopped, filled and rubbed down. In the case of teak free oil shall be removed by cleaning with white spirit.

5.4 Finishing Processes

5.4.1 Internal Plaster

Where emulsion paint is specified three coats shall be applied by brush in addition to any priming paint. Where water paint is specified two coats shall be applied by brush in addition to the Petri liquid. The water paint shall be thinned to the consistency of thick cream.

Where oil paint is specified this shall be two or three coats work as instructed by the Engineer or his Representative, applied by roller or brush, but not by spray, to produce hard gloss, oil gloss, eggshell or flat finish as required.

The finishing coat of paint to walls and ceilings shall be applied after the completion and testing of the electrical installation. Any paint splashes on electrical fittings shall be carefully cleaned off.

5.4.2 Un plastered Block work or Concrete

As for internal plastered surfaces.

Externally cement type paint may be used, and shall be applied keeping a constantly wet edge, in strict accordance with the manufacturer's instructions.

5.4.3 Woodwork Required To Be Painted

As for steelwork.

5.5 **Protection of Factory Finished Work**

The contractor is to allow for protecting all factory finished doors, frames windows, suspended ceilings and the like at all times to ensure that factory finishes are not damaged and must make good or replace a defective component at his own expense.

6 WALL AND FLOOR TILING

6.1 General

The British Standards (BS) govern the work covered in this section. BS EN 197-1:200081 BS EN 197-1:200086 BS 6717

6.2 Materials

Portland cement, fine aggregate and water shall be as previously specified in Concrete Work section. The marble chipping shall be of an approved quality in irregular pieces varying from 2 mm to 10 mm in size depending on the effect required. The pieces should preferably be roughly cubical in shape where flaky shaped pieces shall not be used.

The granite chipping shall be of an approved quality graded from 12 mm down with not more than 5 percent fine material passing a No. 100 sieve.

Marble and granite aggregates shall comply generally with the Table of Grading. In connection with marble aggregates the percentages are approximate only. The actual grading should be selected to produce the surface effects required.

Bs 410 Sieve No.	Approximate	Percentage of aggregate Passing Through Sieve	
	mm	Granite	Marble
-	13	100	-
-	10	95-100	95-100
-	5	30-60	25-60
7	2.4	20-50	5-30
14	1.2	15-40	0-10
25	0.6	10-30	-
59	0.3	5-15	-
100	0.15	0-5	-

Table of Gradings

Note: the above table represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

6.3 Terrazzo Tiles

Terrazzo tiles shall be formed with a (1:2.5) mix of white or coloured cement or white cement with a colour pigment added and granular marble chippings applied as a facing not less than 5 mm thick to a Portland cement and sand (1:5) mix backing.

All floor tiles shall be manufactured in accordance with the BS CP 202:1972, and shall be tested according to BS 6717 for the following:

- Flexural Test
- Tiles Compression Strength

- Absorption And Dimension Test
- Abrasion Test

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

Size	Size tolerances	Minimum total thickness
		mm
200x200	± 0.5	20
250x250	<u>+</u> 0.5	25
300x300	<u>+</u> 1.0	25
400x400	<u>+</u> 1.0	30

Terrazzo Tile Dimensions

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

The Contractor shall submit samples to the Engineer or his Representative approval and bear all laboratory test costs.

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

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

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

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

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

6.4 Marble

Marble shall be supplied and fixed for stairs, flooring, skirting, sills and thresholds where designated on the drawings.

The exposed faces and edges of all marble shall be polished smooth and be free from scratches or other defects. Concealed faces of marble shall be treated with shellac or bituminous paint.

Marble paving shall generally be 30 mm thick and the size, type and pattern shall be as stated in the Bill of Quantities and/or shown on the Drawings. The marble slabs shall be fixed solid on a bed of cement and sand (1:3) mix 30 mm thick with tight joints grouted in lime putty. A protective slurry of lime putty at least 3 mm thick shall be applied to the marble paving and subsequently cleaned off.

Treads shall be <u>30 mm thick</u> fixed solid on a bed of cement and sand (1:3) mix 30 mm thick. Risers to stairs shall be <u>20 mm thick</u> fixed solid on a backing of cement and sand (1:3) mix 30 mm thick. Window sills shall be 40 mm thick bedded hollow on plaster slabs. Skirtings shall be 10 mm thick, in lengths of about 1.5 meters, fixed solid on a backing of cement and to coincide with joints in adjacent pavings. Rounded arrises, nosing and moldings shall be adequately protected by means of timber casings. Treads, risers, skirtings and window sills shall be grouted and protected in a manner similar to paving.

The marble slabs shall be cut square and true and shall be uniform in shape and thickness. Patterns and mouldings shall be accurately formed in accordance with the Drawings.

Exposed edges and mouldings shall be protected by means of timber casing or lime putty coating. The exposed edges and faces of all marble shall be polished smooth and shall be free from scratches or other defects.

6.4.1 Marble Lining

Marble lining to walls, columns and the like shall generally be 20 mm thick and the size, type and pattern shall be as stated in the Bill of Quantity and/or as shown on the drawings.

6.5 Ceramic and Glazed Tiling

6.5.1 Unglazed Ceramic Floor Tiling

Tiles colour and dimensions shall be as indicated on Drawings or Bill of Quantity and subject to the approval of the Engineer or his Representative. Samples must be submitted by the Contractor for the approval of the Engineer or his Representative.

Ceramic floor tiles and fittings shall be in accordance with 85 EN 197-1:200086 type B, vitrified or fully vitrified and the thickness and size shall be as instructed by the Engineer or his Representative.

Glazed ceramic floor tiling shall be of the type, thickness and size as instructed by the Engineer or his Representative.

The tiles shall be true to shape, flat and free from flaws, cracks and crazing and keyed on the reverse side and shall be of manufacture approved by the Engineer or his Representative.

Bedding mortar shall be cement and sand all in accordance with the materials stated in Concrete Work and Block work sections.

Any admixtures to the mortar must be approved before use.

Grout pointing shall be white or colored cement.

Cement and sand mortar bed of not more than 20 mm or thickness of the tile shall be laid.

Tiles shall be firmly tamped into mortar to form a level surface.

The Contractor shall ensure that when fixing tiles with thin bed adhesive, the base to receive tiles is clean, level and dry, with no loose and friable areas and surface dusting.

Cement-based adhesive shall be prepared and used in accordance with the manufacturer's recommendations to form a bed not more than 3 mm thick.

Tiles shall be laid dry and tamped well down into the adhesive to ensure a proper bond with base and a level surface.

When bedding tiles on thick bed, semi-dry cement and sand (1:3) mortar bed shall be spread not less than 25 mm thick.

Before the compacted bed has set a cement and sand slurry (1:1) about 3mm thick shall be spread over the surface.

The tiles shall be laid dry and tamped into the shiny to form a level surface.

Joints shall be even and not more than 3 mm wide, in both directions.

Joints shall be continuous both horizontally and vertically.

The tiles shall be grouted up with white or coloured cement mortar (worked well into joints when bed is sufficiently firm to prevent disturbances of the tiles; surplus grout shall be cleaned off from faces of tiles. Movement joints shall be provided not less than 6 mm wide where shown on the Drawings or as directed by the Engineer or his Representative.

Movement joints shall be carried through the depth of tile and bedding and partially filled with filling strip and finished flush with sealant to manufacturer's recommendations.

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

Tiles shall be cleaned off and polished at completion. No water shall be allowed on new filing until bedding and grouting have completely set and no traffic shall be allowed on the floor until 4 days after completion and then only light traffic for a further 10 days.

6.5.2 Glazed Ceramic Wall Tiling

Tiles colour and dimensions shall be as indicated on Drawings or Bill of Quantity and subject to the approval of the Engineer or his Representative. Samples must be submitted by the Contractor for the approval of the Engineer or his Representative.

Glazed ceramic wall tiles shall be in accordance with BS EN 197-1:200081 with or without cushioned edges and spacer lugs and shall be white or coloured as instructed by the Engineer or his Representative.

Glazed ceramic tile fittings shall be rounded edge or angle bead type to match plain tiles.

The tiles shall be true to shape, flat and free form flaws, cracks and crazing and keyed on the reverse side and shall be of a manufacture approved by the Engineer or his Representative.

Bedding mortar shall be cement and sand (1:3) all in accordance with the materials stated in Concrete Work and Block work sections. Any admixtures to the mortar must be approved before use.

Grout pointing shall be neat white or coloured cement.

The Contractor shall ensure that the cement render backing is at least 14 days old, firmly bonded to its background, free from dust, with surfaces plumb and true to ± 3 mm in any 1800 mm.

The tiles shall be immersed in water for 6 hours or until saturated then stacked tightly together to drain with end tiles turned glaze outwards. Tiles shall be fixed as soon as surface water has drained.

The render coat shall be wetted sufficiently to prevent it absorbing water from the bedding coat.

Mortar bedding shall be applied to render background to an even thickness of approximately 10 mm.

Each tile shall be buffered evenly with mortar and tapped firmly into position so that the bed is solid throughout.

Thickness of finished bed shall be not less than 6 mm nor more than 12 mm.

Any necessary adjustment to tiles shall be made within ten minutes of fixing and tiles cleaned off after not less than two hours.

Tiles shall be cleaned off as soon as bedding is complete.

Joints shall be even and not more than 2 mm wide using spacer lug tiles or spacer pegs. Joints shall be continuous both horizontally and vertically.

Tiles shall be fixed to a finished surface that is plumb and true to ± 2 mm in any 2m.

Joints shall be grouted up not less than 24 hours after fixing tiles to porous surfaces and not less than 3 days after fixing to impervious surfaces.

Tiles shall be grouted by pressing mix firmly into joints, working in areas of not more than 1.0 sq.m.

Surplus grout shall be cleaned off as the work proceeds.

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

Tiles shall be cleaned off and polished on completion.

External tiling shall be protected from inclement weather until grouting is completely set.

No water is to be allowed on new tiling until bedding and grouting have completely set.

6.6 **Protection**

All floor, wall and ceiling finishes shall be protected from damage during subsequent work, and shall be thoroughly cleaned before handing over the works.

7 GLAZING

7.1 General

British Standards (BS) Documents referred to in this section are: BS 952

7.2 Type of Glass

7.2.1 Sheet Glass

Sheet glass shall be flat-drawn clear sheet glass, of the substances shown below.

Nominal Substance	Limits of thickness		Approximate Weight	Normal Maximum Size
of the kness		• •	71 (0)	
	mm	ınch	Ib/ft ²	Inch
20 oz	2.75-3.05	0.108-0.120	1 1/2	80x48
26 oz	3.1-3.50	0.1 22-0.138	1 3⁄4	80x48
32 oz	3.8-4.20	0.150-0.165	2	80x48
3/16 in	4.65-5.25	0.183-0.207	2 1/2	$50 \text{ ft}^2 \text{ max width } 84$
				in
7/32 in	5.3-5.80	0.209-0.228	3	50 ft ² max width 84
				in
¹ / ₄ in	6.25-6.75	0.246-0.266	3 1/2	75 ft ² max width 84
				in

7.2.2 Plate Glass

Plate glass shall be cast, rolled or drawn glass ground and polished on both surfaces, of the thicknesses shown below.

Limits for Clear Plate Glass

Nominal Substance or thickness	Limits of thickness		Approximate Weight	Normal Maximum Size
	mm	inch	Ib/ft ²	Inch
3/16	3.97-5.56	0.156-0.219	2 1/2	100x72
1/4	5.56-7.94	0.219-0.312	3 1/4	175x98
3/8	9.13-10.72	0.359-0.422	5	280x130
1/2	11.91-13.49	0.469-0.531	6 1/2	156x96

7.2.3 Wired Glass

Wired glass shall be polished Georgian wired having both surfaces ground and polished and with square mesh inserted during rolling of the thicknesses shown below.

Limits for Wired Glass

Nominal thickness	Limits of	thickness	Approximate Weight	Normal Maximum Size
	mm	inch	Ib/ft2	Inch
1/4	5.5-7.2	0.126-0.283	3 1/2	130 x 72

7.2.4 Mirror Glass

Mirror glass shall be silvering Quality polished plate glass silvered on one side, copperbacked, varnished and painted according to the BS standard, with pre-drilled fixing holes. Silvering shall be protected against moisture by the clew-copper shellac varnish and pointed backing.

7.3 Installation

Cutting and glazing shall be as recommended by the manufacturer of the glass and according to these Specifications.

Edges shall be clean-cut with no nipped or seamed edges.

All glass shall be cut accurately to fit its particular position.

All glazing shall be done with sash in a closed position.

All surfaces to receiver glazing compound shall be cleaned free from dust, water and any foreign matter, which would adversely affect the installation.

Regular cleaners from sides, bottoms and tops of all glass panels shall be maintained.

Mirrors shall be fixed to walls with compressive spacers, fiber washers and chromium plated dome - headed screws, screwed into prepared plugs let into walls and set flush with surrounding wall finish.

Mirrors used as wardrobe doors or as wall linings are to be bedded with an approved mastic on a painted block - board backing not less than 12 mm (1/2") thick to walls and 18 mm (3/4") thick to doors. Glass sizes will be whole size to doors and minimum 900 mm (3'O") wide to wall linings unless otherwise detailed, and backings continuous where possible. Joints in backings must coincide with joints in mirrors.

7.4 Cleaning

The Contractor shall replace all scratched, cracked or broken glass and clean all glazing on both sides and all mirrors before handing over.

8 CARPENTRY AND JOINERY

8.1 General

British Standard (BS) Documents referred to in this section are:

BS459: 1995	
BS 476-20:1987	Method for determination of the fire resistance of elements of
DG 47(01 1007	construction (general principles)
BS 4/6-21:198/	Method for determination of the fire resistance of load bearing
	elements of construction
BS 476-22:1987	Method for determination of the fire resistance of non-load
	bearing elements of construction
BS 476-23:1987	Method for determination of the contribution of components to the
	fire resistance of a structure
BS EN 942:1996	Timber in joinery. General classification of timber quality
BS EN 636-1:1997	Requirements for plywood for use in dry conditions
BS EN 636-2:1997	Requirements for plywood for use in humid conditions
BS EN 636-3:1997	Requirements for plywood for use in exterior conditions
DD ENV 1099:1998	Plywood. Biological durability. Guidance for the assessment of
	plywood for use in different hazard classes
BS EN 197-1:200002	: Part I
BS EN 197-1:200003	
BS EN 197-1:200004	: Parts 1 and 2
BS EN 197-1:200010	

8.2 Timber

All softwood for carpentry and joinery work shall be well seasoned sound, bright, free form shakes, large loose or dead knots, waney edges, warp, incipient decay, stained sapwood or other defects and shall be to the approval of the Engineer or his Representative.

Timber for carpentry work shall be carefully sawn square and shall hold the full dimensions shown on the Drawings.

The hardwood for joinery work shall comply with the BS EN 942:1996. It shall be well seasoned, close grained and free form all defects. Hardwood for polishing or clear treatment shall be selected and kept clean.

Any preservative treatment shall be approved by the Engineer or his Representative.

The Contractor shall allow for all necessary cuffing of timber to size and shape, for preparation of surfaces, for all fixings, for properly jointing and putting together including farming, gluing, doweling screwing and mortising, for all cutting and waste, notching, sinking, scribing, miters, ends, short lengths and any other sundry items of like nature and for priming all concealed surfaces of joinery. Aluminum primer shall be applied to concealed surfaces of all joinery timber.

All sizes and dimensions shown on the Drawings are finished sizes unless otherwise stated.

Timber for joinery work shall be finished work to the exact sizes shown on the Drawings with pencil rounded exposed arrises and no joinery shall be built in until inspected and approved by the Engineer or his Representative.

The whole of hardwood joinery shall be rubbed down to a smooth surface and left clean and ready to receive any oiled or other finish.

Where screw fixings would show on the surface of hardwood, the heads shall be countersunk 6 mm below timber surface and grain matched fillets not less than 6 mm thick and trapped and cut from matching timber shall be glued in and finished off flush with the face. This will apply equally to hardwood which is to be painted.

8.2.1 Moisture Content of Timber

The softwood generally shall have a maximum moisture content of 12%.

The hardwood shall have a maximum moisture content of 10% and shall have been kiln dried.

The whole of the timber for joinery work shall be properly stacked and protected from rain and ground moisture.

8.2.2 Plywood

The minimum thickness shall be 5 mm or the first higher thickness available.

Plywood face veneers shall comply the requirements of BS EN 636:1997 and DD ENV 1099:1998 and the adhesives shall comply the requirements of BS EN 197-1:200003, Grade 1.

The Contractor shall not be permitted to make up the required thickness by gluing together sheets of thinner plywood.

8.2.3 Timber Face Veneers

All timber face veneers that are exposed shall be selected to the approval of the Engineer or his Representative and shall be hard, durable and capable of being finished easily to a smooth surface.

They shall he free from knots, worm and beetle holes, splits, glue stains, filling or inlaying of any kind, or defects

8.2.4 Fixing And Jointing

Softwood in carpentry work shall be put together with steel nails except where described as framed when it shall be properly jointed and held together with glue and steel screws. Fixings shall be stout steel nails and screws.

Joinery work shall be carefully put together and properly jointed in accordance with best practice, all joints shall be glued and screwed or doweled . Any screws appearing on facework shall have the heads let in and pellated unless otherwise described. Softwood fixings shall be stout steel screws.

Where joinery is required to be put together and fixed with brass cups and screws, the cups for fixing hardwood joinery shall be cast brass cups with milled edges and shall be neatly let in to finish flush with the face of the work.

Nail lengths shall not be more than total thickness of sections to be joined less 5 mm, but otherwise not less than twice the thickness of the section through which nails are driven.

Screw lengths shall be not more than total thickness of sections to be joined less 5 mm, but otherwise not less than 1.5 times the thickness of the section through which screws are driven.

Proprietary plugs shall be approved by the Engineer or his Representative.

Steel nails shall comply with BS EN 197-1:200002: Part 1.

Wood screws shall be brass complying with BS EN 197-1:200010 with slotted countersunk heads.

Screw cups shall be brass complying with BS 1494: Part 2.

Synthetic resin gap-filling adhesives shall comply with BS EN 197-1:200004: Part 1, type WBP.

Synthetic resin close-contact adhesives shall comply with BS EN 197-1:200004: Part 2, type WBP.

8.2.5 Spacing And Additional Supports

Where no dimensions are specified or shown on Drawings, space battens, fillets, grounds studs etc. , shall be used in accordance with the recommendations of the manufacture of the sheets and/or sections being fixed.

Where not shown on Drawings, additional supports shall be positioned and fixed for appliances, fixtures, edges of sheets etc. , in accordance with the manufacturer's recommendations.

8.3 Doors

Doors shall be as shown in the Drawings obtained from one of the approved manufacturers, and shall be capable of withstanding the particular weather conditions of the Middle East.

Doors leaves with a polished finish are to be veneered with approved hardwood veneered plywood, supplied with protective wrappings and with all necessary preparation for ironmongery carried out. All edges are to be lipped with hardwood and all beads and lippings are to match face veneers. All doors shall confirm to BS 459 and BS 476 with adequate blocking out for ironmongery.

Hardwood polished thresholds are to be provided to individual flat entrance doors. All other doors within flats should allow sufficient clearance for fitted carpets. The Contractor should ascertain requirements for clearance in all other positions from the Engineer or his Representative.

Each door shall have a number with a designation letter of the floor it is located at. Type of material, design and color should be approved by the Engineer or his Representative. This must be considered by the contractor in pricing the BOQ.

8.4 Frames

Door frames shall be as shown on the Drawings all in wrought hardwood treated to match doors in accordance with door manufacturer's recommendations and should be manufactured and finished by the door manufacturer where possible.

Frames to doors shall be securely tied to walls by means of steel or similar metal cramps, galvanized or dipped in bitumen and provided three cramps in each side.

Doors shall be carefully and accurately fitted into the frame to give a uniform clearance of not more than 3 mm all round.

8.5 Fittings

In connection with fittings such as wardrobes, cupboards, counters etc., the doors, frames, drawers, rails and framing etc. shall be properly and accurately framed together.

Before starting repetitive fabrication of any component, prototypes shall be prepared and approved by the Engineer or his Representative.

Unless components are specified to be built in, these shall not be made until all site dimensions have been checked.

Matching clearance holes shall be provided for all sizes of screw and matching pilot holes for screws of 6 gauge or more for screwing softwood.

Clearance and pilot holes to match screw sizes shall be provided for screwing hardwood.

Pilot holes shall be provided slightly less than half the diameter of the screw for screwing particle board.

All nail heads which will be visible in completed work shall be punched below timber surface.

8.6 Finish

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

8.7 Protection

All joinery shall be protected from damage during the course of the Works and on completion shall be to the Engineer or his Representative's entire satisfaction. Before handing over the Contractor shall ensure that all doors, drawers, etc., work easily and shall make all necessary adjustments including those needed during the maintenance period.

8.8 Sign Board

Sign Board of a minimum size (1.20X1.50) showing the general legend for the whole station with different colon for each floor.

The board shall be made of 4 Fiber Plastic Board, design and colors should be approved by the Engineer or his Representative and to be placed according to his instructions.

9 **IRONMONGER Y**

9.1 General

British Standard (BS) Documents referred to in this section are:

BS 5872:1995 Specification for locks and latches for doors in buildings.

The Contractor shall provide and fix the ironmongery required by the Bill Of Quantity or shown on the Drawings complete, including all necessary screws, bolts, plugs and other fixings. The use of nails for fixing ironmongery shall not be permitted. The Contractor shall hand over all in a finished state and to the satisfaction of the Engineer or his Representative.

All ironmongery shall be of first quality and shall be obtained from an approved manufacturer. Butt hinges are to be aluminum alloy with silver anodised finish with double stainless steel washers, or as approved by the Engineer or his Representative.

The Contractor shall be required to submit for approval samples of all items of ironmongery he proposes to use.

All doors shall be provided with an approved doorstop plugged and screwed to the floor and all opening areas of aluminum work shall be provided with appropriate friction stays.

9.2 Finish

The finish of the various items of ironmongery shall be as shown on the Drawings or as required and directed by the Engineer or his Representative.

9.3 Fitting And Testing

All screws used for fixing ironmongery shall be of a suitable type, material, finish, size and shape to the satisfaction of the Engineer or his Representative.

The hinges on which doors, windows, etc. . are hung shall be carefully housed or let into the door, window etc. and to the frames.

All fittings shall be removed before commencing any painting operations and shall be refixed in place after all painting works are completed and approved by the Engineer or his Representative.

All ironmongery shall be carefully wrapped and protected until completion of the work and any items or parts which are damaged or defaced or found to be defective shall be replaced at the Contractor's expense before handing over.

On completion of all locks, catches and similar items of ironmongery they shall be clearly labeled, with metal tags approximately 50x20 mm and securely fixed to the keys and handed to the Engineer or his Representative.

Door closers shall be fitted a maximum of two weeks before handover.

All floor and door springs are to be fully charged with oil and their operation checked to the satisfaction of the Engineer or his Representative.

9.4 Standard Ironmongery for Internal Doors

Ironmongery is to be hard satin anodised aluminums alloy of best quality with matching screws fully matching and integrated. Where a supplier cannot offer the particular required ironmongery the Contractor shall produce samples of other suppliers' items most nearly matching the general ironmongery and / or produce alternative ironmongery by the main supplier most closely conforming with the Specification for the approval of the Engineer or his Representative.

All locks are to be provided with 2 keys on a key ring neatly labeled to indicate clearly the corresponding lock. A' Master key locking systems for all doors in station will be provided.

All knob sets shall include the appropriate mortice latch or lock with a 70 mm backset and with standard faceplates and roses unless otherwise noted.

10 METAL WORKS

10.1 General

British Standard (85) Documents referred to in this section are:

BS 5872:1995 Specification for locks and latches for doors in buildings.

10.2 Cleanliness

All materials shall be free form scale, damage or defects. All welding, brazing or hot forging shall be carried out by approved processes.

All metal work shall be approved by the Engineer or his Representative before starting painting works.

10.3 Aluminum Windows

Extruded aluminum sections should be used as approved by the Engineer or his Representative.

All visible surfaces of the sections shall be brilliantly polished prior to anodising. The colour of anodising shall be as described in the Drawings and /or instructed by the Engineer or his Representative. Samples of colour shall be submitted for the Engineer or his Representative's approval before work commences.

The sections shall be anodised to a minimum thickness of 25 microns. The supplier must submit necessary evidence to the satisfaction of the Engineer or his Representative that the thickness of anodisation is not less than 25 microns. In case of doubt the Engineer or his Representative reserves the right to send sample pieces to independent testing laboratories, at the supplier's expense. If the testing laboratory report states that the thickness or quality of the anodisation is deficient, the Employer may ask the supplier to treat the order as cancelled and the supplier in such a case shall indemnify the Employer of any I all losses incurred by the supplier.

All frames shall be made to fit the actual openings with a 5 mm clearance all round. Discrepancies in overall width or height exceeding 5 mm will not be allowed and the frames will be rejected in such cases. All small discrepancies shall have the gaps suitably backed and then filled with gun- applied mastic / sealant as approved by the Engineer or his Representative.

At all opening windows and where there are louvered screens a fly screen shall be provided to the approval of the Engineer or his Representative, constructed following the principles and specifications as described elsewhere in this Specification.

Insect screens shall be in aluminum mesh, 18x10 meshes per inch. The gap between the insect screen and the shutter shall be covered with an adaptor PVC section.

For reference to window types see general arrangement drawings and elevations.

Tolerances are to be approved by the Engineer or his Representative before manufacture.

All ironmongery which is to have the same finish as the frames it is to be installed on shall be approved by the Engineer or his Representative.

The Contractor shall provide shop drawings for aluminum windows, which shall be submitted in quadruplicate to the Engineer or his Representative for approval.

Approval by the Engineer or his Representative of the shop drawings shall not relieve the Contractor of his responsibilities under the Contract.

Glazing sections shall be in special heat-resisting PVC and of channel type. Separate glazing sections on each side of the glass will not be permitted.

10.3.1 Sliding Windows

Weather stripping - high-density acrilan or wool weather - pile shall be used. There shall be double brushes at every contact between shutter and frame sections for complete insulation. These shall be present consistently throughout the unit between the inside and the outside and no portions without it are permitted.

The rollers for sliding shutters for windows shall be of an adjustable type. The adjusting screws shall be accessible in the assembled state of the shutters and a vertical adjustment of 7 mm shall be possible.

All sections for sliding windows shall be of tubular shape and the cross sectional dimensions of same shall be not less than 60x 40 mm.

The outer frame must be suitable for accommodating sliding fly screens as required or as directed by the Engineer or his Representative.

The handle-latch set shall have all visible surfaces of anodised aluminum or similar nonrusting material to approval. The handle shall have a proper grip. A small projecting flange or a recess in the shutter sections shall not be accepted to serve as a handle. The latching mechanism shall not be surface mounted but shall be concealed within the sections.

10.3.2 Side Hung Windows

All windows shall be weather stripped with heat resistant PVC sections. The weather fighting action shall be achieved by a positive compressive action against the PVC section and shall not depend on an external contact with the PVC section. At every contact between two profiles two weathers tipping sections shall be provided for complete weather protection.

The shutter sections for windows shall be of tubular type and shall be of overall size 57x45mm for windows.

The shutters of the windows shall be assembled with concealed corners of high rigidity. Hinges shall be concealed within the sections.

Hinges shall be in anodised aluminum with stainless steel pins and nylon washers. Handles shall be in anodised aluminum and mounted with self- lubricating nylon washers. A mortice cylinder rim automatic dead lock of high quality with double pin tumbler shall be used.

Windows shall have anodised aluminum handles and a latching mechanism securing the shutter to the frame both at the top and bottom.

The glazing vinyl shall be in heat resisting PVC and of channel type to the approval of the Engineer or his Representative.

10.3.3 Fly screens

Fly screens shall be fitted to all opening leaves of windows, consisting of a separate metal sub-frame filled in with fly wire as previously described. The fly screens shall be adequately secured with suitable clips, set screws or turn buckles and shall be removable for maintenance purposes.

10.3.4 Sealing Joints

The Contractor shall ensure that joints are dry and shall remove all loose material, dust and grease. Joints shall be prepared in accordance with sealant manufacturer's recommendations using recommended solvents and primers where necessary as approved by the Engineer or his Representative.

Backing strips shall be inserted in all joints to be pointed with sealant. When using backing strips, the Contractor shall not leave gaps and shall not reduce depth of joint for sealant to less than the minimum recommended by the manufacturer.

Cavities shall be filled and jointed with sealant in accordance with the manufacturer's recommendations.

Sealant shall be tooled to form a smooth flat bed.

Excess sealant shall be removed from adjoining surfaces using cleaning materials recommended by the sealant manufacturer, and shall be left clean.

10.3.5 Expansion Joint Trims

The Contractor is to provide at all expansion joints in floors, roofs, ceilings, walls and columns extruded aluminum expansion joint cover systems as appropriate and as shown on the Drawings and fixed in accordance with their printed instructions including all necessary components and fixings.

Floor joint covers shall be 2" deep. Butt joints within continuing runs shall be a maximum of 20 feet apart and will be sealed during installation. Wall and ceiling joint covers shall be white aluminum strip. Transition pieced at changes of direction and at joints between horizontal and vertical joint covers shall be factory fabricated.

10.4 Steel Doors And Gates

Steel doors and gates shall be made of galvanized steel sheets and profiles, and shall be free of any irregularities in dimension or of shape, or other defects that might, of detriment to the construction. Elements which deviate from the specified shape or form and/or which are defective to such degree that they cannot be repaired without risks of
damaging the material or the element itself shall not be used and have to be replaced immediately.

Each door shall have a number with a designation letter of the floor it is located at. Type of material, design and color should be approved by the Engineer or his Representative. This must be considered by the contractor in pricing the BOQ.

The galvanization for all elements shall be carried out so as to ensure that the zinc covering is uniform, adhering and free from cracks and pits all over the object. The galvanization shall comply with ISO 1461 with a minimum thickness of 65 um for the bolts and 80 um for the other elements.

All deformations of welded elements appearing during galvanization shall be carefully straightened, In such a way that the galvanization is not damaged and the steel does not lose its strength normally, no extra treatment shall be carried out after galvanization. It may be allowed to repair small defects by applying two coats of zinc dust paint.

The execution of the work shall be correct and in accordance with professional usage on the best level.

The use of welding for repair of defects shall only be permitted when there is no risk of damaging the steel! and in no circumstances without the prior approval of the Engineer or his Representative. All welding work shall be carried out as are welding according to BS EN 1011, welding electrodes shall be appropriate for the used base metals and the chosen welding method, and shall be able to satisfy tests.

The Contractor must always be able to produce documentation that the used electrodes comply with the standards for the base metal on which they are applied, as regards resistance and quality class.

10.4.1 Execution

Welding work shall be executed in accordance with the prescriptions of BS EN 1011. During welding there may be no rust, nor any layered scales stemming from rolling, nor any metal coating! nor paint or grease! nor any burrs from punch cuffing nor any other elements which could reduce the quality of the weld, The elements of the construction shall be executed with excess length to compensate for contractions and possibly with a slight camber or similar to eliminate the effect of thermal contractions.

After the welding, the elements of the construction shall, as far as possible have a final shape which makes truing-up unnecessary.

The elements to be joined by welding shall be placed in correct position in relation to each other in order that the welding contractions welding deformations and possible truing-up may be limited to a minimum. The tack welding shall be executed just as carefully as the welding itself.

The tack welding shall be placed as close as possible and be of such a dimension and strength as to be able to resist the contractions appearing during welding.

In case that it is not planned to remove the tack welds as the welding proceeds, these tack welds must be placed and executed in such a manner as to hamper the welding works as little as possible.

Before making the finishing run, it shall be checked that the tack welds have no cracks or other defects, cracked or defective tack welds shall be removed.

Welding run materials shall fill up the groove completely in penetration welds and pass evenly into the base metal and shall, moreover/ be free of surface flaws such as crevices, cutting buns, scales, etc.

Intermittent fillet welds shall not be accepted, and all fillet welds must be closed.

The welding runs must be flat or concave-Possible convexity must not exceed the tolerances Indicated in the standards.

The finished weld must not present any cracks, crevices, faults of adhesion, uneven and rough surfaces, root defects! pores, slag inclusions, or other flaws, which may impair the strength of the weld. Butt welds must invariably be finished by backing runs after removal of welding slags.

Welded points and similar for fixing grips and clamps to keep the construction aligned in correct position shall only be permitted if they do not impair the construction.

All spatters from welding shall be removed before beginning the painting. All defective welds must be removed and replaced by a satisfactory weld.

No repairs may be carried out without the approval of the Employer or the Engineer or his Representative. The Employer reserves the right to effect testing of important welds to be carried out by an approved institute of control.

If, by ultrasonic or other non destructive tests, it is confirmed that there are welding detects necessitating repairs, the Contractor shall remedy those at his own expense and also meet the costs of the supplementary welding tests until it has been demonstrated in a reassuring manner that the quality of the welding work satisfies the specified requirements. The Employer reserves the right to insist on a more extensive control.

10.4.2 Erection

Dismantling, erection and handling of the elements of the construction shall he done with care in order that the surfaces may not be damaged. The elements shall be lifted by means of straps and not by chains.

10.4.3 Sliding Gate

The sliding gate shall slide by automatic mechanism efficiently by using guide rail suitable in size to prevent sliding friction, and using mechanical limit stop to regulate the opening and closing stroke.

The gate shall be equipped with:

- Ratio-motor complete with gear case
- Rack
- Limit stop flasks
- Photo-electric cells
- Mechanical stop
- Key or digital keyboard selector
- Blinker

Antenna

10.5 Handrails

Handrails for corridors or protection shall be supplied and/ or manufactured in accordance with the details shown on the Drawings and in accordance to the instructions of the Engineer's Representative.

They have to be made of Galvanized steel or Stainless steel pipes as indicated in the drawings and BOQ.

Fabricating and erecting the elements shall be comply with the specification and percussions mentioned in section 12.4.

For Stainless steel pipes thickness must not be less than 2 mm, and welding shall be done using the TIG welding method including use of protection gas.

Elbows and flanges of the same materials will be provided as needed/required during installations and to be connected to the fabricated element by welding.

After welding of Stainless steel elements joints shall be cauterized and passivated to the same corrosion resistance quality for the Stainless steel material that has been used. Contractor has to provide method statement and quality assurance for this work for the approval of the Project Manager before starting the welding actions.

10.6 Raised Floor Slabs

The contractor shall provide submittals, materials and installation of the access floor system as specified in this document.

The contractor shall provide clear access, dry secure storage, and a clean sub floor area, which is free of construction debris and other trades during installation of the access floor system. Area to receive the access floor shall be enclosed and maintained at a temperature range of 40 degrees to 90 degrees F and a humidity range of 20% to 70% relative.

Concrete sealer shall be compatible with access floor pedestal adhesive.

The contractor shall provide necessary material and labor to electrically connect the access floor to the building.

10.6.1 System Description

Access floor system shall consist of interchangeable square panels selected to meet specific load requirements. Panels shall be supported by adjustable pedestal assemblies which positively locate, engage and secure panels and which accommodate horizontal grid members when specified.

Finished floor height of the system above the sub floor shall be as shown on the contract drawings.

10.6.2 Shop Drawings and Product Data

Submit drawings showing complete access floor system including floor panel layout and all accessories that are a part of the system.

Submit details and descriptive notes for finishes of components, anchoring, edge details, and interfaces with adjoining work.

10.6.3 Samples

Submit for approval one full size floor panel with finished surface and understructure components for each type of access floor being supplied.

10.6.4 Quality Assurance

Submit certified laboratory test data for approval which indicates that the supplied system complies with the performance indicated herein.

- Test methods for concentrated, ultimate, rolling, overturning movement, and axial loads shall be in accordance with the "Recommended Test Procedures for Access Floors" as published by CISCA, the Ceilings and Interiors Systems Construction Association.
- Test Method for Impact Load: Panel without floor covering shall be supported on actual understructure. An impact load is applied to the panel via a one square inch indentor which is struck by a predetermined load dropped from a height of 36 The panel shall be loaded at its weakest point. Weakest point to be determined by an independent test lab.
- Test Method or Electrical Resistance: The electrical resistance of the access floor system shall be tested in accordance with NFPA 99. The test is modified for access floors where one electrode is placed on the floor surface covering and the other electrode is attached to the understructure.

10.6.5 Acceptable Manufacturers

- Floor Panels shall consist of either 24" or 60 cm steel top sheet welded to a formed steel bottom pan and a painted finish. Panels shall be internally filled with a lightweight cementations product (ConCore).
- understructure System.

10.6.6 Type Of Understructure

I	Finished Floor Height	
	Stringer less	3 1/4" - 18"
	Corner lock	3 1/4" - 24"
	Snap-on Stringer	5" - 24"
	Bolted Stringer	5" - 30"

10.6.7 Pedestal Assembly

- A 30" FFH assembly shall provide a 8000 lb. axial load without permanent deformation.
- Assembly shall provide a range of adjustment from Ito 2" total.
- Provide a means of leveling and locking the assembly at a selected height which requires deliberate action to change height setting and which prevents vibrating displacement.
- Pedestal bases

Fabricated of a square base with not less than 16 square inches of bearing area and assembled to a stud or tube which is designed to engage the pedestal head assembly; secure to sub floor in accordance with manufacturer's instructions.

Pedestal heads.

Fabricated of a head plate with a corresponding stud or tube which is designed to engage the pedestal base assembly. The head must be the proper type to positively locate the floor panel or to receive a stringer system. When specified, the head shall provide a means to fasten the floor panel or stringer directly to the head.

• Stringer system.

Stringer system shall be all steel construction, designed and fabricated to interlock with pedestal head and to form a modular grid pattern with members under edges of all field floor panels. Stringer to be bolted to the pedestal head.

Corner lock fastener.
 Floor panels shall be provided with four corrosive resistant, captured fasteners, which remain with the panel when removed. Panels shall be removable by releasing the four fasteners and shall remain positively locked onto the pedestal head without the fasteners in place.

10.6.8 Floor Surface Covering

- Finish the surface of floor panels with floor covering material as indicated on BOQ or instructed by the Engineer or his Representative. Where floor coverings are by the access floor manufacturer, the type, color and pattern to be selected from manufacturer's standards.
- Vinyl edge trim for the tile coverings shall be mechanically locked and bonded to the panel surface and flush with the surface covering.

10.6.9 Accessories

- Service outlets to be provided in locations and as detailed on the contract drawings. Outlets to accommodate power, communications and data wiring.
- Air Flow Panels shall be all steel welded construction with a 25% open air perforated top sheet and shall be supplied with an adjustable damper assembly. Panels shall be capable of supporting a design load of 1250 and shall provide 525 CFM at a static pressure of 0.1" H2O.
- Provide 10 spare floor panels and 20 square feet of understructure systems for each type used in the project for maintenance stock. Deliver to project in manufacturer's standard packages clearly marked with the contents.
- Provide 5 panel lifting devices.

10.6.10Installation

Qualification

Floor system and accessories to be installed by the manufacturer's authorized representative to maintain the integrity of the products and acceptable performance of the completed installation.

Inspection

Examine sub floor for unevenness, irregularities and dampness that would affect the quality and execution of the work.

Do not proceed with installation until sub floor surfaces are clean, thy, clear of other trades and ready to receive access flooring.

Preparation and Installation

The access floor to be prepared and installed in accordance with the access floor manufacturer's instructions covering preparation, layout, alignment and installation. Installed access floors shall be level within plus or minus 0.060 inches in 10 feet, and plus or minus 0.10 inches over the entire area. Floor to be rigid and free of rocking panels.

Adjust and Clean

Remove access floor installation debris as work progresses, maintaining area under finished floor in a clean condition.

The general contractor is to protect the finished access floor from damage and misuse.

10.6.11Step By Step Installation Of Field Area

In the installation of an access floor, there are certain criteria that should be followed. These are listed in the general order of sequence.

- **STEP 1.** Check the room dimensions and configuration against approved drawings. Using a builder's transit or laser, shoot in the areas to receive access floor to determine how much variation there is in the level of the sub floor within the room and at the termination points, such as elevator and door sills and concrete ledges. If the floor cannot be installed per your drawings, notify the general contractor superintendent for agreement on corrective action. The FFH may have to be changed.
- **STEP 2.** Find the starting point in the room as shown on the drawings. Seek approval to change the starting point if cut panels at the perimeter will be too small to allow proper support. Recommended minimum size of the cut panels for proper support is 6 inches wide.
- **STEP 3.** Having established the proper starting point, lay out two chalk lines at right angles to make sure the room is square. Chalk lines must be used as control lines for installing the access floor. The reason for laying chalk lines for installing the access floor. The reason for laying chalk lines rather than just measuring from the walls is that the walls are not always square. The chalk line system gives a square reference point. Be careful to keep the access floor square at all times during installation.
- **STEP 4.** Chalk the two control lines and spread pedestal assemblies in an area approximately 48 feet x 24 feet, making sure to start at the approved starting point.
- **STEP 5.** Using a laser or transit, shoot in a pedestal assembly to the proper FFH every 8 or 10 feet in both directions (depending on the length of your leveling bar). By spanning two pedestals at proper FFH with the leveling bar, adjust all the pedestals in between to the bottom surface of the bar.

As you adjust each pedestal assembly, center it on the two-foot marks permanently marked on the bar.

- **STEP 6.** Glue each pedestal base in the spread area to the sub floor. Using a spatula type device, tilt up base plate without changing its location and apply adhesive to bottom of base plate.
 - **NOTE:** When using fasteners to anchor pedestal bases, each base should be glued and stringers installed (if part of system) before installing anchors.

The type of fasteners used may also require that panels be installed for later removal and installation of fasteners.

This ensures pedestal location and plumpness when anchored. Caution should be taken to insure that an adequate amount of adhesive is used, especially if project specification requires specific overturn movements on base plate.

- **STEP 7.** If stringers are a part of the system, bolt them to the pedestal heads beginning at the starting point.
- **STEP 8**. Beginning again at the start point, lay four rows of panels along the longest wall. Check to see that you are staying on control lines, and that panels do not rock.
- **STEP 9.** If an panel rocks diagonally when placed in the system, turn it one quarter (900) turn and check it again. If the panel continues to rock when rotated, some debris may be between the panel bottom and the pedestal head or stringer.

Also check to make sure pedestal is not tilted, stringers are properly seated and that panel edges are flush. (See figure 4.) If the panel still rocks, set it aside to be used as perimeter cut panel. The pedestals should not be adjusted unless three or four panels supported on it are rocking. At this point make a minor elevation adjustment to the pedestal.

When installing carpeted panels, the carpet grain direction must be controlled. Each panel has an arrow on the bottom indication proper carpet grain. All panels must be installed with the grain in the same direction. Therefore, they cannot be turned to adjust for rockers. The panel can be bumped or the pedestal assemblies adjusted. It may require two or three pedestals in a row to be adjusted.

STEP 10. After lying the first four rows of panels along the long wall, begin again at the starting point and lay four rows of panels' perpendicular to the first rows. Follow the same previous steps (8 through 9) for laying panels and be sure to follow the control lines. If you do not stay on the control lines, the floor will not be square and your grid lines will not straight.

After laying in the ELL section, check and re —check to be sure it is square. When you are certain the ELL is square, continue to install rows until the ELL becomes a rectangle or square. While you are laying panels in this area, you should have someone spreading, shooting, leveling and preparing the next adjacent area for panels. **STEP 11.** After the first section of a floor is installed, check to see that all the grid lines are straight. If the grid is not square, you can make them square by bumping the rows of installed panel with your foot. If this fails, take up every third or fourth row of panels and tap the bases in the direction of the panels that have to be moved. All grid lines should be straight before cutting in the perimeter panels.

Caution: Be sure not to create a tightness problem that will result in difficult removal and reinstallation of panels.

STEP 12. After installing the first section of A/F, only one chalked control line along the long wall needs to be used for the remainder of the floor. The initial section of floor normally dictates the square ness and location of the rest of the floor. However, it is possible in a long room to allow a curve to develop in small increments in the grid.

Therefore, a dry line should be kept stretched along the short wall until at least a four-panel-wide section of the floor is installed the entire length of the room.

In setting this dry line, secure one end at the starting point on the grid line between the first two panels. Raise the line about one inch off the panel, then stretch the line to the other end of the floor and do the same there. The line should not override the panel edges.

NOTE: If rolling materials, equipment or gang boxes across installed A/F, then 1/4-inch tempered masonite or 1/2-inch plywood should be used as pathways to avoid any damage to the top surface of the A/F panels.

11 ROOFING AND INSULATING

11.1 General

British Standard (BS) Documents referred to in this section are:

BS 476: Part 7 BS 1105:1994 BS 1494 BS 3416 BS 4254:1991 BS 5493

11.2 Corrugated Steel Roofs

All corrugated galvanized steel sheeting (whether fixed to wood or steel framing) shall be of 23 or 24 gauge fixed with a minimum of 50mm end laps and with a minimum of one corrugation side lap.

When instructed to have a one-corrugation side lap, the sheets shall have a cover of not less than 20 mm and all the lapped sides shall be turned downwards. Where practicable the exposed lapped sides shall be arranged to face away from the prevailing wind. When instructed to have a one and a half corrugations side lap the sheets shall be arranged alternatively with a cover of not less than 90 mm, the first sheet being fixed with the lapped sides turned upwards away from the bearer and the cover sheet with the lapped sides turned downwards.

All Sheets must be handled with full care. Any deformation in the sheets may cause it to be refused.

Samples may be sent to Labs to assure the thickness and type of paint. Sight inspection results may cause the panel's refuse.

Sheets shall be secured to purlins at centers not exceeding 300 mm by galvanised self parking screws (minimum 75 mm long) with galvanised diamond shaped washers and lead sealing washers.

All holes for bolts, self parking screws etc., shall be punched from the underside of the sheets and shall be on the crown of the corrugations.

Galvanised steel ridge capping shall be supplied and fixed to purlins as described above. Hook bolts, self parking screws and washers shall generally comply with BS 1494.

Overlapping of sheets is necessary. The corrugated roof must prove impermeable and transparent sheets as well. Permeability test could be ordered if the Engineer find it necessary.

11.3 Screeds

The provisions of Concrete Work section shall apply to the construction of solid reinforced concrete slab roofs and to hollow slab roofs. The actual finish will be specifically shown on the Drawings or in the Bill of Quantity.

Lightweight concrete screeds for obtaining falls or as an insulation layer shall be of approved type of foamed concrete. The materials shall be measured, applied and cured in accordance with the manufacturer's instructions and to the satisfaction of the Engineer or his Representative.

In all cases the finished screed shall be of an approved proprietary type with a dry density of not less than 300kg/m³ to receive the applied roofing. Mixing shall take place using approved mechanical mixers.

Concrete screeds for obtaining falls shall be (1:3:6) mix.

All screeds shall be laid in bays not exceeding 10 square meters and formed between stop boards of the correct height and cut on each side to indicate the slope required in the roofing. The screed shall then be trowelled with a wooden float to true and accurate falls or cross falls up to the stop boards. A 10 mm side gap shall be left between each screed bay for the frill depth of the screed.

The screeds shall be allowed to cure thoroughly to attain maximum shrinkage. Any cracks which appear due to shrinkage shall be made good. The gaps between bays shall then be filled in with cold bitumen.

Where the roof screeds are to be reinforced with one layer of galvanized wire mesh, this shall be supported on top of the base on spacers to ensure that it is maintained at between 10 mm and 15 mm below the top of the finished screeds. It shall be at least 100 mm wide, securely wired together. It shall be stopped 20 mm from the edge of each bay.

11.4 Insulation

When asphalt sheets are used on the top of the screeds, it should have the following properties:

- Asphalt sheets should be supplied in rolls of 1-1.2m width and 4 mm thick.
- Top surface should have a layer of medium size white aggregates (2-3 mm) Applying asphalt sheets should be made according to the manufacturer instructions.

Top surface of screeds should be cleaned and a suitable prime should be sprayed before using asphalt sheets.

An overlap of (10 cm on the side and 15 cm on the edge) should be made on sheets. Black bitumen paint should be sprayed before erecting the sheets, which should be heated (bottom side).

Sheets should have at least 15cm vertical edges, all around the roof (a special groove should be made in the roof parapet to erect the vertical side of the sheets) During erecting asphalt sheets, contractor should prevent air pockets entrained under the sheets, which will be filled by flame applied.

11.5 Expansion Joints

The expansion joints shall generally be of 19 thick fibreboard impregnated with bitumen accurately cut, with bull joints and fixed vertical and straight .The top 10mm of the joint

shall be filled with a grey polyurethane gun grade sealant which confirms with BS 4254. Expansion joints shall continue into the tilted tile, skirtings and fillets.

11.6 Black Bitumen Paint

The black bitumen paint shall be applied in the thickness and number of coats described in the BOQ or drawings, and to be applied with a coverage rate of 8m for concrete surfaces.

All surfaces must be sound and free from dust, dirt, all loose material, grease and oil etc., and dry before applying the black bitumen paint.

The black bitumen paint shall comply with BS 3416 Type I nad II, as well as BS 476: Part 7 class 1 for fire resistance.

11.7 Polyethylene Sheet

Polyethylene sheet of 10 micron thick shall be used in the locations as indicated in the drawings below concrete works attached to soil. An overlap of 10cm should be made on sheets.

11.8 Epoxy Risin Coating

Thyrotrophic pitch extended epoxy resin for all concrete surfaces contacted with sewer. The resin shall comply with BS 5493.

Two coats minimum shall be applied according to the Engineer or his Representative's instructions. All surfaces must be sound and free from dust, dirt, all loose material, grease and oil etc., and dry.

11.9 Waterproofing

Electrometric cementations coating shall be used as a waterproofing coating for the underground water tank. It shall comply with BS 6920:1990 regarding the effect on water.

The cementations material has to be mixed together mechanically according to the manufacturer instructions before being applied into concrete walls.

Surfaces shall be cleaned and dampened with water before starting the work. Applying the material shall be done with soft bristled brush in two coats as follows:

- First coat shall be applied at a minimum wet film thickness of 1 mm; approximate coverage is 1.8 kg/m and shall be brushed into surface.
- The second coat can be applied after the first coat being cured for at least 5 hours, and be applied at a minimum wet film thickness of 1 mm and finished in another direction.

The surfaces shall be tested after completing the work as directed by the Engineer.

11.10 Water Stopper

Hydrophilic solid rubber strip that swells (approximately 300% expansion ratio) when exposed to water to prevent leakage paths in concrete, shall be used in the construction joints as shown in the drawings. The strip cross section shall be 10 x 25 mm, and 100mm

overlaps shall be secured at the ends. The strip must have a hydrostatic pressure resistance up to 50 m.

Concrete surface must be clean, free from loose materials and debris, and dry before fixing the strip. Strip can be fixed either by nails every 30-40 cm at the concrete surface or by an approved bonding adhesive.

11.11 Completion

On completion all roofs and surface are to be left sound water- tight and in clean condition before handing over.

12 STEEL STRUCTURES

12.1 General

The steel structures comprise the following works:

- Steel structures' for machine tower, silo supports, and platforms for the silo complex.
- Supports for equipment (comprised in mechanical works)

The structures and the supports shall be dimensioned with due respect to the equipment chosen by the Supplier.

12.1.1 Technical Codes of Practice

The steel structures and the calculations possibly to be provided by the Contractor shall comply with the following codes:

BS 6399	Loading for Buildings Part 1, 1984 Code of Practice for Dead and imposed Loads.	
85 449	The Structural Steel in Building.	
BS EN 10137-11996	General Delivery Conditions.	
85 EN 10137-2:1996	Delivery conditions for quenched and tempered steels.	
BS EN 10137-3:1996	(BS EN 10137:- Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened conditions).	
85 7668:1994	Specification for weldable structural steel. Hot finished structural hollow sections in weather resistant steels.	
BS EN 10029:1991	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above.	
Parts 1 to 3 of	I	
85 EN 10113:1993	Hot-rolled products in weldable fine grain structural steels Structural steels with improved atmospheric corrosion resistance	
85 EN 10155:1993	Technical delivery conditions.	
85 EN 10210-1:1994	Technical delivery requirements.	
(BS EN 10210:-	Hot finished structural hollow sections of non-alloy and fine grain structural steels).	
BS EN 1011-1:1998 and	General guidance for arc welding.	
B5 EN 1011-2:2001	Arc welding of ferric steels.	
	(BS EN 1011:- Welding Recommendations for welding of metallic materials).	

12.1.2 Climatic Conditions

Any climatic, geological or general information given her under or elsewhere in the Specification is to assist the Contractor at the time of tendering. Such information shall be deemed to be data provided by or on behalf of the Employer under the Conditions of Contract. The information is not warranted by the Employer or the Engineer or his Representative and the Contractor shall make use of and interpret the same on his own responsibility.

Design wind velocity 120 km/hr

Temperature range 10°C - 50°C

12.1.3 State And Quality of Steel

Defects such as serious corrosion exceeding degree C of SIS 065900, scratches, grooves, dents, etc. are forbidden. A copy of the order for steel and of the Contractor's confirmation of order

shall be submitted to the Employer or to the consulting Engineer or his Representative for approval.

The used materials shall comply with current standards.

The steel structures shall be of a suitable quality for welding,

All steel shall be delivered with a certificate in accordance with BS, DIN or DS 10030. All costs stemming from obtaining the certificates shall be met by the Contractor,

Further-more the employer reserves the right to take samples after the delivery of the steel and to catty out tests in order to control and verify that the supplied materials satisfy the prescribed conditions.

The tests shall be carried out by an approved control institute. Both parties shall respect the judgment arrived at by the institute, The expenses arising out of taking these samples and the administration in this connection shall be paid for by the Contractor.

The costs of the actual tests shall be met by the Employer if the results are in accordance with the prescribed specifications-If this is not the case, the costs shall be met by the Contractor.

The certificates and the test reports shall be forwarded to the Employer or to the Consulting Engineer or his Representative for approval.

Steel Quality for Bolts

- The anchor bolts shall be of quality Fe 360 B (GR 40 B) steel, certified according to DIN 50,049-2.1 or to standards specified in 12.1.1 above.
- The bolts for normal assemblies shall be of class 8-8, or DS/150 898 and 2
- The nuts shall be of the same class as the corresponding bolts.
- The thread shall be of ISO standard. Heads and nuts of the bolts shall be of the hexagonal type.

Dimensions and tolerances in the manufacturing of washer plates shall conform to the standards. No other steel qualifies than those mentioned above may be used unless first approved by the Employer or the Engineer or his Representative.

12.1.4 Drawings

The Contractor shall work out construction drawings and all descriptions and instructions necessary for carrying out the Works, The Contractor is obliged to forward to the Engineer or his Representative all those drawings together with the construction procedures arid instructions-Even though the set of drawings may have been approved by Engineer or his Representative the Contract-or carries the entire responsibility that the finished constructions satisfy the requirements of the Technical Prescriptions and the tender drawings and that they are built properly and in accordance with these drawings.

12.2 Execution Of The Steel Structures

12.2.1 Selling out and Tolerance

<u>Setting out</u>

The steel arid concrete structures shall be executed so that the anchor bolts are correctly placed and embedded and in such a way that the maximum anticipated tolerances for the steel and concrete buildings and structures are taken into due consideration, during the execution of the steel structures.

Tolerances for Workshop Work

- Length of columns and beams
- Distance between bolts of different
- Distance between bolts in the same group
- Placing of groups of bolts in relation to construction elements
- Deformation of web in welded beams

Tolerances for the Finished Work

Placing in relation to the modules	$\pm 5 \text{ mm}$
Level of the buildings	<u>+</u> 5 mm

12.2.2 Manufacture in Workshops

The execution of the work shall be correct and in accordance with professional usage on the best level. The workshop work shall be directed by technicians who are qualified and experienced in the field in question. The constructions shall be manufactured and assembled in the workshop to elements, which are as big as possible with respect to transport and handling, so that the assembly work on site is limited to a minimum, if it proves to be necessary to undertake modifications during the execution of the work, the Employer's approval shall be obtained in advance.

The modifications thus made shall then be transferred to the drawings.

The Contractor is obliged to control before and during the execution of the Works whether the materials have any irregularities in dimension or of shape, or other defects that might, of detriment to the construction. The Engineer or his Representative shall be notified of such defects.

Elements for the construction which deviate from the specified shape or form and/or which are defective to such degree that they cannot be repaired without risks of damaging the material or the element itself shall be rejected.

The use of welding for repair of defects shall only be permitted when there is no risk of damaging the steel/ and in no circumstances without the prior consent of the Employer.

The various pieces of the construction shall be manufactured in such a way that they may be placed in correct position between each other without using force, and with the degree of precision required by the chosen method of assembly.

The edges of steel plates, etc. which have been made by cutting tools or by mechanical torch cutting shall not normally be subjected to any further treatment-It can be allowed that the edges are made by punch-cutting, punch-perforation or similar process or by manual torch cutting, but only if supplementary treatment is carried out possible defects in the form of surface cracks, grooves and the like, shall be eliminated. Punch-cutting and punch-pert oration without further treatment, however, shall be permitted for materials of thickness below 10 mm.

Corners in these materials resulting from punch-cutting shall be carried out with a rounding of 20 w obtained by pilot-drilling.

Bending shall be carried out in hot state at approx. 950°C. Bending in cold state shall be permitted for appropriate materials if the cold-worked deformation does not in any place exceed 5%.

The bending radius shall be at least 10 times the thickness of the material; Bending in cold state shall not be performed at temperatures below +10 C.

Bending in cold state with cold-worked deformations exceeding 5% shall only be allowed if the cold-worked object is subsequently relieved by annealing or subjected to another appropriate heat treatment.

Bolt holes in plate thickness exceeding 10 mm shall be bored and all burrs removed from the edges, Control assemblies of all assemblies shall be carried out in the workshop.

12.2.3 Welding

Electrodes

All welding work shall be carried out as are welding according to BS EN 1011, welding electrodes shall be appropriate for the used base metals and the chosen welding method, and shall be able to satisfy tests. Other electrodes may only be utilized if an approved control institute or laboratory considers that they may be safely used, and in all cases only with the prior consent of the Engineer or his Representative.

The Contractor must always be able to produce documentation that the used electrodes comply with the standards for the base metal on which they are applied, as regards resistance and quality class.

Execution

Welding work shall be executed in accordance with the prescriptions of BS EN 1011. It may be requested that a welding program shall be submitted.

All parts and pieces with welds that are not anticipated in the design may be rejected by the Employer. Welders who use a semi-automatic welding apparatus shall be qualified at the same level as those welders who weld manually.

The preparation of the beveling and the welding work shall be executed in compliance with the current DS standards.

During welding there may be no rust, nor any layered scales stemming from rolling, nor any metal coating, nor paint or grease, nor any burrs from punch cuffing nor any other elements which could reduce the quality of the weld. The elements of the construction shall be executed with excess length to compensate for contractions and possibly with a slight camber or similar to eliminate the effect of thermal contractions.

After the welding, the elements of the construction shall, as far as possible have a final shape which makes truing-up unnecessary,

Welding on materials, which have been cold state deformed will normally, not be permitted on plate thickness exceeding 7 mm.

The elements to be joined by welding shall be placed in correct position in relation to each other in order that the welding contractions / welding deformations, and possible truing-up may be limited to a minimum. The tack welding shall be executed just as carefully as the welding itself.

The tack welding shall be placed as close as possible and be of such a dimension and strength as to be able to resist the contractions appearing during welding.

In case that it is not planned to remove the tack welds as the welding proceeds, these tack welds must be placed and executed in such a manner as to hamper the welding works as little as possible. Before making the finishing run, it shall be checked that the tack welds have no cracks or other defects, Cracked or defective tack welds shall be removed.

Welding run materials shall fill up the groove completely in penetration welds and pass evenly into the base metal and shall, moreover, be free of surface flaws such as crevices, cutting burrs, scales etc.

Intermittent fillet welds shall not be accepted, and all fillet welds must be closed. The welding runs must be flat or concave-possible convexity must not exceed the tolerances Indicated in the standards.

The finished weld must not present any cracks, crevices, faults of adhesion, uneven and rough surfaces, root defects, pores, slag inclusions, or other flaws, which may impair the strength of the weld.

Butt welds must invariably be finished by backing runs after removal of welding slag's.

Divergence from this requirement will only be allowed after agreement with the Employer or his representative.

The order of welding shall be so that the elements of the construction can be deformed in the direction of contraction, and so Chat there is room enough to perform the various Welding, If the execution of the welding works presents any risks of weld stress due to deformation, tempering etc which may be harmful Co the building and which can be reduced by suitable heating the base metal shall be pre-heated.

Welded points and similar for fixing grips and clamps to keep the construction aligned in correct position shall only be permitted if they do not impair the construction.

All spatters from welding shall be removed before beginning the painting. All defective welds must be removed and replaced by a satisfactory weld.

No repairs may be carried out without the approval of the Employer or the Engineer or his Representative. The Employer reserves the right to effect testing of important welds to be carried out by an approved institute of control.

If the quality of the examined welds proves to be in accordance with the specified requirements, the expenses incurred in connection with the control shall be met by the Employer.

If, by ultrasonic or other non destructive tests, it is confirmed that there are welding detects necessitating repairs, the Contractor shall remedy those at his own expense and also meet the costs of the supplementary welding tests until it has been demonstrated in a reassuring manner that the quality of the welding work satisfies the specified requirements. The Employer reserves the right to insist on a more extensive control.

The normal extent of the control of a series of welds will comprise at least 20% of the total length of the welds based on a representative sample. The quality of the welds shall in principle be of the green color according to the IIW X-ray scale.

12.2.4 Bolted Assemblies

The length of the threads shall be limited so that the thread stops at the level of the washer, The bolts shall be equipped with an effective system to hinder loosening caused by motors, handling equipment etc.

12.3 Works On Site

12.3.1 Transport and Handling

Handling shall be carried out with care in order to avoid damaging the parts.

All buckling, torsion's/ and bending occasioned by transport or handling shall be carefully trued up before erecting the parts-In case the damages seem to be fairly serious the elements shall be returned Co the workshops, or otherwise may be rejected by the Employer or his representative.

On site and before erection the profiles and the other elements shall be stored on level and accessible areas. Storing shall be arranged so as to avoid that the elements touch the ground directly.

12.3.2 Erection

By means of calculations based on, the chosen method of erection the Contractor shall demonstrate that the necessary security is ensured during all phases of the erection.

These calculations shall be submitted to the Employer or the Engineer or his Representative for approval. Notwithstanding this approval, the Contractor carries the whole responsibility for the strength of the constructions during the different stages of the erection.

The erection work shall be directed, by a Engineer or his Representative or by a person with similar education, who shall be on site from the commencement of the erection work.

This Engineer or his Representative or person with equivalent education shall be authorized to act on behalf of the Contract-of towards the Employer.

Dismantling, erection and handling of the elements of the construction shall he done with care in order that the surfaces may not be damaged. The elements shall be lifted by means of straps and not by chains. However, the Employer shall have the possibility not to accept any handling year which in his opinion is not sufficiently safe for the personnel or for the elements of the Works already in position-All expenses incurred in this connection shall be met by the Contractor.

During welding the contractor shall set up a tent or cover to protect the workstation against the weather so that the welding procedures may not hamper, nor the quality of the weld diminished. All erection welds will be controlled by the Employer.

All bolts shall he drawn tight.

The use of blowlamps to remedy problems caused by the erection of the various steel elements shall be strictly forbidden.

12.4 Surface Treatment

12.4.1 Painted Steel Structures

All steel structures, plating, and other parts shall receive at least the following treatment, unless otherwise stated:

- Sandblasting of the steel to degree 21/2 according to BS 4232.
- Immediately after sandblasting an anti-corrosive alkyd or chlorine caoutchouc primer is applied in a thickness of 30 urn.
- After drying a sub-coating of alkyd or chlorine caoutchouc, thickness 30 urn.
- A finishing coating of alkyd or chlorine caoutchouc is then applied in a layer of 30 urn the colour of the finishing coat is to be agreed by the Employer.

• Total thickness of the layers: minimum 90 urn of dry paint.

These coatings shall be applied in the workshop. All repair works of the painting shall be performed in accordance with the initial treatment.

The thickness of the layers of paint shall be controlled with a measuring instrument, which shall be approved and carefully adjusted.

The total thickness of the coatings shall be controlled by at least two measuring within aim measuring surface per $100m^2$ surfaces. The average coating thickness shall be greater than the specified minimal thickness and no measuring may be thinner than 80% of the specified thickness- The total number of measuring indri a thickness between 30 and 100% of the minimal specified thickness must not exceed 20% of the performed measuring.

Specifications of the paints intended to be applied shall be presented to the Employer for approval before commencing the work.

Before handing over the Works, all portions will be controlled and possible defects shall be repaired as indicated above in order that the prescribed treaty meant may be effective for the entire construction.

12.4.2 Hot Galvanized steel Structures

The following elements shall be hot galvanized:

- Nuts, bolts, and washers.
- flock bolts, including nuts and metal washers,
- The bent metal plate fittings for joints and connections.
- All galvanized parts mentioned in the Contract.

If the Contractor prefers to hot galvanize the beams, columns, purlins and all the accessories, he shall specify so in his offer.

The galvanization shall be carried out so as to ensure that the zinc covering is uniform, adhering and free from cracks and pits all over the object. The galvanization shall comply with ISO 1461 with a minimum thickness of 65 urn for the bolts and 80 um for the other elements.

All deformations of welded elements appearing during galvanization shall be carefully straightened, in such a way that the galvanization is not damaged and the steel does not lose its strength normally, no extra treatment shall be carried out after galvanization.

It may be allowed to repair small defects by applying two coats of zinc dust paint.

12.5 Gangways - Stairs – Ladders - Guard

All plating shall be of chequered floor plate. The plates shall be painted on both sides according to clause 8.1 of the present specifications. A sample of each type of plate shall be submitted to the Employer for approval. This approval does not relieve the Contractor of his responsibility as regards the quality of the plates and theft incorporation in the construction.

Steps shall be of same type of plate as used for floor plating and shall be painted according to specifications.

Guard Rails Ladders.

The guardrails comprise a handrail upper bar, an intermediary bar, and a toe board (kick-plate). The upper and intermediary bars are made of pipes.

The guardrail and the ladders shall be painted in compliance with the specifications. The guardrail shall be designed for 0.74 KN horizontal loads per m run.

All ladders shall be made of stainless-steel as indicated in the drawings.

12.6 Steel Panels

The walls and roof steel panels shall be of durable and sustained the exterior sever conditions. The following specifications shall be the minimum requirements to be achieved for the panels:

- Galvanized steel sheets complied with ASTM A653 Grade SQ 50 with zinc coating to G90.
- Pre-treated for proper corrosion resistant.
- Primer Coat shall be of highly corrosion resistant high film-build primer on both sides, 25 microns thick on the exterior face and 15 microns thick on the interior face.
- Exterior face finish coat shall have a Polyvinyl Fluoride paint of 20 microns nominal thickness; frost white and green colors will be applied.
- Interior face finish coat shall have an off-white polyester color of 7 microns nominal thickness.

12.7 Monorail and Lifting Device

Steel structure for lifting and lowering of the submersible pumps and valves shall be located as shown in the drawings. The Lifting device shall be equipped with electric power source.

The device should be manufactured according to the requirements of the European Union, especially to EG Standard 98/371EG.

Lifting speed:	8 (m/min)
Voltage:	380 (V).
Noise Emission:	81 {db (A)}

The device shall have a lifting capacity and dimensions as specified in the Bill of Quantity and drawings.

13 MANHOLES AND CHAMBERS

13.1 GENERAL

All concrete chambers and manholes to be supplied by the Contractor.

13.2 CLEANING

All manholes and valve chambers specified under this section shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter of any kind and shall be free of any such accumulations at the time of final inspection.

13.3 CONSTRUCTION OF MANHOLES AND VALVE CHAMBERS

All manholes and chambers shall have reinforced-concrete bases. The Contractor shall construct all manholes, chambers, and special structures including transition chambers and outfall structures as indicated on the Drawings and herein specified.

Manholes, chambers, and special structures shall conform in shape, size, dimensions, materials, and other respects to the details indicated on the Drawings or as ordered by the Engineer.

Manhole and chamber cover slabs shall be either precast or cast in place reinforced-concrete as marked on the Drawings. The cast iron frames and covers for manholes and chambers shall be brought to grade by the number of courses of concrete blocks shown on the Drawings and a reinforced concrete frame into which the cast iron frame is embedded. Class A concrete shall be cast to a minimum thickness of 150mm around the concrete blocks for rigidity.

Manhole walls (rings) and cover slabs shall be either precast or cast in place reinforced-concrete. In precast construction rubber o-rings are to be placed in all joints except for the joint between the cast in place roof slab and the top wall ring. In below the manhole cover slab shall have removable plus or minus 30cm high concrete ring.

13.4 FORMWORK OF VALVE CHAMBERS

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

13.5 PRECAST ELEMENTS

Precast elements shall be either of concrete or mortar as shown on the Drawings and as specified hereinafter.

13.5.1 Materials

Precast Concrete Elements

Precast concrete elements shall be of plain or reinforced concrete dimensions, thickness and reinforcement rods and bars shown on the Drawings and stated in the Bill of Quantities.

Precast Mortar Elements

Moist tamped mortar precast elements shall be of a mixture of ordinary or tinted cement and sand (fine aggregate) approximately in the proportions of one part cement to two and one-half parts of sand. The sand shall be specially selected for colour and grading. The sand shall be screened through 1/8" inch square meshes and all oversize particles shall be discarded. Only sufficient water shall be used in mixing to permit the immediate removal of the member from the mould. The pattern, dimensions and thickness shall be as shown on the Drawings and/or as directed in writing by the Engineer.

13.5.2 Mortar

Mortar for joining the precast elements shall be composed of one part of Portland cement and three parts of clean sand unless otherwise specified. The cement and sand shall conform to the requirements of ordinary Portland cement and aggregate for mortar specified herebefore.

13.5.3 Fabrication

Precast concrete or mortar elements shall be cast in mortar-tight metal lined timber moulds and shall be mechanically vibrated when cast. The Precast elements shall be removed from the moulds as soon as practicable and shall be kept. damp for a period of at least 10 days. Any elements that shows checking or soft corners or surfaces shall be rejected. The method of storage and handling shall be such as to preserve true and even edges and corners, any precast element which becomes chipped, marred or cracked before or during the process of placing shall be rejected, sampling of precast elements shall be submitted to the Engineer for approval, prior to fabrication, at the Contractor's own expense.

13.5.4 Workmanship

All precast concrete or mortar elements shall be well cleaned and thoroughly wetted with clean water before placing in their positions shown on the Drawings. The precast elements shall be bedded and jointed in cement and sand mortar (1:3) mix and the joints raked out on both faces to receive plaster or pointing as indicated on the Drawings and/or stated in the Bill of Quantities to the satisfaction of the Engineer.

14 INTERLOCK TILING WORKS

14.1 General

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

14.1.1 Scope Of Work

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

- Leveling and compacting the Subgrade.
- Preparing, leveling and compacting the Sub-base.
- Preparing, leveling and compacting of base course.
- Interlock tiles.

14.2 Subgrade

All subgrade materials of A6 or Al soil groups classification by AASHTO, which are unsuitable as subgrade, should be totally removed for a minimum depth of 60cm and replaced by selected fill of minimum CBR of 25%.

The contractor shall prepare the roadbed surface by sprinkling balding, rolling and lightly scarifying, where necessary, until the proper crown is obtained. The roadbed shall be well compacted, smooth, hard and uniform, all irregularities having been bladed out and rolled down.

All soft and yield material or other portions of the subgrade, which will not compact readily, shall be removed and all loose rock or boulders found in excavation shall be removed or broken off to a depth of not less than 15 cm below the surface of the subgrade. All holes or depressions made by the removable of materials, as described above, shall be filled with approved material, and the whole subgrade brought to line and grade compacted to 95% of maximum dry density.

14.3 Sub-Base

14.3.1 General

The Contractor shall provide the sub base material free from dirt, organic matter, shale or other deleterious matter and shall be of such quality that it will bind readily to form a firm stable sub base. The sub base material shall confirm to the requirements specified in the following Classes:

All Sub-base materials shall confirm to the following physical requirements:

- Loss of Sodium Sulphate Soundness Test (AASHTO T 104) 15% Maximum.
- Liquid Limit (AASHTO -T- 89)
 Plasticity Index (AASHTO -T- 90)
 Sand Equivalent (AASHTO 1 176)
 25 minimum.
- CBR CBS 1377) after 4 days soaking 40% minimum.

14.3.2 Class A Sub-Base

The sub base material shall consist of well-graded gravel with sand and silt, confirming the following requirements.

Sieve Size	Percent Passing
2-1/2 inch	100
2 inch	90-100
No.4	35-70
No.	0-15

14.3.3 Class B Sub-Base

The sub base material shall consist of uniform mixtures of gravel and/or stone fragments with sand, silt and clay, confirming the following requirements:

Sieve Size	Percent Passing
2 incch	100
1-1/2 inch	70-100
1 inch	55-85
3/4 inch	50-80
3/8 inch	40-70
No.4	30-60
No. 10	20-50
No.40	10-30
No.200	5-15

14.3.4 Class C Sub-Base

The sub base material shall consist of well graded sand-gravel, confirming the following requirements:

Sieve Size	Percent Passing
1 inch	100
3/8 inch	65-100
No.4	35-75
No. 10	25-55
No. 40	10-45
No. 200	5-15

14.3.5 Construction

The sub base aggregate shall be spread in layers not exceeding 20 cm by means of approved mechanical box spreaders, distributing the material to the required width and loose thickness. When the required sub base thickness is greater than 20 cm, the material shall be placed in layers of equal thickness; in no case shall a layer be less than 15 cm thick.

Segregation shall be avoided and the segregated materials shall be remixed until uniform. Suitable precautions shall be taken to prevent rutting of the sub grade during the spreading of the sub base materials. The sub base aggregate shall be compacted to an average value of 98% of the maximum dry density determined in accordance with the latest modified AASHTO T-180 Method D with no single value below 96%.

After completion the compaction, the surface of material shall be well closed, free from movement under the compaction plant and free from corruption planes, ridges, cracks or loose materials.

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

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

One sample every 100m shall be tested for Grading, Loss by Abrasion, Maximum Dry Density, CBR, Plasticity Index and Sand Equivalent. One in-situ Density tests every 300m of sub base laid.

14.4 Base – Course

14.4.1 General

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

All base-course aggregates shall confirm to the following physical requirements:

 Loss of Sodium Sulphate soundness Test (AASHTO T 104) 	10% Maximum
 Loss of Magnesium Sulphate Soundness Test (AASHTO T 104) 	10% Maximum
 Loss by Abrasion Test (AASHTO T 96) 	40% Maximum
 Thin and Elongated Pieces by Weight (larger than 1-inch thickness 	
 less than 1/5 length) 	5%
 Friable Particles (AASHTO T 112) 	0.25% maximum
 Liquid Limit (AASHTO -T- 89) 	25 maximum
 Shrinkage Limits (AASHTO -1- 89) 	4% maximum
 Plasticity Index (AASHTO -T- 90) 	6 maximum
 Sand Equivalent (AASHTO T 176) 	40 minimum
 Maximum Dry Density (AASHTO T 180) 	2.00 gr/cc minimum
 CBR (BS 1377) after 4 days soaking 	90% minimum

14.4.2 Aggregate Base Course - Type A

The coarse materials shall be crushed rock or crushed gravel confirming to the following gradation:

Sieve Size	Percent Passing
2-1/2 inch	100
2 inch	90-100
1-1/2 inch	35-70
1 inch	0-10
1/2 inch	0-5

The fine materials of the base course shall be quarry screenings or natural material of suitable binding quality, and free from foreign or organic matter, dirt, shale, clay and clay lumps, or other deleterious matter and shall confirm the following requirements:

Sieve Size	Percent Passing
3/8 inch	100
No.4	85-100
No.100	10-30

The combined material shall consist of a mixture of all aggregate uniformly graded drum coarse to fine, conforming the following gradation.

Sieve Size	Percent Passing
2-1/2 inch	100
2 inch	90-100
1-1/2 inch	75-90
1 inch	65-80
3/4 inch	60-75
1/2 inch	50-70
No. 4	45-55
No. 10	10-26
No. 40	30-45
No. 200	5-15

14.4.3 Aggregate Base Course - Type B

The Base course material shall consist of uniform mixture of crushed rock and/or gravel with sand, silt and clay, conforming the following gradation: Sieve Size

Sieve Size	Percent Passing
1-1/2 inch	100
1 inch	75-100
3/4 inch	60-90
No. 4	30-65
No. 10	25-50
No. 40	25-40
No. 200	5-10

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

14.4.4 Construction

Aggregate for base-course shall be delivered to the area to be paved as a uniform mixture and shall spread in layers not exceeding 15 cm in compacted depth, including any binder that is to be blended on the road. Spreading shall be done by means of approved selfpropelled stone box spreaders, distributing the material to the required width and loose thickness. Segregation shall be avoided and the base-course shall be free from pockets of coarse or fine materials.

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

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

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

The base-course shall be maintained in a condition satisfactory to receive surfacing material. Aggregate base-course which does not conform to the above requirements, shall be reshaped or reworked, watered and thoroughly re-compacted to conform to the specified requirements at the Contractors own expense.

One sample every 1000m shall be tested for Grading, Soundness , Loss By Abrasion, Maximum Dry Density, CBR, Plasticity Index and Sand Equivalent. One in-situ Density tests every 300m of sub base laid.

14.5 Interlock Tiling

The mix for the interlock tiles shall consist for each in the following:

- Cement 400 Kg.
- Sand 600 Kg.
- Well graded coarse aggregate. 1200 Kg.
- In condition that the mix will give result of 300 Kg / cm² after 28 day under the compression test.

The dimensions as shown in drawings with a depth of 6-8 cm.

The interlock files shall be tested according to the BS 6717 for the following:

- Compression Strength
- Absorption And Dimension Test
- Abrasion Test

14.5.1 Construction

Excavation and adjustment the level is required for the site to maximum depth of 30 cm with the reasonable slops.

Then it's damped to the required standard of specification 95% with the complete rising of excess material away. And if there is a need for excavation it should be calculated according to the other articles according to a budget approved by the Engineer or his Representative.

A layer of base course 25 cm thick is spread, compacted according to specifications, then a fine sand layer of 5cm thick is spread over the base course to receive the inter lock tiling between two reinforced concrete edge beams as shown in the drawings.

The tiles are fixed tightly a concrete mix is use to fill the spaces for maximum distance of 5 cm near the edge beams, with the same depth of tiles.

Expansion joints every 20 m. are applied of 2 cm width which will be in between two half pieces of tiles filled with a sand bituminous mix up to 2 cm from the upper level of tiles then the rest 2 cm are filled with sand.

The following shall be considered during the construction of tiles:

- No dirt of concrete or any other material are allowed to be on the tiles.
- The tiles angles should be straight, equal, and smooth.
- No cracks are allowed in tiles.
- The tiles must be transported & stored or kept in a good way.
- Electrical cutting tools must be used to cut the tiles.

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<u>Constructing Medical Waste Treatment Facility in</u> <u>Gaza and North Governorates</u>

Electrical Works Specifications

July 2020

TABLE OF CONTENTS

ELECTRICAL WORKS

1	DESCRI	PTION OF THE WORK	7
	1.1	GENERAL	7
	1.2	SPECIALIST SUBCONTRACTORS	
	1.3	MAIN CONTRACTOR WORK	
	1.4	WITNESSING OF PROCEDURES	9
	1.5	MATERIALS	9
	1.6	NAME PLATES	9
2	RUILDI	NGS AND ANCH LARIES	10
-	21	PREFACE	10
	2.1	DISTRIBUTION	10
	2.2	LICHTING	
	2.5	GENEDAL POWED	
	2.4	DI ANT DOWED	
	2.5	I LANT I OWER	
	2.0	TIKE ALAKIN SI STEM	11 11
	2.7	EADTHING	
	2.0	LICHTNING DEOTECTION	
	2.9	LIGHTNING FROTECTION	11 11
	2.10	HANDING-OVER	
3	GENER	AL STANDARDS AND REGULATIONS	
	3.1	RELATED DOCUMENTS	
	3.2	STANDARDS AND REGULATIONS	
	3.3	COMPLIANCE WITH STANDARDS	
	3.4	SELLING OUT THE WORKS, COMMISSIONING AND TESTING	14
4	GENER	AL EQUIPMENT REQUIREMENTS	
	4.1	EQUIPMENT DETAIL	
	4.2	SHIPPING	
	4.3	STORAGE	
	4.4	SUBMITTALS	
	4.5	APPROVAL	
	4.6	AMBIENT DESIGN CONDITIONS	
	4.7	Delivery	
	4.8	Handling	
	4.9	STORAGE	
	4.10	Protection	
	4.11	COOPERATION WITH OTHER TRADES	
	4.12	STANDARD PRODUCTS	
	4.13	PROHIBITED MATERIALS	
	4.14	FACTORY FINISHES	
	4.15	EXECUTION	
	4.16	TRAINING	
	4.17	WARRANTY	
_	LADELO		20
Э	LABELS	Genied at	
	5.1	UENEKAL	
	5.2 5.2	WARNING NOTICES	
	5.5 5.4	INFORMATION NOTICES	
	5.4	DISTRIBUTION DOARD LABELS	
	5.5 5.6	WARNING LABELS	
	5.0	EARTHING SYSTEM WARNING LABELS	
6	TESTIN	G AND INSPECTION	
	6.1	GENERAL	
	6.2	DISTRIBUTION SYSTEM	
	6.3	TESTS CERTIFICATE	
	6.4	Earth Testing	
7	GENER	AL EXTERNAL PREPARATION	
	7.1	Trenches	

	7.2	SUPPORT	
	7.3	CABLE WARNING TAPE	
	7.4	Rollers	
	7.5	Spacing	
8	DIESEL O	GENERATOR	
-	8.1	STANDARDS	
	8.2	GENERAL	
	8.3	Engine	
	8.4	RADIATOR	27
	8.5	Engine Control l er	28
	86	CHASSIS	28
	8 7	Διτεριατορς	28
	8.8	VOLTAGE RECULATION	20
	80		29
	8.9 8.10	WAVEFORM	
	8.10 8.11	I ELEPHUNE INTERFERENCE	
	0.11	MOTOD STADTDIC	
	0.12	MOTOR STARTING	
	8.13	VOLTAGE SURGES	
	8.14	FREQUENCY REGULATION.	
	8.15	GENERATOR CONTROLS	
	8.15.1	Control Panels	30
	8.15.2	Comprehensive Control System	31
	8.15.3	Transfer System and Timers	31
	8.15.4	Programmed Timers	31
	8.15.5	Repeat Starting Protection	31
	8.15.6	Protection Systems	32
	8.15.7	Alarm and Status Indicators	32
	8.15.8	Set Testing	32
	8.15.9	Automatic Battery Charging	32
	8.15.10	Ouick Fuse Replacement	32
	8 15 11	Integral Circuit Breaker	33
	8 15 12	Plant and Load Protection	33
	8 15 13	Fast Track Wiring	33
	8 15 14	Fully Automatic Operation	33
	8 15 15	Automatic Load Transfer Danal (Ontional)	33
	0.15.15	Clear Essiel Instruction	
	0.15.10		33
	8.15.17	Equipment Finish	33
	8.15.18	Wide Temperature Tolerance	35
	8.16	LOUVERS	
	8.17	SOUND ATTENUATED WEATHER PROTECTIVE	
	8.18	DAILY FUEL TANK	
9	TRANSFO	ORMER AND MAIN SUPPLY	
	9.1	GENERAL	
	9.2	TRANSFORMER	
	9.2.1	Technical Data	37
	9.2.2	Design Standards	38
	9.2.3	Standards	38
	9.2.4	Construction	38
	925	Primary Winding Connections	39
	926	Secondary Winding Connections	40
	927	Painting of Tank	40
	0.2.1	Finish of Accessories Fivings Etc.	40
	7.2.0 0.2.0	Cil	40
	9.2.9 0 2 10	VII Noise I aval and Dadie Interference	40
	9.2.10	Noise Level and Kadio Interference	40
	9.2.11	Inspection and Testing	40
10	L.V. SWI7	ГCHBOARDS	
	10.1	GENERAL	
	10.2	Enclosures	
	10.3	BUS BARS	
	10.4	GLANDING ARRANGEMENTS	

	10.5	OUTGOING CIRCUIT BREAKERS	
	10.6	Earthing	
	10.7	AIR CIRCUIT BREAKERS FOR MAIN DISTRIBUTION BOARD	
	10.8	TRIP MECHANISMS	42
	10.9	TRIP COLLS	42
	10.10	SAFETY SHITTEDS	43
	10.10	Τριρ Μεζη ανικάς	
	10.11	ALIVII LADY CONTACTS	
	10.12	INTEDLOCKS	
	10.15	INTERLOUKS	
	10.14	NEUTRAL LINKS	
	10.15	CURRENT TRANSFORMERS	
	10.16	BUS BARS GENERAL	
11	SUB-MA	IN SWITCHGEAR	
	11.1	RATING VOLTAGE	
	11.2	SHORT CIRCUIT RATING.	45
	11.3	ENCLOSURES-MULTI POLE DISTRIBUTION BOARDS	45
	11.5	SUB-DISTRIBUTION BOARDS ARRANGEMENT	45
	11.5	CONSUMER UNITS	45
	11.5	MINIATI DE CIDCUIT REAVERS	
	11.0	SWITCH FUSES	
	11./ 11.0	L OAD BDEAN SWITCHES	
	11.0	DEGENERAL SWITCHES	
	11.9	KESIDUAL CURRENT DEVICES (KCD)	
	11.10	INSTALLATION OF SWITCH GEAR AND ASSOCIATED EQUIPMENT	
	11.11	FRAMEWORK FOR SWITCH GEAR	
12	POWER	FACTOR CORRECTION	
	12.1	GENERAL	
	12.2	AUTOMATIC CONTROLS	
	12.3	CORRECTION PANEL COMPONENTS	48
	12.3.1	Contactors	48
	12.3.1	Isolators	48
	12.3.2	Protection	48
	12.3.3	Moulded Case Circuit Breaker (M C C B)	40
	12.3.4	Current Transformers	49
	12.3.5	Canaditors	49
	12.3.0	Capacitors	49
13	SWITCH	BOARD PANEL CIRCUITS AND CONNECTIONS	
	13.1	PANEL BOARD	
	13.2	WIRING	
	13.3	SWITCH BOARD CONTROL COMPONENT	
	13.4	LABELS	
	13.5	TERMINAL BLOCKS	
14	INSULAT	TED POWER CABLES	
	14.1	PVC CABLES	
	14.2	XLPE INSULATED POWER CABLES	
	14.3	Armouring	
	14.4	CONDUCTORS	
	14.5	CONDUCTORS SCREENING	
	14.6	OVER SHEATH	
	14.7	CABLE GLANDS	
	14.8	ARMOURED CABLE TERMINATIONS	
15	LAYING	POWER CABLES	
	15.1	BEDDING	55
	15.2	INSTALLATION OF PVC INSULATED POWER CABLES	
	15.3	TESTING	
	15.4	Bends	
	15.5	DELIVERY AND MARKING	
	15.6	FINAL SUB- CIRCUITS WIRING	
	15.7	FEEDERS AND SUB-FEEDERS INSTALLATION	
	15.8	WIRING TESTS	

16	WIRING	SYSTEM USING PVC CABLES IN CONDUIT	57
10	16.1	GENERAL	
	16.2	Installation	57
	16.3	FLEXIBLE CONDUIT	58
	16.4	CONDUIT SIZES	58
	16.5	DRAW-IN BOXES	58
	16.6	FYTEDIOD CONDUIT & PLATES	50
	16.7	HUMIDITY AND TEMPERATURE	59
	16.8	VEDTICAL CADLES	50
	16.0	POUTING	
	16.10	CONDUIT IN CONCRETE	
	16.10	EVING OF CONDUITS	
	16.12	FIXING OF CONDUITS	
	16.12	FILLINUS	
	16.15	METAL OR P VC ADAPTABLE DUXES	
	16.14	DEDITIONS AT MUTORS	
	10.15	PROTECTION	
17	EARTHI	NG SYSTEM	
	17.1	GENERAL	
	17.2	MAINS CONNECTIONS	
	17.3	LABEL	
	17.4	Bonding	
	17.5	TESTS	
	17.6	BOXES	
	17.7	OUTLET LOOP IMPEDANCE	
	17.8	RESISTANCE TO EARTH	64
	17.9	EARTH ELECTRODE SYSTEM	64
	17.10	MAIN SWITCH ROOM FARTHING	65
	17.11	FARTH RODS AND PLATES	
	17.12	METALLIC PARTS BONDING	
	17.12	FARTH BOSSES	65
	17.15		
18	LIGHTNI	ING PROTECTION	
	18.1	GENERAL	
	18.2	AIR TERMINATIONS	
	18.3	JOINTS AND BONDS	
	18.4	EARTH TERMINATIONS	
	18.5	EARTH RODS AND PLATES	
	18.6	INSPECTION PIT	
	18.7	SURGE PROTECTION	
10			(0
19	CABLE I	KAYS & CABLE LADDERS	
	19.1	GENERAL	
	19.2	FIXINGS	
	19.3	INSTALLATION	
20	TRUNKI	NG	
-•	20.1	GENERAL	
	20.2	CONNECTIONS	
	_0		
21	LIGHTIN	\G	
	21.1	GENERAL	
	21.2	Fluorescent Standard	
	21.3	FLUORESCENT BALLASTS	
	21.4	Fluorescent Lamps	
	21.5	LED LAMPS	
	21.6	LED DRIVER	
	21.7	LIGHT EMITTING DIODE (LED) FIXTURES	
	21.8	INSTRUCTION SHEETS	
	21.9	SUPPLY VOLTAGE	
	21.10	LIGHTING FITTINGS GENERAL	
	21.11	LIGHTING INSTALLATION	
	21.12	FLEXIBLE CORDS	
	21.13	CLEANING	

	21.14	EMERGENCY LIGHTING	
	21.15	CONVERSION UNITS	
	21.16	EXIT SIGN	
22	ACCESSOR	IES	
	22.1	LIGHTING SWITCHES	
	22.2	INDICATOR SWITCHES	
	22.3	SWITCHED FUSED CONNECTION UNITS	
	22.4	Socket Outlet	
	22.5	PLUGS (SOCKET OUTLET)	
	22.6	SWITCH SOCKET OUTLET SPARKLESS TYPE	
	22.7	CONVENIENT SOCKET OUTLETS	
	22.8	OUTLET BOXES	
	22.9	WATERPROOF SWITCHES	
	22.10	TIMES SWITCHES	
	22.11	INSULATED TERMINAL BLOCKS	
	22.12	SAFETY ISOLATING TRANSFORMERS FIXED TYPE	
23	FIRE ALAR	M AND DETECTION SYSTEM	
	23.1	SCOPE	
	23.2	PRINCIPLE OF SYSTEM OPERATION	
	23.3	ADDRESSABLE CONTROL PANEL	
	23.3.1	Functions	79
	23.4	TECHNICAL SPECIFICATION	
	23.4.1	Construction	80
	23.4.2	Functions	80
	23.5	MANUAL BREAK GLASS CALL POINT	
	23.6	IONIZATION SMOKE DETECTORS	
	23.7	FIRE ALARM BELL	
	23.8	POWER UNIT	
24	TELECOM	IUNICATION AND SECURITY SYSTEMS	
	24.1	TELEPHONE SYSTEM	
	24.2	LOW CURRENT CABLES	
	24.2.1	Control Cables	82
	24.2.2	Fire Alarm Cables	82
	24.2.3	Telephone Cables	82
25	DATA CABLI	E	
	25.1	CAT-6A CABLE	
26	UNINTERRU	PTABLE POWER SUPPLY (UPS) SYSTEM	
	26.1	UPS (ONLINE) WITH BATTERY BACKUP FOR 10 HOURS	

1 DESCRIPTION OF THE WORK

1.1 General

The work shall include supplying and installing all needed electrical system as specified in specifications, bills of quantities, drawings and Engineer or his Representative of the medical waste treatment facility. The works shall include erection and installations of Transformers, Main and Sub-main Panel boards, Fire alarm system, Lightning protection system, Lighting, Sockets, data network and WIFI access point, and generator (hereafter, The Works). The scope shall include also the testing and commissioning, technical documentation, training and supplying operation and maintenance manuals in both Arabic and English languages.

All works shall be carried out in a manner satisfactory to the Engineer or his Representative and all unspecified materials shall be of approved manufacture. The complete installation is to be to the entire satisfaction of the Engineer or his Representative.

The Contractor shall supply all labor, materials, equipment and tools necessary for training, supplying and installing of the Works. The Works will include but not limited to the followings:

Step down transformer, auxiliary Transformer Low voltage switchboard, the building mains and sub-main cables and distribution units, lighting and power, together with all other apparatus as specified and as required for a complete installation, with the exception of those items stated specifically as being supplied by others.

Engineering work such as construction of switch gear with regard to doors, locking and opening facilities. Release opening in medium voltage rooms in event of short circuit, also ventilation system with acceptable temperatures and relative humidity must be given for all electrical rooms.

Building works shall include the preparation of trenches and provision and laying in such trenches of concrete cement or salt-glazed stoneware pipes, having easy bends to form ducts for entry of main cables. The numbers, sizes and locations of such pipes shall be as required by the Particular Specification.

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

The phrase "or other approved" means that commodities of different manufacture may be substituted if prior approval has been obtained.

The Contractor shall be deemed to include in his price for anything necessary to supply the installation described in the Specifications and as required for a complete installation. If no figure is put against the item shown in the summary it shall be deemed to have been included elsewhere.

The Contractor shall handle, store and fix each commodity in accordance with the manufacturer's recommendations. He shall inform the Engineer or his Representative if there is a conflict with any other specified requirement and submit copies of manufacturers' recommendations to the Engineer or his Representative when requested to do so.

When choice of manufacturer is allowed for any particular commodity the Contractor shall obtain the whole quantity required to complete the work from one manufacturer or obtain approval of any change in source of supply. He shall produce written evidence of sources of supply when requested to do so by the Engineer or his Representative.

All the materials purchased for the work must operate satisfactorily at an ambient temperature of

-10 to +70°C.

Progress reports shall be made by the Contractor, to be inspected and approved by the Engineer or his Representative.

Changes in plans or additional works shall be executed by written approval of the Engineer or his Representative.

1.2 Specialist Subcontractors

The Electrical Works shall be executed by an approved Specialist Subcontractor.

The Main Contractor shall attend on same and provide all the usual services required for such attendance.

1.3 Main Contractor Work

The following is a summary of the work to be carried out by the Main Contractor:

- a. Supply and install lighting system and power sockets system.
- b. Move, supply and install a complete generator system.
- c. Supply and install a complete external lighting system.
- d. Supply and Install Power Factor Correction System.
- e. Supply and install a complete CCTV monitoring system.
- f. Supply and install a complete UV cleaning system.
- g. Supply and install a lightning protection system.
- h. Supply and Install Electrical and control distribution boards.
- i. Supply and install a complete earthing system.
- j. Supply and install a complete bidirectional metering system for the mains lines.
- k. Supply and install a complete MV network including transformer and switches.
- 1. Supply and install a complete fire alarm system.
- m. Supply and install a complete main distribution board, MTS and ATS.
- n. The cuffing and forming of holes for conduits or pipes or conduit or pipe fixings through walls, floors, ceilings, partitions, roof etc. and making good after the work is sufficiently advanced. The building of concrete and/or brick ducts in floors, wails, etc. The building of manholes pits etc.
- o. The excavation, forming of trenches for services etc. and the filling in of same after the cables are laid.
- p. Excavation forming for underground services of ducts and courses.
- q. The cutting or forming of chases, recesses etc. in floors, walls etc. for conduits and fittings, and making good.
- r. Excavation for and laying of cable carrying pipes.
- s. The providing and building of sleeves through slabs and walls.

1.4 Witnessing of Procedures

The testing and Commissioning Procedures will be witnessed by the Engineer or his Representative.

1.5 Materials

All materials shall be as shown on the relevant drawings. The tender shall be based on Materials as specified. The Engineer or his Representative reverses the right to inspect Materials on Site or in factory at reasonable times and to reject any materials not complying with these Specifications.

1.6 Name Plates

The Works and equipment supplied under this Contract shall, where appropriate bear nameplates giving markers name, date of manufacturer, size and type together with all Particulars which aid identification for the future ordering of Spare Parts.

2 BUILDINGS AND ANCILLARIES

2.1 Preface

It is understood and agreed that the Contractor has, by careful examination of the Drawings and Specifications and the site where appropriate, satisfied himself as to the nature and location of the work and all conditions which must be met in order to carry out the work under this Section of the Contract.

The scope of the work consists of furnishing and installing of the complete electrical lighting, power system, fire alarm system, lightning protection system, and electrical installations. The contractor shall provide technical staff, labor, materials, equipment, machinery, and all other items necessary to complete the systems. The contractor shall note that all items of equipment are specified in the singular; however, the contractor shall provide and install the number of items of equipment as indicated on the Drawings and as required for complete work.

Any apparatus, appliance, material or work not shown on drawings but mentioned in specifications or vice versa, or any incidental accessories necessary to make the work complete-and perfect in all respects and ready for operation, even if not particularly specified, shall be furnished, delivered, and installed by the contractor without any additional expenses or claim to the Employer.

Minor details are not usually shown or specified, but necessary for proper installation and operation, shall be included in the contractor's estimate, the same as if herein specified or shown.

The Contractor shall be responsible for the detailed design, manufacture, supply, transport, and installation at site, testing, commissioning, proper operation and safe functioning of the electrical installations.

If the Contractor stipulates otherwise or proposes other current and/or power ratings for motors, heating elements etc. the electrical installations (circuit breakers, contactors, cables etc.) shall be adjusted to fit the new ratings on his shoulder without any financial compensation.

2.2 Distribution

All main distribution cables from the main switchboard shall be run in closed trenches, cable ladder or cable trays according to their routings.

XLPE (N2XY) or PVCWVC (NYY) cables shall be used for the main distribution cables.

Local lighting and power distribution boards shall be located in the cupboards to serve each floor.

Perforated cable tray shall be provided for all weak current and data cable.

2.3 Lighting

Lighting levels shall be designed according to the specifications and as CIE (International Commission on Illumination).

Dust & weatherproof lighting fitting shall be selected to resist the outdoor climate condition, the LUX density shall be calculated according to architecture recommendations.

2.4 General Power

10-63 ampere 380/220, 3-5 pins socket outlets shall be provided recessed or surface mounted and weatherproof type, they shall be served on radial basis.

Local isolators shall be provided for each individual items of equipment that is not served by a socket outlet.

2.5 Plant Power

Frequency drivers control panels shall be provided for large machines. Local isolators shall be provided adjacent to the motors and not far than 1.5 meter.

2.6 Fire Alarm System

Addressable control panel shall be erected at the electrical rooms.

Ionization smoke and heat detectors shall be provided throughout all areas with additional outlets in the vulnerable areas.

Break glass call points will be provided in all fire escape routes.

When an alarm condition exists, the control panel shall identity& which zone has been alerted. Then the fire alarm autodialing panel shall contact the fire defense department immediately.

2.7 Uninterruptible Power Supplies (U.P.S)

The contractor has to provide online UPS system for the CCTV system, which should maintain continuous power supply for up to 10 continuous hours. The time of starting the generator shall range from 6-20 sec or less.

2.8 Earthing

Earthing system installation shall comply with the standards & regulations. Bonding of all metal parts shall be included on the price and surge arrestor shall be connected to the incoming.

2.9 Lightning Protection

The contractor shall install Lighting Protection System at the highest location of the plant in accordance with the standards. PVC sleeved, earth pits & conductors, inspection manholes & copper earth rods or mats shall be installed to comply with the standards. The metal bins shall have special care to ensure tight connection and they must be insulated with a PVC covers.

2.10 Handing-over

Before handing-over, the contractor shall submit the following documentation to the Engineer or his Representative:

1- At the completion of the Contract, the Contractor shall return, a complete set of prints of the Contract Drawings, neatly marked up in, red with all alterations made during the Contract period. This set of prints is to enable the Engineer or his Representative to alter the original contract transparencies to the "as installed" state.

- 2- Complete set of as built drawings, operation and maintenance manuals in English and Arabic, and overhaul.
- 3- Electrical circuits diagrams for the whole system.
- 4- Specifications of all components used in the boards, such as protective relays, current transformers, circuit breakers, contactors, fuses/switches, push buttons, auxiliary relays, measuring instruments etc.
- 5- Part lists with brochures and recommended spare parts for minimum 2 years.
- 6- Schedule for periodic maintenance for all instruments and equipment used in the work.

3 GENERAL STANDARDS AND REGULATIONS

3.1 Related Documents

This specification shall be read in conjunction with the conditions of Contract, the 'Particular Specification' and any supplementary specification (s) schedule (s) and drawing (s).

The electrical specifications are not intended to cover all details; however the contractor is required to provide all elements that are inherent to sound engineering practices and workmanship in order to achieve satisfactory electrical systems

3.2 Standards and Regulations

The installation (s) shall comply with following codes:

BS Standards / Palestinian codes and regulations,

IEC standards,

VDE Standards

The standard shall be considered as the design standards subject to the Engineer's approval in every single case.

The contractor is obliged to keep one set on the site of all standards, which will be used. The Engineer or his Representative shall have the full right to use this standard in the site library.

The following Electrical Data will be used in the project:

- Small power & Lighting 400/230V
- Control Voltage Contactors 230V
- Control Voltage for medium voltage 220V
- Control Voltage for control system 24V
- Frequency 50 Hz

3.3 Compliance with Standards

All equipment, material and apparatus shall be conceived, designed, and carried out in compliance with the following according to their order for priority:

- 1- The mounting instructions and recommendations of the suppliers concerning the installation or the maintenance of the electrical equipment; such instructions and recommendations shall be considered as forming a part of the present specifications.
- 2- The International Electromechanical Commission (IEC)'s publications (and recommendations) shall be applied as a minimum regardless of any national standard, which may normally have been utilized in the manufacture, design or installation of any equipment.
- 3- The general specifications of the present documents and the special specifications issued before.

Before carrying out his work, the contractor shall contact the relevant departments of the local distributor in order to make the necessary agreements and obtain information, which will be useful for the performance of the work. He must agree to all demands,

requirements of verification, and visits made by agents of these departments, and shall submit all such documents and parts as may be required, for approval.

No extra payment will be effected for making the installations comply with the abovementioned codes. Within the tender sum, the contractor shall affect all works and supplies necessary to the contract.

The Contractor shall bear full responsibility that the completed installations function as prescribed with regard to operation.

3.4 Selling Out the Works, Commissioning and Testing

The position of points and equipment, as indicated on the, tender drawings, are necessarily approximate and not necessarily comprehensive. The exact position of points and equipment shall be as shown on the drawings, which shall be thoroughly, studied before the installation commences.

The Contractor, having ensured that electricity, and other necessary supplies are available, shall set to work the completed works or part thereof, at the selection of the client's representative and make all necessary adjustments to ensure correct functioning.

After the installation or part thereof has been set to work and adjusted, the contractor shall demonstrate its operation, at a time selected by, and to the satisfaction of the client's representative.

The test shall demonstrate:

- a. That all Plant and its equipment provided complies with the specification in all particulars and is of adequate capacity for its lull rated duty.
- b. That all items of the plant and equipment operate sufficiently quietly, to the satisfaction of the Engineer or his Representative.
- c. Those all-electrical circuits are properly fused and conduit systems are laid according to the regulations.
- d. That the operating and maintenance manuals match that piece of Plant or equipment.
- e. The details and method of carrying out the recording of the tests shall be agreed with the Engineer or his Representative. Engineer or his Representative shall be at liberty to be present at, and to participate in, the tests.

This shall not relieve the Contractor of his responsibilities for carrying out the tests satisfactorily.

After the contractor has satisfied himself that the systems have been tested satisfactorily, he will then notify the Engineer or his Representative who will request to witness the tests. A final test shall be carried out at the commissioning stage.

The contractor shall make all necessary record during the tests and on completion thereof, shall provide the Engineer or his Representative with a test report and record, both in triplicate.

The contractor shall provide all necessary test instruments, together with skilled supervision and adequate labor for carrying out the tests

If the tests fail to demonstrate the satisfactory nature of the installation or part thereof, then the Engineer or his Representative shall decide whether such failure is due to incorrect, inadequate or defective materials.

The contractor shall provide all certified instruments, equipment, plant, labor and materials necessary for conducting the specified site tests.

The contractor shall ensure that all plant and equipment can be installed within the area provided and that equipment can be removed for maintenance.

The contractor shall ensure that all mechanical and electrical equipment can be installed with ease and that all the routings of the cable tray or trunking do not impede other services. All specified segregations of services should be observed.

4 GENERAL EQUIPMENT REQUIREMENTS

4.1 Equipment Detail

Where the Contractor supplies an item of Plant or equipment, which takes the form of a manufactured assembly of electrical and/or electronic components, he shall supply three sets of written information to the Engineer or his Representative, as follows:

- 1- Specification of each item of equipment showing the standard to which the equipment conforms.
- 2- Circuit diagram for each item of equipment.
- 3- Schedule of electronic or electrical components for each item of equipment with references to circuit diagram.
- 4- The details of equipment interconnection cables, sizes, number of cores and the method of installation.
- 5- The name, address, telephone, facsimile, quotation or other reference of the manufacturer and of the specialist installer, if applicable.
- 6- Operational instructions for the information of the user.
- 7- Maintenance Instructions.
- 8- Spares

The Contractor shall supply the consumable spare parts lists: such as (fuses, indication lamps, controlling accessories & etc.) to enable satisfactory operation for a further two years, beyond the liability period.

4.2 Shipping

- A. Shipments shall be securely packed for export via sea or airfreight, and shall be protected against excessive heat and humidity. The package shall be waterproofed for protection against water damages, when material must be bundled due to excessive size, each bundle shall have a tag made of metal securely tied on with heavy gauge wire. Purchase? s markings shall be die stamped on the tag.
- B. Equipment, relays and other components with moving or fragile parts, shall be properly blocked, tied or packed to prevent damage.
- C. Any component shipped separately shall be clearly marked with description, case and installation instructions.
- D. All packages shall be marked with equipment tag (identification) number for identification, when shipped and when received at site.
- E. Sections shall be grouped in not more than 5 sections per crate.
- F. Each shipping unit shall be equipped with shipping angles and lifting lugs for handling by crane.

4.3 Storage

All the delivered equipment shall be correctly stored and protected from heat or humidity, the storing procedure shall be agreed with Engineer or his Representative. Great care shall be taken in storing the luminaries on site to prevent unnecessary damage by stacking too many luminaries, causing disfiguration.

The Contractor shall be responsible for any damage and shall replace it free of charge.

4.4 Submittals

Submittals shall be made in accordance with standards and with the specific requirements of each Specification Section.

4.5 Approval

Approval of electrical materials and equipment will be based on manufacturer's published data. Where materials or equipment specified to be constructed and/or tested in accordance with any National or International Standards, a proof of such conformance shall be submitted for approval as well as copies of the Standards. A reputable manufacturer's certified statement indicating complete compliance of each item with the applicable National or International Standards, or other commercial standard specified shall be submitted but will not be sufficient as proof or compliance. A certified copy of test reports to the referenced Standards shall be submitted to the Engineer or his Representative on his request. Conformance with the agency requirements does not relieve the item from complying with any other requirements of the specifications.

4.6 Ambient Design Conditions

System design as well as material and equipment ratings will conform to the existing climatic conditions. Maximum ambient temperature is 45 °C in shade. Humidity range 24% - 90% Outdoor equipment will be subject to solar effects, blowing sand, dust, rain and in general the Mediterranean Sea Climatic Conditions.

4.7 Delivery

Deliver electrical materials and equipment in manufacturer's original cartons or containers with seals intact, as applicable unless otherwise specified, deliver conductors in sealed cartons or on sealed reels, ends of reeled conductor's factory sealed. Deliver large multi-component assemblies in sections that facilitate field handling and installation.

4.8 Handling

Handle materials and equipment in accordance with best industry practices and manufacturer's recommendations. List large or heavy items only at the points designed by the manufacturer. Use padded slings and hooks for lifting as necessary to prevent damage.

4.9 Storage

Store all electrical materials and equipment off the ground and under cover. Prevent corrosion, contamination or deterioration. Unless the equipment item is specifically designed for outdoor exposure in a non-operating mode, all items shall be stored in a protected environment.

4.10 Protection

Provide protection of electrical materials and equipment until final acceptance. Protect factory painted surfaces from impact, abrasion, discoloration and other damage keep electrical equipment, materials and insulation dry at all times. If partial dismantling of equipment is required for installation, box or wrap the removed pans until reinstalled.

4.11 Cooperation with Other Trades

Contractor shall, give full cooperation to other trades and shall furnish (in writing, with copies to Engineer or his Representative) any information necessary to permit the work of all trades to be install satisfactorily charily. Where the work or the Contractor will be installed in close proximity to work of other trades, where there is evidence that work of Contractor will interfere with the work of other trades, he shall assist in working out space conditions of make a satisfactory adjustment. If so directed by the Engineer or his Representative, or otherwise required by the Contract documents, the Contractor shall prepare composite working

Drawings and sections at a suitable scale clearly showing how his work is to be installed in relation to the work or other trades. If the Contractor installs his work before coordinating with other trades, or so as cause any interference with work of other trades, he shall make necessary changes in his work to correct the condition without extra charge.

The complexity of equipment and the variation between equipment manufacturers requires complete coordination of all trades. The Contractor who offers, for consideration, substitutes of equal products of reliable manufacturers has to be responsible for all changes that affect his installation and the installation equipment of other trades all systems and their associated controls must be completely installed connected and operating to the satisfaction of the Engineer or his Representative prior to final acceptance and contract payment.

4.12 Standard Products

Materials and equipment to be provided shall be essentially the standard catalogued products of a manufacturer regularly engaged in the manufacture of the products for at least 10 years. Materials and equipment shall meet the applicable requirements of the specification, and shall essentially duplicates material and equipment that have been in satisfactory use at least 2 years.

4.13 Prohibited Materials

Aluminum conduits, fittings support and conductors are not acceptable unless specially approved for each use and location.

4.14 Factory Finishes

Unless otherwise specified in a specific Technical Provisions section, the sheet metal surfaces of electrical equipment enclosures shall be galvanized and coated with a rust resistant primer over the primer apply a corrosion-resistant asked enamel finish on interior and exterior metal surfaces. The color shall be medium light Grey Hardware shall have a corrosion-resistant finish.

All metallic materials shall be protested against corrosion. Aluminum shall not be used. All ferrous metals such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washer's, and miscellaneous parts not of corrosion resistant steel, shall be hot dip galvanized except where other equivalent protective treatment is specifically approved.

4.15 Execution

Install of electrical work in accordance with the Regulations and Standards specified except where more stringent requirements are indicated or specified. Verify that materials and

Equipment properly fit the installation space with clearances comforting to the Regulations and Standards specified except where greater clearance is indicated perform work as required to correct improper installations, at no additional cost to the Employer.

The Contractor shall provide and install power wiring for all fixed electrical equipment complete and ready for operation including load break switches. Throughout the course of the work the Engineer or his Representative may request minor changes and adjustments to drawings and Specifications. The contractor shall make such adjustments without additional cost to the Employer where such minor adjustments are necessary to the proper installation and operation of the work and are within the intent of the contract documents.

4.16 Training

Provide services of competent instructors in operation and maintenance of system including assembly, start up, operation, adjustment, maintenance, repair, and pertinent safety requirements of equipment and systems supplied.

Training shall be specific for the system installed.

Provide training manuals for each trainee, and three additional copies for archival describing in detail data included in each training program, agenda, and defined objectives for each lesson.

Provide equipment and material required for classroom training. One day of training is defined as 8 hours of instruction.

Train three (3) operators. In functional operation of the system installed and procedures that operators will use for the system start- up, operation, maintenance, and repair.

All out- of- pocket expenses related to the training, including travel shall be included in the pricing at the BOQ items.

4.17 Warranty

Provide a one-year warranty for equipment specified in this contract.

5 LABELS AND NOTICES

5.1 General

Every Item which has to be connected electrically shall have its one significant number as well as all cables. All apparatuses and cables shall be labeled, all warning notices and signs that notify the operational staff shall be written in Arabic and English.

5.2 Warning Notices

Each item of low voltage each switchboard, shall bear a warning notice 'Danger 380 Volts' in red letters not less than 13 mm high in both Arabic and English.

Notices shall be engraved in sandwich - type trifoliate or melamine or similar, such that the engraving cuts through the top layer of material to expose the middle layer, which is a contrasting, color, underneath.

5.3 Information Notices

The labels shall be of a minimum size 75mm x 25mm and shall be fixed by screws or rivets. Each label shall provide the phase and item number.

Labels shall be fixed to all control equipment fixed by the Contractor, whether or not he supplied the control equipment.

5.4 Distribution Board Labels

Each distribution board shall have a fixed permanent label in the inside cover indicating the phase, rating and function of each outgoing way.

The labels shall be typed on heavy cartridge paper inserted in a transparent plastic envelope screwed to the distribution board. Labeling shall follow the pattern already in use at the time. The labels shall have a space for each spare way and the material of the label shall allow future users to mark in ink the function of spare ways as they are used. The label size shall be 10 mm.

5.5 Warning Labels

Where switches and / or accessories are adjacent to each other, but on different phase, a warning label 'volts adjacent' shall be fitted to the grid of any switch, and where accessories are concerned, if this is not possible, a Demo label shall be provided with one end wrapped round the live cable(s).

5.6 Earthing System Warning Labels

Every earthing lead must be protected against mechanical damage and have at its point of connection to the electrode or other means of earthing, a permanent label indelible marked with the works 'Safety Electrical Earth - Do Not Remove'.

6 TESTING AND INSPECTION

6.1 General

The Contractor shall provide all necessary testing equipment as required by the Engineer or his Representative to carry out tests as set out in the Regulations and as required by the relevant Electricity Authority.

The Contractor shall also be responsible for the payment of fees to specialists and manufacturers, for testing and commissioning required bringing all such plant and equipment into frilly efficient operation as part of the installation.

The Contractor shall thoroughly test each section of the Contract Works all generally in accordance with I.E.E. and Electricity Authorities regulations, and the tests shall include the following.

- Insulation resistance tests between earth and each phase on all circuits and power consuming equipment by means of a 500 Volt insulation tester. During the test all lighting switches shall be turned off.
- All insulation tests shall be made between phases, between each phase and earth, and between earth and neutral with the controlling switch neutral link removed.
- Insulation tests shall be repeated between phases and between each phase and neutral with all switches off and all lamps removed.
- Insulation resistances below 50 Mohm (Mega Ohm) will not be accepted.
- Earth continuity tests shall be made on each main, sub-main, circuit and subcircuit.
- Polarity of switches and continuity of ring main circuits shall be tested.
- Insulation resistance tests of all connected appliances shall be made.
- Tests of the effectiveness of earthing including resistance of main earth shall be made.

Any other tests the Engineer or his Representative may reasonably instruct the Contractor to make. Such will include readings of potential drop and current balance between phases at full load conditions at various points in the installation.

The Contractor is to provide all necessary labor, materials, test media and instruments required and all instruments must carry a recent calibration certificate from an approved body.

All tests are to be witnessed by the Engineer or his Representative, and triplicate test record certificates, signed by all test witnesses, are to be provided to the Engineer or his Representative as the work proceeds, upon request, or in any event before the commencement of the Maintenance Period.

At least 7 days written notice is to be given of intention to perform any test.

In addition to installation and testing, the sub-contractor has to carry out operation testing of all sections, clean, set, calibrate and fully commission, demonstrate and hand over the entire contract works in a thoroughly complete and operational state to the satisfaction of the Engineer or his Representative. The contractor has to present a list of tests which will be done for the equipment, and to be approved by the Engineer or his Representative. The contractor has to carry out all workshop tests mentioned and required in the coming sections of this specifications and as recommended by the manufacturer.

6.2 Distribution System

Before completion, the installation shall be tested in accordance the standards, and to be demonstrated compliance with the Regulations, and in accordance with the requirements of the Engineer or his Representative.

Inspections will be carried out during installation and after completion of work.

All assistance in the form of Labor and instruments for carrying out such tests and inspections shall be supplied by the Contractor at reasonable times as required by the Engineer or his Representative and the costs of such tests shall be included in the prices quoted by the Contractor for the various items to be installed under the specification.

All cables and cable sheaths shall be tested for continuity and insulation resistance as the work proceeds and before connecting to the main supply.

The Testing procedures shall be performed for as the followings

- i. That the equipment complies with the specification.
- ii. That the installations comply with the Regulations (Latest Edition), the Electricity Supply Regulations, Licensing Authorities and Fire Regulations where applicable.
- iii. Earth resistance testing.
- iv. That all protective devices are correctly adjusted and operated satisfactorily.
- v. Contactor's overload continuity and activity
- vi. Measurement of Insulation Resistance
- vii. Check of Protection by barriers and Enclosures.
- viii. Measurement of the insulation of conducting and non-conducting floors and walls.
- ix. Verification of Polarity
- x. Measurement of Earth Fault Loop Impedance
- xi. Test of Operation of Residual Current Devices
- xii. Tripping times of residual Current devices.
- xiii. That the polarity of all switches, circuit breakers and the phase rotation of the respective systems are correct.

All the above shall be carried out in accordance with the Regulations. The contractor must show for each procedure and calculation, the Engineer or his Representative after completion of each test.

Caution must be exercised in testing PLANT to ensure that the pressure applied does not cause damage and that PLANT is not left in a charged state at the end of the test.

After completing each part of the installation and after carrying out the above tests the contractor shall switch on all electrical loads. The current in each phase shall be measured with a clip-on ammeter and if an imbalance of more than 10% exists, reconnections shall be made to balance the load. Before final test is carried-out on the whole or part of the installation, the contractor shall switch on all of the installation, which is completed at that time. He shall switch on all loads and run the installation for a minimum period of three hours, at 1/3 full load and minimum period of a half-hour at full load. Test certifications shall be of the formed and specified.

Phase sequences shall be tested at each distribution board; the tests shall show that the phase sequence and color-coding is constant throughout the installation, the sequence being R.S.T.

Tests shall be made during and after installation to demonstrate that the phase rotation is correct at all end connections of power cables.

Where electronic equipment is installed, care must be taken when testing to avoid damage due to testing voltages. If necessary, vulnerable devices and equipment must be disconnected.

The Contractor shall also include in his tender for demonstrating satisfactory operation of any section, of the installation to external authorities such as Fire Officers, Factory Inspectors, Licensing Authorities, Insurance Company Representatives.

If any defects occur to any section or the installation after commissioning, the Engineer or his Representative preserves the right to call for such further tests as may be necessary to identify the nature and location of the defect, and to demonstrate the satisfactory completion of the remedial works. The Contractor shall bear all costs involved in carrying out the additional testing.

6.3 Tests Certificate

The tests shall be for electrical tests, to demonstrate satisfactory operation of the equipment. Where protection relays or adjustable over current trips are incorporated, primary injection tests shall be carried out to demonstrate the correct setting of the protection device and its satisfactory operation.

Tests certificates shall be obtained from the testing authorities, and issued by the Contractor when primary tests are carried out.

6.4 Earth Testing

Earth continuity and earth electrodes shall be tested in accordance with the Standard Code of practice CP 1013. It is to be noted that tests of earth continuity and the earth electrodes must be carried out and the system proved satisfactory before any section of the installation is energized

The insulation resistance of lighting single-phase power and 380V three-phase power installations shall be measured with a 500-volt insulation-testing instrument.

Tests of insulation resistance for lighting and single-phase power installations shall be carried out by disconnecting circuit leads from the neutral bar, tripping the MCBs and applying the testing voltage between the distribution board case and the disconnected neutral conductor.

In the case of single-phase power installation all portable apparatus shall be disconnected.

In addition, the testing voltage shall be applied between the respective phase conductors at the MCB terminals and between each phase and the neutral conductor.

7 GENERAL EXTERNAL PREPARATION

7.1 Trenches

Underground cables shall be laid direct in trenches unless otherwise indicated. They shall be drawn through ducts as they routed beneath steel or concrete structures to ensure that anyone can draw them out when desired.

When cables trenches are opened all cables shall be laid and trenches shall be backfilled within twenty-four hours. At all times, safety precautions shall be taken and arrangements made to prevent damage to cables. The contractor has to present the calculation of cable denting according to IEC 364-5-523 taking into consideration the ambient temperature, Type of Laying, Number of Cables and Distance between Cables (grouping factor).

7.2 Support

The excavation shall be kept free of water and properly shored up. Other services uncovered shall be adequately supported by slings or other means and protected.

Before cables are laid the bottom of the trench shall be evenly grades cleared of loose stones and then covered with a 100 mm layer of sand.

100 mm of sand above and below the cable shall be provided and covered at the top of the sand by concrete cable tiles. A suitable cable loop shall be left at every entry to the motors or panels for both MV and LV cables.

7.3 Cable Warning Tape

Cable warning tape shall be laid 300 mm above all underground cables along their entire length.

7.4 Rollers

Power cables shall be pulled in over adequately spaced cable rollers and the resulting surplus cable shall be snaked across the width of the trench.

At each draw-in point, joint or junction box the cable shall be left slack. Cables shall not be pulled taut to straighten them after lying. Cable stockings shall be used for cable hauling. In order to ensure that the strain is taken on the cores as well as the sheath when cables are laid with a cable stocking, a solid plumbed hauling end shall be made. The only permissible exceptions to this requirement are lengths of up to 10m not pulled into a trust boring.

7.5 Spacing

Where more than one cable is laid in trench the cables shall be spaced a part in accordance with their current rating but subject to the minimum spacing specified, cables laid in the same trench may be bunched.

8 DIESEL GENERATOR

8.1 Standards

The following is a specification for generators to be supplied and installed as a part of this contract. The diesel generator is a prime diesel-engine driven generator equipped with Weather and Soundproof Enclosure (Canopy). The equipment and performance shall be in accordance with ISO and BS for Engine and IEC for the alternator and electric equipment.

8.2 General

The prime identical diesel generators are to operate automatically in case of power cut off. The generator units shall be supplied and installed complete with sound attenuated enclosure, exhaust silencers and all controls.

The sets shall be designed to give a supply at a voltage of 380 volts 50 Hz 3 phase 4 wire and be of the totally self-contained design incorporating a diesel engine prime mover, self-existing alternator and electric starter unit.

The sets shall be arranged to start automatically and run up to full speed within 15 seconds.

The complete units shall be maintained on a prefabricated skid base- frame with antivibration mountings, the whole unit arranged to bolt on to prepared concrete foundations. All interlocks shall be provided to prevent paralleling of the supplies.

8.3 Engine

Four cycle diesel engine, 4 cylinders (min) for generators with 300KVA and above, water cooled, with consistent performance and excellent fuel economy, minimum weight and electronic engine control.

The engine shall incorporate the following features.

- a. Tropical radiator suitable for 50 c
- b. Battery charging alternator
- c. 24-volt electric starter
- d. 24-volt fuel solenoid
- e. Heavy duty lead acid batteries (2x I 2V) for generators with 800KVA and bigger.
- f. Battery rack and fitted cables
- g. Spin- on full flow lubricating oil filters
- h. By- pass lube oil filter
- i. Spin- on paper element fuel filters
- j. Oil cooler and gear pump
- k. Lube oil drained piped to chassis
- 1. Fan and pulley guard protection
- m. Self-adjusting fuel system

- n. Fuel pump and twin flexible fuel lines
- o. Heavy duty air cleaner (s) (dry)
- p. Exhaust silencer with flanges
- q. EFC (Electronic Fuel Control)
- r. Instruction and operating manuals
- s. Automatic engine protection system
- t. Low oil pressure
- u. High water temperature
- v. Over speed protection
- w. Visual alarm indication and automatic engine shut down
- x. Four stroke Direct injection and Turbo charged
- y. Water cooled
- z. Original sound attenuated enclosure
- aa. Displacement minimum of 32 Liters.
- bb. Cooling system (Water system); Thermostats and housing, vertical outlet Jacket water pump, centrifugal Water pump, minimum of 55-liter cooling capacity.
- cc. Air to air after-cooled.
- dd. Fuel system; mechanically actuated electronic unit injection system.
- ee. Primary fuel filter with water separator, secondary fuel filter, flexible fuel lines, and fuel cooler.
- ff. Lubrication system; gear type lube oil pump, lubricating oil and filter, and oil drain line with valves.
- gg. Rails engine / generator / radiator mounting with rubber antivibration mounts.
- hh. Dry exhaust manifold with flanged faced outlets, exhaust silencer with flanges, exhaust system backpressure max of 10 Kpa.

8.4 Radiator

High ambient radiator suitable for generator set applications incorporates the following features.

- a. 4-piece fan guard for improved serviceability.
- b. Air to air after cooler line routing.
- c. Fan and belt guards.
- d. Coolant drain line with valve.
- e. Coolant level sight gauge on back side of the tank.
- f. All isolators are in line from front to rear package.

8.5 Engine Controller

Electronic control module with electronic unit injector interface capability incorporating the following features.

- a. Environmentally sealed, aluminum housing isolators from moisture and dirt contamination.
- b. Internal circuits designed to withstand shorts to +battery and -battery.
- c. Temperature accuracy maintained from -40 to 85 C.
- d. Capable of self-diagnostic and fault reporting.
- e. Programmable speed acceleration ramp rate.
- f. Adjustable cool-down duration.
- g. Data link interface.
- h. Capable of calculating the speed and held it within +/- 0.2 Hz for isochronous and droop mode.
- i. Humidity tolerance 0-90% relative humidity over operating temperature.
- j. Input voltage range 18-32 VDC (24 VDC nominal)
- k. Reverse polarity protected.

8.6 Chassis

A robust heavy-duty fabricated chassis, complete with lifting points, anti-vibration mountings, bolt down holes. An eight-hour daily service fuel tank and hand operated rotary fuel transfer pump shall be provided.

8.7 Alternators

High standard alternator meets the requirements of NEMA, IEC, ISO, IEEE, BS, AS. Round lamination stator design. Stator coil pitch, coil distribution designed to produce optimum waveform and minimum total harmonic distortion. Stator slots are insulated by slot liners and coil separators.

The alternator shall incorporate the following features:

- a. Blushless, single- bearing and four pole
- b. Screen protected and drip proof
- c. Enclosed to 1P22 (MEMA standard)
- d. IC 01 cooling system
- e. Fully interconnected damper windings
- f. AC exciter and rotating rectifier unit
- g. Epoxy coated stator windings
- h. Rotor and exciter impregnated with tropical grade insulating oil and acid resisting polyester resin. Dynamically balanced rotor to BS5625 grade 12.5
- i. Sealed for life bearings
- j. Layer wound mechanically wedged rotor
- k. insulation to class 1-1
- 1. Exciter: triple dipped in moisture, oil and acid resisting polyester varnish

- m. Sealed solid state automatic voltage regulator self exciting, self-regulating
- n. Output windings with 2/3 pitch
- o. Close coupled engine/ alternator
- p. Over-speed capability of 150% of synchronous speed at 50Hz.
- q. Waveform deviation, line to line, no load Less than 2%
- r. Paralleling capability; Standard with adjustable voltage droop.
- s. Voltage regulator; 3-phase sensing with variable Volts-Per Hertz response
- t. Voltage regulation, steady state +/-0.5%
- u. Voltage regulation with 3% speed change +/-0.5%
- v. Voltage gain; adjustable to compensate for engine speed droop and line loss
- w. TIF Less than 50
- x. Number of leads 6

8.8 Voltage Regulation

Maintains voltage output to within +-1.5% or +-1% at any pf between 0.8 lagging and unity, at any variations from no load, cold to hot and including speed droop variations at 4.5%.

Voltage trimmer on AVR for adjustment.

8.9 Waveform

Total harmonic distortion open circuit voltage waveform in the order of 1.5%. Three phases balanced load in the order of 3.5%.

8.10 Telephone Interference

THI- better than 50.

8.11 Radio Interference

Suppression to VDE class G and N.

8.12 Motor Starting

It shall withstand a short- term overload between 200% to 300% full load impedance depending on frame size and AVR used.

8.13 Voltage Surges

Surges suppressor fitted protecting exciter rectifier against short circuits or out of phase paralleling.

8.14 Frequency Regulation

+ -0.25% steady state load.

8.15 Generator Controls

8.15.1 Control Panels

The control cubical shall be of digital type with LCD and Touch key and it shall be accessible through a top removable panel with cable glands provided in the base and rear of the panels.

The Generator Control panel shall incorporate the following features:

- a. Programming process approved by the Manufacturer for all required features
- b. Indicator and display test switch
- c. Min. IP22 enclosure
- d. Emergency stop push button
- e. Auto Start/Stop with Safety Shutdowns
- f. LCD readouts for:
 - 1. Engine oil pressure
 - 2. Engine water temperature
 - 3. Engine Speed
 - 4. Engine hours of operation
 - 5. DC Voltage
 - 6. Generator AC Volts and AC Amps for all the three-phase.
 - 7. Battery DC volts
 - 8.Frequency
- g. Indications and warnings through the LCD for the following
 - 1. Low oil pressure
 - 2. High coolant temperature
 - 3. Engine over speed
 - 4. Over crank
 - 6. Fault
 - 7. Alarm
 - 8. Spare
- h. Power Metering options through the LCD
 - 1. Kilowatts kW (total & per phase)
 - 2. Kilovars kVAR (total)
 - 3. Kilovolt-amps kVA (total)
 - 4. Kilowatt-hours kWHr (total)
 - 5. Kilovar-hours kVARHr (total)
 - 6. Percent of rated power (total)
 - 7. Power factor (average total & per phase)
- i. Expanded AC metering through the LCD
 - 1. 3 phase Voltage and per phase (L-N)
 - 2. Current in Amps for all the three phases
- j. Integrated Protective relaying (programmable trip point and time delay)
 - 1. Over-Voltage (alarm and shutdown)
 - 2. Under-Voltage (alarm and shutdown)
 - 3. Over-frequency (alarm and shutdown)
 - 4. Under-frequency (alarm and shutdown)
 - 5. Over-Current (alarm and shutdown)

- 6. Reverse Power (Shutdown)
- 7. Load demand relay (Shutdown)
- 8. Spare relay
- 9. Spare inputs

8.15.2 Comprehensive Control System

Four-position mode selection switch.

- 1. Test on load start and load take over.
- 2. Test off load start and run no load change over.
- 3. Normal alter status with auto start on supply failure.
- 4. Offset cannot be started. Stop control and reset position.

Automatic override in event of power failure during testing.

Illuminated heater switch — mains operated to thermostatically controlled engine heater.

Three phase sensing units with close tolerance and phase displacement sensing. Set of running detection units — monitoring the alternator frequency and engine charge alternator.

Fail to start lock — out unit.

8.15.3 Transfer System and Timers

Transfer delay inhibitor and protection unit re-transfer delay timer for mains return. Runon 0-6 m timer for delay-on stop.

Motorized circuit breakers will not change-over until monitored voltage and frequency attain correct rating, then transfer shall be activated and adjustable timers shall be pre-set at factory.

If public power supply returns during start sequence the system shall abort staring and return to normal. If mains fail again during a run — on time delay the set shall immediately takeover the load.

8.15.4 Programmed Timers

E Function F Start solenoid 0 0 Start pulse 5 4 Start pulse 1 3 2 Start delay 0 Lock—out 5 1 0 Over speed 0

8.15.5 Repeat Starting Protection

Three repeat starting attempts shall be incorporated. The engine shall be automatically cranked for a pre-set adjustable period with pre-set times rest periods between each attempt.

"Failed to start" visual indicator illuminates for fault identification.

8.15.6 Protection Systems

Automatic set shut down shall take place in the event of:

Over- voltage

Over speed

Cooling fault

Low oil pressure

Alternator contactors will trip out in the event of low voltage, low frequency, and overvoltage or over speed.

8.15.7 Alarm and Status Indicators

The LCD of the Generator control panel shall show for the following:

- Alarms
- Low alternator voltage and! frequency:
- High alternator volts
- Low oil pressure
- High engine temperature
- Battery charging alternator fault
- Over speeds failure
- Fail to start
- Status
- Mains on load
- Mains in limits
- Set on load
- Cooling run operational delay on stop
- Battery DC on system operational

Alarms shall automatically latch once activated.

8.15.8 Set Testing

Mode selector switch in "test off load" position can be used for mains failure and anticipated sequence testing. Test on load- full mains failure start and change — over sequence

8.15.9 Automatic Battery Charging

An automatic fully regulating, constant voltage, current limiting battery charger of solidstate construction shall provide for starter batteries when mains supply is available.

Alternator battery charging when set is running.

8.15.10Quick Fuse Replacement

Front access DC and AC HBC instrument and circuit fuses clearly identified shall be positioned on the panel facial.

8.15.11Integral Circuit Breaker

The vibration isolated steel cubical shall contain a fully connected three pole molded case circuit breaker with thermal and magnetic overload and short circuit tripping protection.

8.15.12Plant and Load Protection

The generator contactors shall automatically trip out in the event of under speed, undervoltage, over- voltage, or over speed. Individual LED visual indicators shall identify' the cause of malfunction.

8.15.13 Fast Track Wiring

All AC and DC control wiring shall be clearly identified with coded ferrules at each termination permitting fast faultfinding. Plant wiring shall be fully sleeved, cleared and anchored.

8.15.14 Fully Automatic Operation

The system, when alert status, shall sense a transient, a permanent fall, or a complete failure of the supply voltage on one or more phases of a pre- set value from -1% to -20% of the nominal voltage value. Subject to the pre-programmed time delay settings, a start command signal shall initiate the automatic staring sequence and the multi- set programmer. Once the engine has started, the alternator frequency and voltage shall be checked prior the contactors closure. This ensures correct levels have been attained.

Time from power failure to take- over shall be a maximum of 15 seconds.

8.15.15 Automatic Load Transfer Panel (Optional)

Sealed in a separate heavy-duty steel cubicle which is a part of L.V switch gear cubicles, the change-over shall be motorized circuit breakers comprising:

One pair of mechanically and electrically interlocked, four-pole change-over motorized circuit breakers with over-loading devices. One set of AC and DC terminals to interface with generator control panel. Cables' passage trenches for connecting generators' cables to synchronizer panels input terminals and from its output terminal to change-over system.

Three phase 380V, 50 HZ motorized type, mechanically and electrically interlocked with power rating as shown on drawings comply with the following Standards:

- 1. UL1008- Automatic transfer Switch.
- 2. NEC.
- 3. NEMA.

The ATS shall be mounted in a free-standing enclosure, and bussed together with copper bus to provide a complete and pre-tested factory assembly. Construction shall be such that the power and control wiring connections.

The motor shall be operated on 220 VAC / 110 VDC. Transfer to emergency and Retransfer to normal source automatically. Once initiated, transfer time shall not exceed 1/20th of one second.

Rating: Automatic Transfer Switch shall be rated at 380V, 50 HZ, 4 Pole, normal and emergency Sources. All Current carrying parts shall have 600 Volt insulation. It shall have 50 KA minimum S.C.C With stand and closing Rating when connected to the load side of standard circuit breakers. The transfer switch actuator shall be double throw, single electrical operator, momentarily energized.

To prevent simultaneously closing, the normal and emergency contacts shall be interlocked mechanically and electrically

Main Contacts:

Silver —tungsten alloy. Separate arcing contacts, with magnetic blowouts. Interlocked motorized molded case circuit breaker.

Accessories:

The automatic transfer switch shall include the following features and Accessories:

- 1. Adjustable close differential relay energized from source, factory set to pick up at 90 % and drop out at 80 % of rated Voltage. PT 'S shall be multi-tape for either 220V / 380 V sensing.
- 2. Time delay to override momentary normal source power outages, adjustable (0.5-3 seconds), factory set at 3 sec.
- 3. Time delay on transfer to emergency, pneumatic type, adjustable 1-300 sec.
- 4. Motor driven type, adjustable (0-30) minutes, factory set at 5 minutes. This time delay shall be overridden upon failure of the emergency source.
- 5. Adjustable relay to prevent transfer to emergency until voltage and frequency of generating plant have reached acceptable limits
- 6. Pilot light with flashing lamp which indicates when either the load shed or block transfer relays are energized.
- 7. All components of the assembly except those identified in these specifications by the manufacture shall be a regularly manufactured product. Comprising one set of AC and DC terminals to interface with generator control panel.

Manual Transfer Switch: (Optional)

Identical to ATS except that the operation shall be manual, and the switch shall give the same electrical ratings of capacity, voltage, short circuit withstand and temperature raise capability as the associated ATS.

Mechanical Linkage shall be accomplished through the manual operators from a dead front.

Control and Monitoring Signals

Control and monitoring Signals available at the transfer switch:

Normal position	loss of normal power
Off Position	loss of emergency power
Emergency position	KW, KVAR
By passed to Normal	load shed input
BY Passed to emergency	load shed output
Derangement	

Enclosure:

The Primary bus work of the draw-out automatic transfer switch shall be connected to the stationary bus stabs in the freestanding cubicle by silver-plated, segmented self-aligning, primary disconnect stabs to facilitate proper alignment between the removal draw-out element and the stationary cubicle. The ATS stab

Assemblies shall be drawn-out when the ATS is withdrawn and shall be available for inspection without disturbing or energizing the main bus.

The ATS Shall be provided with self-contained extension rails, rollers or casters to allow it to be rolled from its enclosure by one person.

Each ATS / ISO Switch shall be enclosed in NEMA-1 freestanding general purpose enclosure with front opening lockable door. Access into enclosure shall be from the front.

8.15.16Clear Facial Instruction

All operating and fault and status instructions shall be screen-printed either white on black or red on white onto the panel facial.

8.15.17Equipment Finish

All sheet metal shall be zinc — coated prior to an application of a self-etching primer. The pre-treated and pre painted engine/alternator power pack and the whole unit shall be finished off with an electronically sprayed final coat of high-quality gloss pain.

8.15.18Wide Temperature Tolerance

Control system designed to operate over the temperature range — OC TO +75C up to 95% relative humidity.

8.16 Louvers

Louvers shall be provided with suitably sized inlet and outlet areas to suit the selected equipment characteristics and also to suit the requirements of the architect where penetrations are involved. The louvers shall be moveable blades with engine air pressure.

8.17 Sound Attenuated Weather Protective

With the sound attenuated enclosure, sound in 7m away from the generator sets shall not exceed 72dHA at full load. The enclosure features are:

- 1- Durable weather —resistant enclosure.
- 2- 2- 14 gauge cold rolled steel.
- 3- Polyester powder baked paint enhances durability and appearance.
- 4- Safety glass control panel viewing window for easy monitoring of operation.
- 5- Rust-free stainless-steel hinges and locks and zinc-plated hardware.
- 6- Radiator sight gauge provides easy verification of coolant level from the ground.
- 7- Weather protective enclosure offers three levels of exhaust systems industrial grade.

- 8- Enclosure design incorporates side—mounted control panel and side cable access and accepts as complete range of factory designed and installed attachments
- 9- Exhaust silencing system housed within the enclosure for operator safety and maximum life.

8.18 Daily Fuel Tank

The Generator shall be engaged with a daily Fuel tank to be supplied with fuel automatically from the main fuel central tank, all electrical and mechanical and piping connections and safety controls between the daily tank and the main fuel central shall be included as part of these works.

9 TRANSFORMER AND MAIN SUPPLY

9.1 General

The main supply transformers will be installed in the service building as per drawings. The main distribution boards are going to be erected at separate rooms, the main feeders will be distributed to all sub-main panels.

The contractor shall provide the cubical with metering at the first compartment and proper access for the Electricity Company to check. The contractor shall supply and install all the connections and accessories required to join the MT network with the internal distribution substation. This work mainly includes (concrete markers blocks, cables, wires, clamps, isolating switch, earthing and lightning, steel tower and arms if required).

9.2 Transformer

9.2.1 Technical Data

Transformer shall be equipped with a conservator, max. thermometer, magnetic oil level indicator, buchholz relay, dehydrating breather and pressure switch. Thermometer and pressure switch shall each have two contacts, one for tripping and the other for alarm.

The Contractor shall supply 3-phase, two winding, liquid immersed, hermetically sealed type power transformer of 22/0.4 kV, Oil Immersed Type Transformer for continuous operation under site ambient condition at full rated power, naturally cooled (ONAN), with off load, manual, operated tap — changer.

The following clauses set out all standard requirements for the power transformer and included with this specification indicates the particular requirements and type of the transformer.

Transformer specifications

PATTERN	ONAN
VOLTAGE	$22,000\pm$ 5% primary voltage, 430-430-volt no-load secondary voltage and the power factor of full load is 0.8 P.F.
CONNECTIONS	Delta/Star in accordance with vector reference DYn11 or as specified in drawings and bills of quantities
ADJUSTING TAPPINGS	On the M.V winding covering a taping range of plus 5% to minus 5% in steps of 2.5%, 5 steps.
TAPPING CONTROL	By means of an off-circuit switch controlled from the outside of the transformer tank and supplied complete with tap position indicator and facilities for padlocking ($+1x2.5\%$, $-3x2.5\%$ or as per GEDCo Specifications)
HV TERMINATIONS	3-pole single gland cable box arranged to receive 1-3 core cable from below. Suitable for compound filling and supplied complete with 3 no. copper

cable lugs and a small wiping gland (maximum cable size 185 sq.) and (as per GEDCo specifications). LV TERMINATIONS 4 + 3 poles multi position cable boxes arranged to receive single core cable from below and (as per GEDCo specifications). TYPE OF TANK Breathing type welded steel with bolted on type fixed cooling radiators PAINT FINISH The transformer shall be painted in accordance with system IE. **FITTINGS** Oil conservator of mild steel with oil filler boss with screw cap and Drain Valve Prismatic Oil Level Gauge, Lifting and Jacking Lugs, Thermometer Pocket, Silica Gel Breather, Main Tank Drain Valve. Earthing terminal, Rating and Diagram Plate Skid type Underbars, Cable Box, Compound, Cable Glands, bushing terminals, heating resistance protection relay DPGT-2 fully interfaced with the medium tension breaker, Buchholz relay and Cable Connectors. side insulation **INSULATION LEVEL** Primary 24/50/125kV and secondary side insulation 1.1/3.0k V MAGNETIC CORE Built from interleaved cold rolled grain-oriented steel laminations WINDIINGS tape. Made of copper conductor insulated with cellulose paper

9.2.2 Design Standards

The transformer shall comply with IEC 76,354 and 404-2, and to be low losses design, the design and construction as described above. It must be designed for a temperature rise measured by thermometer in oil not exceeding 50 °C or 55 °C measured by increase in resistance method following a continuous full load run. Overloads would be permitted in accordance with British Standard code of practice CP1010 (1975).

9.2.3 Standards

The transformer and ancillary equipment shall be designed and manufactured in accordance with the standards, and the work shall be co-ordination with PEA and Gaza Electric Distribution Company (GEDCO).

9.2.4 Construction

The transformer herein specified will be connected to the HV. supply provided by others. The cores, windings, tank framework, clamping arrangements and general structure of the transformer when assembled shall be of substantial design so as to form a rigid construction entirely unaffected by short circuit conditions, transport or ordinary handling during installation, inspection and repair.

The cores shall be constructed from cold rolled grain-oriented steel treated with an insulating material, which will be unaffected under operating conditions.

The earth conductors shall be green/yellow PVC covered copper, shall be unbroken from the main earth terminal bar to the earth electrodes and shall be clamped by an earth clamps. The connections to electrodes shall be painted with an exterior grade metallic paint.

A brass label engraved as follows shall be installed adjacent to each connection.

((DANGER - EARTHING SYSTEM, DO NOT DISCONNECT))

The transformer shall be hermetically sealed type and of suitable construction to remain mounted on plain rollers. The loading of it is according with IEC 345. It shall be equipped with flexible corrugated tank walls enabling sufficient cooling of transformer. For lifting purposes, the outer stiffening bars on the tank shall be provided with hooks. The joints between tank and cover and bushing flanges etc. shall be rendered oil tight by the insertion of Concord Type NP5O, or other approved material which is impervious to transformer oil, between surfaces arranged such that the insertion is under controlled pressure.

The oil filling plug shall be removable independently of the core and windings.

The Transformer must be of low losses type and have the following facilities

- Magnetic liquid gauge with N.O. low level alarm contact
- Dial thermometers, for indication of the temporary oil temperature. Contacts for alarm and trip.
- Oil drain valve.
- Off-circuit tap changer handle.
- Earthing terminals.
- Sparking gaps for voltages 15kV and above.
- Rating plate.

9.2.5 Primary Winding Connections

The primary winding connections shall be brought out to a cable box for connection to external cables. The cable box shall be of adequate size to accommodate the cable terminations, allowing adequate space for dressing and shaping of the cable cores.

The cables connected will be as detailed in the Schedule and it is preferred that the cable chamber be air insulated allowing the use of E.P.D.M. Rubber type terminations.

The termination bushings and spacing between phases and earth shall be such as to maintain adequate clearance in air, as specified in the appropriate Standard, and these clearances shall be obtainable with connecting lugs fitted and, preferably, without the use of barriers. Any special fittings or materials necessary to achieve satisfactory clearances shall be supplied and fitted by the transformer manufacturer.

Single core cable entries to the cable box shall be made through a non-ferrous gland plate.

Attention shall be paid to the cable box design so as to ensure that condensation does not allow the accumulation of water within the box. The correct terminal connections shall be marked on an engraved plate fixed to the outside of the cable box.

9.2.6 Secondary Winding Connections

The secondary winding connections shall be brought out to a cable box for connection to external cables. These connections shall include the winding star point connection, which shall be insulated as for the phase connection.

The cables to be connected shall be as detailed. In all other, respects, the termination facilities shall be as for the primary winding connections. The L.V. cables shall be provided with a pre-drilled non-ferrous gland plate.

9.2.7 Painting of Tank

All internal and external steel surfaces of the tank and conservator shall be thoroughly cleaned by shot or sand blasting to remove the rust and grease prior to the application of paint finishes. Internal surfaces shall be treated with a finish resistant to transformer liquid.

External surfaces may be treated generally in accordance with manufacturer's standards provided that the manufacturer guarantees satisfactory trouble-free life in the environment specified herein. Details of the treatment proposed shall be provided with the tender.

9.2.8 Finish of Accessories, Fixings, Etc

Accessories, fixings and all such equipment shall be of a material, which will ensure satisfactory trouble-free life in the environment specified herein.

9.2.9 Oil

The transformer shall be dispatched from the maker's works complete with oil in the tank, radiators, and all inter-connecting pipe work.

9.2.10 Noise Level and Radio Interference

The transformer shall be designed and constructed to operate over the full range of loading without exceeding reasonable noise levels. Standard sound levels as specified in specifications and the applicable Standard will be acceptable.

The transformer shall not produce any emission likely to cause interference with communication equipment.

9.2.11 Inspection and Testing

The transformer shall be subject to inspection during manufacture and inspection and complete set of test protocol shall be delivered.

10 L.V. SWITCHBOARDS

10.1 General

The switchboard shall consist of one or more vertical sections joined together to form a freestanding cubicle rigid, floor fixing assembly, which is extendible at either end.

Each vertical section will have built in rollers for easy section aligning and jointing. Designed and construction of the switchboard in accordance with standards.

The switchboard shall be factory-built assemblies in accordance with IEC 60439-1 international standard.

10.2 Enclosures

The switchboard components shall be housed in cubicle construction, with front access. Constructed from formed and bolted 2 (and 1.6mm for covers and doors) zinc coated mild steel and finished in blue greedy epoxy powder coating. The enclosure should be coated with paint that resisting the dampness, aggressive atmosphere and being suitable for installation in water availability vapor and suitable for water pumping stations environment.

10.3 Bus Bars

Bus bars shall be hard drawn copper bar throughout, tinned plated and frilly fault braced and ASTA certified to withstand thermal and mechanical stresses arising from a maximum fault level of 100KA RMS symmetrical for 1 second.

The main bus bars shall have the largest ampere rating capacity with 100% rated neutral bar and a separate continuous earth rated at 25% of the main bus bar rating. Bus bar size is dependent upon diversity.

Brace shall be achieved by means of injection-molded glass filled polyester insulation, high tensile bolts and washers. Bus bar jointing shall be achieved by single or double bolt per phase and washers to give consistent torque per joint. All bars shall be taped where necessary for identification.

10.4 Glanding Arrangements

All bottom plates of switchgear shall comprise of a vermin barrier plate. Adjustable height gland plate shall be provided, all in and outgoing cables have to be arranged from below.

10.5 Outgoing Circuit Breakers

Outgoing circuit breakers shall be plug-in, thermal magnetic type.

10.6 Earthing

The copper earth bar is fitted at the bottom front of the section and is underlined.

10.7 Air Circuit Breakers for Main Distribution Board

These shall be electrically and manually operated and of the air-break type. All incoming and bus sections breakers shall be of the air-break type with draw-out operation and complying with standards. Incoming ACB's shall be 4-pole; motor operated type with solid-state trips and automatic change-over between transformer income and stand-by income. Bus section ACB's will be 4-pole manually operated non-auto type interlocked with incomers to prevent parallel operation.

Front covers on all breaker compartments shall be hinged. Circuit breakers of the same ampere frame sizes shall be interchangeable.

Circuit breakers shall be air-break, 600-volt class, with stored energy spring load shall be of the power non- enclosed and with draw-able type. Circuit breakers shall be with ampere ratings as indicated on the drawings and contain the following features:

- Each pole shall have a combination of two overloads, series, and direct acting trip device. One with long time delay, the other with short time delay. In addition to another special indicating devices.
- Circuit breakers shall be co-ordinate for a selective arrangement and co-ordinate with the primary circuit breakers.
- Disconnecting devices of approved type shall be provided to facilitate removal of breaker from the housing for test and maintenance purposes.
- Circuit breakers MCCB and MCB must be able to interrupt a short circuit that may occur.
- Trip free from all positions
- Clamp type terminals for outgoing cables
- Arc quenching device on each pole
- Adjustable under voltage trip
- Auxiliary contacts
- Replaceable arcing contacts.

10.8 Trip Mechanisms

The mechanism shall be trip free incorporating the following suitable types:

- 1. Magnetic
- 2. Solenoid
- 3. Motorized
- 4. Spring

Circuit breakers shall be fitted with on/off indication mechanically operated.

10.9 Trip Coils

Trip coils shall be thermal magnetic, single— poles relays 5A for over current protection with inverse characteristics, which shall have a short time delay for normal operation. Adjustment 1.0- 1.6 times CT primary current. Instantaneous operation at 7.5 times rated current of breaker.

Instantaneous magnetic trips 5A and 2A with 1 —2 time's current adjustment.

Shunt trip coil

Under — Voltage coil

The air circuit breaker shall be supported on telescopic slides, with three positions — SERVICE, TEST AND ISOLATED.

10.10 Safety Shutters

With draw able circuit breakers shall have safety shutters, which shall be indecently operated automatic metal shutters fitted over the main with draw able to the inspection to be padlocked in the closed position.

10.11 Trip Mechanisms

The secondary isolating contacts shall be fitted with automatic shutters. It shall not be possible to withdraw a rack in a with draw able circuit breaker when it is closed. The action of withdrawing a circuit breaker shall necessitate a deliberate action distinct from any other operation. It shall not be possible to inadvertently fully withdraw a circuit breaker from its housing.

10.12 Auxiliary Contacts

Each air circuit breaker shall be fitted with either (four normally closed) auxiliary contacts for indication, interlocking and control etc.

Contacts shall be rated at 6A, 500V AC, 4A, 230V DC.

10.13 Interlocks

Air circuit breakers shall be fitted with the normal interlocking features to ensure correct operation. They shall be fitted with a lock of approved nature on the closing mechanism so that only the key holder can close the breaker. Facilities shall be provided for the circuit breaker to be locked in the isolation position.

10.14 Neutral Links

The neutral link(s) shall be mounted on the rear of the board adjacent to the top tier cable box. The links shall be supported on molded mono blocks and provided with sheet steel covers.

10.15 Current Transformers

Current transformers shall comply with standards and shall be integral part of the breaker. They shall be suitable for operating the thermal magnetic relays and an ammeter. All current transformers shall be fitted to the outgoing side of the circuit breaker and shall have the windings extended by separate connections to an accessible insulated terminal block.

10.16 Bus Bars General

4-pole metal clad indoor type air insulated bus bars of uniform cross-sectional area throughout their length shall be arranged horizontally through switchboard sections.

Instrument panels for fuse — switch cubicles or moulded case circuit breaker will accommodate an ammeter and ammeter selector switch per circuit.

Instruments fitted on LV switchboards shall comply the standards.

Electrical indicating instruments shall also comply with the standards, and should range 60 - 80 mm. Relays for use in LV switchboards shall be of the plug — in type. Coils

and contacts shall be rated for their functions, with minimum rating of 10 Amp at rated voltage. The plug — in bases for the relays shall be of the screwed termination type.

Bus Bars shall be covered with suitable heat shrinkable colored cover.
11 SUB-MAIN SWITCHGEAR

11.1 Rating Voltage

All single-phase distribution boards shall be rated one phase 230 V and Three phases 400V.

11.2 Short Circuit Rating

The short circuit rating of any distribution board is equal to the lowest short circuit rating, at the appropriate supply voltage, of any main or branch circuit breaker fined.

11.3 Enclosures-Multi Pole Distribution Boards

The boards shall comprise of zinc coated sheet steel enclosure with an electro statically epoxy finish. The enclosure shall be constructed of cold rolled steel, which has a general thickness of 1.5 mm with a 1.5/2.0 mm thickness for the door. The mounting plate shall be of 2.5 mm thickness.

11.4 Sub-Distribution Boards Arrangement

Distribution boards shall be generally of the wall mounting type, but the large distribution boards shall be of the floor mounted freestanding type. All boards shall be complete with top and bottom removable gland plates, suitable for bottom cable entry and top or bottom cable exit.

The main bus bar shall be of tinned copper suitably rated. The neutral terminal bars shall be of brass. Adequate terminations for the maximum number of outgoing circuits shall be provided. All circuit breakers; neutral terminals and earthing terminals shall be correspondingly number inside the enclosure. A main earthing terminal is provided which may be assembled for internal or external connection.

11.5 Consumer Units

The enclosure shall be manufactured in sheet steel. The unit shall be supplied with a plastic circuit breaker handle cover. The enclosure shall be supplied with a rubber grommet to insulate and seal the coming cable entry.

All circuit breakers; neutral terminals and earthing terminals shall be correspondingly numbered inside the enclosure. In addition, the earthing bar shall have externally accessible terminals for main and bonding conductors. Both neutral and earthing terminal bars shall be made of brass. The tin-plated copper line bus bar spaces shall be shrouded against accidental contact. The units shall accept 6,10,16,32 and 45-amp MCCB.

11.6 Miniature Circuit Breakers

The operating mechanisms shall be of the over centre, trip-free, toggle type, providing positive quick-break manual and automatically trips, the operating handle shall assume a position between on and off and an indicator shall be visible. Two or three pole circuit breakers shall have a common trip with individual spring pressure on each contact. MCB should be rated up to 16KA.

The protection shall be terminal/magnetic trip for overload and short circuits.

Each breaker shall be calibrated individually and tested for overload and short circuit protection in accordance with the standards.

11.7 Switch Fuses

Switch fuses shall be provided with facilities for locking in the "OFF" position. They shall be of the same manufacture as air circuit breakers, fuse switches, isolators and isolating switches.

Switch fuses shall be fitted with fuses, bolted type, class Q1, certified for 415v and category of Duty AC 33.

11.8 Load Break Switches

Electrical characteristics of load break switches such as Ampere rating and number of poles shall be as indicated on the drawings schedules and/or as herein specified. Ratings have to be readjusted by the Contractor and approved by the Engineer or his Representative before ordering if the served load is different than that shown in Schedules.

The LBS shall be a non-fusible, single throw, as indicated, provided with arc quenching devices on each pole, making it capable of interrupting at least six times the normal, switching current.

Switches shall effectively interrupt the power supply for all line conductors and neutral (where it exists), and simultaneously disconnect the supply for control circuits.

The operating mechanism shall be quick-make quick-break with the external operating handle mechanically interlocked with the enclosure cover.

Interlocks shall make it necessary for the switch to be in the off position for normal access to the inside of the enclosure. Switch shall have the means of by passing the interlocks indication to the position of the switch. Enclosure shall be for general purpose indoor application, 1P54 for indoor water protected type and IP65 for outdoor weatherproof installations or otherwise as required.

Enclosure shall have provisions for locking the operating handle in the "OPEN' and "CLOSED" positions. Load break isolating switches shall include facilities for locking them in the "OFF" position. Solid copper links shall be fitted in place of fuses. Switches shall be selected for the ratings suitable for the equipment served and with fault capacities compatible with the remained of the switchgear on the LV switchboard. LBS shall be flush mounted in finished areas and surface mounted in unfinished areas. The distribution boards shall be installed so that the height of the top edge will not exceed 1.8 m from the finished floor. Labeling shall be type written in English and Arabic to indicate load served by each circuit, and shall be mounted in a holder behind protective coating. Contractor shall follow manufacturer's installation instructions

11.9 Residual Current Devices (RCD)

The breakers shall be of the current balance principle and shall be rated to match the loading of the boards that they are serving. The tripping current shall generally be 30 mA, 100 mA or 300 mA units to protect selective equipment.

11.10 Installation of Switch Gear and Associated Equipment

Where individual items of switchgear are shown on the thawing(s) to be grouped together, or where is reasonable to do so, they shall be formed into a composite switchgear panel. Floor-mounted units are preferred.

All apparatus (including associated equipment and accessories) shall be fixed independently of the system of wiring. All fixing screws or bolts shall be of steel and

where the apparatus that a protective coating of zinc or is mounted outside a building the bolts or screws shall be zinc-plate (Electro-galvanizing) coating.

11.11 Framework for Switch Gear

Framework for the mounting of switchgear, distribution board and similar equipment shall be of mild steel plate; section and bar or hot rolled hollow sections, or slotted angles.

Metal hexagon bolts screws and nuts may be used.

Framework mounted within the building shall be wire-brushed of shot-blasted, cleaned and thereafter given a coat of zinc chromate primer brushed on. Manufacturer's standard finishes will be accepted for slotted angles, but all metal exposed by cutting shall be prepared and finished to match the paint finish applied by the manufacturer.

Framework mounted outside a building shall be of galvanized mild steel plate, section and bar or hollow section, or galvanized slotted angles. Bolts, nuts and screws shall be galvanized or zinc plated (Electro galvanized) coating. Untreated areas of metal, e.g.: cut ends holes and areas damaged by welding shall be given a coat of zinc rich paint brushed on.

12 POWER FACTOR CORRECTION

12.1 General

The LV switchboards shall be equipped with suitable automatic power factor correction equipment, connected via PVC/ PVC (NYY) or XLPE (N2XY) copper cables. An appropriate, PFC digital control masters to achieve the target power factor.

12.2 Automatic Controls

An automatic control monitoring system shall be installed in the panel with a front access. The limit shall be multi- stage type, consisting of reactive current relay type and a constant speed reversing motor. Mercury switches operated by the motor shall control the capacitor contractors. Indicating lamps shall incorporate selector switches for automatic 'ON' and 'OFF' positions.

The capacitor bank unit's size and number will be designed according to the load result power factor. The system shall maintain PEA recommended power factor 0.92 lag as long as possible.

12.3 Correction Panel Components

They shall Comply with B.S 1650. The equipment shall be installed in the main LV Switchgear.

12.3.1 Contactors

Contactors shall be rated in accordance with' uninterrupted duty' and utilization category AC- 68 where the load is positively identified as being non-inductive, but excluding tungsten filament lamps.

Contactor coils shall be dc or rectified AC operated. They shall be wound for 220 Volts 50 Hz and shall be protected by cartridge fuse- link triple pole block type, suitable for capacitive current duty and equipped with high energy coils. Control relays Multi stage automatic type with two spare stages for the addition of future banks. The relay shall be fined with a loss of voltage re-starting device with an integrally mounted on/off Selector Switch

Separate Systems shall be of the automatically controlled multi-stage static bank type, capable of correcting the power factor to minimum of 0.92 lagging under the load condition.

The capacitors should be multi units of static capacitors manufactured from impregnated metalized paper and plastic film, having self-heating Capacity. Each unit shall be fitted with thermal protection device, quick discharge resistors and early to make and late to break auxiliary contacts.

12.3.2 Isolators

On load Pattern for closing and breaking the supply. The operating handle shall be interlocked with the cubicle door to prevent access when the isolator is closed.

12.3.3 Protection

The system shall be protected with M.C.C.B to provide short circuit opening capacity as required. Single Phase warning lamps shall be fitted on the panel front.

12.3.4 Moulded Case Circuit Breaker (M.C.C.B)

They shall Provide Complete Circuit Over Current Protection by having Inverse time and instantaneous tripping Characteristics, and where applicable, be current limiting.

Circuit breakers shall be operated by toggle type handle and shall have a quick make and late to break, over switching mechanism that is mechanically trip free. Interrupting current shall be as on drawings or as in bills of quantities or as Specified.

Breakers 150 amp and below shall be thermal Magnetic trip with inverse time Current Characteristics. Breakers with 250 amp and 400-amp frame located in the main distribution board shall utilize Electronic type to trip units with interchangeable rating plug to trip current.

Breakers 600 amp and above shall have solid state trip complete with built-in current transformer, solid state trip.

Breakers 600 Amp and above shall have external testing facilities to test instantaneous, short time, long time and ground fault circuit sin either trip mode or test mode without requiring the actual trip of the device.

12.3.5 Current Transformers

Current transformer shall be installed on the bus bars of the main low voltage switchboard. Removable links shall be fitted to facilitate this and they shall be located such that they sense the total installation current including the capacity load. Wiring back to the control cubicle shall be in PVC conduit and or trunking.

12.3.6 Capacitors

The capacitors installed shall be of different ratings to satisfy' power factor correction during variable load dissipation.

The capacitors shall be manufactured with cylindrical windings, the dielectric is formed by polypropylene which is metalized on one side under vacuum with a special mixture of zinc and aluminum, both ends of the winding are sprayed with a zinc contact layer. The capacitor elements dried with vacuum.

General technical data

Standards:	VDE 0560-41, IEC 831-1, IEC 831-2
Rated voltages:	230, 400, 440,480, 525V
Rated frequencies:	50/60Hz
Tolerance of capacitance:	-5+ 15%, *5%
Maximum surface temperature:	-25°C/D<15kvar -25°C/D≥15kvar
Maximum permissible current:	1.3X IN, higher values on request.

13 SWITCHBOARD PANEL CIRCUITS AND CONNECTIONS

13.1 Panel Board

Switch Boards for electrical equipment shall be made from hot-dip galvanized Sheet steel; where two or more Cubicles are jointed together, they shall be of uniform height. they shall be protected Against dusts, damp, corrosion and entry Vermin without reducing adequate Ventilation and air Circulation, gaskets shall be fitted to doors and removable panels Unless Specified otherwise Cubicles and enclosures shall be proof — standing with lockable hinged from doors where access to live equipment is required. Suitable warning labels and instructions for earthing and isolating shall be fitted where necessary. The Switch boards shall be constructed to BS 5420 up to (1KV) And IP Ratings (I 54) for indoor and (IP55) for outdoor installations

All outgoing circuits shall be separately compartment or screened so that equipment for any circuit can be maintained without risk of contact with live connections on any other circuit.

Supplies for control circuits shall be taken from within the compartments of the related item of switchgear and fuse, fitted with a cartridge element, shall be fixed in an easily accessible position within the respective compartment to protect the control circuit. Where control circuits pass through auxiliary contacts the fuse shall also be used to isolate the terminals of these contacts.

Where auxiliary contacts are used for interlocking purposes and supplies are derived from other sources, isolating facilities shall be provided to render the auxiliary contacts safe. This isolation shall be in the form of auxiliary switches mounted on the respective compartment isolating device or a separate isolator mounted within the respective compartment.

Where incoming or outgoing cables are required to be PVC insulated, steel wire armored cable glands shall be supplied by the contractor installing the cable. The switchboard manufacturer shall provide removable gland plates of dimensions to accommodate these glands.

Where cables are single cores, the gland plates shall be of a non- — ferrous metal.

Small wiring shall be neatly bunched and cleated in harness form, or shall be enclosed in plastic, purpose made small wiring trunking. Metal buckle type clips shall not be used. Wherever wiring is cleated to metal work it shall be insulated from the metal surface.

All small wiring shall be of stranded copper not less than 78/0.67mm PVC insulation. Other types of small wiring may be accepted for use if approved by the Engineer or his Representative at the time of tender, but such approval will not be considered unless comprehensive details of the alternative system are submitted.

13.2 Wiring

Shall be Carried out in 0.6/1 KV PVC cable to BS 6231and the Connectors shall be not less than 1mm². Wiring within the Switch board shall be distinctly colored throughout and marked with ferrules at each end for identification. The letters and numbers used shall be corresponding with the switch board wiring diagram. The Wiring color Code shall be as Follows:

- Phase----- Brown
- 3-Phase----- Brown, Black, Gray

- Phase I Control Current ----- Red
- Neutral ----- Blue
- Earth ----- Green-and-Yellow
- Control current, 24Vdc----- Magenta.

The wiring shall be neatly manner and cleated to the switch board structure and arranged so that access to equipment is not imposed where wiring pass through metal work the access hole shall be fitted with a suitable grommet. Wiring shall be terminated in terminal blocks at each end.

Terminations for screw or stud type terminals shall be crimped on pin type or claw and washer type.

13.3 Switch Board Control Component

The switch board control components shall be as follows: -

Indicating Instrument: All instruments shall be fined with an accessible zero adjuster and shall be positioned not more than 1800mm and not less than 1200mm above finished floor level. Ammeters in motor starter circuits shall be capable of withstanding the starting current. The scale shall be clearly marked with a red line indicating normal full load current comply with BS 89 and shall be of industrial grade accuracy.

Indication Lights Indicator lights shall not be less than 20mm diameter and shall be of the projection type so that they Can be seen from the front and the side of the switch board. They shall be under —run to give long live. Colors of indicator lights shall be:

- Run ----- Green
- Fault ----- Red.

13.4 Labels

All designing labels shall be finished with engraved letters and numbers fitted with black and fixed by non- rusting Screws.

13.5 Terminal Blocks

Terminal Block shall be Screw or clamp type. Punch Screw type blocks shall not be used terminal blocks at different voltages shall be grouped and labeled accordingly. Outgoing Cables shall be supported by Pull Reliefs.

14 INSULATED POWER CABLES

14.1 PVC Cables

The cables shall confirm the VDE standards, insulated cables for Electrical Supply', which specifies requirements for cables for operation at voltages up to and including 3.3 kV.

The cables shall conform generally to international requirements as defined in IEC standard, and suitable designs can be supplied to cater for the National Standards of other countries. It is however not acceptable to use other national standards at random throughout the project. The Engineer or his Representative shall approve the number of cores and the kind of conformable international standards.

The following cables and equipment for operating the plants shall be provided:

Set of cables (steel belt armored type), cable trays, fastening materials (screws, nails, clamps, etc.), set of emergency switches, wall sockets, sufficient to complete the whole power installation in the-storage systems and processing section...

Set of electrical equipment for light installation sufficient to complete the indoor light installation. Set of earthing equipment, consisting of earth rods, special earthing cable for connection between earthing rods and electrical installation, junction boxes, etc.

The cables shall be marked according to electrical drawings.

The system shall be a duplex system and shall be delivered. All supply and installation shall be included. The cables shall be looped progressively from point to point and no joint will be permitted. Cables emanating from different fuse boards and switch fuses shall not be drawn into the same conduits or thaw boxes. The number and size of the cables in any conduit or trunking shall not exceed those given in the current edition of the regulations. Cables shall be installed in such a manner it is possible to withdraw any number from the conduit without disturbing the reminder. The pump cables shall be approved by the Manufacturer of the frequency drivers for any additional requirements with any

14.2 XLPE Insulated Power Cables

The cables shall conform to the standards and shall be rated up to 22 kV.

14.3 Armouring

The armour shall be a single layer of galvanized steel wires, galvanized steel strips, aluminum wires, or aluminum strips. Aluminum glands should be used in conjunction with cables employing aluminum armour. Where necessary, tinned copper wires can be provided in the armour of wire armoured cable to increase the conductance.

Un armoured flexible cables shall be used for connection of motors to safety switches (isolators) or for connection of any object exposed to vibration.

Three core cables shall be normally armoured with a layer of galvanized steel wires or, alternatively, with a double layer of steel tapes. These shall be galvanized or varnished.

Single core cables shall be normally armoured with a layer of aluminum wires. Un armoured three core cables will have a reduces earth fault current carrying capacity.

14.4 Conductors

Unless otherwise specifically indicated on the drawings, all wires and cables for all systems described under this subsection of the specification shall have annealed electrolytic conductors of 98% conductivity. All cables shall be supplied with circular stranded conductors in copper or aluminum. These conductors shall be compacted to reduce their dimensions.

Copper conductors shall be stranded for sections 6 mm and above. Signal and control cables shall have solid conductors. Flexible cords shall have finely stranded conductors.

Conductor sizes shall be metric as shown on the drawings conductors with crosssectional areas smaller than specified will not be accepted. No conductor size less than 2.5mm sq. shall be permitted.

The insulation of each conductor shall be color coded or otherwise identified as required by the "Regulation". Color coding shall be maintained throughout the entire installation.

The cables delivered to the Site shall bear the mark of identification authorized by the "Standard" institution to indicate compliance with the Specification.

Any cable not having this identification mark shall be rejected.

All constitutive components of the cable shall conform to the relevant specifications of the above-indicated "Standard.

Single conductor wires for wiring in conduit or metal ducts shall have high conductivity tinned copper wire conductors insulated with PVC compound, and a PVC sheath for multi-core cables. Wires and cables shall be 600/1000 volts grade to VDE 0250/3.69 and DIN 47702.

Armoured multi-core copper cables shall have high conductivity dinned copper wire conductors, insulated with EVC compound did up, bedded where required, steel wire armoured and sheathed with PVC compound. Cables shall be 600/1000 volts.

14.5 Conductors Screening

All cables shall be supplied with a conductor screen comprising an extruded layer of cross-linked semi- conducting compound of 0.8mm nominal thickness applied in the tandem with the insulation.

14.6 Over Sheath

Cables shall be normally provided with extruded PVC over sheath.

14.7 Cable Glands

The sizing of glands shall be based on nominal dimensions, and for glands having inner seals consideration should be given to the tolerance of the bedding diameters because these can affect the sizing.

The gland seal shall be for use with extruded sheath bedding. All glands shall be available with integral earth facility.

14.8 Armoured Cable Terminations

Where armoured cables are to terminate at switchgear and apparatus the terminations shall be made with compression type glands. The glands shall provide effective earth continuity from the steel wire armour to the gland body. The glands shall provide effective moisture seal and shall be complete with a PVC shroud. All cable sockets shall

suit the size of conductor and shall be hydraulically crimped to the conductor using a compressor.

All cables shall run directly from point to point without joints.

15 LAYING POWER CABLES

15.1 Bedding

For multi-core cables with shaped conductors, the bedding may consist of either an extruded layer of PVC compound or of two or more layer of PVC tape. In cables having circular conductors the bedding is normally an extruded layer of PVC.

15.2 Installation of PVC insulated Power Cables

The cables shall be of 600/1000-volt, and shall be supplied in one length, no through joint will be allowed without the written permission of the Engineer.

The contractor shall be responsible for the correct measurement of all cable lengths.

Cables shall be delivered to site on drums. The size of cables and number of cores shall match the equipment location and no. of cores.

15.3 Testing

Immediately after installation, cables shall be tested with a 500-volt test set to demonstrate that the insulation resistance between cores and earth is satisfactory.

15.4 Bends

The bending radius of cables during installation shall be kept as large as possible, and cables are not be allowed to be bent to a radius less than that specified in the Standards.

15.5 Delivery and Marking

Wire and cable shall be delivered to the site of the project in original packaging or on factory reels, fully identified with tags or labels, indicating the manufacturer's name and date of manufacture. In addition, the name of the manufacturer, insulation type, voltage rating, and wire size shall be clearly identified. Complete installation shall be carried out as a flush installation using P.V.C insulated.

15.6 Final Sub- Circuits Wiring

Final sub circuit work originating from light and power distribution boards shall be arranged. Unless otherwise specifically indicated on the Drawings all final sub circuit wiring shall be single conductor

Wires run inside galvanized, steel and/or P.V.C conduits and/or under floor steel trunks and shall be protected by circuit-breakers with ratings.

All lead and return wires in single phase circuits and all phases of a 3-phase circuit and neutral, if any shall be enclosed in the same conduit or trucking.

Wires shall not be drawn in conduit or in trucking until after the section for that circuit is complete. Excessive bunching of wires in large conduit or trucking will not be permitted. For final sub circuits not more than five wires shall be run in the same conduit. Where final sub circuits are being run straight back of the distribution board, not more than eight wires shall be enclosed in a single conduit. Forty-five percentage spacing factor shall be allowed where cables are bunched in trunking.

Where connections of fixed wiring are to be made to batten lamp-holders, ceiling fittings and similar equipment the fixed wiring shall be terminated to suitable connections contained in the junction boxes and heat resisting flexible cords shall be taken there from to the lamp holders.

At least 15cm of free conductor shall be left at each outlet switch points and pull box for the making of joints or the connection of fixtures or devices except where conductors are intended to loop without joints through lamp holders socket outlets and similar device boxes.

All lighting and convenient socket outlet final sub-circuits shall have conductor nominal cross-sectional area of 2.5mm for secondary circuits and 4mm for primary circuits. Circuits in excess of 30m shall be increased one size to prevent excessive voltage drop.

15.7 Feeders and Sub-Feeders Installation

Feeders any sub feeders from main. Switchboard to distribution boards and load break switches shall be three phase cable laid on cable ladder.

No cable shall be bent to a radius less than 5 times it is over all diameters

No joints or splices shall be accepted on main and sub-feeders.

In no case shall the cables be directly buried in the concrete or in the screed under the floor tiles. Wires and cables shall be routed in such a way that they are not exposed to excessive heat or to corrosive media. If such a condition is unavoidable the wires and cables shall be of a special type designed for the particular condition and subject to prior approval.

15.8 Wiring Tests

The tests shall be performed to detect wrong connections, short circuits, continuity and grounds. Insulation tests shall be made with up-to-date digital Megger recently calibrated and with LCD instrument technology for testing various kinds of test with high percentage of accuracy and low percentage of error. The test shall be done on all cables and conductors.

Power feeders and circuit conductors shall be tested phase to phase, and phase to ground.

Test voltage and application time for the various cables and wires, shall be submitted to the Engineer or his Representative for approval prior to testing.

All the XLPE (N2XY) cables must be tested according to the manufacture's recommendation.

16 WIRING SYSTEM USING PVC CABLES IN CONDUIT

16.1 General

The wiring system shall consist of PVC insulated cables drawn into conduit. The conduits shall be run on the surface or buried in the building structure in accordance with the installation methods described in the specification.

16.2 Installation

Polyvinyl chloride conduits shall be rigid heavy wall, 90°C. All conduits shall be of one type, and low temperature, ozone, corrosion and moisture resistant.

Metal conduits shall, be rigid galvanized steel heavy gauge not less than 20 mm diameter. The surfaces and threads shall be corrosion-resistant coated. All G.S conduit joints shall be threaded using standard tapered thread. Each conduit, length shall be furnished it a coupling and a thread protection cap for outdoor underground installations, RGS conduit shall, be provided with a: factory applied coating of polyvinyl chloride not less than 0.5mm thick bonded to the galvanized surface. Metal conduits shall be manufactured by "National" or approved equal.

Liquid tight flexible metal conduit shall be provided for short connections to equipment as required. Liquid tight conduit shall have an interlocked flexible galvanized steel core. Male liquid tight the headed fittings shall be attached at each end, and shall have an internal copper-bonding conductor wound spirally in the space between each convolution for the equipment ground conductor. The ground conductor shall be connected to the end or fittings with an approved connector.

Provide cast metal conduit outlet bodies, boxes, fittings, gaskets and covers for exposed conduit installations as required cast boxes and fittings shall be finished as specified. The outlet bodies' boxes fittings and covers shall be cast iron alloy unless specified otherwise with threaded hubs and of sufficient it size to provide free space for all conductors that shall be enclosed.

Covers and gaskets shall be provided for all conduit outlet bodies, boxes and fittings. The covers shall be of the same materials as the box, and. equipped with neoprene gaskets.

Plastic fittings shall be solvent weld type, polyvinyl chloride and match the conduit to which they shall, be connected.

Thread lubricant shall be provided for all metal conduits. The lubricant shall inhibit corrosion and maintain grounding, continuity.

Couplings and elbows shall be of the same type as the conduit to which they shall be connected unless otherwise specified. For metallic conduits, the couplings and elbows shall be steel hot dipped galvanized, threaded, and one-piece. For plastic conduits, couplings and elbows shall, have plain ends for tight weld fits, which form watertightjoints.

Provide PVC boxes and fittings as required switch and outlet boxes installed indoors and concealed shall be PVC provided with screw fastened covers. All other boxes installed outdoors exposed shall be of the cast metal type having threaded hubs.

Conduit shall be supported on approved types of galvanized strap hangers, pipe straps or be secured by means of expansion bolts on concrete, wood screw on wood, or machine screw on metal surfaces. Conduit supports shall be provided on each side of conduit bends or elbows and not more than 1m on each side of each outlet. Field made bends and offsets shall be avoided where possible, but where necessary shall be made with an approved conduit-bending machine. Metal conduits shall be securely fastened to all sheet metal outlet junction and pull (draw) boxes with galvanized locknuts and bushings and full number of threads projecting though to permit the bushing to be drawn tight against the box to insure good electrical contact. Sleeves and inserts shall be furnished and installed as required for the electrical work.

The ends of conduits shall be cut square and the length of screw thread shall be sufficient only to allow the ends of the conduit to butt solidly in all couplings and against the shoulders provided in conduit boxes.

Grounding type-insulated bushings shall be provided on conduits at all distribution boards. The grounding bushings shall be bonded together and to the equipment enclosure or where provided to the equipment ground bus. This type of installation shall also be used at pull boxes to ensure ground continuity.

All metal conduit connections shall be made up tight to provide good electrical and activity throughout the entire length of the conduit run including flexible conduits.

All empty conduits shall be provided with 6 mm diameter nylon rope, or other approved. Not less than 25cm of slack shall be left at each end of the conduit run. Empty conduits shall be tagged at each accessible end with a plastic tag identifying the purpose of the conduit and the location of the other end.

16.3 Flexible Conduit

Unless otherwise specified, all connection to rotating mechanical plant or plant subject to vibration shall be carried out by flexible cables installed in flexible conduit. Where flexible conduit is used for the protection of cables, the conduit shall consist of galvanized flexible conduit metallic tubing sheathed with PVC. The flexible conduit shall terminate in the specially designed two-part brass adapters for sealing the PVC sheathing and connecting both to the solid wiring system and/or apparatus.

For the final connection to machines etc., flexible conduit related to standards should be used. These are to be flexible metallic tubing sheathed with PVC with brass adapters securely fixed at both ends. An external 25mm green/yellow PVC insulated copper earth wire shall be installed externally to the flexible conduit, forming an earth continuity conductor between the equipment and the earthing system. The earth wire shall be connected to purpose made connectors fitting to both ends of the flexible conduit.

16.4 Conduit Sizes

Conduit sizes are to be as indicated or in accordance with the Regulations except that none is to be less than 15mm external diameter, and the maximum conduit diameter is to be appropriate to the available space, particularly in relation to screed depths.

However, should the contractor consider that any sizes will produce difficulty in drawing in cables with the access later specified, he may use additional and/or larger conduits and/or additional provided are that there is no increase in the building such as increasing screed depth.

16.5 Draw-In Boxes

Boxes and covers used with plastic conduit systems shall be molded plastic provided with means for securely terminating the conduits.

Boxes and covers for either concealed or embedded indoor installations used with steel conduit installations shall be galvanized pressed steel.

Boxes and covers for exposed surface mounted installations shall be galvanized cast iron with threaded hubs. Outdoor boxes shall be provided with gaskets to ensure water tightness.

Boxes shall be constructed of galvanized sheet steel, (1.5mm mm.) reinforced where required and with removable covers secured with brass machine screws.

Plastic boxes shall be of heavy molded rigid P.V.C provided with brass insert threads and fixed lugs to receive cover screws.

Draw-in boxes shall be provided to give access to all conduits for the drawing in or out of any cable. These shall be of ample size to enable the conduit to be neatly diverted from one conduit to another without cramping.

No joint will be allowed in draw-in boxes. Draw-in boxes are to be provided on straight runs at intervals of not more than two right angle bends at intervals of not more than 7m.

Conduit boxes, which do not carry any accessory or fitting, shall be used only in concealed locations, unless approved by the Engineer.

16.6 Exterior Conduit & Plates

All conduit erected outside the building shall be weatherproof and armoured type.

Plates shall be of square or rectangular shape to adequately cover corresponding outlet boxes and be designed to fit the electrical devices. Various samples shall be submitted or approval and/or selection by the Engineer.

Fixing screws shall be chromium plated, polished. Screw head shall suit the plates.

Combination (multi-gang) plates shall be provided for grouped outlets and devices as detailed on the architectural and/or electrical drawings. Grid switch system shall be as manufactured by "MK Electric Ltd." The Engineer or his Representative shall approve color.

Plates for packet outlet shall match s Palestine particular area.

16.7 Humidity and Temperature

Except where otherwise particularly specified, horizontal conduit runs are to be laid flat without fall with care to avoid low points at which water may collect.

No drainage holes are to be provided and the tendered is to be ensuring that the conduit system is free from moisture before cables are drawn in.

16.8 Vertical Cables

Where cables are enclosed in vertical runs of conduit exceeding 4m in length, suitable clamps are to be fitted at intervals of not more than 2m to relieve strain on the cables caused by their own weight.

16.9 Routing

Conduits run on the surface are to be parallel to the structural lines with several conduits following the same general run brought together in a neat closely spaced group. The contractor should note that the shortest routes would not necessarily be followed.

The Engineer or his Representative shall agree routing of these conduits before the installation commences.

Conduits can only be run in the floor finish with the Engineer or his Representative approval and they will be fixed to the body of the structural with the permission of the engineer.

At the control building, conduit sets through walls will not be permitted and where a change of direction is required after passing through a wall an appropriate back outlet box is to be fitted. Conduits shall run horizontally or vertically or parallel with the features of the building. Unless otherwise specified conduits shall not run on exterior of the structure without agreed permission for the route.

16.10 Conduit in Concrete

Where conduit is laid on the structural floor prior to lying of floor finish, the contractor shall seal the ends of conduit and all-adjustable boxes, circular boxes etc. to prevent ingress of grout. The conduit shall be installed at a depth such that the floor cover over the conduit is at least 25mm.

The contractor shall ensure that the conduit is secured firmly prior to laying the finish to ensure no movement takes place during this operation

Where conduit or conduit boxes are fitted to the ceiling prior to plastering, the tendered shall seal the ends of the conduit and all adaptable boxes, circular boxes etc., to prevent ingress of plaster.

Where conduit is to be installed under plaster finish, the conduit shall be recessed into a chase in the wall to the full depth of the conduit. The installation shall be such that the depth of plaster over the conduit is not reduced relation to the depth over the wall and shall be not less than 10mm.

16.11 Fixing of Conduits

Conduit Hangers and Supports

Conduit throughout the project shall be securely and rigidly supported to the building structure in a neat and workmanlike manner, and wherever possible, parallel runs of horizontal conduit shall be grouped together on adjustable trapeze hangers.

Where surface conduit is specified it shall be fixed by means of spacer saddles and shall terminate in deep pattern conduit boxes. Surface conduits shall not be bent or cut to enter accessories. If a suitable accessory is not obtainable, the accessory shall be mounted on an approved packing piece of sufficient thickness to align the conduit entry with the surface conduit.

No comment, plaster or similar filler or nails may be used to permanently fix conduits.

Conduit boxes and conduit laid in a floor finish shall be finally fixed to prevent displacement while the finish is being laid.

PVC conduits in ceilings are to be fixed at intervals of not more than 1.2m and at least once in any run of less than 2m.

Conduits in wall chases are to be fixed at intervals of not more than 1.2m by crumpets knocked in building cavities surface. Conduit shall be supported at intervals not greater than given below:

SIZE	INTERVAL
20mm	1500mm
25mm	1500mm
32mm	1500mm
38mm	1500mm

16.12 Fillings

All conduit fittings and accessories, including screwed couplers, ordinary clips, saddles, pipe hooks, screwed reducers, stopping plugs, lock nuts and male and female bushed shall be manufactured in conformity with Standards.

16.13 Metal or P VC Adaptable Boxes

Particularly at smaller motors, cable terminations shall be carried out to provide maximum protection from damage and the facility for easy disconnection.

Adaptable boxes shall be of cast iron of finish corresponding to the conduit. The boxes shall be of size suitable for accessories. In surface, wet or exterior positions cast iron adaptable boxes are to be used. Boxes mounted outside a building shall be cast iron with external fixing lugs. Covers shall have a machined surface around the perimeter matching with a similar machined surface on the box. A weatherproof gasket shall be fitted between the cover and the box. A box used with partitioned metal trunking shall have internal metal partitions of the same material as the box. The nominal thickness of the partition shall be at least 1mm.

16.14 Connections at Motors

Where conduit terminates at an item, which can be moved through a limited distance, e.g. motor on slide rails, the conduit shall terminate into a junction box located adjacent to the motor and containing a rigid fixed terminal block with frilly shrouded terminals. From the junction box a suitable size 3 or 4 core PVC/SWA/PVC sheathed cable shall be run to the motor terminal box. Alternatively, flexible conduit with PVC sheathing and containing a circuit protective conductor may be used when approved by the engineer.

16.15 Protection

Where galvanized conduits are used, conduit fittings including switchboxes etc. shall be hot dip galvanized inside and outside and all fixing screws shall be brass. Stainless steel (316) type junction boxes can be used in outdoor areas; the boxes shall be equipped with Cable glands.

17 EARTHING SYSTEM

17.1 General

The Earthing System shall comply with the Requirements of British Standard Code of Practice CP1013 Both HV and LV Earthing System shall generally be as shown on the Drawings.

Insulated copper wires of different gauges shall be used to connect all HV and LV metal work to their respective earth electrodes

The LV neutral resistance to earth shall not exceed 40 ohm and shall be outside the resistance area of I metal work earth.

The earthing resistance measured values shall be submitted to Engineer or his Representative for Approval and additional Electrodes or Mats as required achieving the desired Value.

Rod Diameter shall not less than 19 mm diameter Copper or Copper clad steel provided with hard end tips and Driving Caps.

Each rod shall be provided with non-ferrules clamps for connection of copper tape and shall be housed in —Pre-cast concrete inspection champers set flush with the ground.

All equipment shall be connected to the earthing system, a solid galvanized steel earth bus bar with minimum dimension 30mmx4mm shall be provided within each building's ground beams of the pumping station.

Copper/lead electrodes of 19mm diameter will be used in triangle form with three-meter distance between each other, to enforce the earthing system which uses the galvanized steel tape in buildings' ground beams.

Earth leads and earth tapes shall be of high conductivity bare copper or galvanized steel in internal dry conditions and where they are run underground or in damp locations they shall be tinned for copper and painted with anti-corrosion material for galvanized steel.

As far as possible they shall be continuous without joints, but where joints are unavoidable, they shall be bolted and welded. All such joints shall be coated with anticorrosive paint and wrapped with self- adhesive PVC tape.

Where earth leads and earth tapes are required to be buried, they shall be at a depth of not less than 500 mm (18"). Where they are fixed to building surfaces, they shall be fixed at intervals not exceeding 1.0 m (3'4") with copper or galvanized steel saddles of the spacing type. The saddles shall be tinned or welded where necessary to correspond to the lead or tape being fixed.

An earth test link is to be provided adjacent to all switchboards. The link shall be 13 mm x 3 mm copper strip secured across a 50 mm (2") break in the earth lead tape by high tensile steel bolts and nuts. All earthing cables shall be installed in accordance with the relevant requirements called for in the cables section of this specification -

All bonding leads in the form of cable having a standard conductor shall be terminated in "sweated" sockets and shall be rigidly bolted to earthing terminals.

All earthing cables shall be insulated with a green PVC sheath. Where connection in the earth lead to the Main earth is made with a standard cable, the earth lead shall be double insulated with PVC sheaths, the outer sheath being colored green.

The main ground connection shall be bonded to a grid of electrodes of galvanized water pipes buried in the ground, and shall provide a minimum ground resistance of 2 ohms. The connections from the main ground to the switchboard shall be of 50 sq. mm. copper cables.

17.2 Mains Connections

Connections between the earth bar and principle items of equipment shall be made using copper tape or stranded cable not less than 75 sq mm cross sectional area with an overall green or green I yellow. Connections shall be Secured using brass PVC Covered Saddles Secured with brass Screws at 300 Millimeter canters

The whole of the electrical installation and equipment connected there to shall be effectively earthed in accordance with the regulations, and to the requirements of the local supply Authority.

The entire earthing cable installation together with the metallic sheathing of cables shall be electrically continuous throughout funning a completely bonded system. The followings shall be considered to be connected to earthing system:

All distribution boards shall be provided with a separate earth bus bar.

All motors shall be earthed with a separate earth conductor included in the feeder cable serving same. All outlets and lightning fixtures shall be earthed by means of earth conductor connected directly to the distribution boards.

Electric power systems (machinery) shall be connected to the earthing circuit at the source point of electric current feeding the building, i.e. at the source point and not at the load point.

The bins and steel tower shall be properly earthed.

17.3 Label

Every earthing lead must be protected against mechanical damage and have, at its point of connection to the electrode or other means of earthing, a permanent label indelibly marked with the words 'Safety Electrical Earth-Do Not Remove ', in English and Arabic.

17.4 Bonding

The installation-earthing terminal should be bonded to all metal bodies, the water or gas supply if available.

Suitable fitting shall be used.

The contractor shall bond all interior fixed and exposed metalwork to the main earthing system.

All fortuitous points of contact or possible points of contact between services shall be bond together.

The minimum size of earth conductor for the bonding shall be 16.00 mm2.

All bonding details shall be submitted for comment by the engineer, before the works commences.

17.5 Tests

After installation the contractor shall carry out tests in accordance with the Regulations to ensure continuous and correct earth. The results of these tests shall be recorded and passed to the engineer.

The contractor shall give the Engineer or his Representative two weeks' notice of the timing of all earthing tests so that the Engineer or his Representative may be present.

17.6 Boxes

Earthing terminals shall be provided in all outlet boxes & lighting firings including switch. The earth continuity conductor shall be connected direct to the earth terminals on all metal outlets, lighting, switches, local isolator or motor connections.

17.7 Outlet Loop Impedance

A phase-to-earth loop impedance test shall be carried out at every final outlet position.

a. For final circuits supplying socket outlet, the earth loop impedance at every socket outlet is such that disconnection occurs within 0.4 seconds.

b. For final circuits supplying only fixed equipment, the earth fault loop impedance at every point of Utilization is such that disconnection occurs within five seconds.

17.8 Resistance to Earth

All fixed metal installations including stairs, ladders or any metal body within of any switch, switch socket of other electrical outlet, shall have a resistance to earth of not more that I ohm, and the contractor shall provide the necessary bonding wherever a reading greater than 1 ohm is recorded. The service trunking shall be final sub-circuit cable earth continuity conductor.

17.9 Earth Electrode System

The main switch room shall be provided with an earthing system. The contractor shall be drive 20mm external diameter covered copper earth rods into the site or earth mats, and electrically bond them to the earth tape.

The numbers of rods and length of trench shall be sufficient to give an earth electrode resistance not greeter the 1-ohm.

Earth rods shall be 20 diameter steel cord hard drawn copper sheath supplied in 2.4mm lengths with internally tapped thread at one end and screwed stud at the other, complete with driving head, tape clamp and steel spike. Rods shall be driven to their full depth. Tests clamps shall be installed 300mm below finished floor level in the substation to provide facilities for periodic testing of the earth mat.

The contractor shall take tests with a Megger Earth-meter or equivalent instrument to ascertain the resistance of the rod earth electrode(s) and shall drive or bury further rods as applicable if necessary until the resistance of the electrode (s) is less than specified. When more than one electrode is necessary the contractor shall ensure that the zones of earthing or the rods do not overlap.

All tape surfaces at joints etc. shall be tinned and retained in metal-to-metal contact by means of sweating and riveting.

Bonds to electrodes shall be protected against moisture and corrosion by the application of three coats of anti-corrosion paint.

Joints may be made by the thermal process, as approved by the Engineer or his Representative or by bolted, riveted or clamped. Additionally, it shall be ensured that:

- 1- Copper jointing surface shall be tinned.
- 2- Galvanized steel jointing shall be painted with anticorrosion material.
- 3- Aluminum jointing surfaces shall be treated with approved jointing pastes for jointing to tinned copper or other non-ferrous metals.
- 4- Copper connection to iron earth plates etc. shall be brazed and bolted.
- 5- All bolts, rivets and clamps shall be of brass bronze or similar non-ferrous material.
- 6- Joints and connections to electrodes shall be protected against Moisture and Corrosion.

Earth leads within the buildings shall be secured at intervals not exceeding 1m.

Water mains shall not be used for Earthing. Where water mains are bonded to an electrode the earth electrode resistance to earth required shall not include the resistance to earth or water mains.

17.10 Main Switch room Earthing

In the switch room a main earth bar shall be installed 50cm above the finished floor level. To this all metal enclosures or main switchboards, and other non-current carrying metal parts shall be connected by copper tape. PVC\ PVC cable shall be taken to outside the building and connected to an earth electrode mat with electrodes spaced at least 3 meters from each other. The neutral bus bars of main panels together with the star point of the transforms shall be connected to the earth mat.

The minimum number of rods shall be three, placed in the form of a triangle with 3 meter each side. All the rods shall be interconnected firmly by brazing. The top of each electrode shall be complete with a lid suitably engraved and the assembly installed flush with the ground level. The connection between earth leads and earth rods shall be made by means of high copper alloy cast body connectors with silicon-bronze connection to be buried in-group without danger of corrosion. The resistance should be not more than 2 ohms.

17.11 Earth Rods and Plates

The rods shall be a hard-drawn conductivity copper with purity and mechanical properties. Rods shall be in 20mm diameter x 2400mm section and driven to a depth to achieve the required resistance.

17.12 Metallic Parts Bonding

All Metallic parts shall be bonded to the structure of earthing system, conductor size for bonding I earthing shall be according to IEC Standards.

17.13 Earth Bosses

Earth bosses shall be welded into the main Structure and it will be used for Protective earth Connections.

18 LIGHTNING PROTECTION

18.1 General

The works shall be protected against lightning discharge protection system. This shall be supplied, installed, tested and commissioned. The installation shall comply with the standards.

The system used shall have the following components:

- 1. Air terminations (Aluminum)
- 2. Down conductors (Aluminum)
- 3. Joints and bonds
- 4. Earthing terminations (copper)

18.2 Air Terminations

The system shall consist of horizontal conductors for the protection of the flat surface.

No part of a flat surface shall be more than 9 meters from the nearest protective conductor.

All metallic installations, bins, conveyor, steel frame, ducts, gutters, radio and television aerials on or above the main surface structure of the roof shall be bonded to, and form part of, the air termination network. All such metalwork shall be bonded to the network.

For portions of the structure, which vary in high, the termination network of the lower portions shall, in addition to their own down conductors, be bonded to the down conductors of the higher portions.

18.3 Joints and Bonds

All external metal on, or forming part of, the building structure including the metal roof and skylights, shall be bonded to the lightning protection system with a bond having a cross-sectional area not less than that of the main conductors. The system used shall be as few points as possible.

Joints of dissimilar metals shall be protected from moisture by an inert, tenacious material.

Air termination network shall be connected to the down conductor, which shall continue to the ground floor test point and earth pit.

18.4 Earth Terminations

Each down conductor shall be separately connected to an earth termination. The earth terminations shall be bonded to the earth network or earth conductor of the electrical system, and to the lowest and highest points of metal service and cables. A test clamp mounted a 600mm from ground level shall be provided on every down conductor and labeled 'Lightning Conductor Earth-Test Clamp'.

Each electrode shall consist of 16mm diameter steel cord; hard drawn copper sheathed rods suitably coupled to form a continuous l. length. The rod shall be complete with a hardened driving cap and tip and a conductor strip clamp.

The overall resistance to earth of the lightning conductor system, before bonding to the metal or services in or on the structure shall be less than 5 ohms. If it is not possible to

achieve the 5-ohm resistance with one rod per down conductor, then the number of rods per down conductor shall be increased accordingly.

The contractor shall detail and submit to the Engineer or his Representative for comment the location of all down conductors and shall not commence work before receiving the comments of the engineer.

18.5 Earth Rods and Plates

The rods shall be drawn conductivity copper with purity and mechanical properties. Rods shall be in 19mm diameter x 2400mm section and driven to a depth to achieve the required resistance. Earth plates shall be of the lattice type 900 x900 x 3mm square.

18.6 Inspection Pit

At each rod position a concrete inspection pit shall be installed 325mm square x 225mm deep with left up lid.

18.7 Surge protection

Lightning arrester lightning controller is used to protect the system from transient voltage and lightning voltage.

Lightning controller is a plug — in multiple spark gaps. The device must consist of nine partial spark gaps, formed by ten heavy-duty carbon discs. The precisely defined spacing of the spark gaps is safely ensued by highly heat-resistant Teflon discs. Blade contacts of pressure die-cast zinc, which are screwed to each other, clamp the spark gap together with accurate positioning. Eight of the nine spark gaps are capacitive controlled and thus ensure a precisely defined operating surge voltage of less or equal 2kV.

Lightning Controller lightning arrester

Nominal voltage	230 V/50-60 Hz
Maximum continuous operating voltage	255V
Requirement class to DIN VDE 0675, Part 6 (Draft	B class I
11,89) Al, A2	
to IEC 61643-I	
LPZ	$0 \rightarrow 1$
Insulation resistance	>100 MΏ
Voltage protection level	< 2Kv
Response time	<100 ns
Surge voltage test (10/350)	50 k A
Peak current	25 As
Charge	0.63 MJΩ
Spec. Energy	12.5 kAr.m.s
Mains follow-up current quenching capacity of the arrester at UC	25 k A
Maximum asymmetric short- circuit current	500 Ag L/g G
Max. Series fuse (only required if there is no such fuse	17.6k A r.m.s
already in	
the network)	
Short-circuit strength (series fuse 500 A gL)	25 kA

Maximum asymmetric short-circuit current	-40 C TO + 85 C
Temperature range	<i>≤</i> 95 %
IP Code	IP 20
Tille in the section rigid/flexible/stranded	10-50/0-25/10-35 mm
Mounting MA) at least 4 Nm	AWO 8-2 Snap-fitting on 35 mm
	top-hat rail to DIN EN

19 CABLE TRAYS & CABLE LADDERS

19.1 General

Cable ladder shall be formed perforated steel of not less than 0.9mm thickness up to and including 200mm width, 1.25mm thickness from 150mm up to and including 400mm width and above. They shall be galvanized unless otherwise indicated on the drawings.

Tray shall be adequately sized to support the cables without bunching.

19.2 Fixings

Support shall be by means of steel bracket installed at intervals necessary to provide a rigid fixing and ensure that no undue deflection occurs in the complete installation. Dome headed bolts; nuts and washers of finish suitable to the tray shall be used between tray and brackets.

Fixing of the fabric of the building shall be by means of expansion type plugs or bolts. Fixings shall be galvanized unless otherwise stated.

19.3 Installation

Cables should be laid in one layer closed to each other with suitable distances according to the calculations. The control cables shall be laid on separate cable ladders with distance of at least 300 mm to cable ladder for power cables.

On the cable ladder a small cable tray must be installed for telecommunication and alarm cables.

Cable tray shall be installed using factory formed bends elbows trees, couplers and rises etc. Site fabrication of elbows etc., will only is permitted with the prior approval of the Engineer or his Representative and where it is not possible to obtain the necessary factory-made item.

Where cuts have been made the tray shall be painted with zinc rich paint.

Holes that have been cut to allow cables to pass through shall be suitably bushed.

Suspension sets shall comprise threaded M12 cadmium plate's hanger rods together with nuts and locking washers, vertical hanger brackets, support channel, tray hold down clips etc. all of which shall have a galvanized finish.

All cables shall be securely fixed to tray work and the complete installation must be carried out in a neat and workmanlike manner without crossovers. A 25% reserve margin in size and weight shall be allowed for all cable tray works.

Cables of 30mm dia. and above shall be fixed using the appropriate size cable cleat as manufactured by BICC Ltd., or have approved equal type and manufacture.

On multi light-duty cable run, cable straps of plastic-coated metal shall be used to secure cables. Bunching of cables will not be allowed. Cables shall be clipped by means of copper or brass saddles and clips where high temperature or humid conditions are likely to be experienced. In all cases, saddles, clips straps etc. shall be fixed to the tray by means of brass screws or bolts and nuts.

20 TRUNKING

20.1 General

Cable trunking and connectors used for internal works shall be metal or PVC and including accessories. If the trunking size is not indicated on the drawings, the wiring capacity shall be determined from the standard tables in Regulations. All items of equipment and accessories (e.g. end caps, connecting sleeves; bends etc.) shall be in accordance with the manufacturer list. Only where the manufacturer's standard fittings are inadequate to meet special local situations will fabricated trunking and fittings are accepted.

Where special fittings or section of trunking are fabricated they shall be prepared and finished to be the same standard as the manufacturer equipment.

Standard flange assemblies or flanged adapters shall be used to terminate trunking in apparatus, at adaptable boxes and points where it is desired to connect one section of trunking to another. The practice of cutting and bending the material will not be accepted.

20.2 Connections

Connections between trunking and apparatus shall be by a 4mm-paxolin fillet fixed between the equipment and the trunking to prevent the chafing of capable on metalwork. The cable slot out in the paxolin fillet shall be 6mm smaller all round than the slot cut in the metalwork.

As an alternative a standard flanged adapter or flange assembly shall be used. Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with smooth bore brushes or grommets and the return edge of the lid of the trunking is left intact.

Where connection is made between trunking and distribution board, the cable entry or entries shall be sized to accept all cables from used and 'spare' ways.

Individual pieces of trunking shall be independently supported. On straight runs fixings shall be at regular intervals not exceeding 1800mm.

Where weatherproof trunking is used fixing screws shall be brass.

Cable supports shall be provided at intervals of 900mm in vertical runs to support cables. Where a fire bather is required between floors a 'cable support' shall be provided at floor level and fire-retardant sealing which can resist a fire for at least 60 minutes.

Where extra low voltage circuits are contained in the same trunking as low voltage circuits, cables insulation for low voltage circuits shall be used. The cable for each different system shall be laced together to denote the different service and voltage ranges and installed on cable separators fixed at 900mm intervals.

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 the Regulations.

21 LIGHTING

21.1 General

Luminaries have been selected to provide the illumination levels in accordance with the Lighting standards and handbooks. If the space envelope of any facility is changed from the Contract Drawings, the Contractor shall adjust the lighting layout for that space to/maintain these standards.

Provide all new lighting fittings, wall brackets, lamps, auxiliary lighting units and other fixtures and materials, including proper space, and completes the interior and exterior lighting installations as shown on the drawings.

All outdoor equipment shall be weather proof and gasket, the equipment shall have the manufacturer's corrosion resistant finish, and the lighting equipment shall be completely fabricated, assembled, checked and tested at the factory.

21.2 Fluorescent Standard

Fluorescent tubes shall conform to International Standard where applicable. Where local fittings are proposed the standard shall be submitted for approval.

21.3 Fluorescent Ballasts

Ballast's for fluorescent fixtures shall be equipped with thermally actuated automatic reclosing protective devices. The overheat protective device shall be sensitive to current and winding temper start and shall prevent ballast case temperatures from exceeding the factory identified temperature. The ballast Fluorescent and incandescent lighting equipment shall be surface, recessed and pendant types as shown on Drawings and in individual lighting fittings specifications. The lighting fittings shall be complete and include all the required components, ballasts, lamps, wiring, hardware and supports.

All lighting fittings shall be complete with lamps as specified, throughout the building.

The Contractor shall not order any lighting fitting until final approval of the type and colour finish, has been issued by the Engineer or his Representative.

21.4 Fluorescent Lamps

Lamps shall be provided for each lighting fitting. Service voltage, bases, wattage and mounting shall be compatible with the fitting specified.

Fluorescent lamps shall be rapid start, 120 cm, 36 watt or 60 cm 18 watt. The lamp life shall be approximately 18,000 hours and the initial light output shall be approximately 75 lumens per watt. Incandescent lamps shall be general service inside frosted, 220 volts, with base and watts as specified. The lamp life shall be approximately 750 hours and the initial light output shall be approximately 10 lumens per watt. Fluorescent lamps shall be tri-stimulus 3500°K color.

21.5 LED Lamps

Provide Sylvania, General Electric, Westinghouse, or equal lamps of size and types as indicated on the drawings. Lamps shall be operating before final review of the work is requested.

LED lamp-life hour is approximately 50,000 hours.

21.6 LED Driver

LED driver shall be installed in an electrical enclosure.

Wiring inside enclosure shall comply 600V/105 degrees rating or higher.

LED driver shall comply with UL standard UL1012.

LED driver shall have Class A sound rating.

LED driver shall be UL certified for use in a dry or damp location.

LED driver shall tolerate sustained open circuit and short circuit output conditions without damage.

LED driver shall comply with the requirements of the FCC rules and regulations, Title 47 CFR Part 15 Non-Consumer (Class A).

21.7 Light Emitting Diode (LED) Fixtures

Luminaires shall be controlled by photocells or automatic profile dimming & motion response override as required by the design.

Outdoor luminaires shall have provisions for house side shield to prevent glare to uphill neighbors.

Luminaire shall have door frame and lens with LED arrays and integral airflow ventilation system.

The light distribution pattern of the luminaires shall be suitable for a S/H ratio of approximately 1.8.

Pole mounted lights shall have in line/in pole fusing.

The lighting system shall consist of the type and manufacturer as shown on the drawings or approved equal. If other than fixture shown is submitted complete illumination calculations are required to show equality.

21.8 Instruction Sheets

Provide five sets or instruction sheets covering operation and maintenance for each type or fitting furnished Provide all the equipment installations and wiring installations, including connections as indicated, specified and required. Assure proper fits for all equipment and materials in the spaces identified for the fitting.

21.9 Supply Voltage

All lamps supplied shall be suitable for 220V supplies with control gear. All mercury, metal halide, low and high-pressure sodium lamps described in this section shall operate with 10% reduction in the rated voltage provided that the correct control gear shall be used. Color-plus mercury tungsten lamps must be operated on the correct supply voltage.

21.10 Lighting Fittings General

The contractor shall supply, install, connect and test the various types of lighting fittings as specified. They shall be complete with housing, diffusers, ballast's, capacitors, holders, lamp tubes etc.

All fillings having a discharge lamp shall have a power factor not less than 0.85 lagging.

All fluorescent fittings shall be of the electronic, quick or starter less type. The ballasts shall be totally enclosed in drawn steel housing, polyester filled with low ballast losses or

to suit local standards. Capacitors shall be of the self-healing metalized polypropylene (dry) fibber type. Power factor improvement shall be provided to 0.95. A 0.005 F radio interference suppression capacitor shall be provided.

21.11 Lighting Installation

The contractor shall provide and install the necessary material to give the following methods of connection of luminaries:

- 1. Connections to luminaries into false ceiling shall be made by means of an individual ceiling rose, plug and 3-core flexible PVC cable PVC sheathes. Where connection is to a tungsten lamp fitting the flexible cable shall be heat resisting.
- 2. Connections to surface mounted luminaries shall be made with ceramic insulated connections to which heat resisting tails to the luminaries shall be connected. Heat resistant gasket shall be provided to prevent the lamp heat affecting the sub-circuit wiring.
- 3. Where recessed low voltage fittings are indicated with individual transformers a plug and socket shall be provided.

The transformers and plug shall be arranged so that they can be reached via the cut out provided for the fining.

Circuit cables shall not be routed via luminaries. White break joint rings shall be provided between the fitting and conduit box to mask the joint where necessary.

Except where otherwise specified, the lighting fittings shall be connected to the subcircuit wiring using 10-amp porcelain shrouded brass connectors and 1.00 mm2 rubber compounds insulated and sheathed cord.

For totally enclosed or 'drum type' fittings flexible connection to the hard wiring shall be with glass fiber sheathed flexible cable.

At fluorescent lighting points were incoming cables pass the choke to the terminal block the cables shall be individually sheathed with glass fiber sleeking.

All the lighting fittings shall be earthed with a yellow/green PVC compounds conductor with the same area as the phase conductor.

Under no circumstances shall totally enclosed lighting fillings be mounted, on conduit boxes housing PVC wiring.

Final connections between fixed wiring systems and lighting fittings shall in all cases be carried out in heat resisting flexible cables.

Under no circumstances shall cables insulated with general purpose PVC be used for final connections to lighting fittings.

Cable connections within enclosed wiring systems and fittings shall be of the single insulation type. All flexible cables not enclosed in lighting fittings, conduits or trucking shall be sheathed, and with insulation having a similar temperature rating to the cable conductor insulation.

Multi-core sheathed flexible cables terminating on a conduit accessory shall be secured to the respective termination by means or a brass slurring gland, screwed into the conduit accessory Scout or flanged, coupling lead washer and brass bash fitted to the terminal devices.

21.12 Flexible Cords

The nominal cross-sectional area of conductor shall not be less than 0.75mm2. Where an earthing conductor is required for metalwork in apparatus and lighting fittings it shall be contained within the flexible cord.

21.13 Cleaning

The contractor in accordance with the manufacturer's instructions shall clean all luminaries and shades before they are finally erected in position.

21.14 Emergency Lighting

The self-contained fittings shall be of the non-maintained type with the exception of illuminated exit signs and be compatible sealed nickel cadmium batteries. A light emitting diode shall be provided to monitor battery charging and lamp condition.

The tube voltage shall be either 8-watt as indicated. The emergency duration shall be 3 hours.

21.15 Conversion Units

Where indicated on the drawings standard fittings shall be equipped with a conversion unit. The unit shall consist of a high temperature nickel cadmium battery pack and a module containing a solid-state inverter, charger and changeover sensor. The light emitting diode must be clearly visible from ground.

In the event of a mains failure the tube or one tube of a mullet tube fitting shall be illuminated. The emergency duration shall be 3 hours.

21.16 Exit Sign

The exit signs shall be of the maintained type and complete with sealed nickel cadmium batteries. The emergency duration shall be 3 hours. The lettering shall be in Arabic and English.

22 ACCESSORIES

22.1 Lighting Switches

Wall and ceiling switches shall be of the standards type used in Palestine. Wall and ceiling switches controlling AC lighting circuits shall be rated at 10A, quick make, type unless otherwise stated.

All switch assemblies shall comply fully with the Regulation for the earthing connection with plates, and operating bars or toggles, where the assembly does not provide a direct reliable electrical contact between the cover plate and the box with effective connection of metal operating bars or toggles, then an insulated earthing lead shall be provided solidly connected to the metal plate and operating bar or toggle and terminating at a fixed earthing terminal in the box. This provision shall be made in all cases when switches are grid mounted and also where PVC insulated and sheathed cables are installed. All switches shall be of quick make slow breaking pattern.

All switches for wall or ceiling mounted shall be specified manufacture complete with steel boxes of the same manufacture. Switches shall be single or multi gang, singles, 2 way or intermediate, with or without neon indicators as required. Earthing terminals shall be provided in each switch box. Finish of plates.

Where switches at any locations are connected to different phases, purpose made phase bather switches shall be installed. The phases shall be separated by means of rigidly fixed barriers and the cable for each phase shall be confined to the area enclosed by the barriers for that phase.

Switches connected to a particular phase shall have separate cover or covers fitted over each phase. The cover shall be engraved in Arabic and English "CAUTION 380 VOLTS".

For flush positions on a plastered or equivalently finished wall, the switches shall have overlapping plates. In places where the finish is fair-faced brickwork, the wiring shall be installed on the back of the wall and make a back entry into the accessories

Each switch in these areas shall be neatly recessed and incorporate an overlapping plate.

For surface mounted positions such as plant rooms, electrical switch room etc., employing a surface mounted system of wiring, switches shall be surface mounted having metal front plates of an aluminum finish mounted in matching metal boxes.

Switches used on lighting final, sub-circuits shall be quick-make, quick-break with silver alloy contacts, in an are cresting moulded base, rocker operated, rated 15 amps minimum, 250 volts A C. Each switch shall be capable of interrupting inductive or resistive loads up to 80% of its full rated capacity.

Switches shall be single, two ways or intermediate, multi-gang or in other combination as indicated on the Drawings.

Generally, where a number of switches are mounted adjacent to each other, they shall be grouped in one box and share a common switch plate, unless they are on different phases of power supply.

22.2 Indicator Switches

Indicator switch units shall be of the ratings shown on the drawings and comprise of switch assembly incorporating a red colored plastic lens housing a neon indicator lamp to show when the switch is in the "ON" position.

Where multiple switches are necessary the cover plate of each indicator switch shall be engraved to show the function of each individual switch.

22.3 Switched Fused Connection Units

All switched fused units shall be complete with steel box with earthing terminal. Units shall be flush or surface mounted, switched or un-switched with or without neon indicator and flex outlet as specified.

Switched fused connection units shall be of the type, which does not expose live metal parts when the fuse holder is opened for replacement of the fuse.

Switched fused spur units shall be fitted with a fuse of the correct rating to protect appliance and wiring served.

22.4 Socket Outlet

16 Amp socket outlets shall conform to 1EC309. All socket outlets and plugs shall be supplied and installed

in accordance with the manufacture, types and sizes and finish as indicated in the specification and drawings. All socket outlets shall be of the screened shutter type unless otherwise stated. All socket outlets shall be switched, unless the contrary is stated in the specification and drawings.

All switched socket outlet shall be complete with steel boxes of the same manufacture, complete with earth terminal.

Assemblies shall comply fully with the requirements of the Regulations concerning the bonding of the protective conductor terminals and such terminal shall be connected by conductor having a minimum cross- sectional area of 2.5mm² to a permanent earthing terminal incorporated in the associated box providing an effective, solid connection to the earth continuity conductor of the installation.

Where the assembly does not provide a reliable electrical contact between the cover plate and box with effective connection of metal operating bars and toggles, then an insulated earthing lead shall be provided solidly connected to the metal plate operating box or toggle and terminating at the fixed earthing terminal incorporated in the associated box.

Assembly installed in the plant area shall be of the surface mounted metal clad type comprising a socket and switch. Boxes and cover plates shall be galvanized.

22.5 Plugs (Socket Outlet)

The contractor shall supply one plug for every two switched socket outlet and socket outlet installed within the contract and shall connect plugs to equipment and plant as detailed in the specification.

22.6 Switch Socket Outlet Sparkless Type

Sparkless switch socket outlets shall be of the tilting mercury (sparkless) pattern.

Unless otherwise indicated or as directed by the Engineer or his Representative the sparkless switch socket outlets shall be 16 ampere, two pole and earthing pin. They shall have single pole switches and be of the interlocking pattern.

Plugs shall be provided.

22.7 Convenient Socket Outlets

Contractor shall supply a unified standard type socket outlet for the whole project.

Socket outlet shall be rated 10-32 amp and 220 volts with two rounded poles 19 mm spacing conforming to British Standards.

Socket outlet shall have a molded plastic or porcelain I base and be designed to fit the appropriate plate or the under-floor outlet box as required or as will be approved by the Engineer or his Representative before purchasing. Contacts shall be self-adjusted and have a non-expanding size limiting entry, to prevent permanent distortion. Where duplex socket outlets are shown on the Drawings, two of this type of socket shall be mounted under one common plate.

Weatherproof type socket outlets shall be provided with a push-on cap retaining ring or alternatively a screw cap.

22.8 Outlet Boxes

The location of outlets shown on Drawings shall be considered as approximate and it shall be incumbent upon the contractor, before installing outlet boxes, to study all pertinent drawings and obtain precise information from the architectural schedules, scale drawings, large scale and full size details of finished rooms approved shop drawings of other trades or from the Architects. It shall be understood that any outlet may be relocated a distance from the location shown on the Drawings, if so directed, by the Architects. Contractor shall make any necessary adjustment of his work to fit conditions for recessed fixtures and for outlets occurring in glazed tile, block, cotta, marble, wood paneling or other special finish material, in order that all boxes may register flush with finish and shall be cantered properly. In centering outlets, due allowance shall be made for overhead piping, ducts, window and door trim, variations in thickness of furring, plastering, etc., as erected, regardless of conditions which may be otherwise shown on small scale drawings. Outlets incorrectly located, shall be properly relocated at this Contractors expense.

Outlet boxes for similar equipment shall be mounted at unit form heights within the same or similar areas. Without any restrictions by the Drawings or instructions on Site, and except where they are located above work benches or positioned to suit a particular piece of equipment, switches and socket outlets shall be mounted at 140 cm and 30 cm from the finished floor level, respectively.

All outlet boxes shall be securely fastened Exposed outlet boxes shall be attached to permanent inserts or lead anchors with Machine screws.

All unused openings in outlet boxes shall be closed with knockout closures manufactured for such purpose. Outlet boxes shall be of shape and dimension suitable for their application as used with switches, socket outlets, and lighting fixtures of the various types and mounting methods applicable.

22.9 Waterproof Switches

In damp areas watertight IP65 switches shall be installed. The switches shall comply with the requirements for watertight installations.

22.10 Times Switches

Times switches shall be of the self-starting type with a rated voltage and frequency of 220 volts, 50HZ respectively and rated current shall be 10amp unless otherwise indicated in the specification or drawings or directed by the Engineer or his Representative

Time switches, unless otherwise indicated or as directed by the Engineer or his Representative incorporate the following:

- 1. A 30-hour spring reserve to drive the mechanism during electricity supply interruptions.
- 2. An easily replaceable cartridge fuse-link, inserted in the motor circuit
- 3. A day omitting device to render the switch inoperative.
- 4. An ON-OFF manual switch to enable the circuit to be controlled without affecting normal operation.
- 5. A 24-hour dial with ON and one-OFF level and a single pole, single throw, switch.

22.11 Insulated Terminal Blocks

The rating voltage of terminal blocks shall be 380 volts between terminals, 220 volts to earth. Terminal blocks shall comprise brass tubular connectors with screw connections contained within a molded block formed of nylon 6, melamine-formaldehyde resin or phenol formaldehyde resin.

22.12 Safety Isolating Transformers Fixed Type

Safety isolating transformers shall comply with specifications. The nominal rated input and output voltage shall be 220 volts and trappings shall be provided on the input winding to suit input voltages or 230 and 250 volts.

Socket outlets and plugs for 220-volt supplies shall be as specified for socket outlets and plugs, voltage and frequency discriminating types.

Bunching of conductors into one terminal will not be accepted, a separate terminal shall be provided for each conductor. A separate terminal block shall be provided for input and output terminations and for each output voltage. Conduit entries shall be provided for input and output wiring.

23 FIRE ALARM AND DETECTION SYSTEM

23.1 Scope

A fire alarm indicator control panel shall be installed at location generally observed at the operator room or workshop area with an auto-dialing panel to contact the fire defense if any fire incident occurs.

Ionization smoke and heat detectors shall be installed in all fire escape routes and all high-risk areas as indicated on the drawings where each detector shall be separately identified in the Main firefighting indicator control panel (fife)

23.2 Principle of System Operation

The system shall consist of two zones with individually identified detectors as shown in the drawings and shall initiate an alarm condition upon operation of either an earlywarning fire detector or a break glass manual call point.

The proposed system shall be operated from a 24V DC stand by battery, which is float charged from the mains. The control panel and repeater shall provide visual indication of each detector where a fife incident has occurred. The proposed system will then activate the alarm system.

The technical director shall contact the appropriate team who shall decide if further alarms should be activated and zones evacuated.

The system shall only be silenced and reset by an authorized person at the main fire alarm control panel.

23.3 Addressable Control Panel

The panel shall provide for an automatic fire detection control panel of addressable type designed to give all the necessary functions called.

The plant and equipment shall be completed with a basic control unit providing indication of each specific detector located in the two zones shown in the attached drawings. The Plant and equipment shall be suitable for use with range of detectors, call points and alarms. Power for the control equipment is derived from the Power Unit, which provides a 24v battery and mains operated charger.

23.3.1 Functions

The system shall be equipped with an isolating system to prevent the user control switches from functioning until manual operation of the 'Active Controls' key switched by an authorized person. The system shall include all following indications and controls

Detector compatibility (low voltage)

Ionization smoke detection

Infra- red flame detection

Heat detection (rate of rise)

Heat detector (fixed temperature)

Function Switches

Activate controls, silence alarm, system reset, and general alarm

23.4 Technical Specification

23.4.1 Construction

Stainless steel front panel hinges and removable from sheet steel box. Box finished in stove- enameled black.

23.4.2 Functions

Common fire indication

Common fault indication

Addressable fire detection for each detector

Addressable fault indication for each detector

Power on indication

Alarm silenced indication

Detector line monitoring for open- circuit or short circuit

Two external sounder circuits monitored for open circuit

Alarm sounder fault indication

Fuse monitoring

Mains monitoring

Battery monitoring when coupled with the Power unit

Continued operation of the system in the event of mains or battery failure

Evacuate by manual operation of the 'General Alarm' switch

Alarm silencing, by manual operation of' Silence Alarms'

Operation by manual operation of the 'System Reset' switch.

The Power Unit shall contain a main operated dc power capable of providing standby and specified alarm loads for the system as well as internally mounted sealed lead acid batteries.

23.5 Manual Break glass Call Point

The break glass call points shall be suitable for flush on steel or concrete surfaces and shall be surface mounting as appropriate.

The call points shall be manufactured in red thermoplastic in both Arabic and English languages.

23.6 Ionization Smoke Detectors

An ionization smoke detector to give rapid response to visible and invisible smoke particles in the range of 0.01mm to 1mm shall be installed.

Quiescent current consumption 30 mA.

23.7 Fire Alarm Bell

The 24 volts DC an alarm bell shall be installed as shown in the drawing with all required electrical approved cables and wires and shall be controlled by the main Fire indication
control panel for operation, and reset requirements. The sound level at 3 meters should not be less than 88db. The alarm bell shall be of IP-42 for internal installation and of IP-65 for external use and shall be engaged with rotary flasher. The current consumption to be 0.05 Amps.

23.8 Power Unit

The power unit shall conform to the standards and requirements of the 'Fire detection and alarm systems in buildings.

The power unit shall be suitable for use with the control unit.

24 TELECOMMUNICATION AND SECURITY SYSTEMS

24.1 Telephone System

The contractor shall liaise with the Palestinian Telephone Company (PALTEL) to provide a full detail about the telephone network at that area to enable himself connect the required numbers of lines.

The wiring and outlets shall meet PTC requirements.

A UPS unit shall be provided to ensure that the telephone system continues to operate during supply failures.

24.2 Low Current Cables

A complete loop of cable trays shall be installed and distributed according to the drawings. Cables shall be classified in-groups to supply the followings:

- a. Control cables.
- b. Fire alarm cables
- c. Telephone cables
- d. PLC cables

From the tray, cables shall run in armored conduit or metal trunking to all the served outlets as per drawings.

24.2.1 Control Cables

PVC / PVC Stranded bare copper Conductors, PVC insulated black or white collared with sequential Numbers, and one green / yellow ground core. Cross section of conductor is (0.75-1) mm. Sq in compliance with VDE 0295 / VDE 0250/ 405 / VDEO8 (Cores).

24.2.2 Fire Alarm Cables

Cables shall be of Halogen —free designed and flame Retardant comply with IEC 331 FOR 180 minutes or fire resist E30/E90 Comply with DIN 4102 Part 12, (N)HXCH FE/180, Internal wiring between detector, Break glass unit shall be PF-200 Fire resistant Cable type with at least 0.8 mm 2 section.

24.2.3 Telephone Cables

The cables shall comply with categories 3 or 5 of EIA/TIA-568-A. The conductors shall be solid copper.

UTP Cables will comply with EIA/TIA-568-A.

Thermoplastic —insulated, individually twisted pairs of conductors; NO-24AWG, color-coded; enclosed in PVC jacket.

STP Cables shall comply with EIA/TIA -568-A. Two thermoplastic-insulated, individually twisted pairs of conductors; NO.22AWG, Color-coded, overall aluminum and polyester shield and NO.22AWG tinned —copper drain wire; enclosed In PVC Jacket.

UTP and STP Plenum Cable: listed for use in air-handling spaces. Features are specified above except materials are modified as required for listing.

UTP Cable Connecting Hardware: Comply with EIAJTIA -568-A. IDC type, using modules designed for punch-down caps or tools.

DC terminal Block Modules should be integral with connectors bodies, including plugs and jacks where indicated.

STP Cable Connecting Hardware: Comply with EIAJTIA-568-A for Connectors, plugs, and jack assemblies

Panel: Modular panels housing multiple, numbered jack units with DC —type connectors at each jack for permanent termination of pair groups of installed cables.

25 Data Cable

25.1 CAT- 6A Cable

- Min. 26 AWG Annealed bare solid copper, CAT-6A Shielded twisted pair Cable 4X2X26/7, Channel optimized to 350 Mhz.
- Meets EIA/TIA 568-B.2-1 Category 6 specifications, Passed UL 444 test and meets CM and CMR ratings
- Worst Case Cable Skew: 45 nsec/100 meters
- Characteristic Impendence: 100(+/- 3) Ohms @20°C, 500MHz, Tested till 700 Mhz
- Conductor Annealed copper wire Diameter 0.52 mm (nominal) or better.
- Insulation High Density polyethylene, Diameter 0.94 mm (nominal) or better.
- Support for Fast Ethernet and Gigabit Ethernet IEEE 802.3/5/12, Voice,ISDN, ATM 155 & 622
- Mbps and Broadband
- DC Resistance Max: $148 \Omega/KM @20^{\circ}C$
- UL Listed and Third Party verified by ETL to "ANSI/TIA/ EIA-568-B-2.1" specifications
- Zero Bit Error verified by ETL
- Shielded material: Aluminum/Polyester Foil 100% coverage
- Flammable resistance
- Sheath Fire retardant PVC Compound (FRPVC) Flame Rating: 60 deg. C As per UL 1685 CM
- PAIRS Color code: Blue / White-Blue, Orange / White-Orange Green / White-Green, Brown / White Brown
- Outer Sheath PVC compound Thickness Diameter 0.5 mm (nominal) Outer diameter 6.5 mm (nominal) or better.
- Mutual Capacitance: 5.0 nF/100m Capacitance, unbalance (Max.) : 330pF/100m
- Standard length: 305 Mtrs (1000 ft.) or longer.

26 Uninterruptable Power Supply (UPS) System

26.1 UPS (Online) with Battery Backup for 10 Hours

- Application: Power supply requirement for CCTV system.
- Technology: IGBT, On line double conversion
- Input:
 - o Nominal AC Input Voltage: 1 Phase 230V AC + Neutral + Earth, 50 Hz
 - \circ Line low/ High transfer: + 15%
 - \circ Frequency range: +- 5%
 - \circ Power factor: >0.9
- Output:
 - o Voltage: 220VAC/ 230VAC/ 240VAC
 - Voltage Regulation: +1%
 - Frequency: 50 Hz+/- 0.1%
 - Output waveform: Pure sinewave
 - \circ Harmonic distortion: < 2% (linear load) / 5 % nonlinear load
 - \circ Power factor: 0.7 to unity
 - Crest factor: 3:1
 - $\circ~$ Inverter overload capacity: 110% 15 min./ 125% 10 min./ 150% 1 min./ >~ 150% 1 sec.
 - \circ Efficiency (AC DC): 90%
 - Bypass: Static bypass
- Transfer time:
 - Line to battery mode: 0 ms
 - Battery to line mode: 0 ms
 - Line to bypass mode: <5ms synchronized with mains
 - Bypass to line mode: <5ms synchronized with mains
- Battery:
 - Battery type: SMF
 - Communication interface
 - Standard: RS 232 port for software interface
 - Optional: SNMP
- Display:
 - Standard: 2-line x 20 characters, Backlight LCD
 - AC input voltage, AC input frequency, Battery voltage, AC output voltage, AC output frequency, AC output load %, Temperature
 - UPS status (Mains fail, Individual phase fail, Battery low DC high, Overload with shut down time, output low, Output high, Over temperature, UPS bypass)
- General:
 - \circ Operating temperature: 0 to 45 Deg C
 - Humidity: Up to 95% RH, no condensing
 - Noise level: < 60 dB (*a*) 1 meter
- Indication: Mains ON, Inverter ON/ OFF/ Faulty, Battery level, Static bypass on, Load level, over temperature
 - Audible alarm: Mains failure alarm/ Low battery alarm/ Overload and load on bypass/ DC high/ Inverter fault
 - Protection: Advanced electronic protection for device safety backed with MCB's
 - Parallel redundant option: Unitary/ Parallel redundant/ Redundant hot standby.

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<u>Constructing Medical Waste Treatment Facility in</u> <u>Gaza and North Governorates</u>

Mechanical Works Specifications

July 2020

Table of Content

1	GENERAL CONDITIONS / REQUIREMENTS	7
1.1	INTRODUCTION	7
1.2	Equipment Ratings	7
1.3	COORDINATION	7
1.4	Equipment	7
1.5	SHOP DRAWINGS	7
1.6	RECORD DRAWINGS AND MANUALS	7
1.7	Services for Testing	7
1.8	SPARE PARTS AND TOOLS	8
2	STANDARDS	8
2.1	INTRODUCTION	8
2.2	STANDARDS FOR INSTALLATIONS	8
2.3	SAFETY AND FIRE PRECAUTIONS	8
2.4	CONTRACTOR'S PLANT AND TOOLS	9
2.5	PIPE WORK CONNECTIONS	9
2.6	MATERIALS	9
2.7	STANDARDS	9
2.8	TRADE CUSTOMS AND PRACTICE	9
2.9	DIMENSIONS	9
2.10	Setting Out	10
2.11	NAMEPLATES	10
2.12	INTERRUPTION OF SERVICES	10
2.13	MISUSE OF MATERIALS	10
2.14	Vouchers	10
2.15	Obstructions	10
2.16	INSPECTION, TESTING AND REJECTION	10
2.17	INSPECTION BEFORE CONCEALMENT	11
2.18	VALVE LABELS	11
2.19	PAINTING, GENERAL	11
2.20	CLEANING	11
2.21	INSTALLATION OF PIPES SERVICES	12
2	21.1 Pipework Supports	12
2	21.2 Pipe Supports Spacing	13
2	21.3 Pipe Sleeves	14
2.22		14
2.23	1 Dro Commissioning Cleaning	14
2	23.1 F16-Continuestonning Cleanning	14
2	23.2 She resistanting	15
2		15
3	COLD WATER AND HOT WATER SERVICES	15
3.1	GENERAL REQUIREMENTS	15
3.2	PIPE WORK	16
3.3	UNDERGROUND PIPE WORK	16
3.4	Domestic Cold & Hot Water Pipe Work	16
3.	4.1 Galvanized Steel Pipes	16
3.	4.2 Distribution System	16
3.5	VALVES	17
3.6	STRAINERS	17
3.7	FLOAT VALVES	17
3.8	WATER TANKS	18
3.	8.1 Materials	18
3.	8.2 Bolts and Nuts	18
3.	8.3 Sealing Materials	18
3.	8.4 Supports for Tank	18
3.	8.5 Iank Cover	18

3.	8.6 Air Vent	19
3.	8.7 Cat ladder	19
3.9	WATER HEATERS	19
3.	9.1 Electric Water Heaters	19
3. 210	9.2 Solar Water Heating System	19
3.10	WATER IVIE TERS	20
3 1 1	COLD WATER BOOSTER PLIMPS	20
3.12	Testing	21
4		
4	FIRE FIGHTING SERVICES	21
4.1	General	21
4.2	PIPEWORK	21
4.3	FIRE HOSE CABINET	21
4.4	LANDING VALVE	22
4.5	INLET BREACHING VALVE CONNECTIONS	22
4.0 4.7	ΓΙΚΕ ΓΙGHTING ΓUMP SET Ppe_commissioning Cleaning	22
48	TESTING	23
4.9	Painting	23
4.10	PORTABLE FIRE EXTINGUISHERS	23
4.11	LABELS AND IDENTIFICATION	24
5	SANITADV EIVTIDES	24
3	SANTARI FIATURES	
5.1	General	24
5.2	WASH BASIN	25
5.3	WATER CLOSET -ARABIAN TYPE	25
5.4	SHOWER IRAY.	25
5.5	HAND SPRAY (HOSE DIB)	20
5.0	ACCESSORIES	26
5.0 5.7	ACCESSORIES.	26
5.7 6	ACCESSORIES ABOVE GROUND DRAINAGE INSTALLATIONS	26 26
5.7 6 6.1	ACCESSORIES ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION	26 26 26
5.0 5.7 6 6.1 6.2	ACCESSORIES	26 26 26 26
5.0 5.7 6 6.1 6.2 6.3	ACCESSORIES ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK JOINTS AND CONNECTORS	26 26 26 26 26 27
5.0 5.7 6 6.1 6.2 6.3 6.4	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION PIPE WORK. JOINTS AND CONNECTORS SUPPORTS	26 26 26 26 27 27
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION PIPE WORK. JOINTS AND CONNECTORS SUPPORTS. WATER PROOFING EL COR DR ANI	26 26 26 26 27 27 27
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK. JOINTS AND CONNECTORS SUPPORTS. WATER PROOFING FLOOR DRAIN. TP APS	26 26 26 26 27 27 27 27
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK JOINTS AND CONNECTORS SUPPORTS. WATER PROOFING FLOOR DRAIN TRAPS. ROOF DRAIN	26 26 26 27 27 27 27 27 27 28 28
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION. PIPE WORK. JOINTS AND CONNECTORS . SUPPORTS. WATER PROOFING . FLOOR DRAIN. TRAPS. ROOF DRAIN. ROOF VENT COWI	26 26 26 27 27 27 27 27 28 28 28
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK JOINTS AND CONNECTORS SUPPORTS. WATER PROOFING FLOOR DRAIN. TRAPS. ROOF DRAIN. ROOF VENT COWL TESTING	26 26 26 27 27 27 27 27 28 28 28 28
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK JOINTS AND CONNECTORS SUPPORTS WATER PROOFING FLOOR DRAIN TRAPS ROOF DRAIN. ROOF VENT COWL TESTING RELOW CROUND DRAINAGE INSTALLATIONS	26 26 26 27 27 27 27 28 28 28 28 28
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION. PIPE WORK. JOINTS AND CONNECTORS. SUPPORTS. WATER PROOFING. FLOOR DRAIN. TRAPS. ROOF DRAIN. ROOF VENT COWL. TESTING. BELOW GROUND DRAINAGE INSTALLATIONS.	26 26 26 27 27 27 27 27 28 28 28 28 28
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION	26 26 26 27 27 27 27 28 28 28 28 28 28
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION	26 26 26 27 27 27 27 27 28 28 28 28 28 28 28
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7.1 7.2 7.1	ACCESSORIES ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK. JOINTS AND CONNECTORS SUPPORTS WATER PROOFING FLOOR DRAIN TRAPS ROOF DRAIN ROOF DRAIN ROOF VENT COWL TESTING. BELOW GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK 2.1 Pipe work -Installations	26 26 26 27 27 27 27 28 28 28 28 28 28 28 28 28
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7.1 7.2 7.7	ACCESSORIES ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK JOINTS AND CONNECTORS SUPPORTS WATER PROOFING FLOOR DRAIN TRAPS ROOF DRAIN ROOF VENT COWL TESTING BELOW GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK 2.1 Pipe work -Installations 2.2 Gully Trap	26 26 26 27 27 27 27 27 28 28 28 28 28 28 28 28 28 28 29 20
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7.1 7.2 7.7 7.7	Accessories ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK	26 26 26 27 27 27 27 27 28 28 28 28 28 28 28 28 28 28 29 29 29
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7.1 7.2 7. 7.7 7.7	Accessories ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK	26 26 26 27 27 27 27 27 28 28 28 28 28 28 28 28 28 28 28 28 28 29 29 29
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7.1 7.2 7. 7.7 7.7	ACCESSORIES ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK JOINTS AND CONNECTORS SUPPORTS WATER PROOFING FLOOR DRAIN TRAPS ROOF DRAIN ROOF VENT COWL TESTING BELOW GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK 2.1 Pipe work -Installations 2.2 Gully Trap 2.3 Floor Cleanout 2.4 Excavation For Pipe Lines 2.5 Bedding And Surrounding Of Pipes Beneath Building 2.6 Bedding and Laving Out Of Drain Pipes -External	26 26 26 27 27 27 27 27 28 28 28 28 28 28 28 28 28 28 28 29 29 29 29 30
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7. 7.1 7.2 7. 7. 7. 7. 7. 7. 7. 7. 7. 7. 7. 7. 7.	ACCESSORIES ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK JOINTS AND CONNECTORS SUPPORTS WATER PROOFING FLOOR DRAIN TRAPS ROOF DRAIN ROOF VENT COWL TESTING. BELOW GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK 2.1 Pipe work -Installations 2.2 Gully Trap 2.3 Floor Cleanout 2.4 Excavation For Pipe Lines 2.5 Bedding and Surrounding Of Pipes Beneath Building 2.6 Bedding and Surround of Pipes -Generally	26 26 26 27 27 27 27 27 28 28 28 28 28 28 28 28 28 29 29 29 30 30 30
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7.1 7.2 7. 7.1 7.2 7. 7.7 7. 7.7 7.7	ACCESSORIES ABOVE GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK JOINTS AND CONNECTORS SUPPORTS WATER PROOFING FLOOR DRAIN TRAPS ROOF DRAIN ROOF VENT COWL TESTING. BELOW GROUND DRAINAGE INSTALLATIONS GENERAL DESCRIPTION PIPE WORK. 2.1 Pipe work -Installations 2.2 Gully Trap 2.3 Floor Cleanout 2.4 Excavation For Pipe Lines 2.5 Bedding and Surrounding Of Pipes Beneath Building 2.6 Bedding and Surround of Pipes -Generally 2.8 Backfilling of Trenches	26 26 26 27 27 27 27 27 27 28 28 28 28 28 28 28 28 28 29 29 30 30 30 31 31
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7.1 7.2 7. 7.7 7.7 7.3	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION. PIPE WORK. JOINTS AND CONNECTORS	26 26 26 27 27 27 27 27 27 28 28 28 28 28 28 28 28 28 28 29 29 30 31 31 31
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7.1 7.2 7. 7.7 7.7 7.7 7.7 7.3 7.3 7.3	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION	26 26 26 27 27 27 27 27 27 28 28 28 28 28 28 28 28 28 28 28 29 30 31 31 31 31
5.0 5.7 6 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 7 7.1 7.2 7. 7. 7. 7. 7. 7. 7. 7. 7. 7. 7. 7. 7.	ACCESSORIES. ABOVE GROUND DRAINAGE INSTALLATIONS. GENERAL DESCRIPTION	26 26 26 27 27 27 27 27 27 28 28 28 28 28 28 28 28 28 28 28 29 29 30 31 31 31 31 32

7.	3.4 Fi	rames and Covers	32
7	3.5 To	esting of Manholes	32
7.	3.6 To	esting Of Drains	33
8	OVER-	GROUND FUEL TANK	33
81	STOPAC	F	33
8.2	FUEL SI	e Iddi v Svetem	35
83	FILTERS	911113131EM	34
84	FUEL PI	IMPS	34
8.5	FUEL PI	PES	35
•			
9	AIR CO	ONDITIONING DUCTED, CASSETTS AND MINI-SPLIT UNITS	
9.1	PART 1	: GENERAL	35
9.	1.1 Se	COPE OF SECTION	35
9.	1.2 SI	PLIT UNITS	35
10	PIPELI	NES AND PIPES WORKS	35
10.1	D		25
10.1		AND PIPELINE MATERIAL	35
10	1.1.1	Granular Material for Pipe Bedding	
10).1.2	Percentage by weight Passing Sieve	
10) 1 1	Pipe Classifications and Fressure Ratings	
10) 1 5	Concrete Pines	38
10)16	UPVC Pines and Fittings	<i>3</i> 0 41
10) 1 7	Reinforced Thermosetting Plastic Pipes and Fittings	42
10).1.8	Cast Iron Pines and Fittings	44
10).1.9	Clay Pipes and Fittings	44
10).1.10	Pipes for Land Drains	44
10).1.11	Stone for Land Drains	44
10).1.12	Pipeline Construction	45
10).1.12.1	Storage and Handling of Pipes	45
10).1.12.2	Pipe laying	46
10	0.1.12.3	Pipelines Bedded on Trench Bottom	47
10	0.1.12.4	Pipelines in Concrete Grades and Surrounds	47
10	0.1.12.5	Pipelines on Granular Beds	48
10	0.1.12.6	Placing Surrounds to Pipelines	48
10).1.12.7	Backfilling of Pipelines	49
10).1.12.8	Deflection Measurements on Group B and Group C Pipelines	49
10).1.12.9	Stanks to Pipelines in Granular Bedding	
10).1.12.10	Dines Dinetruding from Structures Compared Sympour de and Anghen Digels	
10) 1 12 17	Protection of Pineline Components	
10) 1 12 13	Indicator Posts to Pressure Mains	55
10) 1 12 14	Enclosing Granular or Stone Surround with Filter Fabric	55
10).1.12.15	Method of Measurement and payment for Pipe Laving	54
10).1.13	Pipe Work	54
10	0.1.13.1	Pipe Work within Structures	54
10).1.14	Standard of Covers and Gratings	55
10).1.14.1	Storm/Land Drainage	55
10	0.1.14.2	Sewerage	56
11	STEEL	PIPES AND FITTINGS	57
111	Ρ τρε	WORK AND FITTINGS	57
11.1	111 11	General	<i>3 i</i> 57
11	1.1.2	Steel Pipes and Fittings	
11	1.1.3	Ductile Iron and Grev Iron Pipes and Fittings	
11	1.1.4	Other Materials for Pipes and Fittings	59
11	1.1.5	Ladders, Hand railing and Access Platforms	59
11	1.1.6	Pipe Ends	60

11.1.7	Bends, Tees, Tapers, etc	61
11.1.8	Flanged Joints	61
11.1.9	Mechanical Couplings, Flange Adapters and Expansion Joints	61
11.1.10	Pipes for Closing Lengths	62
11.1.11	Collars	62
11.1.12	Works Hydraulic Testing	63
11.1.13	Protection	63
11.1.14	External Coating	63
11.1.15	Wrapping	63
11.1.16	Inspection of External Pipe Coating	64
11.1.17	Painting Coating Pipes and Specials	64
11.1.18	Internal Protection at Pipe Ends	64
11.1.19	Pipe-Work for Laying Above Ground	64
11.1.20	End Protection	64
11.1.21	Low Friction Coating	65
11.1.22	Handling	65
11.1.23	Protection in Iransit	65
11.1.24	Notice of Deliveries	66
11.1.25	Inspection	66
11.1.26	Measurement of Steel Pipes and Specials	66
11.2 CAST	IRON PIPES	67
11.2.1	Cast Iron Pipes and Specials	6/
11.2.2	Joints for Cast Iron Pipes	67
11.2.3	Making Flanged Joints	6/
11.2.4	Making Joints with Mechanical Coupling and Adapters	6/
11.2.5	Cast Iron Specials	67
11.2.6	Protective Coating on Iron Pipes	6/
11.2./	Iesting of Iron Pipelines	68
11.3 STEE	L PIPES AND FITTINGS	69
11.4 GENE	RAL VALVES SPECIFICATIONS	12
11.4.1	General	/2
11.4.2	Gate Valves Water Supply	/3
11.4.3	Gate Valves for Sewage and Related Fluids	/4
11.4.4	Air Valves	74
11.4.5	Pressure Reducing Valves	/4
11.4.6	Inlet Float Valves	/4
11.4.7	Metal Flap Valves	/3
11.4.8	Plastic Faced Flap Valves	/ 3
11.4.9	Non-Return Valves	/3
11.4.10	Pressure and Compound Gauges	/6
11.4.11	Butterily Valve	//
11.4.12	Level Kegulator	//
11.4.13	Dismantling Joint.	/8
11.4.14	Pipe Coupling	/8
11.4.15	Finishes to valves	/8
11.4.10	Flow Meter	/8
12 INSPEC	CTION, TESTING AND COMMISSIONING	80
12.1 INSPI	ection and Testing of Pidel ines	80
12.1 11011	Cleaning and Inspection of Pinelines	
12.1.2	Testing of Pinelines General	
12.1.2	Testing of Non-Pressure Pinelines	
12.1.5	Testing of Pressure Pipelines	
12.1.4	Prenaration for Pressure Test	
12.1.4.1	Pressure Test	
12.1.4.2 12.2 TEST	Ing of Water Retaining Structures	85
12.2.1	Testing of Water-Retaining Structures	
12.2.1 12.3 INSDI	ECTION AND TESTING OF ALL MANUFACTURED ITEMS	85
12.3.1	Works Testing and Inspection.	
12.3.2	Testing and Certification of Motors	
12.2.2	and continentation of motorbin	

12.3.3	Site Testing and Commissioning of Mechanical and Electrical Plant	87
12.3.4	Testing of Lifting Equipment	87

1 GENERAL CONDITIONS / REQUIREMENTS

1.1 Introduction

The General Specifications included as part of this Specification indicates the minimum standard of work, workmanship and materials that will be accepted in the provision of a normal installation. It is not intended to cover the requirements of installations of a specialist nature. The General Specifications shall be read and considered in conjunction with, Particularly Mechanical and Electrical Specifications and Drawings that are issued for and appertain solely to the particular installation concerned; in the event of conflict the more stringent condition shall apply and the Engineer or his Representative IS decision shall be final.

The Contractor shall include for the complete installation, testing and commissioning of the mechanical, associated electrical and plumbing systems outlined on the drawings and described in this specification.

1.2 Equipment Ratings

All equipment selected for use on this Contract shall be suitable for continuous and reliable operation under the external design conditions stated. In addition, items of equipment installed in enclosed spaces may be subject to temperatures in excess of those prevailing externally and this shall be taken into account. Where ratings are given in this Specification and/or shown on the Drawings, they are the actual ratings to be achieved after the application of all de-rating factors.

All equipment and enclosures that may be subject to internal condensation shall be fitted with suitably rated electrically operated thermostatically controlled anti-condensation heaters.

1.3 Coordination

The Contractor shall be responsible for all aspects of project coordination as set out in the General Conditions.

1.4 Equipment

All equipment to be installed under this contract shall comply with the requirements of the General Conditions.

1.5 Shop Drawings

The Contractor shall prepare shop drawings for the installation as per the requirement of the General Conditions.

1.6 Record Drawings and Manuals

The Contractor shall prepare record drawings and manuals as per the requirement of the General Conditions.

1.7 Services for Testing

All fuel, oil, gas, water and electricity for the purposes of testing and commissioning shall be provided by the Contractor up to the date of the issue of the Certificate of Temporary Acceptance. This shall include the initial charging of all systems and equipment with water, oil and gas, etc.

1.8 Spare Parts and Tools

After completion of the Works and during the specified maintenance period the Contractor shall be responsible for the supply and installation at the fixed time recommended by the manufacturers of all spare parts and components, required for the ideal running of all engineering services installation.

The contractor will be responsible to provide the list of recommended spare parts for all equipment used in the project and to provide such spare parts for two years after the maintenance period.

2 STANDARDS

2.1 Introduction

This General Specification indicates the minimum standard of work, workmanship and materials necessary for the execution of the Contract to the approval of the Engineer or his Representative and the true intent of this Specification and associated Drawings.

2.2 Standards for Installations

The installation shall conform to:

- a) The general and specific requirements of the local water authority, public health officer, local drainage inspectorate and other local statutory authorities.
- b) Local authority by laws and other regulations.
- c) General and specific requirements of the local fire officer.
- d) Health and Safety at Work.
- e) Central supply of liquefied petroleum Gases to Buildings.
- f) Factory Act Requirements and Regulations.
- g) Relevant codes of practice of the British Standards Institution.
- h) The requirements of the insurance companies concerned.
- i) The regulations for the electrical equipment of buildings, (current edition) published by the Institution of Electrical Engineers.
- j) The recommendations of the manufacturers of all materials, plant and equipment.
- k) CIBSE Regulations for water supply and drainage services.

2.3 Safety and Fire Precautions

The Contractor shall ensure that safe methods of working are followed when using any equipment of materials which may involve a danger to life or to property and he is to take all necessary precautions to safeguard against damage by fire or explosion where the execution of the works may involve the presence of flame or sparks.

2.4 Contractor's Plant and Tools

The Contractor, unless otherwise specified, shall provide all materials, tackles, slings, scaffolding, ladders, haulage, labour and apparatus necessary for the supply, delivery and erection of the plant on site.

The Contractor shall be responsible for providing at his own expense, all the requirements such as hand tools, hand lamps, and transformers, where necessary, to carry out the works including all cabling and intermediate connections from supply point to location of work. All wiring, cabling, etc., serving temporary installations are to be designed, installed and operated, as to be safe and in full accordance with the appropriate regulations.

As soon as any part of the Contractor's Site establishment or plant is no longer required for carrying out the Works, the Contractor shall disconnect and remove the same to the satisfaction of the Engineer or his Representative.

2.5 Pipe work Connections

The Contractor shall include for all pipe work and connections to all sanitary fittings, and specialist equipment as detailed in the specifications and shown on the Drawings.

2.6 Materials

All materials, plant and equipment shall comply fully with any relevant British Standard Specification or Code of Practice current at the time of tendering.

The Engineer or his Representative reserves the right to inspect materials, plant and equipment on Site at reasonable times and to reject any of the same not complying with the Specifications.

The cost of dismantling and re-erection of the installation occasioned by the removal of rejected materials, plant or equipment shall be borne by the Contractor.

2.7 Standards

Corresponding parts of all apparatus shall be interchangeable and where mechanical or electrical details are used or which any part of parts are covered by a British Standard Specification, all such parts are to be made in accordance with such specification as shall be issued at the date at which the parts have been ordered.

Except where otherwise specified, all bolts, nuts and stud screws thread shall be metric and all pipe threads to be to B.S. pipe threads standards.

2.8 Trade Customs and Practice

The Contractor shall be entirely responsible for arranging and ensuring that the various classes of work comply with local trade customs and practice and shall provide accordingly in his Works.

2.9 Dimensions

The Contractor shall take his own dimensions on Site for all plant and material to be supplied by him and shall be entirely responsible for the accuracy of his measurements.

2.10 Setting Out

The Contractor shall set out the Works in accordance with his installation working drawings.

2.11 Nameplates

All plant and apparatus supplied under this Contract shall be provided with brass nameplates, bearing the maker's name shop or reference number, size, type, test and working pressure, speed and other relevant particulars engraved thereon.

2.12 Interruption of Services

The Contractor shall not, without permission of the Engineer or his Representative interrupt or interfere with the operation of existing services such as water, electric lighting and power, buried cables, sewers, drains, etc., nor, in the case of works of statutory authorities or private owners, without the permission of these authorities or owners.

In the event of any such damage, the Contractor shall be responsible for the making good of same to the satisfaction of the Engineer or his Representative, authorities or owners, as the case may be.

2.13 Misuse of Materials

No materials brought on to Site for incorporation in the Works shall be used for scaffolding or any other temporary purpose.

2.14 Vouchers

The Contractor, at the request of the Engineer or his Representative, must produce invoices, paid or unpaid, or accounts if required as proof that the goods are in all respect as herein specified.

2.15 Obstructions

No extra charge shall be made for moving or circumventing any obstruction or other Contractor's equipment that may be laid on the Site and the Contractor must, therefore, allow in his tender for these and any other contingencies likely to arise.

2.16 Inspection, Testing and Rejection

The Engineer or his Representative shall be entitled during manufacture to inspect, examine and test the materials and workmanship for all plant to be supplied under the Contract, whether at the Contractor's or manufacturer's premises or on the Site. Such inspection, examination or testing shall not release the Contractor from any obligation under the Contract. The whole of the installation shall be tested on completion (in the presence of and to the satisfaction of the Engineer or his Representative or his representative) in the relevant Sections of this Specification as applied to the particular installation concerned.

The Contractor must furnish certificates of test, in duplicate, to the Engineer or his Representative, for all plant or materials specified to be tested at maker's works.

The tests on Site specified hereinafter are to be carried out in the presence of the Engineer or his Representative or his Representative. The accuracy of all tests is to be to the satisfaction of the Engineer or his Representative, whose decision shall be final.

The Contractor shall provide free of charge on the Site at his own expense and/or the manufacturer's works, such labour, materials, apparatus and instruments as the Engineer or his Representative may consider requisite from time to time and as may reasonably be demanded to efficiently test the plant, materials or works as far as completed, until the plant is accepted as a whole by the Engineer or his Representative. The Contractor shall at all times give facilities to the Engineer or his Representative or his authorized representative to accomplish such testing.

The Contractor shall demonstrate, if required, the accuracy of any instrument used for testing. At least seven days' notice must be given by the Contractor of any test carried out on the Site to enable the Engineer or his Representative or his authorized representative to be present if they so desire.

Testing of pipes and other apparatus as specified under the various Sections of Specifications may be required to be carried out in parts against testing as a whole and the Contractor must provide accordingly in his tender.

Should the Works on testing not conform to the Specifications, the Contractors must make them so conform at his own expense and, if he fails to do so within a reasonable period, not exceeding fourteen days, the Engineer or his Representative shall be at liberty to call upon him to remove the defective part and reinstate without cost to the Employer.

2.17 Inspection Before Concealment

Whenever work subsequently to be concealed, requires inspection or testing due notice of at least seven days shall be given to the Engineer or his Representative so that inspection may be made or tests witnessed before concealment.

Failure to give due notice may necessitate the Contractor uncover the work and re install it at his own expense.

2.18 Valve Labels

The Contractor shall supply and fix on all valves and stop cocks throughout the system, white ivorine labels with black engraved lettering to provide a clear indication of the precise function of the valve. Each label shall be numbered to agree with the Schedule of Valves and the' As Built' drawings.

2.19 Painting, General

All firefighting pipes, exposed drainage pipes, exposed water supply pipes and all other related mechanical works to be finished or coated as per the consultant instructions.

2.20 Cleaning

Due allowance shall be made for the full and proper protection of all items of plant and equipment, electrical installation and building structure during the whole of the application of the insulation and painting works.

Any damaged insulation/paintwork shall be replaced at no additional cost to the Employer.

2.21 Installation of Pipes Services

Installation of all pipe work shall follow the detail set out in the accompanying drawings and be in accordance with the best-accepted practice.

Details set out in the following clauses of this Section are generally appropriate to all services except where specifically stated elsewhere in the Specifications and Drawings. All exposed pipe runs shall be arranged to present a neat appearance and, where practical be parallel both with one another and with the building structure, taking due regard however to the grading, venting and draining requirements. All vertical pipes shall be plumb.

All exposed pipe runs shall be arranged so that the longest length of tube practicable is used between bends, tees and flanges or unions. Short lengths of tube joined together by sockets shall not be permitted.

No joints shall be formed within the thickness of walls, floors or ceilings.

Unions or flanges shall be provided generally at a maximum spacing of one per 18 meters in position agreed by the Engineer or his Representative.

Where pipes are held in vices, as when screwing or cutting, care shall be taken to ensure that the pipe surface is not damaged. Any pipework so damaged shall not be fitted. Any pipework surface damaged by scoring whilst being installed shall not be accepted.

The Contractor shall ensure that all pipes, fittings, valves, etc. are free from corrosion and internal obstruction. Pipes and fittings showing signs of corrosion shall not be fitted.

The Contractor shall protect the open ends of all pipework. Suitable caps, plugs or plastic covers only shall be used to cover open ends. Wood, rag or paper plugs shall not be used.

The Contractor shall not use a valve fitted to the open ends of a disconnected pipe to prevent the entry of dirt.

Failure to comply with the above instructions shall mean that the Engineer or his Representative shall have the right to order the pipework to be dismantled for as far as considered necessary and the pipework to be thoroughly cleaned internally.

The Contractor shall carry out this work free of cost to the Employer and shall bear all costs incurred by removing, cleaning and replacing the sections of pipework.

2.21.1 Pipework Supports

All pipework shall be adequately supported on galvanized steel hangers or on brackets with rollers in order to permit free movement due to expansion and contraction.

Pipework support shall be arranged as near as possible to joints and changes in direction. The Contractor shall include for the supply of all necessary supports and brackets complete with all bolts, screws and inserts or plug fastenings. Vertical pipework shall be adequately supported at the base of the rise and at all intermediate levels. Branch circuit pipes shall not be used as a means of support for the riser main.

Brackets and support shall be set out so that they do not obstruct the access to valve flanges or fittings requiring maintenance.

Pipes shall be spaced in relation to one another and to the building structure so as not to interfere with any other service and to allow for the required thickness of thermal insulation as specified later.

Pipes shall not be supported from each other, but, where there is no alternative, the Engineer or his Representative's written approval must be obtained. The brackets so installed shall not prevent the removal of any individual pipe where necessary and provision shall be made for any unequal expansion.

Pipes shall not be supported from any item of equipment.

All hangers and supports, except at necessary fixed points, must be allowed to swing freely to make up expansion and contraction.

All brackets, hangers and supports, are to be hot dip galvanized after manufacture to B.S.729.

In addition to the centers given, support shall be provided adjacent all valves, flanged joints and other special components to prevent undue strain on the adjoining pipework and so that the equipment or sections of pipework may be removed, leaving the adjoining pipework adequately supported at the ends.

Main walls and partition walls etc. where pipes pass through sleeves, shall not be considered as pipe supports.

2.21.2 Pipe Supports Spacing

Supports Spacing for Steel/Metal Pipe

Pipe Size	Horizontal Support	Vertical support
Normal dia. mm Spacing	Spacing	Spacing
15	1.5	1.6
20	1.8	1.9
25	2.0	2.3
32	2.4	3.0
40	2.7	3.3
50	3.0	3.6

Supports Spacing for Plastic Pipes

Pipe Size Horizontal Support Spacing

Normal dia. mm	Spacing
15	1.4
20	1.4
25	1.5

40	1.7
50	1.8
75	2.1
100	2.3

2.21.3 Pipe Sleeves

In all cases where pipes pass through walls, floors, ceilings and footings, the Contractor shall provide sleeves which shall be built in and shall be responsible for ensuring that this is performed correctly. Sleeves shall in no case be used as pipe supports, a free annular space always being provided. Puddle flanges shall be provided on pipework passing through walls and trenches intended to be covered by earth, etc., or where passing through bund walls.

Sleeves shall be of pipe cuttings properly reamed, cleaned and trimmed at 90^{to} bore. Sleeves in non-load bearing walls, floors ceiling and partitions shall be copper or mild

steel to suit the particular pipe materials.

Sleeves shall be provided with an inside diameter of not less than 15 mm. larger than the insulated outside diameter of the pipes.

2.22 Pressure Gauges

Pressure gauges shall be Bourdon tube type with 100mm diameter dial with needle pointer, normal operating pointer, brass casing, bronze syphon and bronze gauge cock, all suitable for the working pressure of the system. Each gauge shall be calibrated in kPa from Zero to 1.5 times the working pressure at the point selected, all to the Engineer or his Representative's approval. All pressure gauges shall be fully tropicalized and fitted with a red indicating needle set to show the normal operating position.

2.23 Testing and Commissioning -General

- At least three (3) working days written notification of all site tests shall be given to the Engineer or his Representative.
- Fuel, water and electricity necessary for the operation of systems in preliminary runs and for adjustments and tests will be provided free of cost by the Contractor.
- The Contractor shall supply all labour, apparatus and instruments necessary for the prescribed tests. The accuracy of the Contractor's instruments shall be demonstrated if required.
- Any defects of workmanship, materials, performance, design of equipment,
- maladjustments or other irregularities, which become apparent during the tests, shall be rectified by the Contractor and the tests repeated at the Contractor's expense, to the satisfaction of the Engineer or his Representative.

2.23.1 Pre-Commissioning Cleaning

Tubes and all items of equipment shall be delivered stored and maintained in storage with their open ends effectively plugged, capped or sealed. All fittings, valves and sundry items shall be stored in clean bins or bagged and stowed in suitable racks. All such stored items shall be maintained under weatherproof cover to be supplied by the Contractor until they are ready for incorporation in the works. Particular care shall be taken to ensure the electrical equipment components are kept clean and dry.

Before installations are handed over or subjected to the inspection and tests required the entire installation shall be thoroughly cleaned, both internally and externally.

All water installations shall be flushed out with clean water. This shall be preceded by chemical cleaning. During the flushing out process provision shall be made to exclude filters, pumps and any other items of plant, which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Engineer or his Representative.

Cold water services shall, after pre-commissioning cleaning and hydraulic testing, be sterilized by the application of chlorine as detailed in BS 6700.

2.23.2 Site Tests

The Contractor shall be responsible for site tests on static systems in order to ensure safe operating conditions consistent with design performance. Such tests shall include inspection and testing of welds and pressure testing for soundness of hydraulic systems.

2.23.3 Commissioning

All aspects of the commissioning procedure shall follow the recommendations in the relevant CIBSE Commissioning Codes. Commissioning shall include:

- Preliminary checks to ensure that all systems and system components are in satisfactory and safe condition before start up.
- Preliminary adjustments and setting of all plant and equipment consistent with eventual design performance.
- Energizing and setting to work all plant.
- Final regulation and demonstration that the installation delivers the correct rate of flow of fluids at the conditions specified in the Contract Documents.

The entire commissioning procedure shall be performed to the satisfaction of the Engineer or his Representative. The results of the commissioning shall be recorded by the Contractor and shall be endorsed by the Engineer or his Representative. The items on the certificate shall be read in conjunction with the appropriate Clauses of this Specification and the design requirements of the drawings and the certified results and statements pertaining to the commissioning procedure shall be interpreted accordingly.

3 COLD WATER AND HOT WATER SERVICES

3.1 General Requirements

The cold and hot water system, as well as the required flushing water system, shall be executed as shown on the drawings, complete with all water distribution piping, water tanks, pumps, solar heat. etc.

The Contractor shall be responsible for providing the main cold water supply pipe and accessories from the municipal water network including obtaining the necessary permits, performing all legal matters and making the tie-in to the water source in accordance with

local codes, regulations and requirements of the water authorities having jurisdiction and including the provision of the water meter or orifice installation as might be required and as instructed by the authorities or the Engineer or his Representative , all on his own account, if it does not exist in the site.

All works shall be carried out to comply with BS6700, current local water and public health regulations and other byelaws and shall be to the entire satisfaction of the Engineer or his Representative.

3.2 Pipe work

Galvanized steel pipes shall be used for the external cold and hot water supply for domestic use. All connections of Galvanized steel pipes to threaded fittings shall be via adapters. Cut threads shall not be allowed.

3.3 Underground Pipe work

All underground potable water pipes shall be galvanized steel pipe (schedule 40). Underground water pipes shall not be run in the same trench as sewer pipes. Adequate precautions shall be taken for protecting underground water pipes from contamination from any source.

All underground pipe work unless otherwise indicated shall be laid at a depth of a 900 mm below finished level.

Underground pipe work shall be bedded on sand with a compaction ratio of less than 0.15, or small gravel. Initial backfill to a cover of 300mm shall be hand consolidated. Backfill material shall be no greater than capable of passing through a 20mm diameter B.S. 1377 sieve. Mechanical ramming of subsequent backfill shall not commence until at least 300mm cover has been hand compacted.

3.4 Domestic Cold & Hot Water Pipe work

3.4.1 Galvanized Steel Pipes

Where specified, pipes for water supply shall be seamless galvanized screwed and socketed mild steel tubes and fittings in compliance with BS 1387 -1967 standard for class B galvanized steel.

For pipe diameters 3" and above, flanges shall be used. For pipe diameters below 2", unions shall be used.

Unions and flanges are required at each side of equipment.

3.4.2 Distribution System

Distribution system shall include hot and cold-water distribution and connection to sanitary fixtures.

All hot and cold-water pipe shall be distributed through under tiles to each sanitary fixture through wall (concealed) to connect their respective fixtures. All hot and cold-water pipe distribution (horizontal) under the tiles shall be PEX pipe within conduits. The outside diameter of PEX pipe shall be 16-mm and its wall thickness shall be 2.2 mm. The pipe

shall be flexible and shall run in conduits (sleeves) to each individual outlet. The conduits shall be flexible corrugated polyethylene pipe of 25-mm outside diameter and 20-mm inside diameter.

Isolating valves shall be installed on cold & hot water supply lines. The valve size shall be of the same bore as the pipe work connection and shall be connected to Cold-water services and hot water services feeders by copper fittings.

The connections of PEX pipes to the taps, mixers etc., shall be made using brass elbow/adapter housed in PVC box (Termination Box) built inside the wall. The boxes shall have provision for incoming flexible conduit.

The termination box shall have compression connection for PEX pipe on one side and female thread for the tap, mixer connection on other.

The complete assembly shall be such that the PEX pipe can be withdrawn and replaced without damaging the wall finish.

The connection of elbow to the tap, mixer etc. shall be made using chrome plated angle valve complete with flexible connection as per the Specifications.

3.5 Valves

All valves shall be of 16 bar working pressure rating.

Gate valves shall be bronze body and trim, solid wedge disc, non-rising stem screwed in bonnet with hand wheel. Gate valves up to and including 50 mm diameter shall be threaded to BS 21. Gate valves above 50 mm diameter shall be flanged to BS 4504.

Check valves installed on the discharge side of pumps shall be of the silent, non-slam, and spring-loaded type to prevent water hammer when the pump stops. Silent check valves shall be threaded with bronze body, bronze seated disk and stainless-steel spring. The valve body shall be of 20 bar working pressure rating.

Gate valves and check valves shall be to BS 5154.

Ball valves shall be chrome plated brass body and cover. The ball plug and valve stem shall be coated with chrome. The ball valves shall be equipped with level handle covered with epoxy plastic. The ball valves shall be threaded to BS 21.

3.6 Strainers

All strainers shall be of 16 bar working pressure rating. Strainers shall be y -type, bronze body with 26-mesh stainless steel screen with 0.8 mm diameter perforations. Strainers shall be threaded to BS 21.

3.7 Float Valves

Float valves shall be of all bronze construction including levers and anus, with plastic float and shall be suitable for a cold-water working pressure of 10 bars.

Float valves shall be of the full bore, equilibrium ball type, designed to close tight against maximum valve disk and balancing piston bucket. Float valves shall conform to BS 1212.

3.8 Water Tanks

PE roof Tanks must be obtained from a manufacturer who is approved. PE roof tanks shall be white color 3 layers and cylindrical in shape.

3.8.1 Materials

White color 3 layers.

3.8.2 Bolts and Nuts

- Bolts, nuts and washers shall be stainless steel grade A4-316 and not A2-304.
- Rubber Capped bolt sets shall be used for fixing the flanges for pipe catchments-
- Diameter of tank fixing bolts shall not be less than 12mm & at a rate of 8 bolt sets per meter.

3.8.3 Sealing Materials

Materials used for joints sealing shall be chemically stable. For locations whereby the respective sealant is in contact with water, such sealant must be non-toxic and must be tested for such non-toxicity in accordance to the SISR 245-1981.

Material for the roof sealant shall be made of EPDM and the main solid sealant shall be made of S.E.B.S. (Stylene Ethylene Butyrene Styrene) i.e. Solid synthetic Rubber.

The main sealant shall be ribbed in not less than 4 locations. These ribs shall be continuous along the length of the sealant without any breaking. Such main sealant shall remain flexible and resistant to ultra-violet rays.

The main sealant shall be subject to testing in accordance to SS245 for the following:

- Effect on taste, odour, colour and turbidity.
- Toxic metals.
- Cytotoxicity.

Such test shall be performed and witnessed by an approved neutral party.

No Resin putty, Fibreglass material, silicon, or non-approved rubbers against non-toxicity, shall be used to seal the joints between the panels.

3.8.4 Supports for Tank

Water tanks shall be provided with transverse stiffened integral support beams or legs capable of spreading the load onto a flat bearing plinth. The number of legs and spacing should be determined by the tank manufacturer to ensure the structural adequacy of the tank and bearing plinth.

Any Internal A4-316 and A2-304.

3.8.5 Tank Cover

• Access manhole panel shall have a 610rnrn diameter opening and complete with Stainless Steel locking device and Hinges-

• The manhole cover shall be designed to facilitate the manhole to be opened fully and/or detachable.

3.8.6 Air Vent

The air ventilator shall be 50mm or 100mm diameter made of UPVC suitably covered with net of mesh to prevent access of mosquitoes and insects.

3.8.7 Cat ladder

- External ladder shall be fitted to all water tanks of height more than 1 meter.
- The external ladder shall be made of the hot dipped galvanized steel conforming to J.I.8. G3101 88400 and H8641.

3.9 Water Heaters

3.9.1 Electric Water Heaters

Electric water heaters are required to supply hot water to sanitary fixtures and shall be designed and rated in accordance with current British Standards.

Electric heater units shall be of the immersed type; heating elements made of nicklerplated copper about 8 wattlcm2 density, with thermostat hot water trap and cold-water inlet baffle.

The units shall be made of heavy gauge stainless steel lined with improved glass or copper, with magnesium alloy or nickel chrome alloy anode and stainless-steel dip tube.

The units shall be provided with 50mm fibreglass insulation and enamelled steel jacket, temperature and pressure relief valves, non-return valve and drain valve.

Each electric water heater shall be fitted with 2 No Y2 " diameter valve for inlet and outlet water.

The top and bottom covers should be made of synthetic material and shape in order to permit easy cleaning of the appliance and has an up-to-date design.

The particular construction should permit rust proof installation in project location. The outlet hot water temperature should be of 60 C in winter.

3.9.2 Solar Water Heating System

Solar water heating systems shall be executed as shown on the drawings, complete with all solar collector units, piping, pumps, electrical connections, fittings, expansion tanks, supports, accessories and all civil works, etc.

The collector units or panels are grouped into assemblies as shown on the drawings. Each of the units shall comply with the following requirements:

Type:	Liquid heating solar flat plate collector
Aperture:	Area: 1.18 SQ.M
Glazing material:	4mm float glass (Outer)

Non (Inner)	
Gross Dims	Height: 10 cm
Width:	75.4 cm
Length:	175.4 cm
Area	1.32 SQ.m.
Weight (Empty)	52 kg
Fluid hold up volume	3.4 LTRS
Absorber Plate Material	Unimetal steel fin-tubes
Coating:	Alkyd base flat finish
Flow Path	Crid parallel
Gen. Desc:	Network of 7 steel tubes pressed Omega - In
	into steel sheet. Tubes are in 10 cm spacing CC.
Insulation:	Under absorber plates: 4 cm rock wool board.
Density	60 Kg/MCU. Coated with aluminum foil
Headers:	Galvanized steel pipe on inch diameter
Absorptivity	85%
Max. working pressure	60 PSI
Max. test pressure	90 PSI
Recommended Flow rate	0.45 GPM/SQ. M

3.10 Water Meters

Water meters shall be provided by the Contractor and procured from the local water authority or approved suppliers. The Contractor shall be responsible for liaison with local Water Authority to ensure that the meters are available at the programmed time. The Contractor shall include for water meters, their handling, storage, installation, labeling etc.

3.10.1 Water Meter Cabinet

The Contractor shall supply and install water meter cabinets in accordance with the Specifications and local regulations. Cabinets shall be manufactured from galvanized steel sheet of minimum 3 mm thickness. The steel sheet shall be Electro-galvanized, powder coated and oven backed at 180 deg.C.

Cabinets shall be sized to house the required number of water meters and shall be provided with a concealed architrave trim, doors, door handle and locks, etc. "

3.11 Cold Water Booster Pumps

Cold-water booster pumps shall be centrifugal type as previously described and multistage where necessary.

Pumps may be an integral part of a packaged booster set. The pump set shall consist of two pump, pressure vessel, and control panel.

The capacity of each pump shall be as shown on Drawings and Bill of Quantity.

Pumps shall be complete with a motor starter/control panel with provisions for water level controls at storage tanks including all level sensing devices and interconnecting wiring. Each cold-water booster pump set shall be controlled and monitored by the MCC. Pump operations shall be controlled by roof tanks level switches and by the main underground

tank low level switch. The later shall act as a dry protection level switch. The set controller shall alternate the pumps in operation, periodically. And shall switch to the second pump; automatically; should the first pump fails.

Run and trip together with high- and low-pressure indication shall be given at the panel. High and low water pressure shall also raise visual and audible alarm at the panel.

Each booster set shall be complete with integral pressure controls, duty sharing and automatic pump changeover etc.

3.12 Testing

The Contractor shall ensure that all pipe work is completely clear of obstructions, debris, or superfluous matter before any tests are applied. Pipe work shall be slowly filled with water, so as to exclude all air. The pipe work shall be tested at 10 bars or 1.5 times the maximum pressure in the system (whichever is greater) for a period of two hours without loss.

The Contractor shall give the Engineer or his Representative two working days' notice of his intention to test a section of pipe work. The Contractor must ensure that each test is witnessed by the Engineer or his Representative and shall maintain signed test reports for the complete installation.

All items of plant and pipe work, which are individually pressure tested, may be isolated from the system (using blanking plates) for the duration of the test. However, the complete system shall then be pressure tested for working pressure after successful pressure testing as described above.

4 FIRE FIGHTING SERVICES

4.1 General

The firefighting services shall be executed as shown on the drawings. All firefighting components shall be approved by the Local Civil Defense Department.

4.2 Pipework

All pipe work shall be galvanized seamless steel to BS 1387 heavy grade. Pipework with screw fittings shall be supplied with screw and socket ends. Pipework for gas and arc welding, where permitted by the Engineer or his Representative, shall be supplied with plain ends, bevelled for butt welding. All pipework and fittings shall be to NFP A 14. For pipe work installation, hangers, welding, etc., details refer to Section 14-22 of these Specifications.

Under tiles, steel pipe work shall be protected against corrosion by two layers of hessian and tar to the Engineer or his Representative IS approval.

Valves, strainers, etc. shall be as specified in Section 3.11 of this Specification.

4.3 Fire Hose Cabinet

Fire hose cabinets shall be installed where shown on the drawings. The fire hose cabinet shall be automatic swinging recessed type of dimensions 80X80x25 mm. Hose reels shall be in accordance with BS 5274.

Where specified, the rubber fire hose shall be 1" x 30m smooth seamless reinforced with double synthetic textile yams layer capable of withstanding a working pressure of 20 bar and a bursting pressure above 50 bar. It shall be complete with 1" nozzle.

Where specified the hose connected to the landing valve shall be 2" x 30m long circular woven synthetic fibre and root proof yam capable of withstanding a working pressure of 16 bar and a bursting pressure of 50 bar. It shall be provided with suitable male and female instantaneous coupling so that it can easily be fixed to the landing valve at one end and to a jet/spray nozzle at the other end.

The hose reel shall be equipped with shut-off valve for connecting with pipe work.

The hose nozzle shall be chrome-plated brass, JET/SPRAY/SHUTOFF nozzle.

The cabinet shall be heavy Aluminum construction finished with red colour paint labelled "FIRE HOSE REEL II in English and Arabic.

4.4 Landing Valve

Landing valve shall be 50mm size screwed inlet gunmetal construction, fitted with 50mm instantaneous coupling with removable blank cap and retaining chain.

The valve shall be hydraulically tested at 20 bar before connected to the riser, and shall be compatible with the local fire authority regulations.

Valve hand wheel shall be 150mm minimum diameter and marked with "OPEN" and "SHUT" direction plate. It shall be normally secured shut with strap padlock.

4.5 Inlet Breaching Valve Connections

Inlet breaching valve connections shall have bronze body with 6Smm (2Y2 inch) nom. dia. threaded bottom outlet and two (2) nos. threaded front inlets with individual, internal drop flaps, extension nipples, chrome plated brass, rectangular escutcheon with lettering "Stand pipe -Fire Department Connection", 2 nos. 50mm (2 inch) nominal diameter, instantaneous male inlets with chain and cap etc. complete.

4.6 Fire Fighting Pump set

The firefighting pump set shall consist of two pump, pressure vessel, and control panel. The capacity of each pump shall be as shown on Drawings and Bill of Quantity.

The pump set shall be provided with motors, starters, controls, pressure gauges, accessories and all other components for the proper operation.

The pump set shall be mounted on concrete foundation extended 300mm above finished floor level.

The fire pump set components, controls and operation shall be as detailed for cold water booster pump set in Section 15 of these specifications with the exception of the following:

- Impeller shall be of bronze construction.
- The pump set shall operate under the control of pressure switches.

- Standby pump shall be diesel engine direct driven-
- The engine may be of the air-cooled type and shall automatically start on demand if the duty pump fails to maintain system pressure.
- The standby pump shall be manually switched off. The engine exhaust pipe shall be insulated and arranged to discharge outside. Multi attempt relay shall be included in control panel to allow at least 3 attempts for the engine to start.
- The control panel shall include an earth leakage sensor with hooter, mute push button and indication lamp.

The fire pump set shall be constructed to Local Civil Defense requirements and a certificate stating this shall be provided with the pumps.

4.7 Pre-commissioning Cleaning

Tubes and all items of equipment shall be delivered, stored and maintained in storage with their open ends effectively plugged, capped or sealed. All fittings, valves and sundry items shall be stored in clean bins or bagged and stored in suitable racks. All such stored items shall be maintained under weatherproofed cover to be supplied by the Contractor until they are ready for incorporation in the works. Particular care shall be taken to ensure that electrical equipment and components are kept clean and dry.

Before installations are handed over or subjected to the inspection and tests, the entire installation shall be thoroughly cleaned, both internally and externally.

All fire protection installations shall be flushed out with clean water. During the flushing out provision shall be made to exclude any items of plant, which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Engineer or his Representative.

4.8 Testing

All pipe work shall be pressure tested at PN 16 and to the satisfaction of the Engineer or his Representative and local Civil Defense Authority.

4.9 Painting

All pipe work for fire protection services shall be given one coat of rich primer and two coats of 'Post Office Red' paint after installation and pressure testing.

4.10 Portable Fire Extinguishers

The Contractor shall supply and install portable fire extinguishers in the positions shown on the drawings.

All fire extinguishers located outside hose reels cabinets shall be complete with wall mounting brackets, and placed inside recessed type, red color cabinets clearly marked (Fir Extinguisher).

Where fire extinguishers are located within fire hose cabinets they shall be placed on the floor of the cabinet.

Dry powder fire extinguisher shall be ABCE type 6 Kg capacity with a rugged all bras operating valve, large size operating lever, full vision pressure gauge, discharge hose and heavy duty drawn steel cylinder with hard, scratch resistant finish.

CQ2 gas fire extinguisher of 5 Kg capacity with a rugged all brass operating valve, large size operating lever, full vision pressure gauge, discharge hose and heavy duty drawn steel cylinder with hard, scratch resistant finish.

4.11 Labels and Identification

All items of Fire protection system shall be labelled and identified according to the requirements of local Civil Defense Authority.

5 SANITARY FIXTURES

5.1 General

The Contractor shall furnish and install all the sanitary fixtures as shown on the drawings and as specified below, complete with all their trim and accessories as specified. Prefix numbers identify and locate the fixtures on the Drawings relative to the fixtures described herein.

Sanitary fixtures shall be of vitreous china of white color. Fixtures shall have smooth glazed surface free from warp, cracks, flaws discoloration or other imperfections.

Imperfect fixtures will not be accepted.

Sanitary fixtures shall be supplied complete with all required metal trim and accessories, as specified, including but not necessarily limited to faucets, wastes, traps, supplies, stop valves, wall flanges, hangers, plates, brackets, anchors, supports, soap holders, toilet paper holders etc.

All exposed piping and metal trim for the sanitary fixtures shall be chrome-plated brass to BS 5750 Part (I) with polished finish.

All vitreous china accessories shall match the sanitary fixtures and shall be of the same manufacture and color.

All sanitary fixtures, trim and accessories shall be the product-approved manufacture and as far as practicable shall be procured from one manufacturer unless specified otherwise.

Sanitary fixtures and their trim and accessories shall be installed in a neat, finished and uniform manner as directed by the Engineer or his Representative. They shall be set straight, true, and securely attached to the supporting surfaces. Roughing shall be accurately laid out to conform to finished walls and doors.

Sanitary fixtures shall be connected to the drain and water supply pipes in an approved gastight and watertight manner and as detailed on the Drawings.

Strap or padded wrenches shall be used on chrome-plated pipe, fittings, valves and other trim.

Sanitary fixtures, metal trim and accessories shall be thoroughly cleaned of labels, plaster, paint dropping and all foreign matter and shall be well polished and tested for perfect working condition before turning them over to the Employer.

Concealed brackets, hangers and pales shall be painted as directed by the Engineer or his Representative.

The Contractor shall submit to the Engineer or his Representative a list of all fixtures, trim and accessories that he proposes to use indicating manufacturer, type and model number, with descriptive catalogues clearly marked as to the item proposed.

The Contractor shall submit samples of all fixtures, trim and accessories when asked to do so by the Engineer or his Representative. The Contractor shall not charge the Employer with the cost of such samples nor shall he use any item different from the approved sample.

5.2 Wash Basin

Shall be white vitreous china, with or without pedestal as approved by the Engineer or his Representative, complete with one tap hole, waste and over flow. Basin shall be securely fixed to wall with fixing brackets or on pedestal.

Taps shall be 15-mm (1/2in) chrome plated (CP) single level monobloc mixer with ceramic disc cartridge combing on-off water flow and hot-cold water mix in one lever control.

Wash basins shall be complete with pop-up waste mechanism.

Pedestal screwed to the floor, if required, 32-mm dia. chrome plated bottle trap with 75mm seal, CP waste tail to wall and CP flange 15-mm dia. C.P. angle valves with rigid CP tail connections and CP wall flanges.

5.3 Water Closet -Arabian Type

White vitreous china Arabian W.C complete with the following trim and accessories: -

- 9-litre vitreous china cistern screwed to wall, provided with PVC flush pipe and brackets.
- Valve less cistern fittings including syphon, bottom inlet ball valve, bottom overflow, right hand lever.
- 15-mm dia. angle valve with flexible copper tubes and wall flange.

5.4 Shower Tray

Where required, shower trays complete with cold/hot water mixers and showerheads shall be provided in locations shown on the Drawings.

Shower tray shall be made from an approved GRP material of dimensions 700 x 700 mm complete with drain (50mm) and plug.

Handicap Shower tray shall be made from an approved GRP material of dimensions 800 x 800 mm complete with drain (50mm) and plug.

The cold/hot water mixer and showerhead shall be as specified under the item for Bath Tub elsewhere in the Specifications.

5.5 Hand Spray (Hose Bib)

Hand Spray shall be complete with CP angle valve, I-meter metal, flexible tube, hand spray, wall hook etc. The metal flexible tube shall be provided with transparent plastic cover. Hand spray to be provided to the right side of each WC for washing purposes.

5.6 Kitchen Sink

- Stainless steel kitchen sink shall be single or double bowl and drainer as specified or shown on the Drawings. Stainless steel shall be type 304 and 1.6-mm thickness. The sink shall be provided with three tap holes for pillar mixer, chain stay hole and overflow and with back splash end.
- The sink shall be complete with the following trim and accessories.
- 40-mm dia. chrome plated waste with stainless steel grating and chain stay and plug.
- 40-mm plastic bottle trap with extension tube-
- Flexible plastic tube for overflow connection.
- 15-mm dia. chrome plated angle valves with flexible copper tube and wall flange.
- 15-mm dia. chrome plated pillar mixer with swivel spouts projection 210-mm.

5.7 Accessories

The sanitary fixtures accessories shall be as shown and detailed on the architectural drawings and shall be from approved suppliers to the Engineer or his Representative's approval.

6 ABOVE GROUND DRAINAGE INSTALLATIONS

6.1 General Description

The work under this section of the specifications shall include all above ground drainage pipe work waste, soil, vent and rain water, complete with all drains, traps, gullies, cleanouts, vents and all accessories, as shown on the drawings and as specified hereafter.

The above ground drainage pipes shall mean all building pipework not buried underground and located as follows: -

- Above floor slab
- Suspended under floor slab
- Under tiles
- In walls
- All vertical pipes (risers)

6.2 Pipe work

The pipes and fittings used for above ground drainage installations shall be unplasticised polyvinyl chloride UPVC and shall conform to BS 3505, BS 4514 and BS 5255, and shall be push-fit type with rubber ring seal.

All change in direction in drainage pipes shall be gradual and not abrupt.

Long sweep fittings and 45-degree fittings, of solvent weld sockets type shall be used.

All pipes shall be plain-ended for seal ring connection to all fittings.

All pipe jointing and supporting shall be made as recommended by the pipe manufacturer.

All pipes and fittings including adapters, couplings and connectors shall be marked with the manufacturer name, BS. number and diameter.

All exposed pipes shall be provided with suitable paint for protection against U.V. rays.

6.3 Joints And Connectors

All joints for above ground drainage pipe work shall be airtight and water tight and- care shall be taken to ensure that no jointing materials projects inside the bore of the pipe.

Seal ring coupling (expansion joint) fitted with black rubber seal ring shall be provided for each vertical pipe (not embedded) located between every two floors, and for horizontal pipes (not embedded) at 4.0 m. intervals.

The connection of UPVC pipes to all water closets shall be made by WC-connector with solvent weld socket and pan seal socket.

Special UPVC connectors and adapters shall be used for connecting the pipes with dissimilar material of other pipes or fittings such as bottle traps, P-traps of plumbing fixtures.

The connection between vertical pipes and under-ground pipes shall be made by long radius sockets bend fitted with rubber seal rings.

6.4 Supports

Vertical pipes shall be supported at a minimum of 1.8 m intervals, and at least two pipe support brackets at the floor height.

All buried pipes shall be supported along their entire length on clean and well compacted layers of fine sand that should not contain any stones.

All hangers and supports shall be of approved types, as recommended by the pipe Manufacturer.

6.5 Water Proofing

Where UPVC pipes pass 'through roofs, they shall be provided with paddle flange to make watertight seal around the pipes at roof level.

The method of waterproofing shall be made as per the drawings and the manufacturer's instructions.

6.6 Floor Drain

Floor drains shall be UPVC trapped floor gully with 110mm diameter top socket, three side inlet sockets, and one 75-mm diameter outlet socket equipped with screwed plug for rodding.

Each side inlet socket shall be 50 mm diameter blanked off and must be cut out of inlet used.

The top socket shall be fitted with 110 mm. diameter raising piece with a 150 mm. square top to suit standard floor tiles complete with a nickel bronze screw down grating.

6.7 Traps

All traps in washbasins, sinks and floor drain, etc. shall have 75 mm water seal. All traps shall have the same bore throughout the trap, connection to the buildings fixed drain shall be via an "0" ring fittings.

6.8 Roof Drain

Roof drain shall be cast aluminium type supplied with socket outlet of size to fit with the rainwater pipes as shown on the drawings.

6.9 Roof Vent Cowl

Roof vent cowl shall be provided for all vent pipes as shown on the drawings. Roof vent cowl shall be UPVC with screened cap and connected to the vent pipe by solvent welding.

6.10 Testing

The work shall be inspected and tested during installation. Testing shall be carried out by applying a 3m water head above the highest section of the pipe under test for a period of 2 hours.

All work, which will be concealed, shall be tested before it is finally enclosed.

A final test shall be made upon completion of the work for soundness and performance in accordance with BS 5572: 1978 Code of Practice for Sanitary Pipe work.

7 BELOW GROUND DRAINAGE INSTALLATIONS

7.1 General Description

The work under this section of the specifications shall include all building underground pipe work complete with gullies, traps, cleanouts, manholes, and all accessories, as shown on the drawings.

The following types of pipes will be used in the work and to be covered by this specification:

- Unplasticised Polyvinyl Chloride UPVC.
- Stainless Steel Pipes.

7.2 Pipe work

The pipes and fittings shall be unplasticised polyvinyl chloride UPVC, push-fit type with rubber ring seal. Pipe size 110 mm and 160 mm shall conform to BS 4660. Pipes shall operate under working pressure of8 bar.

All change in direction in drainage pipes shall be gradual and not abrupt.

Long sweep fittings and 45-degree fittings shall be used.

All pipes and fittings including adapters, couplings and connectors shall be marked with the manufacturer name, BS number and diameter.

7.2.1 Pipe work -Installations

The installation of pipe work shall be carried out in accordance with the requirements and recommendations of BS 5955 Part (6)-1980.

Connections to manholes and main sewers shall be made in a completely watertight and approved manner.

Any connections to existing systems shall be made with minimum disturbance to the existing lines.

Any existing pipelines or structures, which are damaged while making connections, shall be replaced or reconstructed to the satisfaction of the Engineer or his Representative and without any cost to the Employer.

Pipes shall be kept clean until final acceptance of the work. Exposed ends of all uncompleted lines shall be closed with wooden plugs and adequately secured at all times when pipe laying is not actually in progress.

Pipes shall be installed on a good foundation and adequate means taken to prevent settlement. Pipes laid in trenches shall be provided with a solid uniform bearing throughout the entire length.

Pipes shall not be buried at less than 600 mm. below finished grade for protection against mechanical damage. Pipes shall not be run closer than 1 m. to building bearing walls and footings for protection against building settlement.

All pipes shall be laid to a uniform slope as shown on the drawings. The free vertical drop of a sewer pipe into a new or an-existing-manhole shall be limited to 450 mm. between the invert level of the pipe opening and the bottom of the manhole.

Where conditions necessitate that the drop would exceed 450 mm. a drop manhole shall be used, of detail as shown on the drawings.

Trenches shall be kept free of water by pumping, use of well points, under drains or other approved means during pipe laying operations so that all pipe joins are made in the dry.

Precautions shall be taken to protect uncompleted work from floating due to storms or from any other cause. All pipe lines or structures not stable against uplift during construction shall be well braced or otherwise protected.

All joints shall be inspected and an inspection of the lines as a whole shall show all pipes to be true to line and grade with full circle visible at the manholes.

If on inspection the completed sewer or any part thereof shows any structures, pipes or joints which are defective, the defective work shall be replaced or repaired as directed.

7.2.2 Gully Trap

The gully trap shall be UPVC provided with 110 mm diameter, 160mm, P-trap and gully piece as detailed on the drawings

The gully trap shall be provided with 300 x 300 mm clear opening cast iron cover and frame Grade (B).

7.2.3 Floor Cleanout

The floor cleanout (FCO) shall be UPVC rodding eye with 110 mm dia. spigot outlet and supplied with 150 x 150 mm. nickel bronze cover screw down. Floor cleanout shall be provided at each change in pipe direction.

7.2.4 Excavation For Pipe Lines

• Trenches for pipes shall be excavated to a sufficient depth to allow a 100 mm

minimum bed below the underside of the pipe.

- Trench width shall not be less than the outer diameter of the pipe plus 300 mm and not wider than necessary.
- The sides of trenches, manholes and other excavations shall be adequately supported at all times.
- Any material excavated in forming pipe drains shall, if found unsuitable, be run to spoil and replaced with suitable approved material. All suitable excavated material shall be used as backfill except in trench drains-
- Where drain trenches are to be excavated beneath foundations or below the level of adjacent foundations, the sides of the excavation shall be supported by such substantial planking and strutting as steel trench sheeting driven plumb in advance of the excavation proceeding. The trench sheeting shall be carefully withdrawn after compaction of the backfill material so as to cause the minimum disturbance to the backfill and adjacent ground.

7.2.5 Bedding And Surrounding Of Pipes Beneath Building

- All pipes shall be bedded on Class C20 concrete and shall be supported at the concrete cradles placed behind the sockets or on each side of the joint by methods approved by the Engineer or his Representative. The supports shall be provided with soft contact padding such as roofing felt or other approved material.
- The annular gaps inflexible joints shall be sealed with approved means to prevent the intrusion of concrete. The pipes to be in contact with concrete shall be washed clean of any mud or clay.
- Concrete shall be gently and evenly placed over the entire width of the trench of bedding as shown on the drawings, and to within 25 mm. of the bottom of the pipe. Then, without stopping, it shall be placed gently on the side of the pipe only and carefully worked under the pipe, ensuring that no voids are left below the pipe.
- Concrete shall be brought up equally on each side of the pipe to the required finished height, care being taken not to force the pipes off their supports.
- No fill material shall be placed over the concrete until the concrete has reached a crushing strength of 14 N/mm2. The concrete and the pipes shall be kept damp and protected from sun or frost until the concrete has reached the required strength for filling to take place.

7.2.6 Bedding and Laying Out Of Drain Pipes - External

- Immediately following the trench excavation, the pipes shall be laid and jointed on pipe bedding material-
- The pipes shall be laid so that one is in contact with the bed throughout the length of its barrel. Bedding material being scraped away at each socket so that the 30/87

socket does not hear on the bed. Pipes and channels shall be laid with the sockets leading up the gradient. All drainage runs shall be commenced at the point of outfall or at a manhole.

7.2.7 Bedding and Surround of Pipes -Generally

After jointing the pipes, the bedding shall be brought up equally on both sides of the pipe, first to the level of the centre of the pipeline and then up to a height of 300 mm. above the top of the pipe barrel. This material shall be placed in layers not exceeding 150 mm. in thickness and shall be carefully compacted with wooden rammers.

7.2.8 Backfilling of Trenches

- All backfilling shall, as far as practicable, be undertaken immediately after the specified operations preceding it have been completed.
- The backfilling shall be undertaken only after completion of testing for such pipes as described herein. From 300 mm. above the barrel of the pipe up to the formation level of the road, the filling in the trench shall continue with selected approved material from excavations, in layers not exceeding 150 mm. in thick. Each such layer shall be solidly rammed before the next layer is added.
- Where the drain does not run under a road, the backfill material shall be solidly rammed up to the existing ground level in the manner described above.

7.3 Manholes

Manholes shall be of precast reinforced concrete construction and shall be of details shown on the drawings.

Manholes shall be constructed to the required depth. The manholes top shall have a 600mm diameter clear opening and shall be shaped to accommodate a standard size manhole frame and cover.

Inverts shall have a cross section of exact shape as the sewers and all changes in sewer size shall be made gradually and evenly: The floor shall have a gradual slope from the sidewalls to the central channel.

All manhole rings and covers surfaces that connected to the soil shall be coated with asphalt, while the surfaces connected to the sewer must be coated with epoxy paint after pointing between rings and testing the manhole to ensure watertight construction.

If leaks occur, they shall be caulked, repaired or the entire work shall be removed and rebuilt.

Attention shall be particularly paid to the necessary of keeping the water level below all parts of the manhole until the cement has obtained adequate set.

7.3.1 Benching and Inverts Of Manholes

The open channel in the bottom of the manholes shall be formed in the benching with half round of pipe. All side branches shall be connected to the main channel so that the discharge is in the direction of the flow in the main channel.
The benching shall be concrete and shall rise vertically from the edge of the channel pipe to a height not less that the outgoing pipe and be sloped upwards from there to meet the wall of the manhole at a gradient of about I in 6. Rendering to benching shall be applied in a coat of cement mortar (1:1) to a final thickness of 20 mm trowelled to a smooth hard finish.

7.3.2 Temporary Covers

Temporary covers shall be fitted and retained in position on all manholes from the time the top access is formed or the concrete cover slab installed, until the permanent cover is installed.

7.3.3 Step Irons

All manholes of depth greater than 1000 mm shall be provided with galvanized step irons complying with BS. 1247. Step irons shall be staggered in two vertical runs at 300 mm centers vertically and 225 mm horizontally.

The top iron shall be no more than 350 mm below the underside of the manhole cover slab and the lowest no more than 300 mm above the benching. Manhole cover frames shall be bedded in 1:3 sulphate resisting cement sand mortar.

7.3.4 Frames and Covers

The Contractor shall provide for each manhole cast iron frame and cover with a 600 mm diameter clear opening of the following grades of duty service:

- Minimum Duty Load Capacity 8 tons
- Medium Duty Load Capacity 25 tons

Covers shall have the word "SEW AGE" cast thereon in English and Arabic.

The frame shall be thoroughly embedded in mortar, frame, and cover set level and to the proper grade.

All castings for frames and covers shall be of tough grey iron and shall be made accurately to dimensions and machined to provide even bearing surfaces. Covers shall fit the frames in any position and if found to rattle under traffic shall be replaced. No plugging, burning in or filling to obtain tight covers will be allowed.

All castings shall be carefully coated inside and outside with coal tar pitch varnish of approved quality.

All frames and covers shall comply with BS 497 of grades as indicated on the manholes schedules.

The Contractor shall provide at least two keys for each type of manhole/gully trap cover.

7.3.5 Testing of Manholes

Manholes shall be subjected to a hydraulic test. Pipe stoppers shall be inserted into all pipe ends and the manhole filled with water to a height of 300 mm above the highest point of the benching. This water shall stand for five minutes and then be topped up as necessary. The water shall then remain at this level for a further ten minutes to satisfy the test. If the water level falls, then all defects shall be made good to the satisfaction of the Engineer or his Representative, and the test shall be repeated as many times as may be necessary until the manhole satisfactory.

7.3.6 Testing Of Drains

- The Contractor shall provide the necessary labour and equipment and include in his Tender for testing and work to the requirements and satisfaction of the Engineer or his Representative and all relevant public authorities.
- Drains shall be tested by either water or air as directed by the Engineer or his Representative and the results of the test must be approved by the Engineer or his Representative before concerting. A further test shall be carried out after backfilling of excavations. The test shall be carried out in the manner described in the following paragraph.
- To facilitate the general building programme, tests shall be made of sections as the work proceeds; such testing however will not absolve the Contractor from his liability for any subsequent or final testing.
- Any defects that become apparent during these tests of any part or parts of the installation shall be rectified at the Contractor's expense and the part, or parts, retested to the satisfaction of the Engineer or his Representative and the relevant public authorities.
- For a water test, the drain lines shall be subjected to test pressure of at least 3m head of water above the highest point of the section under test. Allowance should be made for added water until absorption has ceased, after which the test proper should be commenced and the water level be maintained for a minimum of 30 minutes without the addition of further water.
- For an air test, a gauge in the form of a glass 'U1 tube shall be provided and connected to the drain plug of the length of drain under test. Air shall be pumped into the length of drain until a pressure equivalent to 100 mm. head of water is indicated on the gauge. Without further pumping, pressure should not fall below 75 mm. during the period of five minutes.
- The whole of the installation shall be left clean and free from debris
- The Contractor shall keep a record of the tests carried out on the drainage installation throughout the Contract, recording date of test, by whom tested and the result, one copy of the records shall be sent to the Engineer or his Representative on completion of the Contract.

8 OVER-GROUND FUEL TANK

8.1 Storage

The supplier/manufacturer will supply and install over ground fuel storage and fuel supply system complete with all necessary items to ensure that it is fully functionally to meet the Principals needs with supporting documentation and installation manuals.

The fuel storage tanks shall be horizontal cylindrical type of 4000 litter and shall be constructed from black steel (6mm) welded sheets to the size as indicated in the drawings.

The tank shall be provided with the following:

- One Φ 50 mm screened air vent.
- One Φ 50 mm fill lines complete with isolation valve gunmetal cap and chain.
- One Sight Tube level gauge from PE transparent color.
- Two $\Phi 100 \text{ mm}$ capped sockets to include purpose made brass dip rods. Rods to be calibrated in liters engraved onto the brass at not greater intervals than 0 100mm.
- One $\Phi 25$ mm suction line from tank to daily fuel tank through feeding pump, complete with isolation valve and foot valve.
- One Φ 20mm return line from daily tank over flow
- Two 60x 60x70 cm manhole, fitted with a lid raised and securely fixed by bolts and gasket to provide a liquid and vapor tight joint.
- One Ladder shall be provided for external access into the tank.
- One Grounding system shall be cupper electrode (3.6 m x 019 mm)

8.2 Fuel Supply System

The fuel supply system shall comprise of one main supply line. The supply line from the tank to feed the generator daily fuel tank is by fuel pumps.

8.3 Filters

Single type fuel filters shall be fitted on the inlet side of the fuel pumps.

The filters shall be line size, tested to 20.6 bars and shall have gunmetal body and covers, stainless steel internals with a stainless steel mesh element and be complete with brass drain plug. The elements shall be capable of filtration down to 100 microns.

8.4 Fuel Pumps

Duty and stand-by fuel pumps shall be provided in the generator room. The pumps shall be of the positive displacement gear type pumps, with mechanical shaft seal, close-grained cast-iron body and steel internals. One pump is manually operated, and the second pump is electrically operated. The motor shall be of flameproof induction type, direct-coupled impeller by stainless steel shaft. A fuel filter shall be filled at the inlet of the pumps. Both pumps shall operate in an alternation manner.

Pumps shall operate with a following:

Capacity: o $5m^3/hr$, Head of 10 m.

8.5 Fuel Pipes

Pipes shall be black seamless steel to BS 1387 heavy gauge with black threaded malleable iron fittings for pipes up to 50mm diameter.

9 AIR CONDITIONING DUCTED, CASSETTS AND MINI-SPLIT UNITS

9.1 PART 1: GENERAL

9.1.1 SCOPE OF SECTION

Air Cooled Condensing Unit

1. System Description

- Outdoor Mounted, air cooled split system outdoor section shall be suitable for on the External walls installation. Unit shall consist of a hermetic compressor, an air-cooled coil, propeller type blow-thru condenser fan, accumulator, holding refrigerant charge, and control box.
- Ducted units shall be installed on the ceiling each Room or Floors or Halls according to Drawings.
- cassettes' units shall be installed on the False ceiling of the Rooms, Halls or Floors according to Drawings.
- AHU's shall be installed on the Roof of the building.
- 2. Quality Assurance: System shall be rated and certified in accordance with ASHRI standards

9.1.2 SPLIT UNITS

- Factory assembled, single piece, air cooled outdoor unit, contained within the unit enclosure shall be all factory wiring, piping, controls, compressor, holding charge of R-22 or R-410, Refrigerant, and special features required prior to field start up.
- Unit cabinet shall be constructed of galvanized steel, compressor compartment shall be isolated to assure quiet operation.
- Condenser fans shall be direct drive Propeller type, and motors shall be totally enclosed.
- Compressor shall be fully hermetic reciprocating or Scroll type Copland or Hitachi for small size (1 TR to 4 TR) and Copland or Danfuss for big size (> 4TR)
- Condenser coil shall be constructed of aluminum fins mechanically bonded to internally enhance seamless copper tubes.

10 Pipelines and Pipes Works

10.1 Pipe and Pipeline Material

10.1.1 Granular Material for Pipe Bedding

Granular material for pipe bedding shall be free-draining, hard, clean, chemically stable gravel, crushed stone or crushed slag, graded in accordance with the following table: -

10.1.2 Percentage by Weight Passing Sieve

Test Sieve for Pipes of Diameter

for Pipes of

mm	400 mm and above Below.	Diameter 600 mm
63	-	-
37.5	100	-
20	85 - 100	-
14	-	100
10	0 - 50	85 - 100
5	0 - 10	0 - 25
2.36	-	0 - 5

Note: For pipes 400 mm to 600 mm diameter, either grading is acceptable.

The material shall have a Compaction Fraction value not exceeding 0.2 when determined in accordance with the following test:

A representative sample of about 40 kg shall be heaped onto a clean surface and quartered to obtain approximately 10 kg. The moisture content of the sample should not differ materially from that of the main body of material, at the time of use in the trench.

A 150 mm internal diameter open ended cylinder 250 mm high shall be placed on a firm flat surface and loosely filled, without tamping, from the 10 kg sample. Any surplus material shall be struck off level with the top of the cylinder. The area around the filled cylinder shall be cleared of all surplus material and the cylinder then lifted clear of its contents and placed alongside the material.

Approximately one quarter of the material shall then be replaced into the cylinder and compacted by tamping vigorously with a 40 mm diameter metal rammer weighing about 1 kg until no further compaction can be obtained. This operation shall then be repeated for each of the remaining quarters, tamping the final surface as level as possible.

The distance from the top of the cylinder to the surface of final layer shall then be measured and this value, divided by the height of the cylinder, shall be taken as the Compaction Fraction.

Pipe bedding material to concrete pipes shall not contain more than 0.3 per cent sulphate, expressed as sulphur trioxide.

For uPVC pipes only rounded aggregates will be permitted but for all other pipe materials crushed aggregates may also be used.

10.1.3 Pipe Classifications and Pressure Ratings

For structural purposes pipes shall be classified into three groups: -

Group A: Rigid pipes which do not depend on lateral support from the bedding and trench sides for structural strength.

Pipe materials include: -

- Concrete
- Clayware
- Asbestos Cement
- Pitch Fiber
- Grey Iron

Group B: Flexible pipes which depend on lateral support from the bedding and trench sides for structural strength and to prevent distortion.

Pipe materials include:-

- RP (Reinforced Thermosetting Plastic Pipes)
- uPVC (unplasticized Polyvinyl Chloride)
- HDPE (High Density Polyethylene)
- PP (Polypropylene)

Group C: Pipes which have some flexibility but which have sufficient strength to support some loadings without assistance from the ground.

Pipe materials include:-

- Steel
- Ductile Iron

Pressure pipes shall be supplied to the following rated pressure classifications:-

Asbestos Cement	12 bar
RP	12 bar
uPVC	12 bar (12 bar rated pipes)

10.1.4 Joint Requirements and Limitations

Unless pipes are detailed with rigid joints or are specified differently all pipelines shall be jointed with approved mechanical, flexible joints with elastomeric joint rings. The whole joint assembly shall be compatible with the pipe construction and with the specified performance of the completed pipeline.

Flexible joints

May comprise either an integrally formed socket (bell) and spigot assembly with single sealing ring, or a separate sleeve coupling and double spigot assembly with two sealing rings.

The completed joint shall be capable of accepting the following ranges of deformation when subjected to internal pressure without losing its seal at the specified test pressure, without direct contact between spigot and socket/coupling and without inducing stresses or strains in the pipe material beyond the safe working limits.

Pipe Diameter		Minimum Angle
Angular deflection: (all materials)	up to and including 200 mm	30
	Over 200 and not over 500 mm	1.750
	Over 500 and not over 1350 mm	10
	Over 1350 mm	0.50

Shear:

Pipe materials which are listed in structural groups A and C shall be loaded to 20 N/mm of pipe diameter. Pipe materials which are listed in structural group B shall be subjected to 5% elliptical deflection of the spigot end forming part of the joint.

If the approved standard for a pipe material does not include a shear test for the jointing system, this test shall be carried out in accordance with test procedure of another appropriate pipe material standard.

Elastomeric joint sealing rings shall be manufactured from ethylene propylene rubber (EPM, EPDM) and shall have a hardness measured in International Rubber Hardness Degrees (IRHD) compatible with the pipe material.

Gaskets for flanged pipes shall be manufactured from ethylene propylene rubber (EPM, EPDM) 3.2 mm thick and shall be dimensioned to full face of the pipe flange and to suit the flange drillings. The hardness of the rubber (IRHD) shall be to the manufacturer's recommendations to suit the pipe material but for pipe materials in Groups A & C shall be in the range 66 to 75.

10.1.5 Concrete Pipes

The materials, manufacture, physical requirements, dimensional variations, workmanship and finish for the manufacture of pipes shall meet the requirements of BS 5911.

In all cases the Engineer shall approve the sources of materials for pipe manufacture and shall supervise the necessary tests on representative samples to ascertain their compliance with the Specifications prior to importation of the pipes to the site of works. All tests shall be performed by or under the supervision of the Engineer and at the Contractor's expense.

The Contractor shall be solely responsible for securing all pipes and fittings required for the Contract regarding quantity, type and quality from any source unless otherwise specified and the Employer shall not guarantee the availability of such materials on the local market.

All cement used for the manufacturing of concrete pipes shall be of a fresh and approved quality Portland approved cement Type I, complying with the requirements of ASTM C150.

Reinforced and unreinforced concrete pipes shall be of sound manufacture.

Unreinforced concrete pipes shall generally conform to BS 5911 spigot and socket type except in respect of internal diameter, minimum crushing strength and internal dimensional tolerances.

The crushing test loads in KN/linear meter of effective length when tested in accordance with BS 5911and shall be not less than given in Table below.

Crushing Strength of Unreinforced Pipes

Nominal Internal Diameter of Pipe (mm)	Load (KN/linear meter)
250	35
300	39
350	44
400	48
450	52
500	55

Reinforced concrete pipes shall generally conform to BS 5911 except in respect of internal diameters, minimum crushing strength and internal dimensional tolerances.

Unless otherwise agreed with the Engineer pipes up to and including 1400 mm internal diameter shall be of the spigot and socket type and pipes with internal diameters in excess of 1400 mm shall be of the joint type.

The crushing test loads in KN/linear meter of effective length when tested in accordance with BS 5911 shall be not less than given in Table below.

Nominal Internal Diameter of Pipe (mm)	Load (ken/linear meter)	
600	105	
700	105	
800	140	
900	155	
1000	175	
1200	210	
1400	225	
1600	270	
1800	310	
2000	350	

Crushing Test Loads of Reinforced Concrete Pipes

In the event that the minimum crushing test requirements are not satisfactory and upon the approval of the Engineer and at his discretion, the pipes shall then be protected by encasing them in (250 kg/cm2) concrete in accordance to Concrete Work of these Specifications and the engineer's instructions. The thickness of concrete encasement shall be sufficient to obtain the same minimum crushing strength requirements but shall not be less than 150 mm. No additional payment shall be made in lieu of this work other than that for the pipes at the rates indicated in the Bill of Quantities. The Contractor shall not be entitled to claim for an extension of time with respect to this work.

All pipes and fittings shall be marked indelibly after manufacture. The markings shall include:

- (a) Name of Manufacturer.
- (b) Date of manufacture and serial number.
- (c) Nominal diameter.

Nominal diameters shall refer to internal diameters of pipes.

The tolerances of the nominal diameter of pipes shall be ± 5 mm for 250 to 500 mm nominal diameter, ± 10 mm for 600 to 1000 mm nominal diameter and ± 15 mm for 1200 to 2000 mm nominal diameter.

The tolerance on the length of an individual pipe shall be ± 20 mm. The checking of dimensions and tolerances shall be done with special gauges approved by the Engineer, to be supplied by and at the expense of the Contractor.

All pipes manufactured in accordance with BS 5911 shall be tested and certified in accordance with the requirements of BS 5911. All rejected pipes shall be promptly stamped "Rejected" in a conspicuous location on the pipe.

10.1.6 UPVC Pipes and Fittings

British Standard shall apply all pipes works.

The contractor shall furnish, install and test the UPVC pipes, fittings and appurtenances, as indicated on the Drawing and as herein specified.

All pipes, fittings and appurtenances shall be of make upon or similar approved by Engineers Reprehensive. Pressure pipe shall be of class PN10 (10MPa) and gravity joints of class N (5MPa). Unless specified otherwise, pipes and fittings shall have socket and spigot and jointed with butyl rubber rings as supplied by the pipe manufacturer.

UPVC pipes and fittings shall be manufactured and tested to the relevant approved standard for their pressure or gravity duty.

UPVC pipes for gravity pipelines shall have a standard dimension ratio, D:t (diameter to thickness), of between 35 and 42.5.

Any pipes exhibiting cracks, notches or deep scratches or other damage will be condemned and shall not be incorporated into the permanent work under any circumstances.

Prior to shipment from factory all types of pipes shall be hydraulically testes to the manufacturer's test pressure, and the contractor shall submit to the Engineer's Representative for each consignment of shipment an authenticated certificate to indicate that the pipes and fitting have been tested by the manufacturer and found to comply with these Specifications.

BS 3503: 1986	Specification for un-plasticized polyvinyl chloride (UPVC) pressure pipes.		
BS 3506: 1969	Specification for un-plasticized polyvinyl chloride (UPVC) pressure pipes.		
BS 4346	Joints and fittings for use with UPVC pressure pipes.		
BS 4660: 1986	Specification for UPVC pipes and fittings.		
BS 5481: 1989	Specification for un-plasticized polyviny1 chloride (UPVC) pipes and fitting for gravity sewers.		

All UPVC pipes and fittings shall be Rigid conforming to British Standard for unplasticized standard. The material from which the pipe is produced shall consist mainly of poly-chloride to which may be added small quantities of those additives needed to facilitate the manufacture of the polymer. The finished pipe shall be of good and sound quality surface finish mechanical strength and capacity. No chemicals shall be used in the pipe manufacturing process that will impair it's again and strength properties.

All pipes and fittings shall be packed in such a manner to prevent warping of pipes and loss of fittings. Prior to installation all pipes and firings shall be inspected by the

Engineer's Representatives representative for any defects. Any pipe of fitting which in the opinion of the Engineer's Representatives Representative shows signs of defects in material or workmanship shall be rejected and removed from site.

Pipe dimensions shall be designed by the outside diameter and the wall thickness shall confirm to British standard.

All pipes shall be homogeneous throughout and free from visible cracks holes and foreign inclusions. External and internal surface of the pipes shall be smooth, clean and free for grooving or other defects. The pipe ends shall be cleanly cut and square with the axis of the pipe.

All UPVC fittings shall be of the same quality as the pipe and confirm to the manufacturer's standards.

The spigot end of socket and spigot pipes shall be marked at a distance from end equal to the depth of the socket. The two jointing surfaces shall be cleaned and dried immediately before joints are made and where applicable, lubricant is applied. Only gaskets or rings, and joints lubricants supplied by the pipe manufacturer shall use for making joints.

The pipe laid shall be accurately aligned with the pipeline before the joints is pushed home to the location mark on the spigot end. Levers, jacks or pullers as recommended by the manufacturer and approved by the Engineer's Representatives Representative, shall be used for pushing joints together. A feeler gauge or visual check shall be made to ensure that the jointing ring is positioned correctly and is not twisted or displaced from its groove.

Any pipes damaged as a result of the jointing operation shall be replaced at the expense of the contractor.

10.1.7 Reinforced Thermosetting Plastic Pipes and Fittings

Pipe manufacturers must be Members of, or affiliated to, a quality control or certification authority relevant to the pipes or fittings proposed for incorporation in the Works.

GRP units will be manufactured using materials to the approved standard. The laminate construction will include a resin rich inner layer of minimum thickness 1.50 mm and a resin rich outer layer of minimum thickness 1.00 mm.

The incorporation of silica sand onto the outer layer will be permitted.

Silica sand aggregate fillers shall be graded and between the sizes 0.50 mm and 3.00 mm.

The resin shall be cured to reach hardness not less than 90% of the resin manufacturer's recommended hardness using a prescribed test.

A manufacturer's tolerance of $\pm 2.00\%$ shall be allowed on the nominal diameter of the pipe. The pipes shall be supplied in standard lengths of 3, 6 or 12 meters with a tolerance of ± 25.00 mm. The deviation from straightness of the bore of the pipe shall not exceed 0.30% of the effective length or 15.00 mm whichever is smaller and shall apply when measured on site. Up to 10% of the pipes will be allowed in random lengths.

The ellipticity of any pipe when measured resting freely on the ground shall not be more than 2% of the mean diameter at any point. No pipe known to have undergone a deflection greater than 10% shall be incorporated into the works.

Calculations shall be provided to show that the proposed form of pipe manufacture will give the specified physical properties.

The stiffness of the pipe is defined as EI/D3

Where E = bending modulus of pipe wall Circumferentially (in N/m2).

- I = moment of inertia of pipe wall per unit length (in m4/m)
 - D = nominal diameter in meters

Pipes shall have an initial stiffness of not less than 2,500 N/m2. They shall have a resistance to longitudinal tensile force per unit of circumstance as under: -

Diameter	up to 700 mm	100 N/mm
Diameter	700 mm to 1,000 mm	120 N/mm
Diameter	1000 mm to 1,600 mm	160 N/mm
Diameter	1600 mm to 2,400 mm	250 N/mm
Diameter	2400 mm to 4,000 mm	300 N/mm

When subjected to a parallel plate loading test no evidence of crazing or cracking shall be evident with a deflection of 10% and no structural failure with a deflection of 20%.

Evidence from the manufacturer shall be provided of the satisfactory completion of the "strain corrosion test" on a sample of pipe representative of those to be supplied together with an assurance that such tests are continuing. The appearance of blisters, delaminating, wicking or any other structural degradation of the test sample will constitute failure of the test notwithstanding the wording of the standard test procedure.

The jointing system shall be an approved bell and spigot or coupling system. Where the system involves separate reinforced plastic couplings of sockets formed by a lay-up process subsequent to pipe production, the resins used shall be clear and non-pigmented to permit visual examination within the laminate.

Where GRP laminate is cut, exposed ends shall be sealed with a suitable resin and the whole approved prior to incorporation into the works. Where such cutting and sealing takes place at site the resins used and the methods of storage, mixing, application and curing shall be strictly to the manufacturer's recommendation. Before any such work takes place, the manufacturer's representative shall visit the site to demonstrate and give clear procedural advice to the Contractor in the presence of the Engineer's Representative.

1) A scratch of greater depth than 0.30 mm.

2) Cracks of any type on the inside of the pipe.

3) Cracks on the outside, longer than 200 mm

- 4) Circumferentially or 6 mm longitudinally.
- 5) Delimitations.
- 6) Damaged ends including bubbles, cracks, voids,
 - 7) exposed reinforcement or extraneous matter.
 - 8) Internal protruding fibers.
 - 9) More than 25% of the external area with protrusions of any sort.
 - 10) Air voids and blisters exceeding 5 mm diameter or 1 mm in depth, greater in area than 0.50% of internal or 1.00% of external surfaces.

- 11) Pitting to more than 5% of the internal or 10% of the external surface area and individual pits more than 1 mm diameter or 0.5 mm in depth.
- 12) Wrinkles over than 3% of the surface area and individual wrinkles more than 2 mm deep.

10.1.8 Cast Iron Pipes and Fittings

Cast iron pipes and fittings for sewers, rising mains, drains or other purposes may be gray iron or ductile iron, to the approved standard unless either material is specifically detailed on the drawings.

Unless a "higher" pressure rating is necessary for the pipe duty cast iron, pipes shall be rated for 10 bar working pressure.

Unless detailed to the contrary to suit existing pipe work, flanges for cast iron pipes shall be rated for 10 bar working pressure and drilled accordingly.

10.1.9 Clay Pipes and Fittings

Clay pipes and fittings shall be normal pipes of standard strength unless extra strength or chemically resistant pipes are specifically called for on the drawings or in the Bills of Quantities.

Pipes may be glazed or unglazed.

10.1.10Pipes for Land Drains

Pipes for land-drains shall be uPVC pipes for gravity duty complying with the requirements of this Specification. The pipes shall be perforated with holes or slots to a configuration subject to approval by the Engineer's Representative. The minimum cross-sectional area of the perforations, at the inside surface of the pipe barrel, shall be 2700 mm² per meter run of pipe.

10.1.11Stone for Land Drains

Stone for land drains shall be nominal single size 20 mm and/or nominal single size 63 mm in accordance with the following table and placed as shown on the drawings. The stone shall also comply with the requirements the specifications.

Percent by Weight Passing	<u>Test Sieve</u>	<u>Nominal size of</u> <u>Single size stone</u>
mm		
75	63 mm	20 mm
63	85 - 100	-
37.5	0 - 30	100
14	0 - 3	85 - 100
10	-	0 - 25
5	-	0 - 5
2.30	-	-

10.1.12Pipeline Construction

10.1.12.1 Storage and Handling of Pipes

Method Statements must be approved for the transportation, handling and storage of pipes before any pipes are delivered to site.

All pipes shall be handled and stored in compliance with the manufacturer's recommendations subject to the following limitations:-

At every point of loading or unloading, all pipes or castings must be handled by approved lifting tackle. Unloading by rolling down planks or any other form of inclined ramp will not be allowed.

Pliable straps, slings or rope shall be used to lift pipes, and steel cables or chains will not be used without written permission.

Nesting of pipes for transportation will be permitted provided method statements demonstrate that effective precautions will be taken to protect inner surfaces from damage.

All coated pipes shall be thoroughly inspected on arrival at site for detection of any damage to the coatings which shall be made good in an approved manner.

Reinforced Thermosetting Resin Pipes

When pipes are transported or stacked they shall be supported on cradles conforming to the shape of the pipe at not more than 5 meter centers. Pipes must on no account be stacked directly on the ground but if individual pipes are placed on the ground prior to laying care shall be taken to remove all rocks and any potentially damaging debris.

Thermoplastic Pipes

Care shall be taken to prevent distortion of the pipes during transportation, handling and storage. They shall be stacked either on bearing timbers on a level surface staked to prevent movement, or in suitable racks. Not more than two layers shall rest on the bottom layer, and for spigot and socket pipes, sockets shall be at alternate ends so that no pressure comes on a socket. Bearing timbers shall be spaced at not more than 1 meter and shall be wide enough to prevent denting of the pipe wall. Sharp edges (e.g. of metal) shall be avoided. Similar care shall be taken with pipes in transit.

All thermoplastic pipes shall be shaded from direct sunlight during handling, storage and laying.

The Contractor shall ensure that thermoplastic pipes do not come into contact with bituminous or other hydrocarbon based materials.

Trench Widths for Pipeline

Nominal trench widths for single pipelines shall be defined as the diameter plus 500 mm.

Nominal trench widths for <u>two or more pipes in the same trench</u> (laid in parallel with similar invert levels) shall be defined as the sum of the internal diameters plus 450 mm between the pipes, plus 450 mm.

Any excavation from the bottom of the trench to 300 mm above the level of the crown of the pipe which exceeds the nominal widths defined above shall be filled with concrete or the specified bedding materials as directed on site.

Except where wide trenches are required to suit ground conditions as defined below, method statements may propose trench widths narrower than the nominal widths defined but they must be sufficiently wide for safe working and to allow the pipes to be correctly laid and jointed and the bedding and surround compacted. In all cases the considered trench width is the diameter + 50cm.

Pipelines in Wide Trenches

Wide trenches shall be constructed to not less than the defined widths for those categories of Group B flexible pipelines in granular defined below.

Prior to commencing trench excavation in an area an assessment of the Modulus of Deformation (E's) shall be made of the soils likely to be encountered at springing level of the pipes. In no cohesive soils, approved static cone penetrometer tests shall be carried out. In cohesive soils other approved methods shall be used to determine E's. Tests shall be carried out at intervals to be determined on site which in variable ground conditions may be to every pipe length.

If the value of E's determined from the results of such tests is greater than 2.5 MN/m2 then trench width is not critical. If less than 2.5 MN/m2 then trench widths shall be constructed to the widths defined in the following table unless alternative means of increasing the passive resistance of the trench sides are detailed or are proposed in method statements where economic or environmental restrictions make wide trenches undesirable.

Non-Cohesiv	ve Soils	Wide Trench Widths
Static Cone Penetrometer Test Kg/cm2	Modulus of Deformation E's (MN/m2)	D = Pipe Diameter
8.5 - 7.7 7.7 - 6.1 6.1 - 3.1 3.1	2.50 - 2.25 2.25 - 1.80 1.80 - 0.90 0.90	2.5 * D 3.0 * D 4.0 * D 5.0 * D

10.1.12.2 Pipe laying

Pipes shall be laid and jointed in accordance with all relevant recommendations of the manufacturer. Any variations between the manufacturer's recommendations and this specification shall be highlighted in the Contractor's Method Statements and a ruling will be given with the approval.

Pipes shall be checked for soundness and be thoroughly cleaned out immediately prior to laying.

The setting of the pipeline to the required levels and alignment shall be carried out by approved procedure such as boning between sight rails. Large diameter pipes, 1000 mm diameter or greater, shall be individually set to level and line by instrument.

For pipelines laid in trenches and headings the permissible tolerances in line and level unless otherwise specified shall be ± 3 mm in level and ± 12 mm from centerline between manholes or access points. Also where a gravity pipeline or sewer is shown as a straight line between manholes it will not be accepted as having passed the final test unless a light can be sighted through the length concerned.

For pipeline jointing systems incorporating flexible jointing rings pipes shall be laid with a gap between the end of the spigot and the base of the socket, or between spigots. This gap shall be not less than 6mm or greater than one third of the straight draw test dimension specified for the pipe joint and it shall be achieved by approved means, such as marking the outside of the pipe or using removable metal or hardwood feelers.

Where flexibly jointed pipes are laid to curves the horizontal displacement at any joint as laid shall not exceed three quarters of the maximum allowed by the manufacturer.

Pressure pipelines shall be secured at all changes in direction by concrete anchor blocks.

For pipelines laid in headings the individual pipes shall not exceed 1.50 m in length and the headings shall be driven complete from shaft before pipe laying is commenced.

After laying a length of pipeline but before preliminary testing is carried out, the pipeline shall be checked for level and gradient on top of the pipes. If a pipe is not at the correct level it shall be un jointed and removed, the bed shall be adjusted and the pipe shall be relaid and rechecked for line and level.

After the joint has been made and the preliminary testing completed the annular gap at a socket or collar outside the flexible jointing ring shall be closed with fine grained clayey soil to prevent the entry of granular material.

10.1.12.3 Pipelines Bedded on Trench Bottom

Where pipes are to be bedded directly on the trench bottom the formation shall be trimmed to provide even bedding of the pipeline and to be free of extraneous matter that may damage the pipe or its coating.

Joint holes at each pipe joint shall be scooped away in the trench bottom to enable the joint to be made.

10.1.12.4 Pipelines in Concrete Grades and Surrounds

Where pipes are to be laid with a concrete cradle or surround they shall be supported initially above the trench bottom on concrete setting blocks. The blocks shall either be laid accurately to level and covered with damp-proof sheeting beneath the pipe barrel or shall be provided with two hardwood wedges each to an approved pattern to enable the pipe level to be adjusted.

The blocks and wedges shall be of sufficient size and strength to prevent settlement of the pipes during laying and at least two concrete blocks shall be provided for each pipe.

The concrete shall be poured on one side of the pipe until it can be worked under the pipe along its full length to ensure that no voids develop. The concrete shall then be brought up equally on both sides of the pipe until the required level is reached.

Approved measures appropriate to the pipe material shall be provided to prevent flotation or other movement during placement or curing of the concrete. Concrete cradles to pipes of all diameters and surrounds to pipes of one-meter diameter or less shall be poured in a single lift. Concrete surrounds to pipes over one-meter diameter shall normally be poured in two lifts, with a horizontal joint not more than 100 mm below the crown of the pipe. Concrete shall be prevented from entering pipe joints.

Concrete cradles and surrounds shall be interrupted over their full cross-sectional area at each pipe joint, by shaped expansion joint filler. The thickness of filler shall be 18 mm for pipe diameter less than 450, 36 mm for pipe diameter 450 to 1200 and 54 mm for pipe diameters greater than 1200.

In spigot and socket pipelines the joints in the bed shall be at the face of each socket, and in all flexible joints the concrete shall be prevented from entering the pipe joint.

10.1.12.5 Pipelines on Granular Beds

Where granular beddings to pipelines are detailed the minimum thickness of bedding material beneath the pipe shall be: -

150 mm (minimum 100 mm under sockets) for pipes not exceeding 300 mm internal diameter except when bedded on rock.

200 mm (minimum 100 mm under sockets) for pipes exceeding 300 mm internal diameter or for pipes of 300 mm internal diameter or less when bedded on rock.

The time interval between placing bedding material on the trench formation and commencing pipe laying shall be as short as is practicable.

The bedding material shall be compacted in layers not exceeding 200 mm with one pass of a plate vibrator for gravels and two passes for sands or other approved equivalent mechanical method. Hand tamping or punning will only be permitted where insufficient space is available to allow the use of mechanical plant.

Recesses shall be formed in the bedding to accommodate pipe joints while ensuring continuous even support along the pipe length. Bedding material shall be prevented form entering pipe joints. After the joint has been made bedding material shall be carefully placed and hand compacted beneath the joint barrel to close any void left by the recess.

Where the formation of the trench is of silt or soft clay and is below the natural water table a 75 mm blinding layer of sand shall be substituted for the specified bedding material directly above formation and carefully compacted if directed on site.

10.1.12.6 Placing Surrounds to Pipelines

Group A Pipe Materials

Except where concrete surrounds are detailed, either granular bedding material or approved selected excavated granular material shall be introduced at both sides of the

pipe and compacted until it has been brought up to at least 150 mm above the crown of the pipe.

The methods of selecting excavated materials may include sieving either in bulk or above the trench.

Wherever practicable the placing and compaction of the surround material shall be carried out in sequence with the removal of the trench supports. In particular trench sheets or boards shall be raised clear of each layer prior to its compaction.

Group B and C Pipe Materials

Except where concrete surrounds are detailed Group B and C flexible pipelines shall be laid with granular bedding and surround, as specified, to at least 300 mm above the crown of the pipe (unless concrete protection slabs are detailed).

In narrow trenches and where the Contractor's method of working involves the use of trench sheets or other forms of trench support it is imperative that, unless Contractor is instructed to leave them in place and burn or cut off the tops, the trench supports are carefully withdrawn to a point above the crown of the pipe as the backfill material is placed to ensure that voids between surround and trench side will be eliminated.

Compaction of Pipe Surrounds

The granular material shall be carefully laid and compacted at the sides of pipes according to one of the following methods for alternative types of compaction plant as agreed with or directed by the Engineer's Representative.

Alternative Methods

Surround	(Number of Passes of Max. Layer Compaction Plant).				
Material	Thickness mm Rammer	Hand Plate	Vibrating Rammer	100 kg Power	
Gravel	200	2	1	2	
Sand	150	3	2	4	

10.1.12.7 Backfilling of Pipelines

After completion of placement and compaction of the surrounds to the pipelines backfilling shall proceed using selected excavated materials or importing suitable backfilling as directed by the engineer and in accordance with the specifications for earthworks.

The use of power rammers will not be permitted over any pipe until the depth of fill above the crown of the pipe is at least 300 mm.

10.1.12.8 Deflection Measurements on Group B and Group C Pipelines

All Group B and C pipelines will be subjected to in-situ deflection measurements. Any section of pipe failing to meet the deflection criteria defined below shall have its surround material re-compacted, such procedure being repeated until the in-situ deflection is found to be satisfactory. Pipes will be regarded as damaged and shall be removed from the trench and condemned if their in-situ deflection at any time exceeds the values stated.

Type of Pipe		Deflection Criteria %			
Materi	ial SDR	After comple- tion of Surround Permissible ranges verti- cal diameter elongated only	At least two weeks after completing to be the trench backfill. Maximum measured in any plane.	Damaged and not re-used	
uPVC	10-15	0 - 1.0	1.0	2.25	
uPVC	15-25	0 - 1.5	2.0	3.75	
RP	30-40	0 - 1.5	2.0	4.50	
RP	40-50	0 - 2.0	2.5	5.25	
uPVC	25+				
RP	50+	2.5	3.0	7.50	

SDR' is the Standard Dimension Ratio, which is the ratio of pipe diameter divided by the pipe wall thickness.

In the above paragraph deflection shall be considered as the maximum difference between the measured in-situ diameter and the stated non-deflected diameter on any axis divided by the non-deflected diameter.

For pipelines of 600 mm diameter and above, internal measurements of deflection shall be made continuously in the vertical plane and readings shall be recorded at each pipe joint, at the mid-point of each pipe length, at any point where the limiting deflections above are exceeded and at any other point directed by the Engineer's Representative. Where the length of pipeline between manholes or access points exceeds 100 meters the measurements shall be taken progressively on completion of backfilling and shall be verified after temporary reinstatement of the trench within reasonable limits of each access point.

For pipelines smaller than 600 mm diameter deflections shall be checked by pulling through an approved cylindrical plug dimensioned to suit the permissible minimum deflected diameter of the pipe.

10.1.12.9 Stanks to Pipelines in Granular Bedding

Where pipes are laid on a granular bed or with a granular backfill, a stank, i.e. an impermeable barrier shall be provided across the full width of the trench and for the complete depth of the bedding and fill at intervals not exceeding 50 m, and generally mid-way between manholes.

The stank shall consist of: -

either a 300 mm long plug of fine-grained clayey soil or a 300 mm long plug of a mixture of sand and bitumen consolidated in an approved manner.

or a mixture of sand and clay, compacted to form an impermeable barrier at least one meter in length.

or a layer of thick polyethylene cut to fit around the pipe across the full width of the trench and lay on the granular bedding material at its natural repose angle.

All methods must form an impermeable barrier. Bitumen shall <u>not</u> be used for thermoplastic pipes.

10.1.12.10 Thrust and Anchor Blocks to Pressure Pipelines

Concrete thrust blocks shall provide al all bends, tees and valves along the pipeline. The Contractor shall submit details and calculations of the thrust block size to withstand the hydrostatic test pressure. Calculations and drawings shall be submitted to the Engineer's Representative for his approval at least 14 days before concrete is placed.

It is important that all pipe joints are kept free from concrete, and concrete formwork shall be placed so that pipes joints can be dismantled after thrust blocks are cast.

The concrete shall be quality B-250 in accordance with B.S standards and shall contain at least 250Kg Portland cement per cubic meter.

Thrust block concrete shall be cured at least seven days before applying hydrostatic test pressure. If this is not possible, a temporary thrust block using preferably wood and wooden wedges shall be supplied by the contractor at his own cost.

All costs related to provisions of calculations and drawings shall be deemed to be included in the unit rates for placing of pipes.

Underground pressure pipelines shall be provided with concrete blocks as follows:-

Thrust/anchor blocks shall be provided at every installed bend, tee or angle branch.

Anchor/thrust blocks shall be provided on pipelines laid to gradients steeper than 1:20, up to 1:15 every third pipe shall be anchored, up to 1:10 every second pipe and at 1:5 every pipe shall be anchored.

Concrete shall extend to undisturbed ground on thrust faces of thrust blocks and on both faces of anchor blocks.

Where details are not shown on the drawings the Contractor shall prepare proposals for thrust and anchor blocks and submit them to the Engineer's Representative for approval. Such approval shall not relieve the Contractor of his responsibility for the adequacy of his proposals.

Special details shall be shown on the drawings or instructed at site where environmental or ground conditions dictate.

10.1.12.11 Pipes Protruding from Structures, Concrete Surrounds and Anchor Blocks

Unless otherwise detailed a pipeline at or below ground level protruding from a structure shall have two flexible joints adjacent to the structure located as follows: -

Pipe Diameter mm	Distance to First Joint (mm)	Distance betw First and Seco Joint (mm)	een nd
Up to 300	150	<u>Min</u> . 450	<u>Max</u> . 2.5 * dia.
300 to 100	300	1.5 * dia.	2.5 * dia.
above 1000	450	1.5 * dia.	2.5 * dia.

Method statements may propose that the first joint be formed by building an appropriate sleeve, collar or coupling into the wall of the structure. Where such a detail is proposed the sleeve, collar or coupling must be capable of maintaining an effective seal under the specified deflection and loading conditions specified for flexible joints "Joint Requirements and Limitations".

In the case of Group 'B' pipe materials; particular attention will be placed on elliptical deflection conditions.

These joints will be required at surrounds and anchor blocks unless directed otherwise on site.

Group A and C Pipe Materials

Between the structure and the first joint any disturbed ground below the pipe will be removed and replaced with Grade B concrete in the form of a cradle, all to the direction of the Engineer's Representative. The cradle shall not extend beyond the first joint.

Beyond the first flexible joint within the excavated working space of the structure the concrete fill shall be brought up 300 mm below the pipe invert only. Specified bedding materials will then be used.

Group B Pipe Materials

Within the excavated working space for the structure disturbed ground below the pipe will be removed and replaced with Grade B concrete to within 300 mm of the underside of the pipe. Specified bedding materials will then be used to support the pipe.

The width of the concrete backfill shall be not less than the nominal widths.

Where a flexible pipe passes through a rigid concrete face to a structure or surround the pipe shall be protected from stress concentration and possible fracture of the pipe at the concrete face. A 10 mm thick neoprene or other approved synthetic rubber strip shall be wrapped around and cemented to the pipe unless special wall protection units are used.

The neoprene will normally extend through the width of a wall to a dry chamber or structure but will be limited to 150 mm or 100 mm where exposed to liquid (groundwater or liquid inside the structure) a sealant groove shall be formed if detailed and filled with an appropriate, approved, joint sealant.

Care shall be taken to ensure that the rubber strip is not displaced during concreting.

Where a pipeline protrudes from a concrete surround, no protection from stress concentration will be required if the surround ends at a flexible joint leaving the next pipe free. If the surround ends on a pipe barrel the specified protection will be provided and, for pressure pipes only, the protruding pipe will be wrapped from the edge of the neoprene strip along to the next flexible joint at which the concrete surround is interrupted with an approved compressible material such as damp-proof sheeting or building felt of minimum thickness 2 mm.

10.1.12.12 Protection of Pipeline Components

All buried valves, couplings, flange adaptors, and other metal components shall be encased to guard against corrosion. Other pipe joints, valves and similar items on both buried and exposed pipelines shall be encased where specified or shown on the drawings.

The encasing shall be by one of the following methods, as detailed.

- 1) Surrounding with Grade B concrete.
- 2) Enclosed by an approved hot-poured bitumen compound.
- 3) Wrapped with tape.

Method (2) shall not be used with plastic pipes.

The item to be encased shall first be cleaned and its original surface treatment made good. The surface shall be dry before encasing is carried out, which shall not be done before the pipeline has been tested.

The bitumen compound shall be cast in purpose-built moulds in accordance with instructions issued by the supplier.

Before wrapping with tape the item to be encased shall be enclosed with an approved mastic or inert putty-like filler which shall be molded by hand so as to provide a smooth surface for the tape. The tape shall be tightly spirally wrapped with 25 mm overlaps so as to enclose the whole of the item and a minimum of 150 mm of pipe length on each side. The enclosure shall be firmly wrapped with 25 mm overlaps so as to enclose the whole of the item and a minimum of pipe length on each side. The item and a minimum of 150 mm of pipe length on each side the item and a minimum of 150 mm of pipe length on each side. The enclosure shall be firmly wrapped with 25 mm overlaps so as to enclose the whole of the item and a minimum of 150 mm of pipe length on each side. The enclosure shall be firmly pressed out to prevent air being trapped under the wrapping.

10.1.12.13 Indicator Posts to Pressure Mains

Where pressure mains pass through waste ground or across roads, the Contractor shall erect indicator posts of approved precast reinforced concrete design at locations described to him by the Engineer's Representative.

The depth, location and size of the pressure main shall be detailed in Arabic and English, to an approved design, on an engraved plastic or non-corrodible plate attached to the post.

In addition, at non-ventilated air valve chambers, the Contractor shall erect indicator signs on posts, to an approved design, at locations described to him by the Engineer's Representative.

The words 'WARNING Gas on Entry' together with an appropriate pictorial representation shall be detailed in Arabic and English, to an approved design, on an engraved plastic or non-corrodible plate attached to the post.

10.1.12.14 Enclosing Granular or Stone Surround with Filter Fabric

Where filter fabric is used to enclose granular or stone pipe surrounds, the fabric will be placed on the prepared trench formation and carefully supported during pipe laying operations. When the pipe has been laid complete with surround to the correct level the filter fabric shall be closed over the top of the surround by forming a 'lap' of minimum width 500 mm. All membrane joints shall be overlapped a minimum of 500 mm. Care shall be taken not to puncture or damage the membrane in any way during these operations or during backfilling of the trench.

10.1.12.15 Method of Measurement and payment for Pipe Laying

Method of Measurement and Payment for pipe laying shall include excavation in trench. Measurement for pipe trenches shall be the meter run for each pipe diameter and for each 0.5 meter depth stage or as in B.O.Q. Measurement shall be for the length of trench only and shall exclude manholes, gullies etc. Measurement for depth of each trench shall be the average of the depth at each end i.e. manhole to manhole or inlet to inlet, and shall be calculated from the existing ground level or from the finished grade level or from the finished sub grade level, whichever is the lowest to the trench invert level.

In the case where a pipe is (A) partly in fill and partly in original ground or (B) totally above original ground level and is enclosed in fill, the measurement for depth shall be the lesser of dimensions (i) and (ii) as calculated below.

Where trenches are to be excavated across existing roads or pavement which is to be reopened to traffic on completion of the construction work specified herein, the depth of such trench excavation shall be calculated from the level of the top of the existing road or pavement to the trench invert level.

Dimension (i) - The depth between finished ground level or finished sub grade level, whichever is lower, and the underside of the pipe or pipe bedding (including concrete blinding) whichever is lower.

Dimension (ii) - The outer diameter of the pipe plus 1000 mm.

Length of pipes shall be measured along their center lines. Lengths of pipes in trenches shall include length occupied by fittings and exclude lengths occupied by pipes ad fittings comprising backdrops to manholes. Lengths of pipes entering manholes and other chambers shall be measured to the inside surfaces of the chambers except that pipes and fittings comprising backdrops to manholes shall be included in the items for the manholes.

Payment for excavation in all types of soil shall be included in the rate in the Bill of Quantities for pipe work, which rate shall include for all temporary works dewatering, bracing, sheeting, pipe bedding, installation and jointing of pipes, testing, backfilling, compaction, and the use of approved surplus excavated material for filling (including compaction) in other areas of the site, for the disposal of surplus excavated material and/or unsuitable material as specified and for all other items necessary to complete the Works.

10.1.13Pipe Work

10.1.13.1 Pipe Work within Structures

1) Pipe work shall be supplied to the general arrangements and limits indicated on the Contract drawings and shall be supplied complete with all joint rings, gaskets, washers to each side of a bolted joint, nuts, bolts, grease and any other components necessary for the complete installation.

- 2) The layout and design of the pipe work shall be such as to facilitate its erection and the dismantling of any section for maintenance of associated plant by inclusion of approved mechanical coupling or flange adaptors.
- 3) Where a common delivery pipe is used, individual pump delivery branches unless otherwise shown on the drawings shall be jointed to it in a horizontal plane and angled to prevent sharp changes of flow.
- 4) Adequate supporting and anchoring arrangements for all pipes shall be included which may take the form of straps, stays, tie bars or concrete cradles.
- 5) Cast iron pipes shall be provided with puddle flanges where they pass through the walls of underground or water retaining structures.
- 6) Small bore pipe work for sump pumps, vents, etc. may be galvanized steel or approved plastic materials.
- 7) All pipes connected to pressure vessels, pumps etc. shall have flanged connections.
- 8) All pipes shall be checked for alignment and mating of flanges and connections before secured. Pipes shall not be sprung into position.

10.1.14Standard of Covers and Gratings

	MANHOLE		GULLEY GRAT		PUMPING
REQUIREMENT					STN.ACCES
			FLUSHED	UPSTANI	COVER
	in road of	in road out of road		KERB	(3)
Shape	Circular	Circular	Square	-	Rectangular
Size of clear Opening	600 dia.	600 dia.	width Nom.450	weir dpt 165	600 x 750 600 x 900
Standard	EN (BS)	EN (BS)	EN (BS)	EN (BS)	EN
Strength	D 400	C 250	D400	150 KN	D 400
Material	cast iron	cast iron	ductile iron	ductile iron	ductile iron
Protective Coating	bitumen epoxy	bitumen epoxy	bitumen epoxy	bitumen epoxy	bitumen epoxy
Ventilation	No	No	-	-	No
Construction	Solid	Solid	-	-	Concrete infi
Sealing Plate	No	No	-	-	-

10.1.14.1 Storm/Land Drainage

Inscriptions	Storm	Storm	Storm	Storm	Storm
Tightness	Yes	Yes	-	-	-
Rocking	No	No	No	-	No
Locking	No	No	No	-	No
Interchange abilit	Yes	Yes	Yes	Yes	Yes
Other	-	-	-	GRP GRIP	Special Keys

10.1.14.2 Sewerage

DEGUDENENT	MANHOLE		HOUSE	PUMPING STN.
REQUIREMENT	in road	out of road	CHAMBER	ACCESS COVER (3)
Shape	circular	circular	circular	Rectangular
Size of clear Opening	600 dia.	600 dia.	600 dia.	600 x 750 600 x 900
Standard	EN (BS)	EN (BS)	EN (BS)	EN
Strength	D 400	C 250	C 250	D 400
Material	cast iron	cast iron	cast iron	cast iron
Protective Coating	bitumen epoxy	bitumen epoxy	bitumen epoxy	bitumen epoxy
Ventilation	No	No	No	No
Construction	Solid	Solid	Solid	Concrete infill
Sealing Plate	Yes	Yes	Yes	-
Inscriptions	Sewerage	Sewerage	Sewerage	-
Tightness	Yes	Yes	Yes	-

Rocking	No	No	No	No
Locking	No	No	No	-
Interchange- ability	Yes	Yes	Yes	Yes
Other				Special Keys

Notice

- 1) In Arabic and English
- 2) European Standard (British Standard) Kite Mark or
- 3) European Equivalent.
- 4) Removable beam can be used only with special acceptance of the Engineer.
- 5) The guarantee is required that spare parts (e.g. covers only) shall be delivered by suppliers for at least 10 years after the contract is completed.
- 6) Covers shall be single seal, closed key ways.
- 7) All covers, gratings and frames shall be delivered to site with a transit protective coating.
- 8) Double triangular covers must be loosely coupled by bolts with nuts incapable of undue tightening and loosening.

11 Steel Pipes and Fittings

11.1 Pipe Work and Fittings

11.1.1 General

Pipes and fittings for general purposes (water, sludge, and air) shall be made of steel, galvanized steel, ductile iron or gray iron. In some special cases, other materials (stainless steel, polyethylene, PVC) will be used, e.g. for chemical pipe-work.

Pipes passing through walls of structures retaining water or solution shall have puddle flanges or flanged anchoring sleeves. They shall be connected to the adjoining pipe-work by flanged joints or dismantling joints.

The term "pipe-work" means pipe of any description and includes associated flanges, adapters, couplings, jointing material, fittings, fixings, supports, valves, traps and the like which are necessary to complete station pipe-work systems associated with the Equipment.

Pipe-work shall conform in every respect to the requirements of the relevant I.S./BS/Din/iso All recommended tests shall be carried out and certified in writing.

Adequate provision shall be made to anchor, support, drain, vent, pressure test, dismantle and clean all pipe-work. Valves, meters, strainers and the like shall be supported independently of the pipes to which they are connected.

Pipe-work systems shall be designed to withstand the maximum internal and external forces which could occur in service and under hydraulic test pressures. The configuration and method of support shall be such as to minimize bending stresses.

Systems shall be sized so that the maximum design flow of fluid through the pipe-work will not produce cavitations, erosion or an excessive level of noise and vibration. Systems shall also be sized where practicable so that the minimum operating flow of fluid will prevent deposition of suspended solids. No forces developed within the pipe-work system shall be transferred to the civil structure without the approval of the Engineer.

Plastic pipes, flexible pipes and hoses of less than 50 mm nominal bore shall be supported throughout their length by a separate structure.

All pipe-work shall be free draining to convenient drain points where the piped fluid may be collected or discharged safely.

The Contractor shall make provision to accommodate within pipe-work systems expansion, contraction, differential movement and all other factors necessitating built-in flexibility. Flexible joints to the approval of the Engineer shall be installed where pipe-work spans construction and expansion joints in the civil structure or at points where differential movement of supports may occur.

The configuration and flexibility of the pipe-work shall be capable of accommodating the civil construction and pipe-work erection tolerances. Where practicable, flexible devices shall be of the type which transmits axial loads so that longitudinal thrusts are transferred throughout the pipe-work, thus keeping external anchorage to a minimum.

Flexibility shall be included in the pipe-work to facilitate erection and future dismantling.

Particular care shall be taken to ensure those pipe-work thrusts and stresses transmitted to associated machinery and equipment is minimized and is of a magnitude acceptable to the machinery or equipment manufacturer.

Pressure gauges shall be of the circular dial type having a 270 degree scale of not less than 100 mm diameter. The gauge parts shall be of corrosion resistant materials and no aluminum parts shall be used. The faces shall be protected with toughened glass or acrylic plastic. They shall be calibrated in Mpa (1 MPa = 98 m) and meters water column.

Pressure gauges shall be adequately supported. Fixed connection piping below 25 mm nominal bore shall be compression jointed heavy gauge copper unless otherwise approved by the Engineer.

Where the gauge is mounted on a panel or otherwise located remote from the main system, an isolating valve shall be fitted on the connection pipe near the tapping.

Where the fluid in the main system contains solids in suspension, a diaphragm or other barrier shall be provided at the point of connection to the main system and the connection there from to the gauge shall contain a suitable clean fluid.

11.1.2 Steel Pipes and Fittings

- Steel pipes of nominal size not exceeding 50 mm shall comply with I.S./BS/DIN/ISO and shall be hot rolled seamless pipes with steel of grade TU 34.1.
- Steel pipes of nominal diameter exceeding 50 mm shall comply with I.S./BS/DIN/ISO and shall be hot rolled seamless pipes with steel of grade TU 37.
- The corresponding fittings shall comply with I.S./BS/DIN/ISO.

- Steel pipes of nominal diameter exceeding 250 mm shall be manufactured with steel sheets grade E 24.1. Formed and electrically welded in accordance with I.S./BS/DIN/ISO.
- Wall thickness of pipes shall correspond to the minimum thickness in API 5L.
- Steel pipes having nominal size above 1,000 mm shall be manufactured with steel sheets, grade E 24.2, complying with I.S./BS/DIN/ISO. formed and electrically welded according to NF, I.S./BS/DIN/ISO.
- The used steel pipes for the pressure line shall be externally anticorrosive protection of three layers extruded polyethylene or polypropylene and internally with cement lining to confirm to the international standards & in accordance with DIN 30670 & DIN 30671.

11.1.3 Ductile Iron and Grey Iron Pipes and Fittings

- Ductile iron pipes shall comply with ISO 2531 standard.
- Unless otherwise specified, their thickness in millimeters shall be at least:

$$C = 9 (0.5 + 0.001 \text{ ND})$$

- Grey iron pipes shall be horizontally cast with FT 20 gray iron.
- Flanged fittings generally made of gray iron (FT 20) shall comply with I.S./BS/Din/iso.

11.1.4 Other Materials for Pipes and Fittings

The following materials shall comply with the ISO standards or equivalent approved by the Engineer:

- PVC pipes and fittings
- Polyethylene pipes and fittings
- Copper pipes
- Stainless steel pipes
- Galvanized steel pipes
- Flanges shall comply with iso 2531 for PN 10.

11.1.5 Ladders, Hand railing and Access Platforms

Ladders and hand railing shall be made of aluminum alloy 5052-0 tested to ASTM No. B210, Light Duty Aluminum, 5 KN/m^2 .

Access platforms shall be not less than 750 mm wide, and shall sustain a uniform loading of not less than 5 KN/m^2 , the deflection at this loading not exceeding 0.005 of the span or 10 mm, whichever is the lesser. Higher loading shall be used as appropriate where heavy loads will be supported during installation, operation and maintenance of items of Equipment.

Flooring shall be metal of a non-slip self-draining pattern securely fixed to the supporting structure. Sections of flooring shall be arranged so that the pattern is continuous from one

section to another. The sections shall fit without gaps and shall sit square on the supporting structure.

The weight of the removable sections shall not exceed 25 kg per piece.

11.1.6 Pipe Ends

Ends of pipes to be jointed shall generally be as follows:-

- a) Spigots and sockets for jointing in trench or above ground.
- b) Plain ends for use for with welded collars, mechanical couplings or flange adapters.

The spigot and socket joints for the spherical type shall be designed to take angular deflections of up to 5 degrees from the axial to accommodate changes of pipe gradient and/or direction at individual joints. For hemispherical type, the angular defalcations shall be up to 2 degrees.

Spigot and socket joints shall be of the spherical or hemispherical sleeve type with a minimum penetration of the formed ends. The joint design shall provide for the contact surface of the spigot end and the sleeve end to be formed to the same spherical radius which shall be more than 50% of the outside diameter of the barrel of the pipe for the spherical type and shall not be less than 50% of the outside of the barrel of the pipe for the hemispherical type. The minimum penetration of the spigot into the socket shall not be less than four times the pipe thickness and this overlap shall be obtained at the maximum deflection of 5 or 2 degrees. At zero deflection the minimum overlap shall be the minimum penetration as above increased by such allowance as is necessary to ensure contact between the spigot and socket over the specified maximum amount of joint movement. The joint engagement tolerance in any position shall not exceed an average of 1.60 mm with maximum isolated gaps of 2.00 mm adjacent to the weld seams.

Pipe ends of the spherical or hemispherical type shall be formed by hydraulic pressing using a full circle die or expending former capable of forming ends consistently to a constant spherical contact surface throughout the pipe production run.

The internal surface of the socket and the external surface of the spigot shall be ground smooth along the shop fusion welds for a distance of 150 mm from pipe ends measured along the pipe axis.

The external surface of the plain-ended pipes shall be similarly prepared.

All sockets shall have two tapped holes spaced at 90 degrees apart on the circumference. They shall be of not less than 6 mm diameter and shall be provided with matching plugs to facilitate the air pressure testing of field welds. These tapped holes shall be located within the end 30 mm of the sockets and shall be cleared of welding runs.

Ends prepared for butt welding shall be subject to manufacturing tolerances in accordance with Table 6.3 of Std 5L or Table 6.2 of Std 5L/S.

Plain ends for use with mechanical joints or flange adopter joints shall be truly circular with a diameter tolerance of = 1 mm over a distance of 225 mm from the pipe ends.

11.1.7 Bends, Tees, Tapers, etc.

Special items such as bends, tapers, tees, etc, shall be formed from completely lined pipes as specified by suitable insertion of rubber spacers during lining operation. The coating and lining on the straight pipes shall be cut back from the ends to be welded or cut for a sufficient distance to ensure that no material which is intended to remain part of the coating/lining is damaged or affected by the welding or cutting process.

Pipe specials shall be designed to withstand the full-specified factory test pressures. Compensation plates and gusset plates shall be in accordance with BS 5500.

Welding shall be of a standard equal to that of straight pipes and each butt weld shall be subjected to a 100% radiograph test. Fillet welds shall be subjected to air tests where appropriate and/or magnetic crack detection tests.

The outside diameter of specials conforms to the outside diameters of the standard straight pipes. The ends of plain ended specials shall be truly circular and shall conform to the tolerances required for the fitting of mechanical couplings and flange adapters.

11.1.8 Flanged Joints

All flanges shall be of steel welded to the pipe by the electric are process or other approved method. They shall conform in all respects with the requirements of BS 4504 unless otherwise specified. Their mating dimensions shall generally be in accordance with the Standard for PN 10, (in which case they will also be in accordance with ISO 2531 and NF E 29-201 for the same value of PN). They shall be of the raised face type and shall be truly faced over their whole width. Bolt holes shall be drilled off center lines, truly in line end to end with the longitudinal axis. All flanges shall be rated as 10 bars. All flanges shall be adequate to withstand test pressures for the specials to which they are attached.

All materials required for use in the making of flanged joints including nuts, bolts washers and joint gaskets shall be supplied by the works contractor. Joint gaskets shall be contained within the bolt pitch circle and shall be made from 4.5 mm thick rubber to BS 1154 Class Y3 reinforced with two layers of fabric in accordance with BS 5292. Each bolt shall be supplied and installed with a nut and two washers and each bolt shall be of sufficient length to show two threads past the nut when so installed.

Test certificates for the flange material shall be supplied. The finish on flange joint surfaces shall be in accordance with Clause 4.4 of BS 4504.

Blank flanges shall be designed and supplied by the Works Contractor for an end loading equivalent to the rating pressure of the flange. Lifting eyes or handles and air release cocks shall be provided as necessary.

Thrust flanges shall be designed to withstand a longitudinal force equal to the loading applied to a blank flange of equivalent diameter.

11.1.9 Mechanical Couplings, Flange Adapters and Expansion Joints

Mechanical couplings for jointing plain ended pipes shall be of an approved make capable of maintaining a watertight joint over a range of axial movement between the pipe ends of at least 80 mm and with up to 3 degrees angular deflection between the longitudinal axes of the pipes.

Flange adapters for jointing plain-ended pipes to specials shall be of an approved make capable of maintaining a watertight joint over a range of axial movement of at least 25 mm and an angular deflection of not less than one and a half degrees.

Expansion joints shall be provided to conform to details as shown on the drawing. They shall be supplied complete with all accessories.

All necessary couplers, joint rings, nuts, bolts and washers, etc. required for completing joints shall be supplied by the Works Contractor.

Couplings shall be supplied with or without a central register or locating plugs as required. The central collar shall be at least 1.5 mm thicker than the equivalent standard pipe thickness.

Every coupling, flange adapter and expansion joint shall be capable of withstanding without leakage the pressure required for the works hydraulic test of the section of pipeline in which it will be incorporated. The pressure rating shall be clearly stamped on all couplings and adapters. The rubber joint rings shall be Type 1 to BS 2494 having a hardness range of 45-65 degrees measured in accordance with BS 903 and tensile stress-strain properties corresponding to the relevant hardness.

All metallic parts are to be descaled to second quality standard in BS 4232 and protected in accordance to the specification.

All welding protrusion shall be machined finished Mechanical couplings and flange adapters shall be hydraulic tested at the place of manufacture one in every five for each size of coupling and adapter.

Every expansion joint shall be hydraulic tested at the place of manufacture prior to delivery.

11.1.10Pipes for Closing Lengths

Pipes to be used for closing lengths shall be correctly sized over their full length so that accurate alignment for split collar joints can be obtained. All such pipes shall be clearly marked.

11.1.11Collars

Collars shall be provided for jointing cut pipes or closure pieces by means of internal and external fillet welding. Minimum lengths of collars shall be 250 mm. Collars may be provided as single split collars with temporary bolts and lugs. Collars shall have two tapped and plugged holes of not less than 6 mm diameter to permit air pressure testing of the joints after field welding, one each side of the collar clear of the welding runs and approximately 25 mm form the edge of the collar. The collar shall be 1.5 mm thicker than the equivalent standard straight pipe thickness. Collars shall make close contact around the circumferences of both pipes connected and the gap between the ends of a split collar after tightening shall not exceed 3 mm. Split collar ends shall be prepared for butt welding in the same manner as plain ends of pipes prepared for butt welding in accordance with Std

5L/S. The tolerances of the collar shall be such than nowhere shall the gap between the inside surface of the collar and the outside surface of the pipe at fillet weld locations exceed the tolerances permitted for spigot and socket joints.

The overlap on each pipe shall not be less than 75 mm. Collar joints shall not be required to take any deflection.

11.1.12Works Hydraulic Testing

All pipes shall be hydraulically tested at the place of manufacture in accordance with Section 5 of Std 5L/S.

Full test pressures shall be maintained for at least 3 minutes during testing at the factory and automatic pressure recorders must be installed on hydraulic testing machines.

Any pipe, which fails to withstand the hydraulic test pressure, or which exhibits signs of porosity shall be deemed not to comply with this Specification and shall be rejected unless otherwise decided.

11.1.13Protection

All pipes shall be protected both internally and externally against corrosion. The pipes shall be protected externally with a double reinforced bitumen enamel wrapping followed by internal protection with spun concrete lining. Both types of protection shall be applied under factory conditions but not necessarily at the place of manufacture of the pipes.

Internal and external protection at joints shall be completed on Site after acceptance of joint weld test.

11.1.14External Coating

The pipes shall be coated with bitumen generally in accordance with Clauses 29 of BS 534 except that the protection shall have a minimum thickness of 6 mm for pipes over 324mm od. The bitumen shall be Type 2 of BS 4147 and there shall be not less than 2 mm of bitumen between the inner and outer wraps, and between the pipe and the inner wrap.

The coating shall be stopped short as shown on the Drawing for ends of all spigot and socket pipes, and 250 mm from the ends of all plain ended pipes for use with mechanical couplings or flange adapters. The edge of the wrapping shall be chamfered at 25 degrees.

11.1.15Wrapping

The wrapping materials shall be spirally wound onto the pipes and specials simultaneously with the bitumen coating. Each wrap shall be from 150-225 mm wide and the edges shall overlap by 12-25 mm. Care shall be taken to ensure that the inner wrap does not come in to contact with the pipe metal or with the outer wrap.

The inner wrap shall be a glass fiber resin-bonded tissue reinforced in the longitudinal direction with parallel glass threads spaced 10 mm apart. The nominal thickness shall be 0.5 mm and the minimum weight shall be 0.046 kg/m2.

The outer wrap shall be of glass fiber resin-bonded tissue reinforced in the longitudinal direction with parallel glass threads spaced to 10 - 25 mm apart. It shall be impregnated with a material fully compatible with the bitumen coating to give a finished thickness of 0.75 mm.

11.1.16Inspection of External Pipe Coating

All coated pipes and specials shall be rigidly inspected for defects. Thickness shall be determined by a pit gauge, continuity with a holiday detector and coating quality by cutting out 75 mm square samples at the rate of one sample per 5 lengths of pipe manufactured.

The whole coated surface area of all pipes and specials shall be tested for pinholes or other invisible defects in the coating using an approved holiday detector at a potential of 14,000 volts.

Any lengths on which the coating is in the opinion of the Engineer poorly applied shall be cleaned to bare metal and re-coated. Minor defects may be repaired by touching up. All repairs shall be checked for thickness and continuity.

11.1.17Painting Coating Pipes and Specials

All coated pipes and specials shall be given two coats of undiluted commercial "Matex" or similar approved vinyl acetate paint to reduce the risk of the coating becoming tacky.

11.1.18Internal Protection at Pipe Ends

Concrete shall be omitted at the following locations:

Spigot & Socket Ends	The lining shall terminate as shown on the Drawing. The edge of the lining shall be angled back at 3mm to the pipe axis in order to provide a positive key for in-situ joint protection.		
Plain Ends	For butt straps or collar joints, the lining shall terminate 90mm back from the pipe end. The edge of the lining shall be angled back at 30° .		
	For mechanical coupling and flange adapter joints, the lining shall be brought right against the retaining rings.		

11.1.19Pipe-Work for Laying Above Ground

Uncoated steel pipes and specials required for installation above ground shall be protected with three coats of approved zinc chromate primer after cleaning down to a bright metallic finish as to BS 4232 first quality standard.

11.1.20End Protection

The concrete lining and the external coating of pipes and specials to be jointed by welding shall be omitted for a sufficient distance from the ends to prevent damage to the protection during site welding.

The unlined surfaces shall be protected with a suitably approved ensues oil or similar material during manufacture so that extensive cleaning of the surface is not required before and after jointing on site.

11.1.21Low Friction Coating

Where necessary, the external surfaces of the pipe ends for use with mechanical couplings and flange adaptors shall be given, after blast cleaning to BS 4232 first quality, an approved system of low friction viny1-based protective coating. The coating shall be applied in accordance with the manufacturer's instructions. Where zinc or bituminous coatings adjoin the low friction coating, they shall over lap the low friction coating by 25 mm. The length of pipe barrel to be so protected by the low friction coating shall be 300 mm unless directed otherwise.

After curing but before removal from the factory the coating shall be wrapped with tape suitable for protecting the coating from damage in transit to and on the site. The tape shall be removed immediately prior to installation of the pipe or special so coated.

A coating, which conforms to the above requirements, is "Amercoat 23" system manufactured by Ameron, Protective Coatings Division. Brea. California 92621.

11.1.22Handling

Coated pipes shall be lifted and moved only by wide non-abrasive slings or by other means acceptable to the Engineer. Wire ropes, chains and hooks shall not be permitted to come in contact with the coatings. No pipe shall be moved by rolling.

Coated pipes shall be stacked in one layer only and in such a manner that the coating is not damaged. Adequate packing between pipes for this purpose must be supplied by the woks contractor. Coated pipes must be kept clear of the ground and rested on padded sleepers or supports.

The pipes shall be so handled. Stored and transported as to prevent undue distortion and shall not be moved in any manner involving rotation of the pipe about the longitudinal pipe axis.

The pipes shall be lifted by means of tow reinforced canvas slings at least 300 mm wide suspended from a lifting beam so that the slings are positioned at a distance of one-fifth of the pipe length from each end of the pipe.

The works contractor shall provide suitable timber end struts and sufficient intermediate struts to strengthen the pipes to the engineer's approval to prevent distortion during handling and delivery. Such struts shall be left in position when thin wall pipes of 1400 mm and above are delivered to the storage areas.

11.1.23Protection in Transit

All pipes and specials shall be protected prior to dispatch from the manufacturer's works. All flanges shall have wooden discs bolted on. All other ends of pipes and specials shall be protected against impact damage and entry of foreign matter. The protection shall take into account the end use intended for the pipes and whether or not the final protection has been completed.

Pipes and specials shall be wrapped or cushioned so that no load is taken directly on the external coating.

11.1.24Notice of Deliveries

The Works Contractor shall send to the Engineer advance notices of all consignments. Every consignment shall be accompanied by a detailed delivery note with the item number of each pipe or special.

11.1.25Inspection

The Engineer shall inspect all pipes and specials to be supplied under the Contract or an Inspector appointed by the Company at the Works Contractor's premises or at the places of manufacture if manufactured at other premises.

The Works Contractor shall provide such office facilities, assistance, labor, materials, electricity supply, fuel, stores, and apparatus and instruments including X-ray or gamma ray equipment, ultrasonic thickness indicators and high voltage holiday detectors as may be necessary to allow a thorough and extensive inspection to be carried out.

The Engineer or the Inspector shall be entitled at all times during manufacture to inspect, examine and test on the Works Contractor's premises or at the places of manufacture if manufactured at other premises, the materials and workmanship of the pipes and specials. Such inspection, examination or testing including the inspection by the Engineer or Inspector shall not relieve the Works Contractor from any of his obligations under the Works Contract.

11.1.26Measurement of Steel Pipes and Specials

The quantities set out in the Bill of Quantities are provisional only and they are not to be taken as the actual, limiting and correct quantities of the pipes and specials to be supplied by the works Contractor in fulfillment of his obligations under the Contract. For the purpose of this clause, spigot and socket ended pipes shall be measured and paid in effective length. The effective length shall mean the net length of the pipe as laid, i.e. after deduction of the length of overlap at any spigot and socket joint to be made with the pipe.

The cost of all works testing and all other requirements of the Specification including lining, coating, wrapping, etc, involved in the manufacture and delivery of the steel pipes shall be deemed to be included in the Contract Rates.

11.2 Cast Iron Pipes

11.2.1 Cast Iron Pipes and Specials

Cast iron pipes shall be spun iron pipes complying with BS 4622 and BS 4772 for gray iron spun pipe and ductile iron spun pipe respectively. They shall be centrifugal cast pipes made by pouring molten cast iron into a horizontal water-cooled metal mould which is rotating at high speed.

11.2.2 Joints for Cast Iron Pipes

Types of joint to be used shall be as specified unless otherwise stated to meet the approved Manufacturer's instructions.

11.2.3 Making Flanged Joints

Flanged joints shall comply with BS 4504 (metric) and shall be very carefully aligned before the bolts are inserted and the flanges pulled together. The rubber ring inserted between the flanges shall be of such diameter that it lies inside the bolt circle but shall not intrude into the pipe bore.

Flanged joints underground shall be protected by two layers of an approved bitumenimpregnated tape.

11.2.4 Making Joints with Mechanical Coupling and Adapters

Joints made with mechanical couplings and shall be made in strict accordance with the instructions given by the manufacturer.

11.2.5 Cast Iron Specials

Special pipes and castings, including bends tees and branches shall comply with BS 78: Part 2. Joints shall be approved flexible joints unless otherwise specified.

T-pieces for air valves shall be spigot and socket with a flanged branch drilled to suit the air valve, unless otherwise specified. T-Pieces for washouts shall be double sockets with a flanged branch unless otherwise specified, level with the invert and drill for a sluice valve.

11.2.6 Protective Coating on Iron Pipes

Spun iron pipes shall be coated inside and out with a coal tar pitch giving a smooth surface. For extra exterior protection, pipes may be sheathed with a 6.6 mm sheathing of filled bitumen, sometimes reinforced with glass fiber wrapping as and when specified.

Alternatively, the pipes and specials shall be sheathed in sleeves of 0.25. mm (1000 gauge) polyphone sleeving which shall be sealed together with tape. Self-adhesive PVC tapes,
having a thick layer of mastic compound on one side or fibrous tapes impregnated and coated both sides with a similar compound shall be wound spirally lapping, over the joints externally to complete exterior protection before polyphone sleeving.

11.2.7 Testing of Iron Pipelines

Recommended test and working pressures shall be as set out in BS 4622, BS 4772 and CP 2010 Part 3.

When applying field test pressures, which are higher than the working pressure, care shall be taken to ascertain that thrust blocks at bends, etc. have been designed for the test pressure and not for some lower working pressure.

11.3 Steel Pipes and Fittings

Scope

This shall apply to the construction of steel pipelines and pipe work, installation and assemblies of back raked screens, air vessel, penstocks, valves, couplings, fittings, etc. British Standard shall apply for all pipe work.

The contractor shall furnish, install and test the pipelines and pipe work, fittings and appurtenances, as indicated on the Drawings and as herein specified.

All steel pipes, fittings and appurtenances shall be of make stainless steel. Pressure pipe shall be of class PN10 (10 MPa) and gravity joints of class N (5 MPa).

Prior to shipment from factory all types of pipes shall be tested at the place of manufacture, and the contractor shall submit to the Engineer's Representative for each consignment of shipment and authenticated certificate to indicate that the pipes and fittings have been tested by the manufacturer and found to comply with these Specifications.

Description of Pipes

Except as otherwise specified steel pipes shall be stainless steel and meet the requirements of B.S 1387 for the types and classes as shown in the drawings or detailed in the particular specification. Pipes shall be either with plain ends for butt welding or with a bell on one end for fillet welded lap joints. Both internal and external coating of pipes shall be specified by the manufacturer.

Transporting, Handling of Pipes and Fittings

Pipes and fittings shall be allowed to drop or strike objects which will injure them. When lifting pipes or their open ends, special hooks or plated shaped to fit the wall shall be used. Pipes shall be lifted by padded straps at least 20 centimeters wide. Care shall be exercised in transporting, handling or storing pipes and fittings in order to avoid distortion, flattening, denting, scoring or any other damage to pipes and fittings to their outer wrap and/or inner lining (if any).

Repairs of Defective Pipes

Should lamination, cracks or other defects be discovered on any pipe, or its coating or lining. The Engineer will issue instructions as to whether such defects shall be repaired or the defective part shall be cut out or the defective pipe shall be removed.

Welding of Pipes

Welding methods

All welds shall be made by the manual shielded metal-arc method. The welding procedure for stainless steel pipes to be applied by the contractor shall be submitted to the Engineer for approval, before the commencement of the work. All welds shall be made only by welders having passed the welders' qualification test in accordance with B.S Welds will be either butt welds for plain-ended pipe joints or fillet weld for lap joints (bell and spigot). The use of welding machines with two outlets will not be permitted; every welder shall work with a separate machine.

Electrodes

Electrodes used for welding shall meet the requirements of the pipe manufacturer's specification. Generally, with D.C. generators, class S 6010 electrodes shall be used. In any event, the electrodes proposed by the contractor shall be subject to the engineer's approval prior to their use. Electrodes shall be stored in the unopened original containers in such a manner as to prevent absorption or loss of moisture or mechanical damage to the coating. Electrodes in open containers shall be protected against moisture. Electrodes that have been damaged, become moist or otherwise deteriorated shall be rejected.

Cleaning of Pipes

Before pipe ends are welded together they shall be thoroughly cleaned of any dirt, oil, residues of paint and asphalt, and any other foreign matter that may adversely affect the quality of the weld. Paint and oil residues shall be removed with kerosene or benzene.

Welding of Joints

The pipes will be joined by a spigot bell welded joint. The number of beads in each weld seams shall not be less than two, and their thickness shall not exceed 3.0 mm each.

In fillet welds (bell and spigot joint), the thickness of the throat shall be at least 0.70 times the pipe wall thickness. Cutting back of the edge of the bell shall be kept to a minimum.

All weld metal shall be thoroughly fused to the parent metal and to the previously placed weld metal.

After the completion of each bead, the weld shall be thoroughly cleaned of all scale, slag, or dirt. All spots on the weld where electrodes are changes shall also be cleaned.

A penning hammer and steel brush may be used for cleaning, provided it is done to sound and bright metal.

The finished seam shall be thoroughly cleaned by means of steel brushers.

Welding Positions

The welds shall be made of either by roll welding or position welding. Roll welding will be permitted, provided alignment is maintained by the use of skids and roller dollies supporting two or more lengths of pipe.

Positions welding shall be done with the pipes resting on skids at the proper height over or alongside the trench, so as to permit competing the weld on the whole circumference. All requirements as to the quality of the welds shall apply equally to roll welding and position welding.

Jointing of Line Sections

Pipes shall be connected to each other by welding as specified above, while they are placed on suitable supports over the trench or on the ground beside the trench.

The length of sections to be welded together before lowering shall be as determined by the Engineer. The position of every pipe or elbow in the section shall be such that, when the section has been lowered to the trench bottom, the longitudinal seams will be located

between the figures 10 and 2 on the clock face, so that repairs on the seams can be done in the trench without necessitating deep excavation.

Before being connected to the line, each pipe and each elbow shall be cleaned on the inside.

Repair of Weld Defects

The Engineer may permit repairs of defects in the root or filler beads to be made, but any weld that shows evidence of repair work having been done without such permission may be rejected.

Pinholes and undercuts in the final bead may be repaired shall be subject to the Engineer's approval. Undercuts not exceeding 1.0 mm in depth will not be considered as defects.

Before repairs are made, the defective areas shall be removed by chipping grinding, or flame gouging. All slag and scale shall be removed by wire brushing. When cracks are found, the entire seam shall be cut and re welded.

The contractor shall clearly mark with oil paint on top of the pipe any defect that may be discovered in the pipe or weld.

Various Welding Work

Cutting and Preparing Pipes for Welding

Square cuts shall be in a plane perpendicular to the pipe axis. Oblique cuts shall be done accurately to the required angle in such a manner that the cut edge is in one plane. Pipe ends for butt welding shall be believed to an angle of 300 degrees with the plane of the edge, with a permissible variation of + 50 or - 00 degrees.]

All cutting shall be done with a mechanical tool, or by acetylene flame cutting by means of special cutting device or Arc-air (carbon electrode with air jet). Flame cut surfaces shall be filed smooth. Cutting of lined pipes shall always be done with Arc-air cutting equipment. After the metal has been cut and pipe edge through to the lining, the later shall be carefully broken along the cut and pipe edge prepared for welding as required.

Welded Elbows

These shall consist of suitable obliquely cut pieces of pipe (mitres) welded together. These mitres shall be accurately cut so that they form the required shape and accurately fitted together so that after welding the completed elbow will have the exact shape and angle required. The ends of the mitres shall be believed for welding as specified as above.

In all elbows having a diameter of more than 250mm the seams between mitres shall also receive an internal weld pass, which shall be made after the weld root has been thoroughly cleaned.

Fabrication of Branch Outlets

Fabricated T and Y branch connections shall be produced by cutting the branch pipe to the correct inter-section shape to fit the curvature of the main pipe, cutting the required opening in the main pipe and welding the branch pipe to the main pipe.

The quality of welds shall be specified for pipe connections. The inside of the pipe intersection shall be cleaned and smoothed to ensure unobstructed flow in the pipe.

Where instructed by the Engineer, the contractor shall install and weld reinforcement saddles to fabricated T and Y branches specified above. The saddle shall cut and bent to the required shape and slipped over the branch, its outside edges shall be welded to the main pipe, while the edge of its opening shall be welded to the branch pipe.

Quality of welds shall be as specified above. The edge of its opening shall be welded to the branch pipe. Quality of welds shall be as specified above for welding of pipe.

Fabrication of Pipe Reducers

The contractor shall fabricate reducers from steel plate properly cut, rolled and welded or by cutting out wedge-shaped pieces from a length of pipe the diameter of which shall be equal to the larger diameter of the required reducer, squeezing the pipe together to the shape of the reducer and welding along the cut edges, which shall be straight and believed for welding, the gap between them being of uniform width over the whole length. On pipes having a diameter of more than 250mm an internal pass shall be added to each weld, which shall not protrude more than 1.5mm into the inside of the pipe. The ends of the pipe reducer shall have edges in parallel placed perpendicular to the pie axis and shall be believed for butt welding.

Prefabricated Fittings

Prefabricated elbows, tees and reducers shall be jointed to pipes by square butt welds or by welds as specified above for pip-welding, care being taken that the true alignment and correct position of the fittings are ensured.

11.4 General Valves Specifications

11.4.1 General

Unless otherwise specified all valves and penstocks shall be anti-clockwise opening and the maximum effort required, applied at the circumference of the hand wheel to operate the valves against the maximum unbalanced head shall not exceed 220 N.

All hand wheels shall have the words " to open " and " to close" in Arabic and English with arrows indicating the direction of rotation cast on and shall be coated in plastic, nylon or other approved materials in order to withstand the ambient conditions.

Unless otherwise specified or agreed the screwed portion of spindles and extension and extension spindles shall be of stainless steel.

Rising spindles to be installed in open air shall be protected with suitable metal or plastic cover

Extension spindles, where required, shall be connected to the screwed spindle with a suitable muff-coupling. Universal joints shall be provided at cranks.

The nuts shall be of gunmetal or synthetic material and mating surfaces of gates and bodies shall be of gunmetal, copper alloy or synthetic material. Nylon or other thermoplastic materials liable to attack shall not be used where hydrogen sulfide is likely to be present.

Where "operation by tee key" in specified the valve or pen-stock shall be supplied with a suitable yoke with a squared cap of standard size to receive the tee key.

The keys shall be supplied at the rate of one key per two valves or two pen-stocks unless the valve or pen-stock is to be installed in an isolated location in which case one key shall be supplied for each fitting location.

All valve waterways are to be coated internally with a solvent free epoxy or polyester lining of 100 solid content to be applied at the place of manufacture.

Valves and penstocks shall be capable of withstanding corrosion in the ambient conditions and any parts manufactured from a material, which is not it self resistant must be protected.

All valves and penstocks will normally be witness tested at works.

Before delivery to site all working surfaces shall be thoroughly cleaned, and, if metal, protected by grease.

Packing must be sufficient to ensure complete protection of the fitting during transit and storage.

Valves under 300 mm diameter together with all hand wheels an other easily detachable items on both valves and pen-stocks are to be packed in timber packing cases and properly bound with steel packing bands.

All valves of 300 mm and over are to be protected with wood or plywood discs or flanges together with straw rope and Hessian wrapping.

11.4.2 Gate Valves Water Supply

Unless higher pressure rating is required for the pipeline, gate valves shall have a nominal pressure designation of 10 bars which shall be marked on the valve body. Unless detailed to the contrary to suit existing pipe work, flanges shall have a pressure designation of 10 bars and shall be drilled accordingly. The face to face lengths of the valves shall be in accordance with ISO 5752 Series 2. Valves with lengths to Series 14 may be used with suitable make up pieces to achieve the Series 3 lengths.

Valves stem seals shall be of the stuffing box and gland form. Valves shall not be fitted with resilient seals.

Indicators, hand wheels, caps for key operation, extension spindles, capstan head stocks and locking devices shall be provided as specified as or shown on the drawings.

Valves shall be "open end "tested.

Valves for which witnessed tests at works are required are so specified.

11.4.3 Gate Valves for Sewage and Related Fluids

Unless higher-pressure ratings are required for the pipeline, gate valves shall have a nominal pressure designation of 10 bars which shall be marked on the valves body. Unless detailed to the contrary to suit existing pipe work, flanges shall have a nominal pressure designation of 10 bars and shall be drilled accordingly. The face to face lengths of the valves shall be in with ISO 5752 Series 3 valves with lengths to Series 14 may be used with suitable make up pieces to achieve the Series 3 lengths.

Valves shall normally be metal seated with valve bodies of iron and the seating copper alloy faces. The gates shall be of wedge pattern, copper alloy faced with inside screw nonstuffing box seal.

Where resilient seal gate valves are detailed the valve bodies shall be of iron. The gates shall be of iron and wedge pattern with nitrile rubber covering and wit inside screw non-rising stems of stainless steel or iron. The gates shall be of iron and wedge pattern with nitrile rubber covering and with inside screw non-rising stems of stainless steel or forged bronze. They shall have a seal of nitrile rubber O rings.

Where actuator operated, valves larger than 300 mm shall have copper alloy faced guides and slippers. When 300 mm dia. And smaller actuator operated valves are installed other than in a vertical position they have machined guides and gates.

Valves shall normally be provided with drain plugs.

11.4.4 Air Valves

Air valves for pumped pressure pipelines will be the special high pressure "Dual" large orifice type with a maximum working pressure of 100 meters head and a body test pressure of 200 meters head, for other duties, such as distribution mains single, small orifice type valves may be used.

11.4.5 Pressure Reducing Valves

Pressure reducing valves shall be flanged with cast iron bodies and shall be supplied complete with inlet and outlet pressure gauges and adjustable regulating weights. The maximum sustained inlet pressure shall be determined from the closed valve pressure of the installed pumps.

11.4.6 Inlet Float Valves

Inlet float valves shall be of the streamlined needle type complete with stilling and control basins and 38 mm dia. syphon. The sizes of the valves for each installation are shown on the drawings.

11.4.7 Metal Flap Valves

Flaps and frames shall be of close grained cast iron. Mating surfaces of flaps and frames shall be of non-ferrous metal (excluding aluminum) machined to ensure a watertight fit in the closed position.

Hinge pins shall be of phosphor bronze, all flaps shall be double hung.

All cast iron surfaces shall be cleaned by grit or shot blasting to be free from grease, then coated as specified for the environment. Hinge pins and mating surfaces shall be smeared with grease.

11.4.8 Plastic Faced Flap Valves

Flap valves shall be faced in an approved synthetic material so as to be corrosion-free in the ambient conditions. The flap shall be weighted to assist closing and shall be suitably braced and reinforced.

Hinge pins shall be of stainless steel and all flaps shall be double hung and seated off the vertical.

Mating surfaces shall be accurately molded or machined to ensure a watertight fit in the closed position.

11.4.9 Non-Return Valves

Unless higher-pressure ratings are required for the pipelines non-return valves shall have a pressure designation of 10 bars. Unless detailed to the contrary to suit existing pipe work, flanged valves shall have there flanges to a pressure of 10 bars and be drilled accordingly. The face to face lengths of the valves shall be either $2 \times ND + 100 \text{ mm}$ or ISO 5752 Series10, the longer length to be allowed for in all cases using make up pieces where necessary to achieve the required lengths.

Valves shall be of the single door swing check type and shall have a cast iron body, copper alloy seating and resilient faced disk.

All valves shall be clear way and lugs provided on screwed seats etc., for assembly purposes shall be removed.

Valves shall, unless impracticable through size, or otherwise specified as capable of passing solids not exceeding 90 mm dia.

Valves shall be provided with a removable cover on top of the body casting, to enable the hinge and door to be inspected or removed.

The door opening shall be restricted to a maximum, of 70^0 at the hinge, measured from a plane passing through the hinge at right angles to the axis of flow. Valves shall be provided with extended spindles to the doors fitted with level arms suitable for balance weights.

The valve should be provided with limit switch, operated by external cams rigidly attached to the door spindles. The limit switch shall operate when the valve door has moved through approximately 10^0 . The switch shall provide one normally open and one normally closed electrically separated contacts of the make before break type.

11.4.10Pressure and Compound Gauges

Pressure gauges for use with sewage and sludge shall be Borden gauges. The pressure transmission system shall be of the air-filled or oil-filled sealed type incorporating reinforced plastic or stainless steel capillary tubing and diaphragm transmitter.

For the air-filled system, the diaphragm shall be mounted in clean-out housing. The transmitter housing shall be mounted directly onto a 25 mm or greater bore straight through isolating cock. The cock shall be mounted directly onto the pressure tapping.

Where the gauge is mounted directly on the pressure tapping a Schaffer diaphragm gauge may be used. Schaffer diaphragm gauges shall be fitted with 20 mm or greater born straight through isolating cocks.

Gauges shall be graduated in meters of water and bars gauge, together with vacuum where appropriate. The accuracy of the system shall be = 1.50 of range or = 2.50 m bar. Gauges shall have 150-mm diameter circular faces.

Part	Material			
Drainage Elbow	Polypropylene			
Seal Plug Assembly	Nylon, Fiberglass Reinforced			
Float	Foamed Polypropylene			
Clamping Steam	Nylon, Fiberglass Reinforced			
Body	Nylon, Fiberglass Reinforced			
Cover	Steel DIN st. 37			
O-Ring	Buna-N			
O-Ring	Buna-N			
Slotted Nut	Stainless steel SAE 303			
Plastic Base	Nylon, Fiberglass Reinforced			
Inlet for flushing	Steel SCH 40			
Stopper	Acetal			

Air Release Valve for Sewage

Parts Specification

Spring	Stainless Steel SAE 303			
Retaining ring	Stainless Steel SAE 303			
Bolt and Nut	Galvanized steel Chromate plated			
Stem	Stainless Steel SAE 303			
Float	Stainless Steel SAE 316			
Ball Valve	Brass ASTM B- 124			
Body	Steel DIN St. 37			
	Table 3			

11.4.11Butterfly Valve

The butterfly valve is bi-directional, leak tight and appropriate for on-off regulating service due to its resilient seat. The parts are:

- 1. **Body** Double flanged solid one-piece construction made out of cast iron as standard, other materials are available upon request.
- 2. **Bushing** self lubricates to minimize shaft friction under maximum torque.
- 3. **Seals** Complete sealing is made as vulcanized seat against disk and vulcanized sleeve along shaft and "O "rings on stem.
- 4. **Stem** Stub shafts made of polished stainless steel. Motion is transferred to disc with fitted square end.
- 5. **Disc** The disc is especially shaped with a smooth contoured edge to minimize friction losses and provide a drop tight seal. This special design guarantees long service life of disc and seal and reduced maintenance costs.
- 6. Liner vulcanized to body in an extramurally accurate manner to form a drop tight resilient seal with low friction and long life. Various rubber and artificial compounds are available for different service conditions
- 7. **Base** Stub shaft is sealed by bushing and plug.

11.4.12Level Regulator

The level regulator is consisting of a float linked to a cable and equipped with switches.

The maximum depth immersion is 20 m (65 ft).

The casing of the regulator will be-made of polypropylene and the cable sheathed with a special PVC compound.

The level regulator contains a micro switch with two positions common with on/off. The liquid density is for wastewater and storm-water.

Other specifications:

- Standard ISO 9001 / 9002 or BS equivalent.
- Cable 20 m length.
- Electrical waterproofs IP58.

11.4.13Dismantling Joint

The dismantling joint is installed close to a valve (or check valve) to enable easy dismantling.

It is available in the range of the valves and must be installed above-ground or in a chamber.

This joint consists essentially of two flanged spigot pieces, one of which slides in the other, and a loose gasket which has a trapezoidal cross-section. This joint is clamped by means of studs.

The three components constituting the joint are in welded steel and the bolts and nuts are cadmium plated.

It complies with the standards ISO 2084 or BS 4504 for flanged pipes and fittings.

Dimensions and weight:

DN	mm	100	150	200	250	300
Length Maxi	mm	225	225	245	245	245
Maximal service pressure	bar	10	10	10	10	10
Weight (+ 20%)	kg	20	35	50	65	75

11.4.14Pipe Coupling

For pipe couplings there are brass compression fittings a full range of fittings suiting PE pipes from $\frac{1}{4}$ " to 2" O. D. also for couplings, elbows, tees, etc. there is a long pipe piece inside the fitting, thick and wide gasket, three tooth gripping ring ensuring full installation safety and tightness at 10 bar.

11.4.15Finishes to Valves

Internal unmachined surfaces of valves shall be coated with two coats of approved epoxy paint and machined surfaces liable to corrosion with an anti-corrosion composition. External surfaces for valves in chamber shall be coated with two coats of epoxy paint.

11.4.16Flow Meter

A flow meter shall be provided on the outlet line where shown on the drawings or as otherwise specified.

The flow meter for use on the outlet line shall be of the inline propeller type. It shall be fitted with steel saddles prepared for welding into steel mains and shall incorporate a bolted hatch for easy access to the immersed mechanisms. The capacity of the meter shall be related to the main diameter and should be the most suitable for the different flows encountered. The mechanism shall incorporate a propeller of high quality polymer or nylon with gearbox of bronze and stainless steel shafts.

The meter shall have an easy to read register consisting of a six digit integrator calibrated in cubic meters of total flow.

The flow meters shall be "main-line meters" of the welded saddled type, as manufactured by Sparling Envirotech Limited, Victoria Road, Burgess Hill, Sussex RH15, England, or approved equal.

12 Inspection, Testing and Commissioning

12.1 Inspection and Testing of Pipelines

12.1.1 Cleaning and Inspection of Pipelines

During and after construction the Contractor shall take reasonable measures, including the provision of plugs where appropriate, to prevent the ingress of deleterious matter into pipelines.

After backfilling pipe trenches and completing chambers, hatch boxes etc. and before the trench surfaces are reinstated, the interior of pipelines shall be cleaned of slit and debris by approved methods for inspection by the Engineer's Representative as follows: -

Pipelines of 600 mm (nom.) internal diameter and smaller shall have a loose plug passed through them to show that they are clear of obstruction and free from deflection. The loose plug shall be dimensioned to suit the permissible minimum deflected diameter of the pipe.

Pipelines greater than 600 mm (nom.) internal diameter will after cleaning be inspected from the inside and the Contractor shall provide a suitable trolley for this purpose.

Pipelines will be inspected again before commissioning or taking over (whichever is sooner) and if required by the Engineer's Representative shall be cleaned again in whole or in part.

Before the works are accepted by the Engineer's Representative, the entire pipe system, including all manholes, shall be thoroughly cleaned by flushing or by passing a brush, sphere or other suitable tool through it, or by any other approved method, to ensure that it is clean, and free of obstructions.

12.1.2 Testing of Pipelines General

Prior to commencement of flushing or testing approval shall be obtained to the method of disposal of all fluids used for flushing or testing purposes.

Under no circumstances will permission be given for the discharge of such fluids into the drainage system.

If permission is given to use new or existing pipelines or culverts, which are not part of a live system, they shall be thoroughly cleaned of all silt and any resulting damage made good after use.

If lagoons for the storage of such fluids are permitted, they must be suitably protected with fencing and attended by day and night to prevent access by the general public and will not be sited adjacent to buildings. Approved means of preventing the formation of mosquito larvae on the surface of the lagoons will be employed.

Testing of pipelines shall in all cases be applied in the presence of the Engineer's Representative. The Contractor shall provide complete plant and all struts, thrust blocks, etc., as may be necessary for effectively testing the pipelines to the specified pressures.

For both gravity and pressure pipelines only testing of new or replaced sections of pipelines and fittings will be required under the Contract, in accordance with this

Specification, unless detailed otherwise. Such testing will be carried out before making final connections to the existing network. However where tees or other fittings are inserted into existing pipelines and where lengths of pipeline are replaced no backfilling will be allowed at the tees or fittings or at the joints between new and existing pipe work until the pipeline has been returned to service and a visual inspection of all such fittings and joints made at the network pressure.

Should any inspection be unsatisfactory or any test fail the Contractor shall replace defective pipes, leaking joints or otherwise re-execute defective work as instructed following which cleaning and testing will be repeated until the Engineer's Representative certifies the pipeline to be satisfactory.

12.1.3 Testing of Non-Pressure Pipelines

Ogee jointed pipelines shall not be tested or subject to infiltration limitations.

All other non-pressure pipelines of 750 mm nominal and smaller internal diameters shall be given a preliminary test when the pipeline is bedded and jointed before backfilling and a final test after backfilling.

Unless otherwise instructed non-pressure, pipelines shall be tested in sections between manholes. In addition, pipelines shown as straight lines on the drawings shall be subjected to a light as detailed in the pipe laying specification.

Preliminary and final tests will not normally be applied to pipelines greater than 750 mm (nom.) internal diameter and acceptance of these pipelines will be dependent on satisfactory visual inspection of the pipes and joints.

Preliminary Test

Air shall be pumped into the pipeline until a pressure of 100mm head of water is indicated on a water manometer and the pressure shall not fall to less than 75 mm during a period of 5 minutes.

The Contractor will not be permitted to commence testing later than 4 hours after sunrise or earlier than 4 hours before sunset during the summer period unless otherwise directed by the Engineer.

Final Test

The part of the pipeline under test shall be filled with water to a level 1.25 m above its highest point. After standing for 30 minutes the water shall be topped up if necessary and in the following 60 minutes the loss off water shall not exceed 7.5 liters per meter of diameter per 30 m of length of pipeline under test.

Where in the opinion of the Engineer's Representative the above test is not sufficiently indicative of water tightness by reason of high ground water levels the test will not be applied. Acceptance of the pipelines will then depend on satisfactory inspection or testing for infiltration as referred to below, and air test of the pipeline in manhole lengths.

Testing Gravity Sewers

1- Sewers shall be tested by the contractor after they are jointed and before any concreting or backfilling is commenced, other than such as may be necessary for structural stability whilst under test.

- 2- Sewers up to and including 750mm nominal diameter shall be tested by means of an air or water test and sewers greater than 750mm nominal diameter by a visual examination.
- 3- A further test shall be carried out after the backfilling is completed.

Air Test for Gravity Sewers

As soon as a length of pipe has been laid and before backfilling, when applicable and when ordered it shall be subjected to the following Preliminary Test: air shall be pumped into pipeline by suitable means a pressure of 300 mm head of water is indicated on a water manometer and the test will not be satisfactory if the air pressure fails to less than 275 mm during a period of 5 minutes. Pipelines shall be given a Final Test using water after they have been backfilled, cleaned and inspected.

Pipelines of 675 mm or more internal diameter shall have each joint individually tested by means of an approved joint testing apparatus. Pipelines of lesser size shall be tested in convenient lengths by filling with water under pressure.

Unless specified elsewhere, the test pressure shall be 900 KN per square meter (91.8 m head) for cast iron and asbestos cement pipes shall be 50% above the manufacturer's rated working pressure for the approved pipes for steel, plastic and other pipes.

The pressure test shall be sustained for a period of 30 minutes and the volume of water required maintaining the test pressure shall be determined in an approved manner.

The test will not be considered satisfactory if the rate of loss of water from full pipe exceeds 1 litter per hour per 100 mm diameter per kilometer of pipeline under test, or from an individual joint test, if the loss of the pressure during the test period exceeds 70 KN per square meter.

Each test shall be restricted to pipes of one class and wherever practicable the length of pipeline to be pressure tested at one time shall not exceed 500 meters. Particular care must be taken to isolate air valves, etc, not to apply higher pressure than specified at any point on the pipelines and to ensure that the pipelines are adequately anchored before any test is carried out.

Wooden plugs shall be provided and maintained in all open ends of the pipelines so as to exclude silt and deleterious matter until the pipelines are commissioned.

Water Test for Gravity Sewers

- 1- The test pressure for sewers shall not be less than 1.2m head of water above the pipe soffit or ground water level, whichever is the higher, at the highest point and not greater than 6m, head at the lowest point of the section. Steeply graded sewers shall be tested in stages in cases where the maximum head, as stated above, would be exceeded if the whole section were tested in one length.
- 2- The sewer shall be filled with water and a minimum period of 2 hours shall be allowed for absorption, after which water shall be added from a measuring vessel at intervals of 5 minutes and the quantity required to maintain the original water level noted. Unless otherwise specified, the length of sewer shall be accepted if the quantity of water added over a 30 minutes period is less than 0.5 liter per liner meter of nominal diameter.

3- Notwithstanding the satisfactory completion of the above test. If there is any discernible leakage of water from any pipe or joint, the pipe shall be replaced and/or the joint remade, as appropriate and the test repeated until leakage is stopped.

CCTV Inspection of Gravity Sewers

- 1- Before a CCTV inspection is carried out and prior to the issuing of a Final Certificate, the Contractor shall confirm in writing to the Engineer that all of the following conditions have been met.
- 2- All planned connections have been made in accordance with specifications and standards.
- 3- The sewer and manholes are clean.
- 4- All debris has been removed from connected sewers and drains and,
- 5- All highway construction proposed above the sewer is complete except for its final surfacing.
- 6- The contractor shall afford all reasonable facilities for personnel employed in the execution of CCTV inspection work in the site.

Infiltration Test

After completion of backfilling and restoration of normal subsoil conditions all pipelines and manholes shall be examined for infiltration which shall be nil.

<u>Ball Test</u>

Newly laid gravity pipelines shall be tested for deformity and obstruction. A ball 3 percent smaller in diameter than the pipe shall be rolled through the entire pipeline from one manhole to the next. If the ball sticks due to the ovality of the pipe, a ball 5 percent smaller shall be used. The maximum permitted deformity is 7 percent of the pipe bore, and if the deformity exceeds 5 percent when the pipe is first tested, the test shall be repeated three months after completion to ensure the 7 percent limit has not been exceeded.

Video Documentation

The inside of all pipelines constructed by the contractor shall record on a video tape by passing a video camera through each pipe.

Video recording shall be carried out so that each section of recording shall be clearly marked with date, section between manholes, etc.

Video recording shall be unacceptable to the Engineer's Representative shall be repaired by the contractor at his own expense. The final acceptance certificate for each pipeline depends on the satisfactory completion of the foregoing tests and inspections.

12.1.4 Testing of Pressure Pipelines

12.1.4.1 Preparation for Pressure Test

The Contractor shall provide written notice to the Engineer of any tests two days before the test is to be carried out. All tests must be witnessed by the consultant's Engineer. The Contractor shall maintain written records of the tests and provide copies of the records to the Engineer prior to the completion of the project.

The Contractor shall provide all water, fittings, pipe stoppers, test pump pressure gauges and the necessary equipment and tools for pipe work. Hydraulic pumps, gauges and apparatus shall be equipped with locking devices to prevent tampering during the test period.

Filling of the distribution work with water shall not begin until 7 days after the last concrete structures have been cast. Prior to filling the lines, all joints and structures shall be inspected and be in good condition and proper functioning of all valves shall be ascertained. When testing a section not ending in a valve, the open end shall be a bulkhead and securely anchored. The testing installation and the working of the pump shall also be examined.

Prior to hydraulically testing the pipelines the Contractor shall provide adequate temporary thrust blocks at the ends of uncompleted sections, pipes shall be partially backfilled to about 500 mm above the crown of the pipe, in order to anchor the pipes during testing. Joints and fittings, however, shall remain uncovered until the pipeline has been tested satisfactorily.

12.1.4.2 Pressure Test

The pressure test shall be 1.5 times the maximum working pressure. The pressure shall be raised slowly to the specified test pressure and maintained at that pressure for a period long enough for the Engineer to examine the whole section under test. Thereafter, for a period of not less than 4 hours, the leakage of water as measured by the amount drawn into the pumps to maintain the pressure shall not exceed 1 liter per 100 millimeter of pipe diameter per kilometer of pipeline per 24 hours for each 30 meters head of pressure applied at the lowest point. Expected losses due to absorption shall be as specified by the pipe manufacturer.

Should any inspection be unsatisfactory or any test fail, the Contractor shall replace defective pipes, leaking joints or otherwise re-execute defective work as instructed following which cleaning and testing will be repeated until the Engineer's Representative certifies the pipeline to be satisfactory.

The pressure test shall also serve as a strength test for the concrete anchor and thrust blocks, thus these structures shall be designed by the Contractor accordingly. Any structures failing the test shall be replaced by the Contractor at his own expense.

12.2 Testing of Water Retaining Structures

12.2.1 Testing of Water-Retaining Structures

As soon as possible after completion, all water retaining structures shall be tested for water tightness. Each structure shall be filled with water and shall stand for a period of three days, to allow for absorption. The structure shall be considered satisfactory if, subsequent to this period, there shall be no fall in level over a period of 24 hours (after making the allowance for rainfall and evaporation) and no visible leaks, or damp surface areas.

This shall be carried out before any backfilling and before the application of any external concrete protection has taken place.

12.3 Inspection and Testing of All Manufactured Items

12.3.1 Works Testing and Inspection

All manufactured items for incorporation in the Works shall be offered for inspection, examination and witness testing and shall be supported by certificates to demonstrate compliance with this specification and with the approved manufacturing and testing standards specifications.

Where manufactured items are to be shipped the packaging shall also be offered for inspection before dispatch.

Inspections when required shall be carried out by the Engineer or his appointed Inspecting Engineer.

The Contractor shall give to the Engineer and the Inspecting Engineer reasonable notice, which shall normally be of two weeks, of the date and place at which plant will be ready for prescribed testing.

If the tests are beyond the resource of the manufacturer, he shall make arrangements for these to be carried out elsewhere. Any variation of this requirement shall be agreed and confirmation in writing shall be obtained from the Engineer.

The Contractor shall supply four unpriced copies of all suborders for manufactured items. Two copies of each of these suborders shall be forwarded to the Engineer and two to the appointed Inspecting Engineer at the time of the sub-orders shall indicate the Works for which the Item is required, state in detail the inspection and test requirements, give sufficient information for ready identification and shall state that these items will be subject to witness testing and inspection.

Four copies of all test certificates and, where relevant curves shall be supplied to the Inspecting Engineer within two weeks of completion of any witnessed tests.

Where witness tests are not required the test certificates and curves shall be forwarded to the Inspecting Engineer within two weeks after instructions to waive witness tests have been received.

On each certificate sufficient information shall be provided to enable the Engineer to issue a release certificate including the Contract Number and details shall be given for ready identification of the material or equipment to which the certificate refers.

No inspection or passing by the Engineer, the Inspecting Engineer or the Engineer's Representative of the work, plant or materials covered by this Contract, whether carried out or supplied by the Contractor, shall release him from any of his obligations under the Contract.

The Contractor shall be entirely responsible for complying with the above testing and inspection requirements, including the provision of test certificates, curves and any other information required by the Engineer and shall ensure that due care is taken by himself and his Sub-Contractors or suppliers before presenting the Plant for inspection or test. If unauthorized delivery has taken place the Contractor may be required to arrange for the Plant to be returned to the manufacturer for inspection and/or witness testing by the Inspecting Engineer.

All apparatus, instruments and connections required for the tests shall have been tested for accuracy within the preceding 12 months.

Any equipment used in the testing of the Plant shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the men working thereon.

The Contractor shall carry out tests as stated in the approved standard; performance tests and such other tests as are necessary, in the opinion of the Engineer, the Engineer's Representative or his Inspecting Engineer, to determine that the Plant complies with the Specification either under test conditions in the manufacturer's works, on site or elsewhere or in the ordinary working.

Where pumps are included in the Contract, at least one unit of each size shall be tested with the suction rigged to conform to site conditions.

All cast metal components designed for the retention of liquids, e.g. pump casings, gear boxes, engine crank cases, etc., shall be checked for soundness after machining etc., but before assembly or painting by treating with paraffin or similar method.

Where tests and inspection have been completed to the Engineer's satisfaction, and when the test certificates, curves etc., have been checked, the Engineer will confirm acceptance in writing and the Plant shall not be incorporated in the work or delivered until this acceptance has been received.

12.3.2 Testing and Certification of Motors

Witness testing may be waived on standard types of small motors from recognized manufacturers and on small components used in the manufacture of units of plant.

Motors of 15 kW and above shall be witness tested for performance to the approved standard.

Type test certificates shall be provided and shall include the following information for all motors:-

- (1)Approved standard of manufacture
- (2)Class of insulation
- Size and type of cable fittings (3)
- (4)Type of bearings, sizes and lubricant (5)
 - Type and rating of heaters

- (6) Brush sizes and maker (if fitted)
- (7) Line current all phases
- (8) Phase current balance
- (9) Efficiency and P.F. at 100%, 75% and 50% Full
- load

After initial witness testing each motor shall be combined with its driven units and witness tested to demonstrate satisfactory performance, correctness of assembly and ease of re-assembly at site. The assembled units shall be adequately marked and dowelled.

12.3.3 Site Testing and Commissioning of Mechanical and Electrical Plant

- (1) Cables laid underground shall be tested in accordance with the appropriate standard specification and to the local Electricity Company's requirements for insulation resistance, and continuity of earth circuit in the presence of the Engineers' Representative before the cable trenches are back-filled. All joints made during the installation of cables which prove faulty when tested shall be remade and re-tested to the satisfaction of the Engineer.
- (2) The connections of all electrical circuits shall be proved to be correct and the whole installation shall be tested for insulation resistance and earth loop resistance in the presence of the Engineer or the Engineer's Representative and the local Electricity Company's Representative with instruments provided by the Contractor. Any faults or defects shall be remedied at the Contractor's expense. Certificates in accordance with approved standard regulations of all service authorities shall be issued to the Engineer.
- (3) On completion of erection all pipelines shall be tested to ensure tightness of joints and connections to a pressure agreed between the Contractor and the Engineer. Test pressures will not exceed standard specification requirements unless otherwise specified.
- (4) Lubricating and fuel lines, sumps, tanks, etc., shall be adequately flushed to remove any foreign matter before being put to use.
- (5) On completion of erection of each item of Plant the Contractor shall test and check it and as far as is possible proving it under working conditions.
- (6) As soon as is practicable after erection the Contractor will be required to co-operate under the supervision of the Engineer in test running the completed installation (of which the Plant may form the whole or a part) and, as far as is possible, proving it under working conditions.
- (7) The installation shall then be operated continuously by the Contractor(s) for 24 hours, or such time as the Engineer may specify, during which time the Contractor will check that the installation is complete, in safe working order and fulfills the function for which it is intended.

12.3.4 Testing of Lifting Equipment

The Contractor shall set and fix runway beams and rails for traveling cranes within the dimensional tolerances permitted by the crane manufacturer.

Before lifting equipment is used it shall be tested to lift and maintain a minimum test load of 125% of the safe working load. During this overload test each movement in turn shall be maneuvered and the equipment shall sustain the load under full control.

The Contractor shall provide the necessary test loads and carry out the tests on all the equipment he has supplied.

The tests shall be carried out in the presence of the Engineer's Representative, who may require to measure deflections or make other observations during the tests. The tests may also need to be witnessed by others.