Rainwater Harvesting at Al Zahar Area

Technical Specifications

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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

Percent by Weight Passing

Sieve Designation (Square Openings)	**Class A**	**Class B**
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

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	½”	3/8”	#4	#10	#30	#60	#200
% Pass	90-100	80-90	58-72	42-50	28-38	8-18	2-5
	70-100	60-85	50-75	30-60	20-40	10-25	0-10
	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 avenge 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 l5xl5 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 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 foundations)	
Near faces wetted or contact with soil	75

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.

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 ± 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.

Table 4.1: Coarse Aggregate

BS 410 Test Sieve	**Percentage by weight passing BS sieves**							
	Nominal Size of Graded Aggregate		**Nominal size of Single – Sized aggregate**					
mm	**400 mm to 5 mm**	**200 mm to 5 mm**	**14 mm to 5 mm**	**63 mm**	**40 mm**	**20 mm**	**14 mm**	**14 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 4.2: Fine Aggregate

BS 410 Test Sieve	Percentage by Weight passing Bs Sieves			
	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 kg/cm^2		Max Agg. mm	Limits of agg/ Cement ratio by weight		Use of concert if not otherwise specified
	At 7 days	At 28 days		Max.	Min.	Plain concrete foundation
	100	150	20	10:1	8:1	Plain concrete foundations
B-150	100	150	37	10:1	8:1	Blinding layer under RC Foundations
B-200	150	200	20	7:1	5:1	RC structures in general
	150	200	37	8:1	6:1	RC Foundation
B-250	175	250	20	5.5:1	4:1	High load columns
	175	250	37	6.5:1	4.5:1	High load foundation
B-300	200	300	20	5:1	3:1	As specified
	200	300	37	5:1	3:1	As specified
B-400*	300	400				
	300	400				

Note: for grade of concrete B-400, trail mix shall be applied and approved by the engineer or his representative.

Table 4.4: Standard Mixes

Grade of concrete	Minimum works Cube Strength kg/cm2		Weight of dry sand per 50 kg of cement	Weight of dry coarse aggregate per 50 kg of cement						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-400*	300	400								

Note: for grade of concrete B-400, trail mix shall be applied and approved by the engineer or his representative.

Table 4.5: Workability

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

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.

Recommended Minimum Rates Sampling

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

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.

Table 4.6: Minimum Cement Content

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

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/m^2 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:

Stage 1: 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.

Stage 2: 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 Pipelines *AND PIPES WORKS*

3.1 Pipe and Pipeline Material

3.1.1 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:-

3.1.2 Percentage by Weight Passing Sieve

Test Sieve mm	for Pipes of Diameter 400 mm and above Below.	for Pipes of 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.

3.1.3 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 (unplasticised 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) used to allow for temperature derating).

3.1.4 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	3o
	Over 200 and not over 500 mm	1.75o
	Over 500 and not over 1350 mm	1o
	Over 1350 mm	0.5o

Straight draw: Not less than 10 mm or the following proportions of the length of the longest pipe/unit at any joint:

1% for polyethylene pipes

0.5% for polypropylene, polybutylene or ABS pipes.

0.3% for RP and uPVC pipes

0.1% for steel, ductile iron, Asbestos cement

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.

3.1.5 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.

Crushing Test Loads of Reinforced Concrete Pipes

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

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.

3.1.6 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 Representative. Pressure pipe shall be of class PN10 (10MPa). 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 polyviny1 chloride (UPVC) pressure pipes.
BS 3506: 1969	Specification for un-plasticized polyviny1 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 un-plasticized 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 from 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 used 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 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.

3.1.7 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 ± 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.

3.1.8 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.

3.1.9 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.

3.1.10 Pipes 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 mm^2 per meter run of pipe.

3.1.11 Stone 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 mm	Test Sieve	Nominal size of Single size stone
	63 mm	20 mm
75	100	-
63	85 - 100	-
37.5	0 - 30	100
20	0 - 5	85 - 100
14	-	-
10	-	0 - 25
5	-	0 - 5
2.36	-	-

3.1.12 Pipeline Construction

3.1.12.1 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 **two or more pipes in the same trench** (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/m^2 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-Cohesive Soils		Wide Trench Widths
Static Cone Penetrometer Test Kg/cm2	Modulus of Deformation E's (MN/m2)	D = Pipe Diameter
8.5 - 7.7	2.50 - 2.25	2.5 * D
7.7 - 6.1	2.25 - 1.80	3.0 * D
6.1 - 3.1	1.80 - 0.90	4.0 * D
3.1	0.90	5.0 * D

3.1.12.2 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 re-laid 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.

3.1.12.3 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.

3.1.12.4 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.

3.1.12.5 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.

3.1.12.6 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 Material	(Number of Passes of Max. Layer Thickness mm	Compaction Plant). Hand Rammer	Vibrating Plate	100 kg Power Rammer
Gravel	200	2	1	2
Sand	150	3	2	4

3.1.12.7 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.

3.1.12.8 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 %		
Material	SDR	After completion of Surround Permissible ranges vertical diameter elongated only	At least two weeks after completing the trench backfill. Maximum measured in any plane.	Damaged and not to be 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
RP	15+			
HDPE	10+			

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.

3.1.12.9 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 not be used for thermoplastic pipes.

3.1.12.10 Thrust and Anchor Blocks to Pressure Pipelines

Concrete thrust blocks shall provided 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.

3.1.12.11 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 between First and Second Joint (mm)	
		Min.	Max.
Up to 300	150	450	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.

3.1.12.12 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 150 mm of pipe length on each side. The enclosure shall be firmly pressed out to prevent air being trapped under the wrapping.

3.1.12.13 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.

3.1.12.14 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.

3.1.12.15 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 re-opened 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.

3.1.13 Pipe Work

3.1.13.1 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.

3.1.14 Standard of Covers and Gratings

3.1.14.1 Storm/Land Drainage

REQUIREMENT	MANHOLE		GULLEY FLUSHED KERB	GRATING UPSTANI KERB	PUMPING STN.ACCES COVER (3)
	in road	out of road			
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	-	-	-
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

3.1.14.2 Sewerage

REQUIREMENT	MANHOLE		HOUSE CONNECTION CHAMBER	PUMPING STN. ACCESS COVER (3)
	in road	out of road		
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.

4 Steel *PIPES AND FITTINGS*

4.1 Pipe Work and Fittings

4.1.1 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.

4.1.2 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.

4.1.3 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:

$$C = 9\ (0.5 + 0.001\ ND)$$

- 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.

4.1.4 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.

4.1.5 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.

4.1.6 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.

4.1.7 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.

4.1.8 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.

4.1.9 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.

4.1.10 Pipes 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.

4.1.11 Collars

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.

4.1.12 Works 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.

4.1.13 Protection

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.

4.1.14 External 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.

4.1.15 Wrapping

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.

4.1.16 Inspection 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.

4.1.17 Painting 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.

4.1.18 Internal 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^{O}. For mechanical coupling and flange adapter joints, the lining shall be brought right against the retaining rings.

4.1.19 Pipe-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.

4.1.20 End 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.

4.1.21 Low 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.

4.1.22 Handling

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.

4.1.23 Protection 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.

4.1.24 Notice 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.

4.1.25 Inspection

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.

4.1.26 Measurement 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.

4.2 Cast Iron Pipes

4.2.1 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.

4.2.2 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.

4.2.3 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 bitumen-impregnated tape.

4.2.4 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.

4.2.5 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.

4.2.6 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.

4.2.7 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.

4.3 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.

4.4 General Valves Specifications

4.4.1 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.

4.4.2 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.

4.4.3 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 non-stuffing 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.

4.4.4 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.

4.4.5 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.

4.4.6 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.

4.4.7 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.

4.4.8 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.

4.4.9 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 x ND + 100 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.

4.4.10 Pressure 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.

Air Release Valve

Parts Specification

Part	Material
Screw	Polypropylene
Protective Cover	Polypropylene
Bolt and Nut (X6)	Galvanized Steel, Chromate Plated
Cover and Nozzle	Brass ASTM – B – 124
O-Ring	Buna-N
Float	Polypropylene Natural Rubber Coated
Screen-Basket	Polypropylene
Body	Cast Iron ASTM – A-48
Male Adapter	Brass ASTM – B – 124 ¾” x 1”
Filter	Nylon
Seal	Fiber
Cover	Cast Iron ASTM-A-48
Nozzle	Natural Rubber on Bronze Seat
O-Ring	Buna – N
Basket 2”	Polypropylene
3” , 4”	Cast Iron
Float	Polypropylene
Body	Cast Iron ASTM-A-48
	Table 1

Air Release Valve (Barak)

Parts Specification

Part	Material
Body	Nylon, Fiberglass Reinforced
Seal Plug assembly 2a, Bolts	Stainless Steel SAE 316

2b, plug Cover	Nylon, Fiberglass Reinforced
2c, Rolling Seal	Rubber E.P.D.M.
2d, Plug	Nylon, Fiberglass Reinforced
Clamping Stem	Nylon, Fiberglass Reinforced
Float	Foamed Polypropylene
O-Ring	Buna – N
Base	Brass ASTM – B – 124 or Nylon
Drainage Elbow	Polypropylene
	Table 2

Air Release Valve for Sewage

Parts Specification

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
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

Non Release Valve

Parts Specification

Part	Material
Body	Cast Iron ASTM – A - 536
Cover	Cast Iron ASTM – A - 536
Arm	Bronze ASTM – B – 26
Arm Pin	Stainless Steel SAE 303
Cotter Pin	Stainless Steel SAE 304
Rubber stopper	E.P.D.M
Flap	Bronze ASTM – B – 26 or Cast Iron
Flap Vulcanized Coating	E.P.D.M
Lifting Ring	Bronze ASTM – B – 26
Cover O – Ring	Buna – N
Cover Nut	Galvanized Steel
Cover Bolt	Galvanized Steel
Disc Arm Key	Stainless Steel SAE 304
Sealing Ring O – Ring	Buna – N
Sealing Ring	Stainless Steel SAE 304
Sealing Ring	Bronze ASTM – B – 26
Hinge Shaft	Stainless Steel SAE 303
Plug Bolt	Stainless Steel SAE 304
Plug	ASTM – B – 26
Plug O –Ring	Buna – N
Hinge O - Ring	Buna – N

Spacer	Brass ASTM B – 124
Counterweight	Cast Iron SAE 37

Table 4

Gate Valve

Parts Specification

DENOMINATION	DESIGN A – FOR LIQUID AND GASES UP TO 70ºC
Protecting Ring	Perbunan Extra
O – Ring	Perbunan Extra
Locking Nut	Brass MS 58
O – Ring	Perbunan Extra
Slide Ring	Nylon 6
Cover	Nodular C.I. GGG 50
Stem	Stainless Steel Cr. > 13%
Stem Nut	Bronze Cu Al 10 Ni
Bolt	Stainless Steel
O – Ring	Perbunan Extra
Body	Nodular C.I. GGG 50
Resilient Wedge	Nodular C.I. Perbunan Coated.
PIN	Brass
Hand wheel	Cast Iron GG 20

Table 5

Air Release Valve

Parts Specification

Part	Material

Screw	Polypropylene
Protective Cover	Polypropylene
Bolt and Nut (X6)	Galvanized Steel, Chromate Plated
Cover and Nozzle	Brass ASTM – B – 124
O-Ring	Buna-N
Float	Polypropylene Natural Rubber Coated
Screen-Basket	Polypropylene
Body	Cast Iron ASTM – A-48
Male Adapter	Brass ASTM – B – 124 ¾” x 1”
Filter	Nylon
Seal	Fiber
Cover	Cast Iron ASTM-A-48
Nozzle	Natural Rubber on Bronze Seat
O-Ring	Buna – N
Basket 2”	Polypropylene
3” , 4”	Cast Iron
Float	Polypropylene
Body	Cast Iron ASTM-A-48

Table 6

Gate Valve

Parts Specification

DENOMINATION	**DESIGN A – FOR LIQUID AND GASES UP TO 70ºC**
Protecting Ring	Perbunan Extra
O – Ring	Perbunan Extra
Locking Nut	Brass MS 58
O – Ring	Perbunan Extra

Slide Ring	Nylon 6
Cover	Nodular C.I. GGG 50
Stem	Stainless Steel Cr. > 13%
Stem Nut	Bronze Cu Al 10 Ni
Bolt	Stainless Steel
O – Ring	Perbunan Extra
Body	Nodular C.I. GGG 50
Resilient Wedge	Nodular C.I. Perbunan Coated.
PIN	Brass
Hand wheel	Cast Iron GG 20

Table 7

General Specification:

Flange Drilling PN 10 to BS 4505 or DIN 2501

Pressure Rating (See Table No 6) 10/6/4 BAR

Body Material Cast Iron BS 1452 GR 250

Gate Material Stainless Steel BS 970 GR 304

Seal HI Nitrite Rubber

DN	K	D	No of Holes	No of Tapped Holes	O	T	P.B. Max BAR
250	355	405	12	4	M24	21	10
300	410	460	12	4	M24	21	10
350	470	250	16	4	M24	18	6
400	525	580	16	4	M27	24	6
450	585	640	20	6	M27	28	4
500	650	715	20	6	M30	28	4

600	770	840	20	8	M33	32	4
700	840	910	24	8	M33	35	4
800	950	1025	24	8	M36	46	4
900							4
1000	1170	1255	28	10	M39	40	4
1200	1390	1485	32	12	M45	50	4

Table 8

4.4.11 Butterfly 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.

4.4.12 Level Regulator

The level regulator is consists 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.

4.4.13 Dismantling 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

4.4.14 Pipe Coupling

For pipe couplings there are brass compression fittings a full range of fittings suiting PE pipes from ¼" 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.

4.4.15 Finishes 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.

4.4.16 Flow 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.

5 INSPECTION, TESTING AND COMMISSIONING

5.1 Inspection and Testing of Pipelines

5.1.1 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.

5.1.2 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.

5.1.3 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 litters 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.

Ball Test

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.

5.1.4 Testing of Pressure Pipelines

5.1.4.1 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.

5.1.4.2 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.

5.2 Testing of Water Retaining Structures

5.2.1 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.

5.3 Inspection and Testing of All Manufactured Items

5.3.1 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.

5.3.2 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

(3) Size and type of cable fittings

(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.

5.3.3 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.

5.3.4 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.