9.1. 2.5 PRE-CAST CONCRETE

9.1.2.5.1 Scope of Work

The Contractor shall furnish all labour, materials and plant to perform all work necessary for the product design, fabrication and erection of such reinforced concrete components which by their definition are not normally constructed directly in their final location but elsewhere and installed thereafter as prefabricated units. This includes all inserts and all material for seating the pre-cast members.

Grouting of joints, making connections and finishing the erected work is also included. All pre-cast concrete work shall be carried out as shown on the drawings, or as directed by the Engineer and as specified herein:

The work included consists of the following:

1. Removable concrete covers
2. Pre-cast concrete curbs
3. Miscellaneous pre-cast concrete units

9.1.2.5.2 Shop Drawings

The Contractor shall submit to the Engineer for approval six (6) sets of detailed drawings and detailed calculations of all prefabricated elements and specifications outlining methods of fabrication, transportation, handling and sequence of erection. The shop drawings shall accurately locate and show dimensions of all necessary holds, embedded parts, inserts and other details as specified on the drawings.

9.1.2.5.3 Material and Fabrication

If the fabrication of the pre-cast members is not carried out on the job site, the Contractor shall notify the Engineer at least three (3) weeks ahead of the time of commencement of such work so that the Engineer can arrange for the necessary supervision, inspection and testing of materials and work.

The concrete shall conform in general to the Concrete Section of these specifications. The maximum size of coarse aggregate shall be 20 mm.

The pre-cast units, if not cast on the site by the Contractor, shall be manufactured by a manufacturer of pre-cast concrete products approved by the Engineer. All pre-cast units shall be poured in accurately made forms with a concrete slump of not more than 5 cm and shall be vibrated into place in a manner that will give a smooth even surface. All wires, strands or bars shall be free from oil, lubricants, loose rust scale. Tolerances on all pre-cast and pre-stressed concrete work shall be in accordance with the ACI Standard 347. Reinforcing steel in pre-cast concrete shall conform to Section 9.1.2.2: "Concrete Reinforcement".

All welding required for the anchorage of component parts as shown on the drawings shall be in accordance with the General Requirements of these specifications.

The forms shall be of substantial construction and shall produce a uniformly smooth surface on all formed sides. A minimum concrete cover of 5 cm over all reinforcing steel shall be maintained

with the use of spreaders or by bundling in areas adjacent to openings or inserts. Ties shall also have a minimum cover of 50 mm at these locations.

Void forms shall be held in place against uplift or lateral displacement during the placing and vibrating of the concrete by wire ties or other satisfactory means.

The concrete shall be vibrated internally or externally, or both. The vibrating shall be done with care and in such a manner as to avoid displacement of reinforcing steel, void forms, or other components. There shall be no interruption in the concrete placement for any one of the elements. Concrete shall be carefully placed in the forms and vibrated sufficiently to produce a surface free from imperfections such as honeycomb, segregation, cracking, or checking. Any deficiency noted, such as honeycomb or segregation, may be a cause for rejection.

The topside surface of the element shall be given a uniformly smooth trowel finish to match the finished surface of the formed sides.

If elements are to be steam cured, the curing shall be done under a suitable enclosure to contain the live steam in order to minimise moisture and heat losses. The initial application of the steam shall be from two to four hours after the final placement of concrete to allow the initial set of the concrete to take place. The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 4°C per hour until a maximum temperature in the range of approximately 60°C to 70°C is reached. The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam, the ambient air temperature shall not decrease at a rate to exceed 4°C per hour until a temperature has been reached about 11°C above the temperature of the air to which the concrete will be exposed.

Side forms carrying no load may be removed after 24 hours with the permission of the Engineer.

No patching or finishing of the completed elements will be allowed unless permitted by the Engineer. The Contractor's proposal for methods and materials to be used in the patching or finishing operation shall be submitted to the Engineer for his approval. Projecting fins and surface imperfections shall be removed from the elements in a workmanlike manner.

9.1.2.5.4 Inspection and Testing

The material and workmanship of all pre-cast concrete elements shall, at all times, be subject to inspection by the Engineer. The Contractor or his subcontractors shall co-operate with the Engineer in permitting access for inspection at all times and to all places where work is being done. No pre-cast concrete member shall be shipped from the manufacturer's plant until approved.

The Contractor shall design and submit for approval by the Engineer, a concrete mix meeting the requirements of this specification. A minimum of three standard concrete test cylinders shall be taken from each batch of concrete by the Contractor. One cylinder shall be broken to determine the 7 day strength and second for the 28 day strength. The third cylinder is a reserve cylinder which may be used after 28 days in case the first cylinders do not show the required strengths. If the required strength is not achieved, the item shall be rejected. The cost of these tests shall be at the Contractor's expense. The Engineer shall have the right to duplicate the taking of concrete cylinders and testing without additional cost to the Employer. The results of these tests shall also be a basis for acceptance or rejection of the concrete elements and test results by the Engineer shall take precedence over tests taken by the Contractor. All tests shall conform to ASTM Standards.

The Contractor shall keep accurate records of the concrete mix, concrete strengths, and details of curing. The Contractor shall also provide certification of the steel for reinforcing bars or wire. The certification shall in no way limit or prevent the Engineer from testing samples of reinforcing steel to determine conformity with the drawings, shop drawings and specifications. The costs of these tests shall be borne by the Contractor.

9.1.2.5.5 Erection and Installation

Pre-cast concrete elements shall be installed as shown on the drawings, or as approved by the Engineer.

9.1. 2.6 REINFORCED CONCRETE PILING - CAST IN SITU PILES

9.1.2.6.1 General

The Contractor shall install reinforced concrete cast insitu piles as detailed herein and as shown on the Drawings or as directed by the Engineer.

(1) Approval of Proposals

Before any piling is started, the Contractor shall satisfy with the information given in the soils investigation report which forms a part of the contract document. The Contractor shall submit to the Engineer a complete detailed programme and the method of construction he proposes for approval. This should include the method he proposes to adopt for excavating/boring, stabilising the hole, any dewatering, placing of concrete, testing of piles, load testing of working piles, the plant, machinery and equipment he proposes to use and a comprehensive programme of work. Selected number of working piles shall be load tested and all piles shall be tested for integrity by an approved method.

(2) Workmanship

Workmanship shall comply with the recommendations given in BS 2004 "Foundations".

(3) Labour

The Contractor shall maintain at the site a specially qualified and experienced supervisor together with the necessary gangs of trained labour experienced in casting of piles.

(4) Plant

The Contractor shall provide all plants, machinery and equipment, appliances and temporary works, required for the entire piling operation.

9.1.2.6.2 Tolerances

Setting out shall be done by the Contractor, and approval shall be obtained prior to commencement.

The maximum permitted deviation of pile centre from the centre point shown in drawing shall be 75mm in any direction.

The maximum permitted deviation of the finished pile from the vertical is 1 in 75.

9.1.2.6.3 Drilling Fluid

(1) Supply and Mixing

Drilling Fluid, Bentonite, if used shall be in accordance with specification DFCP 4 of the Oil Companies Materials Association or similar. A certificate shall be obtained by the Contractor from the manufacturer/supplier, and shall be forwarded to the Engineer.

Bentonite shall be mixed thoroughly with clean fresh water to make a suspension which will maintain the stability of the pile bore for the period necessary to place concrete and complete construction.

(2) Tests

Control tests shall be carried out on the bentonite suspension, using suitable apparatus. Density of freshly mixed bentonite suspension shall be checked daily. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite supplied to the pile bore. The results shall be within the range indicated below;

Property to be Measured	Range of Results at 20^0c	Test Method
Density	less than 1.10 g/ml	Mud density balance
Viscosity	30 -90s or lesser than 20 cp.	Marsh cone method Fann viscometer
Shear Strength (10 minute gel strength)	1.4 - 10 N/mm^2 or 4 - 40 N/mm^2	Shearometer Fann viscometer
PH	9.5 - 12	pH indicator paper or electrical pH meter

The frequency of testing shall be as specified by the Engineer. When the results show consistent behaviour, the tests for shear strength and pH value may be discontinued with the approval of the Engineer.

9.1.2.6.4 Boring

(1) Boring Locations

Piles shall not be bored close to other piles which have recently been cast and which contain workable or unset concrete that a flow of concrete could be induced from or damage caused to any of the piles.

(2) Temporary Casings

Temporary casing of approved quality or an approved alternative method shall be used to maintain the stability of the pile bore which might otherwise collapse.

Temporary casing shall be free from significant distortion. They shall be of uniform cross section, and shall be free from internal projections or encrusted concrete.

The use of a vibrator to insert and withdraw temporary casing may be permitted by the Engineer subject to the limits of noise and disturbance, damage to adjacent structures and disturbance to the ground which would adversely affect the construction or capacity of piles.

Where piles are bored under water or bentonite suspension in an unlined state, the insertion of a full length loosely fitting casing to the bottom of the bore prior to placing concrete will not be permitted.

(3) Stability of Pile

Where boring takes place through unstable water-bearing strata, the process of excavation and the depth of temporary casing employed shall be such that soil from outside the area of the pile is not drawn into the pile section and cavities are not created outside the temporary casing as it is advanced.

If the drilling fluid is used for maintaining the stability of the bore, an adequate temporary casing shall be used in conjunction with the method so as to ensure stability of the strata near ground level until concrete has been placed. During construction, the level of drilling fluid in the pile excavation shall be maintained within the cased or stable bore so that it is not less than 1.0m above the level of external standing ground water at all times.

In the event of a rapid loss of drilling fluid from a pile excavation, the bore shall be backfilled without delay and instructions of the Engineer shall be obtained before boring at that location is resumed.

(4) Spillage and Disposal of Drilling Fluid

All reasonable steps shall be taken to prevent spillage of bentonite suspension on the site. Discarded bentonite shall be removed from the site without undue delay, and shall be disposed as approved by the Engineer and relevant Authorities, without causing an adverse environmental effect.

(5) Pumping from Pile Bores

Pumping from pile bores shall not be permitted unless the bore has been sealed against further water entry by casings or unless the soil is stable and will allow pumping to take place without ground disturbance below or around the pile.

(6) Inspection

Each pile bore which does not contain standing water or drilling fluid shall be inspected directly or indirectly prior to concrete being placed in it. The inspection shall be from ground surface. Torches or other approved means of lighting, measuring tapes and means of measuring vertically shall be provided.

(7) Cleanliness of Pile Bases

Any loose, disturbed or softened soil shall be removed from the bore before concreting. Large debris and / or accumulated sediment shall be removed using appropriate approved methods, which shall be designed to clean while at the same time minimising ground disturbance below pile bases. Where bore contains water or drilling fluid, it shall be maintained throughout and following the cleaning operation.

9.1.2.6.5 Reinforcement and Concrete

Special specifications applicable to piles cast in-situ are indicated below. Other general specifications also given in the relevant sections of this chapter shall be applicable here too.

(1) Reinforcement

The number of joints in longitudinal steel bars shall be kept to a minimum. Joints in reinforcement shall be such that the full strength of each bar is effective across the joint and shall be made so that there is no detrimental displacement of the reinforcement during the construction of the pile.

Reinforcement in the form of a cage shall be assembled with additional support such as spreader forks and lacings, necessary to form a cage which can be lifted and placed without permanent distortion. Intersecting bars shall be fixed together by approved means. Links shall fit closely around the main longitudinal bars and be bound to them by approved wire, the end of which shall be turned into the interior of the pile. Reinforcement shall be placed and maintained in position to provide an adequate projection of reinforcement above the final cut off level.

The cover to reinforcement shall be 50mm. The spacers shall be designed and manufactured using durable materials which will not lead to corrosion of the reinforcement or spalling of the concrete cover.

If any welding is used, it shall be carried out in accordance with BS 5135 after getting Engineer's prior approval.

(2) Concrete

The concrete shall be grade 30 or more and placed without interruption as would allow the previously places batch to have hardened. The method of placing shall be approved.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of concrete in a temporary casing. No soil, liquid or other foreign matter which would adversely affect the performance of the pile shall be permitted to contaminate the concrete.

Slump measured at the time of discharge into the pile bore shall be in accordance with the standards shown below;

Typical Conditions of Use	Slump	
	Min. (mm)	Range (mm)
Placed into water-free unlined bore, with reinforcements widely spaced	75	75 - 150
Where reinforcement is not spaced widely, and pile bore is water free	100	100 - 200
Where concrete is to be placed by tremie under water or drilling mud or by pumping	150	150 or more

Internal vibrators shall not be used to compact the concrete.

Measures shall be taken to ensure that the structural strength of the concrete placed is not impaired through grout loss, segregation or bleeding.

Concrete shall be directed vertically into the centre of each vertical pile so that grout is not lost from the initial discharges.

When concrete is placed under water or drilling fluid, Contractor shall ensure that there is no accumulation of loose material or debris at the base of the boring.

The Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the tremie pipe, has not accumulated at the bottom of the hole.

(3) Placing Concrete Under Water / Drilling Fluid

Concrete to be placed under water or drilling fluid shall be placed by tremie and shall not be discharged freely into the water or drilling fluid. Pumping of concrete may be approved by the Engineer where appropriate.

A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.20 the placing of concrete shall not proceed. In the event, the Contractor shall modify or replace the bentonite as approved, to meet the specification.

The concrete shall be placed in such a manner that segregation does not occur.

The hopper and pipe of the tremie shall be clean and water tight throughout. The pipe shall extend to the base of the bore and a sliding plug or a barrier shall be placed in the pipe to prevent direct contact between the first charge of the concrete in the tremie and the water or drilling fluid. The pipe shall at all times penetrate the concrete which has previously been placed and shall not be withdrawn from the concrete until completion of concreting. A sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water or drilling fluid. The internal diameter of the pipe of the tremie shall not be less than 150mm for concrete made with 20mm aggregate and not less than 200mm for concrete made with 40mm aggregate. It shall be so designed that external projections are minimised, allowing the tremie to pass within the reinforcing cages without causing damage. The internal face of the pipe of the tremie shall be free from projections.

9.1.2.6.6 Extraction of Casings

(1) Workability of Concrete

Temporary casings shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted. During extraction, the motion of the casing shall be maintained in an axial direction relative to the pile.

(2) Concrete Level

When the casing is being extracted, a sufficient quantity of concrete shall be maintained within it to ensure that the pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in section not contaminated.

The concrete level within a temporary casing shall be topped up where necessary during the course of casing extraction in such a way that the base of the casing is always below the concrete surface until the casting of the pile has been completed.

Adequate precautions shall be taken in all cases where excess heads of water or drilling fluid could occur as the casing is withdrawn because of the displacement of water or fluid by the concrete as it flows into its final position against the walls of the pile bore.

(3) Water Levels

During extraction of temporary casings, where circumstances are such that newly placed unset concrete is brought into contact with external ground water, precautions shall be taken to ensure that the internal concrete pressure at all levels within the pile exceeds the external ground water pressure.

(4) Temporary Backfilling

After each pile has been cast, any empty bore remaining shall be protected and shall be carefully backfilled as soon as possible with approved material.

(5) Cutting Off Piles

The piles shall be cast to a level above the specified cut-off so that, after trimming to remove all debris and contaminated concrete, a sound concrete connection with the pile can be made.

When cutting off and trimming piles to the specified cut-off levels, the Contractor shall take care to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and the pile repaired in an approved manner to provide a full and sound section at the cut-off level.

9.1.2.6.7 Rejection of Piles

(1) Additional Piles

If any pile is rejected, either due to its incorrect position, poor workmanship or materials or due to any other cause, the Engineer may order an additional or if necessary, two additional piles, to be installed and incorporated in the pile cap re-designed to the approval of the Engineer.

(2) Payment

If at the direction of the Engineer, the Contractor installs an additional pile, or if necessary two additional piles, the Contractor will not be paid for the rejected pile, but he will be paid for one additional pile. The Contractor shall himself bear the costs of the second pile if two are ordered, plus the additional cost of the pile cap over the amount for the designed pile cap allowed under the contract, and plus also all costs involved in amendments necessary to the supported structure as a result of the altered positions of the pile and the special design of the pile cap.

9.1. 2.7 REINFORCED CONCRETE PILING - PRE-CAST AND DRIVEN

9.1.2.7.1. General

The Contractor shall install reinforced concrete pre-cast piles as detailed herein and as shown on the Drawings or as directed by the Engineer.

(1) Approval of Proposals

Before any piles are installed, the Contractor shall satisfy with the information given in the soils investigation report. The Contractor shall submit to the Engineer for approval a description, accompanied by drawings and programme of the lengths of piles and methods he proposes to adopt for handling driving and testing of piles, to enable them to perform in accordance with the loading requirements of this specification giving full particulars of all plant and equipment to be employed. Without any approval of the Contractor's proposals by the Engineer the Contractor shall not commence any work related to piling.

(2) Workmanship

Workmanship shall comply with the recommendations of the BS 8004 -Foundations

(3) Labour

The Contractor shall maintain at the Site a specially qualified and experienced supervisor together with the necessary gangs of trained labour experienced in the installation of piles.

(4) Plant

The Contractor shall provide all plant, appliances and temporary works, required for handling, pitching and driving and, if required, extraction of piles.

9.1.2.7.2. Pre-cast Concrete Piles

Pre-cast piles shall be of 350 mm x 350 mm cross section similar to those available from the State Development and Construction Corporation of Sri Lanka or equivalent subject to the Engineer's approval.

9.1.2.7.3. Handling and Driving of Concrete Piles

(1) Plant

All piles shall be adequately supported in the pile driver leaders against damage during pitching and driving. The use of followers will not be permitted. The weight of hammer used shall be sufficient to ensure a final penetration of not less that 2.5 mm (1/10 inch) per blow.

(2) Storage

Piles shall be stored on firm ground to avoid undue bending due to unequal settlement under self weight. They shall be stacked in such a way as to facilitate easy identification and lifting, and such that the piles can be used in the order of maturity.

(3) Handling

No concrete pile shall be lifted from its casting bed until its age as specified herein has been attained. Piles shall only be supported at the specified points and, if necessary, at additional points between them.

Care shall be taken at all stages of handling the piles to avoid damaging the piles. If the piles are put down temporarily after being lifted, they shall be placed on trestles or blocks located at the lifting point.

(4) Driving

Piles shall be driven true to position, plumb or inclination. Any pile which has been driven out of position or alignment shall not be forcibly brought back to correct alignment.

Piles shall be driven to the required depth and on reaching such depth to the required set as shown on the Drawings or as directed by the Engineer.

(5) Tolerance

Any pile that deviates more than 50 mm (2 inches) from its correct position or more than 25 mm (1 inch) in 1.80 m (6 feet) out of the correct alignment will be rejected. Any pile so rejected shall be extracted and, if undamaged, shall be re-driven with the approval of the Engineer. Alternatively, at the entire discretion of the Engineer, the driven pile may be accepted provided that all costs incurred in modifying the supported structure as a result of the inaccuracy in piling are borne by the Contractor.

(6) Protection of Pile Head

Heads of piles shall be protected by packing and helmets during driving. The packing shall at all times be in good condition and suitable for its intended purpose and shall be renewed frequently. Piles that are broken or split or otherwise damaged shall be withdrawn and replaced.

(7) Stripping Pile Heads

Where required, heads of concrete piles shall be stripped carefully to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and made good with new concrete properly bonded to the old.

(8) Cutting Off Pile Head

After driving to the required depth and set, piles shall be cut off allowing for a projection of reinforcement upto a height of not less than 600 mm for a monolithic construction of the pile cap with a pile.

(9) Risen Piles

Piles which have risen as a result of driving adjacent piles shall be re-driven to the original depth or set, unless in the opinion of the Engineer re-driving tests on neighbouring piles have shown this to be unnecessary.

9.1.2.7.4. Rejection of Piles

(1) Additional Piles

If any pile is rejected, either due to its incorrect position, poor workmanship or materials or due to any other cause, the Engineer may order an additional or if necessary, two additional piles, to be installed and incorporated in the pile cap re-designed to the approval of the Engineer.

(2) Payment

If at the direction of the Engineer, the Contractor installs an additional pile, or if necessary two additional piles, the Contractor will not be paid for the rejected pile, but he will be paid for one additional pile. The Contractor shall himself bear the costs of the second pile if two are ordered, plus the additional cost of the pile cap over the amount for the designed pile cap allowed under the Contract, and plus also all costs involved in amendments necessary to the supported structure as a result of the altered positions of the pile and the special design of the pile cap.

9.1.2.7.5. Records

(1) Daily Pile Installation Record

The Contractor shall supply to the Engineer's Representative daily, in duplicate, a complete record of all piles installed in the day. The record shall include the following where appropriate:-

a) Serial No. and position of pile;
b) Date of casting pile (if pre-cast);
c) Type and dimensions;
d) Ground level (in MSL);
e) Total penetration;
f) Times of starting, stopping, delays etc.;
g) Positions of pile joints;
h) Continuous driving record of hammer drops and number of blows per ft. of penetration;
i) Final set for the last 10 blows and the final drop or frequency of blows;
j) Sum of elastic compression of pile, Cp, and quake of subsoil, Cq, for the last 10 blows measured in accordance with the method described in C.P.4;
k) Type and condition of the packing on the pile head and the dolly on the helmet;
l) Errors in position and inclination of completed pile;
m) Level of top of pile head after driven to final set;
n) Details of re-driving, if any.

(2) Pile Test Record

Within 48 hours of completion of any pile test, the Contractor shall submit to the Engineer's Representative two copies of complete records of time, loads, settlement and any other relevant information together with graphs of load against time and settlement against time. The time within which the Engineer is required to issue instructions for the remaining works piles shall not commence until the requirements of this clause have been satisfied.

(3) Records Confidential

All pile test records shall be considered confidential and shall not be disclosed by the Contractor to any third party without the express permission in writing of the Employer.

(4) Record Drawing

On completion of installation of all piles the Contractor shall prepare and submit in duplicate, drawings showing the actual positions and depths of all piles installed relative to an approved datum.

9.1.2.8 STATIC LOAD TESTING OF PILES

9.1.2.8.1 General

Static Load

The testing of piles described herein shall be applicable to both cast in-situ piles and driven piles.

- One preliminary test pile, which will be incorporated into the system as a working pile later.
- Two working pile, randomly selected by the Engineer from the group of piles in foundation

The number of piles at any location that may require to be tested will be as instructed by the Engineer.

The piles shall be tested as a "Maintained Load Test", as specified.

The Contractor shall give the Engineer at least 48 hours notice of commencement of construction of preliminary test pile.

A detailed record of the conditions experienced during boring or of the progress during driving shall be made and submitted to the Engineer daily. Where the Engineer requires soil samples to be taken or in situ tests to be made, the Contractor shall present the results within a reasonable period of time.

The pile test shall not be started until the strength of the test cubes taken from the pile exceeds twice the average direct stress in any pile section under the maximum required test load or as directed by the Engineer.

9.1.2.8.2 Supervision

The setting up of pile testing equipment and tests shall be carried out only under the direction of an experienced and competent supervisor conversant with test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

Equipment shall be checked to ensure that the setting up is satisfactory before the commencement of load application.

9.1.2.8.3 Safety Precautions

Design, erection and dismantling of the pile test reaction system and the application of load shall be in a manner to safeguard operatives and others who may be in the vicinity from all avoidable hazards.

(a) Kentledge

Where kentledge is used the Contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structure in such a manner that there will not be differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of operation. The kentledge shall be adequately bonded, tied or otherwise held together to

prevent it becoming unstable because of deflection of supports or any other reason. Weight of kentledge shall be greater than the maximum test load for the test.

(b) Tension Piles, Reaction Piles, Ground Anchorages

Where tension piles, reaction piles or ground anchorages are required to provide the necessary load reaction, they shall be so designed that they will resist the forces applied to them safely and without excessive deformation which could cause a safety hazard during the work. No working pile of the structure shall be used as a tension pile.

(c) Testing Equipment

In all cases, the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head, the whole system will be stable upto the maximum load to be applied.

If in the course of carrying out a test, any unforeseen occurrence should take place, further loading shall not be applied until a proper engineering assessment of the condition has been made and steps have been taken to rectify the fault.

Where an inadequacy in any part of the system might constitute a hazard, means shall be provided to enable the test to be controlled from a position clear of the kentledge stack or test frame.

The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a pressure of 1 1/2 times the maximum pressure used in the test without leaking.

The maximum test load expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

(d) Pile Head for Compression Test

For a pile that is tested in compression, the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile, sufficiently large to accommodate the loading and settlement measuring equipment and adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment.

9.1.2.8.4 Reaction Systems

Compression tests shall be carried out using kentledge, tension piles or specially constructed anchorages. Where kentledge is to be used, it shall be supported on cribwork and positioned so that the centre of gravity of the load is as close as possible to the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack.

No working pile shall be allowed to use as a reaction piles without the prior written approval of the Engineer. Where working piles are used as reaction piles, their movement shall be measured and recorded to within an accuracy of 0.5mm.

Where kentledge is used for loading, the distance from the edge of the test pile to the nearest part of the crib, supporting the kentledge stack in contact with the ground shall be not less than 1.3m.

The centre to centre spacing of reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction pile, or

2m whichever is greatest, except in the case of piles 300mm diameter or less, in which case the latter dimension may be reduced to 1.5m.

Where ground anchorages are used to provide a test reaction for loading in compression, no section of fixed anchor length transferring the load to the ground shall be closer to the test pile than three times the diameter of the test pile.

The reaction frame support system shall be adequate to transmit the maximum test load in a safe manner without excessive movement or influence on the test pile. Calculations shall be provided to the Engineer when required to justify the design of the reaction system.

The method employed in the installation of the reaction system shall be such as to prevent damage to any test pile or working pile.

9.1.2.8.5 Equipment for Applying Load

The equipment used for applying load shall consist of a hydraulic jack. The jack shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. Proposals to use more than one jack will be subject to the approval by the Engineer. The complete system shall be capable of safely transferring the maximum load required for the test. The length of stroke of the jack shall be sufficient to cater for deflection of the reaction system under load plus a deflection of the pile head upto 15% of the pile shaft diameter unless otherwise specified or agreed prior to commencement of test loading.

9.1.2.8.6 Measurement of Load

A load measuring device shall be used and in addition a calibrated pressure gauge included in the hydraulic system. Readings of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data, the values given by the load measuring device shall normally be used; the pressure gauge readings are required as a check for gross error.

The load measuring device may consist of a load measuring column, pressure cell or other appropriate system. A spherical seating of appropriate size shall be used to avoid eccentric loading. Care shall be taken to avoid any risk of buckling of the load application and measuring system. Load measuring and application devices shall be short in axial length in order to secure stability. The Contractor shall ensure that axial loading is maintained.

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. Certificates of calibration shall be supplied to the Engineer.

9.1.2.8.7 Control of Loading

The loading equipment shall enable the load to be increased or decreased smoothly or to be held constant at any required value.

9.1.2.8.8 Measurement of Pile Head Movement

In the maintained load test, movement of the pile head shall be measured by one of the following methods;

(1). With Reference Beams and Dial Gauges

Independent reference beam or beams shall be set up to enable measurement of the movement of the pile. The supports of a beam shall be founded in such a manner and at such a distance from the test pile and reaction system the movements of the ground do not cause movements of the reference beam which will affect the accuracy of test. The supports of the beams shall be at least three times test pile diameter or 2m from the centre of the test pile, whichever distance is greater.

Check observations of any movements of the reference beam or beams shall be made and a check shall be made of the movement of the pile head relative to the remote reference datum at suitable intervals during the progress of the test.

The measurement of pile movement shall be made by four dial gauges rigidly mounted on the reference beam or beams bearing on prepared flat surfaces fixed to the pile cap or head, and normal to the pile axis. Alternatively, the gauges may be fixed to the pile and bear on prepared surfaces on the reference beam or beams. The dial gauges shall be placed equidistant from the pile axis and from each other. The dial gauges shall enable readings to be made to an accuracy of at least 0.1mm and have a stem travel of at least 25mm. Machined spacer blocks may be used to extend the range of reading. Equivalent electrical displacement measuring devices may be substituted.

(2) Optical Levelling Method

An optical levelling method by reference to a remote datum may be used.

Where a level and a staff are used, the level and the scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5mm. A scale attached to the pile or pile cap may be used instead of a levelling staff. At least two reliable independent datum points shall be established. Each datum point shall be so situated as to permit a single setting up position of the level for all the readings.

No datum point shall be located where it can be affected by the test loading or other operations on the site.

(3). Reference Wires and Scales

Two parallel reference wires, one on either side of the pile shall be held under constant tension at right angles to the test pile axis between supports formed as in the method described in (i) above. The wires shall be positioned against scales fixed to the test pile head in an axial direction and the movement of the scales relative to the wires shall be determined.

Check observations of any movement of the supports of the wires shall be made and a check shall be made on the movement of the pile head at approved time intervals. Readings shall be taken within an accuracy of 0.5mm.

(4). Other Methods

The Contractor may submit for approval any other method of measuring the movement of test pile head.

9.1.2.8.9 Notice of Test

The Contractor shall give the Engineer at least 24 hours notice of commencement of the test. No load shall be applied before the commencement of the specified test procedure.

9.1.2.8.10 Test Procedure - Maintained Load Test

The load which shall be applied for the test shall be 1.5 times the design verification load (DVL) of the pile.

The loading and unloading shall be carried out in stages as shown in the table below.

Following each application of an increment of load, the load shall be maintained at the specified value for not less than the period shown in the table, and until the rate of settlement is less than 0.25mm/hr and slowing down. The rate of settlement shall be calculated from the slope of the line obtained by plotting values of settlement versus time and drawing a smooth curve through the points.

Load	Minimum Time of Holding Load
25% DVL	30 minutes
50% DVL	30 minutes
75% DVL	30 minutes
100 % DVL	1 hour
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour
100 DVL	6 hours
125% DVL	1 hour
150% DVL	6 hours
125% DVL	10 minutes
100% DVL	10 minutes
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour

For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load at not more than five minute intervals upto 15 minutes, at approximately 15 minute intervals upto 1 hour, at 30 minute intervals between 1 hour and 4 hours, and 1 hour intervals between 4 hours and 12 hours after the application of the increment of load.

Where the methods of measuring pile head movement given in clause 9.1.2.8.8 (2) or (3) are used, the periods of time for which the loads must be held constant to achieve the specified rates of settlement shall be extended as necessary to take into account the lower levels of accuracy available from these methods and to allow correct assessment of the settlement rate.

9.1.2.8.11 Results

During the progress of test, all records taken shall be available for inspection by the Engineer.

A preliminary copy of the test records shall be provided within 24 hours of the completion of the test, and a complete report within 10 days. If, in the opinion of the Engineer, the results of the test are unacceptable, the Contractor shall repeat the test on a pile as directed by the Engineer, at his own cost.

9.1.2.9 MISCELLANEOUS REQUIREMENTS

1. No-fines concrete. No-fines concrete shall be made using natural aggregate conforming to BS 882 and cement to BS 12. Fine aggregate shall not be used. The grading of the coarse aggregate shall be

    - Not less than 95% by weight passing a 20 mm BS sieve;
    - Not more than 5% by weight passing 10 mm BS sieve.

The proportion of aggregate, cement and water shall be determined by trial mixes by the Contractor starting a cement: aggregate ratio of one to eight by volume. The trial mix shall be considered suitable when all the aggregate particles are coated with a film of cement grout. The water content shall be just adequate to ensure that the cement paste completely coats the aggregate. The concrete when placed shall contain no layer of laitance. No fines concrete shall not be mixed by hand.

Vibration shall not be used to compact the no-fines concrete. Three test cubes of no-fines concrete shall be made of each preliminary mix. The minimum crushing strength of the mix shall be 15 N/sq. mm at 28 days.

Porosity be such that water will pass through a slab 300 mm thick at the rate of not less than 7 litres/sec/m^2 of slab with a constant 100 mm depth of water on slab.

9.1.3 PIPES, FITTINGS AND VALVES

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9.1.3 – PIPES, FITTINGS AND VALVES

9.1.3 PIPES, FITTINGS AND VALVES

9.1.3.1 GENERAL

9.1.3.1.1 Scope of Work

The Contractor shall furnish all pipes, fittings, adapters, valves, hydrants and other materials of the various sizes and diameters, complete with jointing materials in accordance with these specifications and drawings.

All pipes fittings and valves shall be in every respect suitable for storage, installation, use and operation in the condition of temperature and humidity appertaining in Sri Lanka. The temperature of the water to flow in pipelines will be about 30 °C.

Pipes and pipeline components, including their protective coatings and joint materials, that will or may come into contact with portable water shall not constitute a toxic hazard, shall not support microbial growth, shall not cause taste or odour, cloudiness or discoloration of the water and shall be approved by a recognised certifying authority as being suitable for use in portable water supply schemes.

The materials to be furnished under this Contract shall be the product of a manufacturer who has designed and manufactured similar materials having a record of successful operation. The Contractor may be required to submit the evidence to this effect together with a representative list of overseas supply consignments of the manufacturer.

All pipes, fittings, valves, hydrants and accessories furnished shall be new and from a current manufacturer. A certificate from the manufacturer stating that the materials furnished are new and out of a current manufacture shall be furnished to the Engineer.

9.1.3.1.2 Affidavit of Compliance

The Contractor shall provide the Employer with an affidavit in quadruplicate from the manufacturer that the pipe, valves, fittings, meters and any other products or materials furnished under the Contract comply with all applicable provisions of these specifications.

The Contractor shall also produce the certificates to the effect that the items supplied comply with the relevant ISO 9000 series.

9.1.3.1.3 Rejection

Material that fails to conform to the requirements of the specifications will be rejected and the Contractor will be notified accordingly by the Engineer.

9.1.3.1.4 Shop Coating and Lining

The Contractor shall supply all labour, material and equipment for the preparation of surfaces and the shop application of protective coatings and linings specified under each section.

The Contractor shall furnish a manufacturer's certificate of compliance for each coating or lining material prior to its use in the work. The certificate shall include material identification, quantity, batch number, and date of manufacture.

Coating, where not specified will be selected by the Engineer from manufacturer's samples submitted by the Contractor.

9.1.3.1.5 Marking

Each pipe and fitting shall be legibly and durably marked with the following:

- Name of the Employer as "NWSDB"
- Material of pipe indicated as "DI"
- Nominal Diameter or size
- Year of Manufacture
- Class designation
- Reference Standards such as BS, AWWA, JIS or ISO
- Manufacturer's identification mark
- Pressure rating of flange
- Angle of bends in degrees
- Socket penetration lines of each pipe with push-in joints

All markings shall be of a permanent nature.

9.1.3.1.6 Packing

All pipes and fittings, valves and specials and all other products shall be packed in such a manner as to prevent damage in ordinary handling and transportation. Each box, bundle or crate shall be legibly marked identifying the contents, and giving the name and address of manufacturer, name of the project "TEH PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA", consignee "NATIONAL WATER SUPPLY & DRAINAGE BOARD, SRI LANKA", and date of dispatch.

Bolts of the same length and size (and their accompanying nuts and washers) shall be packed together in boxes not exceeding 100 Kg. Gross weight. Joint rings and gaskets shall be packed in boxes and separate packages shall be provided for each size and description of ring or gasket. Each box and package therein shall be clearly labelled stating the number, size and description of the contents.

9.1.3.1.7 Transporting and Handling

The Contractor shall provide protection, to the approval of the Engineer, for the ends of all pipes and fittings prior to the pipes and fittings leaving the place of manufacture in order to guard effectively against damage during transit and storage and the ingress of foreign matter inside the pipes and fittings.

In handling pipes and fittings every care shall be taken to avoid distortion, flattening, denting, scouring or other damage. Pipes and fittings shall not be allowed to drop or strike objects and shall be lifted or lowered from one level to another by means of approval equipment only.

When required pipe and fittings shall be lifted by means of a mechanical forklift, or similar equipment, belt slings shall be applied at the correct lifting points along the length of the pipe section, with tackle suitably padded to prevent damage to the coating.

Pipes and fittings that is damaged during transportation, handling or stockpiling shall be satisfactorily repaired. If the damage to any pipe or fitting is serious or beyond the capability of repair in the field, the contractor shall replace it with new one.

9.1.3.1.8 Storage and Security

All pipes, fittings, valves, hydrants and appurtenances shall be stored at sites in or around Project Area approved by the Engineer in accordance with the manufacturer's recommendations until they are incorporated in pipe laying work. The Contractor shall be responsible for providing security including fencing, watching and lighting for the materials at his own cost.

Pipe shall be stockpiled on timber cradles on level ground, in such a manner as will prevent damage to any part of the pipe. During stacking and removal operations, safe access to the top of the stack is essential. Stacking types and the maximum stacking height shall be in accordance with manufacturers recommendation or comply to BS 8010 Section 2.

9.1.3.1.9 Submittal

The Contractor shall submit to the Engineer and obtain approval before starting the works the manual for handling, storage, installation, maintenance and repair, test report on materials to be used for manufacture and shop drawings giving complete dimensions of all pipes and fittings.

9.1.3.1.10 Material Reconciliation Schedule

Upon completion of the work the Contractor shall submit to the Engineer a materials reconciliation schedule in respect of the materials supplied under Supply Bills. The schedule shall give the following detailed for each item:

(a) Quantity ordered – According to each and every supply bill items.
(b) Quantity Delivered - According to each and every supply bill items.
(c) Where used – According to each and every installation bill item.
(d) Quantity surplus and in good condition
(e) Quantity surplus but partially complete cut or damaged and in repairable condition.
(f) Quantity surplus but damaged beyond repair.
(g) Quantity missing or lost.

The Contractor shall collect and transport the surplus materials in (d) and (e) to a central location for inspection by the Engineer's Representative. Materials in group (d) shall be stacked separately. All material shall be in a reasonably clean state and each piece shall be marked with its item number for easy identification.

The Employer, may accept some or all of the surplus materials for maintenance purposes. The Contractor shall load the materials to be taken into stock and transport and off-load them at the Employer's stock yards.

The Contractor will be paid under Supply Bills for all materials installed in the permanent works and those surplus in good condition taken into stock.

9.1.3.2 PIPE MATERIAL

9.1.3.2.1 Ductile Iron (DI) Pipe and Fittings

(1). General

(i) Scope of Work

Where shown on the drawings the Contractor shall supply ductile iron pipe and fittings in accordance with the details shown on the drawings and specified herein, including all jointing materials. In addition, the Contractors shall supply additional materials for maintenance to the Employer as specified herein.

(ii) Standard Specification Reference

The following standards are referred to:

ISO 9000 Series	Quality Assurance Standards
ISO 2531	Ductile Iron Pipes, Fittings, and accessories for Pressure Pipelines
ISO 4179	Ductile Iron Pipes for Pressure and Non-Pressure Pipelines - Centrifugal Cement Mortar Lining General Requirements
ISO 6600	Ductile iron pipes centrifugal cement mortar lining (composition controls for freshly applied mortar)
ISO 7005 (Part 1&2)	Metalic Flanges
ISO 8179	Ductile Iron Pipes - External Zinc Coating
BS EN 545	Ductile Iron Pipes, Fittings, accessories and their joints for water pipelines. Requirements and test methods.
BS EN 1563	Founding Spheroidal graphite cast iron
BS EN 1564	Founding Austempered ductile cast iron
BS 3063	Specification for Dimensions of Gaskets for Pipe Flanges
BS 4504 (Part 1)	Circular Flanges for Pipes, Valves, and Fittings
BS EN 1092	Flanges and their joints, circular flanges and accessories
BS 2494	Elastometric seals for joints in pipe work and pipelines.
BS EN 681-1	Elastrometric seals. Material requirements for pipe joints seals used in water and drainage applications
BS 3416..1991	Bitumen based coating for cold application.
BS 4147	Bitumen based hot applied coating materials for protecting iron and steel.
BS 4865	Dimensions of non-metallic gaskets for pressures upto 64 bar.
BS 8010	Part 1 Code of practice for pipelines on land: General Part 2 Design, construction and installation Part 2 Section 9.1.2.1 Ductile Iron.
BS 6076..1996	Polymeric film for used as a protective sleeving for buried iron pipes and fittings
BS 970	Wrought steel for mechanical and allied engineering purpose.
BS 1706	Method for specifying electroplated coatings of zinc and cadmium on iron and steel
JIS G5526	Ductile Iron Pipes
JIS G5527	Ductile Iron Fittings
JIS G5528	Epoxy-Powder Coating for Interior of Ductile Iron Pipes and Fittings

AWWA C151	Ductile Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids
AWWA C110	Ductile Iron and Grey Iron Fittings. 3 inch through 48 inch for Water and Other Liquids
AWWA C104	Cement Mortar Lining For Ductile Iron Pipe and Fittings for Water
AWWA C213	Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipeline.

(2) Manufacture

(i) General

Ductile iron shall conform to the material specification given in one or more of the standards listed in Clause 1.(ii) except for the requirements stipulated herein. The pipe and fittings shall be manufactured in accordance with one or more standards listed in Clause 1.(ii) or any other national standard which is equivalent or superior to those quoted above except as stipulated herein.

(ii) Mechanical Properties

The mechanical properties of pipes and fittings shall be as follows:

Minimum Tensile Strength	420 N/sq. mm
Minimum Bending Strength	590 N/sq. mm
Modulus of Elasticity	14 to 18 x 10^4 N/sq. mm

(iii) Hydrostatic Pressure Test

Ductile iron pipes and fittings shall have working pressure of 16 bar and shall be in accordance with ISO 2531 or with BS EN 545. The standard classes of pipes and fittings shall be as follows unless otherwise stated.

- Socket & Spigot Pipes	K	9
- Flanged Pipes & all other fittings except tees	K	12
- Tees	K	14
- Flanges	PN	16

Each pipe and fitting shall withstand the working hydrostatic test pressure given below:

Nominal Diameter (mm)	Hydrostatic Test Pressure (bar)	
	Pipe	Fitting
80 to 300	50	25
350 to 600	40	16
700 to 1000	32	10
1100 to 1200	25	10

(iv) Wall Thickness

The pipes and fittings shall have the following wall thicknesses:

Pipe Diameter (mm)	Wall Thickness (mm)					
	Pipe (ISO 2531, K=9)		Tees (ISO 2531, K=14)		Other Fittings (ISO 2531, K=12)	
	Nominal	Minimum	Nominal	Minimum	Nominal	Minimum
100	6.1	4.7	8.4	6.0	7.2	4.8
150	6.3	4.9	9.1	6.7	7.8	5.4
200	6.4	4.9	9.8	7.3	8.4	5.9
250	6.8	5.3	10.5	8.0	9.0	6.5
300	7.2	5.6	11.2	8.6	9.6	7.0
350	7.7	6.1	11.9	9.3	10.2	7.6
400	8.1	6.4	12.6	9.9	10.8	8.1
500	9.0	7.2	14.0	11.2	12.0	9.2
600	9.9	8.0	15.4	12.5	13.2	10.3
700	10.8	8.8	16.8	13.8	14.4	11.4
800	11.7	9.6	18.2	15.1	15.6	12.5
900	12.6	10.4	19.6	16.4	16.8	13.6
1000	13.5	11.2	21.0	17.7	18.0	14.7
1100	14.4	12.0	22.4	19.0	19.2	15.8
1200	15.3	12.8	23.8	20.3	20.4	16.9

(v) Fitting Compatibility

The Contractor shall supply the fittings manufactured by the same manufacturer of pipes, using the same kind of material and compatible standards.

The Contractor shall also ensure the dimension compatibility of pipes, fittings and couplings.

(vi) Joints

Joint types shall be as shown on the drawings and meet the following requirements.

o Flexible Joint (Push-In Joints)

Except where flanged joints are required, standard pipes and fittings for pipelines of ductile iron shall be supplied with push-in socket and spigot joints similar to joint type A.1 illustrated in BS 8010: Part 2 : Section 2. The material of the joint rings use shall be in accordance with the requirement of BS 2494:1990 type W.

Where pipes and fittings are not available with this type of joint, they shall be supplied with mechanical type flexible joints of the bolted gland type. Glands, bolts, and nuts for mechanical joint shall be of ductile iron having the same mechanical properties as the fittings.

o Flange Joint

PN 16 pressure rated flanges shall be flat faced and shall conform to the requirements of BS 4504 Part 1 (or to ISO 2531 or BS EN 1092 which are compatible with BS 4504 Part 1 for the same nominal diameters)

The flanges of all fittings including Tees shall be integrally casted with the fitting. The flanges of Flanged pipes may be screwed, welded or integrally cast with the pipe unless otherwise stated.

"Welded" means that the flanges should be welded to the pipes at the point of manufacture under factory conditions.

All bolts to be supplied with flanges shall be of galvanised mild steel to the approval of the Engineer. Flanged joints shall be complete with all nuts, bolts, gaskets and two washers per bolt. Protection of all bolts, nuts, washers etc. and the joint as a whole shall be covered with Denso paste and primer, Denso mastic, Denso tape and PVC or Polythene outer wrapping.

Gaskets for flanges shall be inside bolt circle type, with dimensions complying with BS 3063, and be manufactured from material complying with BS EN 1514, BS 2494 : 1990 Type W listed in the Directory of the Water Research Centre, UK or equivalent.

The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, including where connections are required to pipe work and valves associated with pumping plant and inlet/outlet pipe work at service reservoirs or other structures.

o Restrained Self Anchoring Joints

The design of restrained joints shall comply with BS 8010, ISO 10804-1 or equivalent.

o Slip-on Coupling and Flange Adapter

Bolted sleeve type couplings, stepped couplings and flange adapters may be used for connecting plain ended steel, ductile iron, grey iron, uPVC and other rigid or semi-rigid pipe materials, subject to approval of each type by the Engineer. Couplings, etc. shall be designed and manufactured in accordance with AWWA C219 "Bolted, Sleeve-type Couplings for Plain-end Pipe" except that elastomeric gaskets shall comply with BS 2494 Type W and or BS EN 681-1.

Couplings included in this section will effect a connection between two pipes of either the same pipe materials, or of two different pipe materials, at the same nominal bore.
Couplings and flange adapters shall be manufactured from one of the following materials:

Carbon steel :	BS EN10025 Grade Fe 430A, or JIS G3101 SS400, or ASTM A283 grade C
Malleable Cast Iron	BSEN 1562:Grade B35-12, or JIS G5702 FCMB340 or 360, or ASTM A47 grade 32510 or 35018

Ductile Iron	BS 2789 Grade 420/12, or JIS G5502 FCD400, or ASTM A536 65-45-12

Gaskets shall be of elastometric conforming with the requirements of BS 2494 Type W. Gasket shall have a hardness rating of 80IRHD to prevent gasket extrusion at the bottom tolerance of the fitting. All gaskets shall have identification to detail size range, mould number compound and year and quarter of manufacture.

Nuts, bolts and tee bolts for fasteners shall be manufactured from alloy or carbon steel conforming to BS 970 Part 1 grade 070 M20 or JIS G4051 S20C.

Bolts shall be restrained against rotation by means of "D" shaped necks which will locate in similar "D" shaped holes in the end rings to facilitate single spanner operation. Washers shall be provided to prevent damage to the coating of the fittings.

Centre sleeves, end rings and flange adapters bodies shall be coated with Rilsan Nylon 11 coating, to a uniform minimum thickness of 250-300 microns, having been shot blasted and suitably primed prior to application of coating, maintaining the minimum thickness throughout the fitting. Holding points shall be touched in with the appropriate Rilsan repair coating.

Fasteners shall be electroplated to BS 1706 grade Zn10 or equivalent followed by a suitable primer and then with a coating of Rilsan Nylon 11 to a uniform thickness of 60 - 120 microns.

Flange adapters for jointing flanged specials to plain-ended pipes shall conform to the foregoing contents of this clause. Prior to the commencement of the manufacture the Contractor shall submit to the Engineer for approval detailed drawings of all couplings and flange adapters.

When harness is specified with coupling or flange adapter, the harnessing shall be provided as recommended by the manufacturer of couplings or flange adapters. Harness joint shall be designed and manufactured to withstand for the pull-out force caused by the internal pressure of 16 bar at the joint.

(vii) Length of Straight Pipes

Length of straight pipes shall conform to the requirements in ISO, BS, JIS or AWWA to be applied. Pipes longer than specified may be used in accordance with the recommendation of the manufacturer. However, it shall be the sole responsibility of the Contractor to examine the difficulties he is likely to face in transporting, storing, handling and installing such longer length pipe. While ordering the pipes the Contractor shall ensure the possibility of negotiating the horizontal and vertical bends as shown in the drawing.

Three percent of all straight pipes shall have applicable external diameter to the joints for full length of barrel and shall be suitable for usage by cutting at sites. Such pipes shall be clearly marked.

(3) Coating and Lining

(i) External Coating

Pipes and fittings shall be externally coated with metallic zinc and bitumen paint conforming to BS EN 545 or ISO 8179, which shall not contain any constituent soluble in water or any ingredient liable to leach in water after drying. The coating shall have good adherence to the pipe and fittings and not scale off. Thickness of the coating shall not be less than 70 microns.

(ii) Internal Lining

Internal surface protection shall be either of:

(a) Cement mortar lining, or
(b) Fusion-bonded epoxy coating

(a) Cement Mortar Lining

Pipes and fittings shall be internally lined with cement mortar using sulphate resisting cement confirming to BS 4072 . The thickness of lining shall be as follows:

Pipe Nominal Diameter (mm)	Thickness of Lining (mm)	
	Nominal	Minimum
80 to 250	4	3
300 to 600	6	5
700 to 900	8	6
1000 to 1200	10	7

Inside of socket shall be free of cement mortar lining and shall be coated with the material used for external coating. Internal lining shall be done in accordance with BS EN 545, ISO4179, JIS5314, AWWA C104, or equivalent.

(b) Fusion-bonded Epoxy Coating

Fusion-bonded epoxy coating for ductile iron pipe shall conform to JIS G5528, AWWA C213 or equivalent.

Material shall consist of a one-component powdered fusion-bonded material composing of epoxy resin, hardener, and fillers. Composition of epoxy resin hardener shall not be less than 55 percent in weight.The standard film thickness shall not be less than 300 microns except for the socket portion where the minimum film thickness shall be 100 microns.

The physical properties of coating shall satisfy the requirements of JIS 5528, ANSI/AWWA C213 or equivalent. ANSI/AWWA requirements are shown below:

Item		Requirement	Test Method
i.	Impact	Min. 1.1 kg-m	AWWA C213
ii.	Bendability	Pass	AWWA C213
iii.	Appearance	Pass	AWWA C213
iv.	Shear adhesion	Min. 210 kgf/sq. cm	ASTM D1002
v.	Penetration	Less than 10 %	ASTM G17
vi.	Abrasion resistance (5000 cycles-gm loos)	Max. 0.3	ASTM D1044
vii.	Cathodic disbondment area	Max. 9.7 sq. cm	ASTM G8
viii.	Hot water resistance	Pass	AWWA C213
ix.	Water extractable	Max.0.078 mg/sq. cm	AWWA C213
x.	Taste and odour	Pass	AWWA C213

Should the coating fail to satisfy the requirements of the tests or the coating be damaged, the defective or damaged area shall be repaired by using a two-component liquid type epoxy paint.

(4) Special Protections

(i) Polythene Sleeving for aggressive soil conditions

The Polythene sleeving supplied shall conform to BS EN 545 or BS 6076 specifications by the manufacturer for the particular DI pipe. The Contractor shall furnish all the relevant technical specifications of the sleeving he intends to use in the works to the Engineer for approval, before the sleeves are used.

The sleeves supplied shall include necessary adhesive tapes and any other material that may be required for the purpose.

(ii) Tape Wrapping for highly aggressive soil conditions

The tape wrap shall be self adhesive bituminous rubber compound providing self sealing joints at over laps and shall be high resistance to cathodic disbondment. Site application shall be conforming to the recommendations of the manufacturer. The Contractor shall furnish all the relevant technical specifications of the tape wrap he intends to use in the works to the Engineer for approval, before use.

9.1.3.2.2 Unplasticized Polyvinyl Chloride (uPVC) Pipe and Fittings

(1) General

(i) Scope of Work

Where shown on the drawings the Contractor shall supply polyvinyl chloride pipes and fittings in accordance with the details shown on the drawings and specified herein. In addition, the Contractor shall supply additional materials for maintenance to the Employer as listed in the Bill of Quantities.

(ii) Standard Specification References

The following standards are referred to:

SLS 147:1983	Specification for Rigid Unplasticized Polyvinyl Chloride Pipes for Potable Cold Water Supplies
BS 3505:1986	Specification for Unplasticized Polyvinyl Chloride pressure pipes for cold portable water
BS 4346	Joint and fittings for use width Unplastized PVC pressure pipes
BS 2494	Materials for Elastromeric Joint Rings for Pipe work and Pipelines
BS 4504	Circular Flanges for Pipes, Valves, and Fittings
ASTM F 477	Specification for Elastromeric Seals for Joining Plastic Pipe
ASTM K 138	Rigid PVC Pipe for Pressure and Non-pressure Applications
JIS K 6353	Rubber Goods for Waterworks
JIS K 6380	Rubber Packing Material for Industrial Use
JIS K 6720	Polyvinyl Chloride
JIS K 6741	Unplasticized Polyvinyl Chloride Pipes for General Use
JIS K 6742	Unplasticized Polyvinyl Chloride Pipes for Waterworks
JIS K 6743	Unplasticized Polyvinyl Chloride Pipe fittings for Waterworks

(2) Materials

Unless otherwise specified, pipe shall be rigid, unplasticised polyvinyl chloride conforming to SLS 147:1983, or equivalent.

Pipe shall be furnished in standard laying lengths of 6m and shall be grey in colour.

Pipes shall be designed for a minimum working pressure of not less than 6 kgf/sq. cm or 6 bars for type 600 pipe, and 10kgf/sq.cm or 10 bars for type 1000 pipes at a temperature of 29 °C.

All fittings shall have the same characteristics and strength as the connecting pipes. Fittings shall be confirm to BS 4346 Part 1 and Part 2.

Fittings made of polyvinyl chloride shall be manufactured by a heat injection moulding machine or extruded machine. Fittings fabricated by heat-fusion or solvent-cement technique are not acceptable.

(3) Joint

Unless otherwise specified, joints for underground pipe 110 mm and larger shall be push-in type using rubber gaskets.

Unless otherwise specified, joints for underground pipe and bends of 90 mm and 63 mm shall be welded using solvent cement. Other fittings of 90 mm and 63 mm shall be push-on type using rubber gaskets.

Unless otherwise specified, joints for all exposed pipes and for pipes smaller than 63 mm shall be welded using solvent cement.

All joints shall be designed to have the same characteristics and strength as the connecting pipe.

(i) Push-in Type

The pipe ends shall be integral bell-end type at one end and plain end at the other end. The bell-end section shall be designed by the manufacturer.

One neoprene gasket shall be furnished with each standard length of pipe and fitting.

The neoprene rubber gasket shall be manufactured in conformity with BS2494, ASTM F477, or JIS K6353, or equivalent.

(ii) Welding Type

The bell-end section shall be designed by the manufacturer.

Solvent cement shall be confirm to BS 4346 Part 3 or SLS 935, 1991. Solvent cement shall be mixed in strict accordance with the manufacturer's instructions. Any impurities in the cement shall be a cause for rejection. Data on the pot life of the solvent cement shall be approved by the Engineer.

(iii) Flanged Joint

Flange joint shall be flange adopters as specified 9.1.3.2.1.6 (iv) or confirm to BS 4346 Part 2:1970.

(4) Coating

Fitting made of cast iron shall be coated internally with non-toxic epoxy resin of not less than 100 microns (4 mils) and externally with coal tar epoxy of not less than 200 microns (8 mils) after the hydrostatic test has been carried out.

(5) Testing

Pipe and fittings shall be tested in accordance with JIS K6741, or JIS K6742 or equivalent.

Each standard length of pipe and each fittings shall be tested under an internal hydrostatic pressure of not less than 12 kgf/sq. cm for the duration of 60 seconds.

The Contractor shall furnish copies of certificates of tests carried out for quality control during manufacture of the pipe in accordance with Section 7.2 of SLS 147:1983 and Appendices A to E of BS 3505:1986 and shall if required by the Engineer undertake such additional tests as he considers necessary.

9.1.3.2.3 Steel Pipe (SP) and Fittings

(1) General

(i) Scope of Work

Where shown on the drawings the Contractor shall supply steel pipes and fittings in accordance with the details shown on the drawings and specified herein, including gaskets and other jointing materials and pipe adapters necessary for connections to Ductile Iron piping. All pipes shall be designed for maximum working pressure of 16 kg/cm^2 unless otherwise specified. Where specified, prior to completion of the work the Contractor shall supply additional materials for maintenance by the Employer as specified in the Bill of Quantities.

(ii) Standard Specification References

The following standards are referred to.

BS 4504	Circular Flanges for Pipes, Valves, and Fittings
BS 534-1990	Steel pipes, joints and specials for water and sewage.
BS 4515	Welding of steel pipe lines on land and off shore
AWWA C104	Cement Mortar Lining for cast-iron and Ductile-Iron Pipe and Fittings
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C203	Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied
AWWA C205	Cement-Mortar Lining for Steel Water Pipeline
AWWA C206	Field Welding of Steel Water Pipe Joints
AWWA C208	Dimensions for Steel Water Pipe Fittings
AWWA C210	Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe
AWWA C602	Cement Mortar Lining of Water Pipelines 4 inch (100 mm) and larger -In Place
AWWA Manual	Steel Pipe Design and Installation M11
ASTM A185	Welded Steel Wire Fabric for concrete Reinforcement
ASTM A283	Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality
ASTM 307	Carbon Steel Externally Threaded Standard Fasteners
ASTM A570	Hot-rolled Carbon Steel Sheet and Strip, Structural Quality
JIS G3101	Rolled Steel for General Structures
JIS G3451	Fittings of Coating Steel Pipe for Water Service
JIS G3457	Arc Welded Carbon Steel Pipes
JWWA A109	Mortar-Lining of Steel Pipes for Water Works

(2) Materials and Fabrication

(i) Pipes

Steel pipes shall be fabricated from steel sheets or plates and shall be arc welded or electric – resistance welded, shop fabricated, tested and cleaned. Steel sheets or plates shall have a minimum yield point not less than 2,300 kgf/cm^2 (226 N/mm^2) and shall confirm to the following standards.

JIS G 3101, Class 2 SS 400
or JIS G 3452, SGP
or JIS G 3457, STPY
or ASTM A 283, Grade D
or ASTM A 570, Grade 33

The Fabrication of Steel pipe shall be in accordance with JIS G 3457 or AWWA C 200 or BS 534.The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means except that with the approval of the Engineer, manual welding by a qualified procedure and welder may be used.

All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt welded. The maximum allowable number of shop seams shall be one longitudinal seam and three girth seams per length of pipe. The length of pipe shall be six (6) meters or smaller unless otherwise specified.

The longitudinal shall be staggered on opposite sides for adjacent section. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of pipe.

All pipe ends shall conform to the requirements specified in the Para 4 (Joints and Pipe Ends) of Section 9.1.3.2.3

(3) Dimensions

(i) Pipe Dimensions

The nominal pipe diameters shown on the drawings shall be of the following outside diameters and minimum wall thickness before lining and coating.

TABLE 9.1.3.1 Dimension of Steel Pipe

Unit (mm)

Nominal Pipe Dia.	Outside Diameter	Wall Thickness (as minimum)
150	168.3 ± 1.6	3.5
200	219.1 ± 1.6	4.0
250	273.0 ± 1.6	4.8
300	323.9 ± 1.6	4.8
400	406.4 ± 1.6	5.2
500	508.0 ± 1.6	6.4
600	610.0 ± 1.6	7.1
700	711.0 ± 1.6	7.1
800	813.0 ± 1.6	7.1
900	914.0 ± 1.6	7.1
1000	1016.0 ± 1.6	8.7
1100	1118.0 ± 1.6	9.5
1200	1219.0 ± 1.6	9.5

(ii) Fitting Dimensions

All steel fittings shall be of the same materials and fabrication , strength, outside diameter and wall thickness as that of pipes, and shall be provided with reinforcing rings and saddles on the exterior when and where required in accordance with AWWA Manual M11 to meet the specially high pressure.

The minimum wall thickness and outside diameter of fittings shall conform to the following standards or requirements specified in para (2) (a) above.

The dimensions of fittings shall conform to either JIS G 3451 or AWWA C 208 (Table 1 and Fig. 1, and Table 2 A to 2 D and Fig. 2).

All steel fittings except bends having a deflection angle less than 5 degrees shall be shop fabricated. Bends having a deflection angle less than 5 degrees may be field fabricated from shop fabricated steel pipe by means of field cutting and welding.

Bends having a deflection angle of 22.5 degrees and smaller shall be two- piece bends. Bends having a deflection angle of over 22.5 degrees and up to 45 degrees shall be fabricated using three pieces. Bends having a deflection angle of over 45 degrees shall be four – piece bends.

(4) Joints and Pipe Ends

(i) General

All steel pipes and fittings shall be furnished with bevelled ends for welding unless otherwise specified. Steel pipe end (s) where specified shall be standard flange joint or plain end for sleeve coupling or others. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

(ii) Flanged Joints

Pipes and fittings to be jointed by flexible coupling shall have the plain end.

Where shown on the drawings, flanged joints shall be provided. Flanges shall be made as seamless forging or cut and fabricated from steel plates and shall conform to BS 4504. Class of flange shall be PN16 unless otherwise specified on the drawings.

Material for flanges, bolts and nuts shall be the same steel used for fabrication of steel pipes and fittings. Flanges shall be steel welding neck flanges, having a raised face attached to pipes or fittings by means of single butt-weld. All flanges shall be flat faced with bolt holes straddling the vertical axis of the pipes or fittings, and all gaskets shall be of at least 3.0 mm thick asbestos or neoprene, full face with bolt holes correctly sized and spaced. Flanges shall be supplied complete with the required size, quantity and quality bolts, nuts and gaskets. Unless otherwise particularly indicated on the drawings, all plate and neck flanges shall, in mating dimensions and drilling, conform to BS4504.

Bevelled end for Welding

Pipe ends for welded joints shall have bevelled ends. Ends for pipes in sizes 700 mm and under shall have bevelled ends to permit a "single-welded butt joint" from the outside of the pipe.

Ends for pipes in sizes 800 mm and over with a wall thickness of 15 mm and thinner shall have bevelled ends to permit a "single-welded butt joint" from inside of the pipe. Ends for pipes in sizes 800 mm and over with a wall thickness of 16 mm and thicker shall have bevelled ends to permit a "double-welded butt joint" from both the outside and inside of the pipe. Shape of the bevelled end shall be for ACE welding and in accordance with the manufacturer's standard approved by the Engineer.

(5) Lining

Unless specifically noted otherwise, all steel pipe and fittings shall be epoxy lined on the inside in accordance with AWWA C213.

The lining systems such as epoxy shall be shop applied. They shall consist of the following:

(a) Epoxy System

a. One (1) coat of liquid two-part chemically cured rust-inhibitive epoxy primer
b. One (1) or more coats of a liquid two-part epoxy finish coat which contains no coal tar

Primer and finish coat(s) shall be from the same manufacturer.

The epoxy lining system may alternatively consist of two or more coats of the same epoxy coating without the use of a separate primer. This alternative system shall conform to requirements of AWWA C213 and the first coat of this alternative system shall be considered as the primer.

The total dry film thickness of both coating systems shall not be less than 400 microns nor more than 600 microns.

(6) Coating

The outside coating for all pipes and fittings, excluding sleeve pipes, to be placed underground, shall be shop-coated and conforming to the followings:

i) AWWA C203: "Coal Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot-applied" which shall consist of, but not limited to, the followings:

a) Coal-tar primer
b) Coal-tar enamel 2.40 0.8 mm. thick
c) Bonded asbestos-felt wrap or fibrous glass mat
d) Coal-tar enamel 0.8 mm. thick
e) Bonded asbestos-felt wrap
f) Water-resistance white wash or Craft-paper finished coat

or

ii) BS534: "Specification for Steel Pipes, Fittings and Specials for Water, Gas and Sewage" which shall consist of, but not limited to, the followings:

a) Coal-tar primer
b) Coal-tar enamel 2.40 0.8 mm. thick
c) Glass tissue inner wrap
d) Coal-tar enamel 0.8 mm. thick
e) Coal-tar impregnated reinforced glass tissue outer wrap
f) Water-resistance white wash or Craft-paper finished coat.

The above-ground pipe and fittings shall be shop-coated with one or more coats of non-breeding type coal tar epoxy followed by additional two or more coats of epoxy-resins Micacous Iron Oxide (MIO) paint. The total uniform dry film thickness of non-breeding type coal tar epoxy coating shall not be less than 0.15 mm. while that of the MIO point shall be at least 0.06 mm. The method of surface preparation and coating shall conform to the manufacturer's standards and recommendations.

The exterior of sleeve pipe shall be coated with non-breeding type coal tar epoxy at the total uniform dry film thickness of at least 200 microns.

(7) Lining and Coating at Pipe Ends

(i) Bevelled Ends

Where shop lining is applied, at bevelled ends of pipe and fittings 600 mm and larger in diameter, both shop lining and coating shall have a cutback of 200 mm to facilitate field welding.

At bevelled ends of pipe and fittings smaller than 600 mm in diameter, only coating shall have a cutback of 200 mm, and lining shall be extended to the pipe ends.

All interior surface left as cutback at the bevelled ends shall be given Cement-Mortar lining conforming to AWWA C205 or JWWA A109 after jointing the pipe. All exterior surface left as cutback at bevelled ends shall be given:

- o one shop coat of Type B coal tar primer conforming to AWWA C205 for underground buried pipe and fittings, or
- o one shop coat of epoxy primer conforming to the paint manufacturer's standards for above-ground exposed pipe and fittings.

(ii) Plain Ends

At all plain-ends and shouldered-ends specially prepared for sleeve couplings and other flexible or expansion joints, only the coatings except primer shall have a cutback of required length for replacing the coupling or joint. The exterior area which may contact with handling liquid shall have the same coating as the pipe lining specified after removing the said primer completely. After setting couplings or joints, the remaining area which has only the said primer and the exterior of couplings or joints shall be finished with petrolatum corrosion protective tape which will be specified hereinafter. The lining shall be extended to the pipe ends.

(iii) Flanged Ends

At all flanged ends, no cutback of lining and coating shall be provided.

For underground buried pipe and fittings including those installed in concrete valve chambers, coal tar epoxy lining shall be extended to the entire flange surface.

For above-ground exposed pipe and fittings, coating system consisting of non-bleeding type coal tar epoxy and MIO paint as specified for above-ground exposed pipe and fittings shall be extended to the entire flange surface.

(8) Manufacturer's Mark

Each pipe and fitting shall bear the mark of the manufacturer; the nominal diameter; wall thickness; year of manufacture; the wordings "Steel Pipe" or "SP", and the owner's name "NWSDB". The marking shall be conspicuously painted in non-toxic paint on the inside of each section of pipe and each fitting.

(9) Shop Testing

(i) Pipe

Shop testing and inspection of the pipe shall be conducted in accordance with AWWA C200 in the presence of the representative of the Engineer. The minimum hydrostatic test pressure for straight pipe shall be determined in accordance with Section 3.4 of AWWA C200 using the design stress equal to 75 percent of the minimum yield point of the steel used. When approved by the Engineer, the hydrostatic test may be replaced by other appropriate non-destructive testing methods such as ultrasonic and/or radiographic testing methods.

During pressure test, all welds shall be thoroughly inspected and all parts showing leakage shall be marked. Pipes that show any leakage under test shall be re-welded at the points of leakage and subjected to further hydrostatic tests until satisfactory results are obtained.

(ii) Fittings

Upon completion of welding, but before lining and coating, each fitting shall be bulk headed and tested under the same hydrostatic pressure as for the pipe. Provided, however, that if fittings are fabricated from previously tested straight pipe, only those welding seams that were not previously tested in the straight pipe may be tested by means of ultrasonic or radiography method or other methods as approved by the Engineer, with no further hydrostatic test.

Any leakage and porous welds which may be revealed by the test shall be chipped out and re-welded and the fitting be re-tested until satisfactory results are obtained.

(10) Flexible Coupling

Flexible couplings to join the plain ended pipes shall conform to the requirements as specified for couplings and flange adapters for Ductile Iron Pipes in this specification.

(11) Harness Joint

The harness joint shall be provided where shown on the drawing. Steel plate for lugs shall have the same properties as the pipe. Tie rods shall be made of steel conforming to ASTM A307 "Carbon Steel Externally and Internally Threaded Standard Fasteners, Grade B" and shall be hot-dipped galvanised.

The dimensions of nut shall conform to BS4140 "British Standard Specification for ISO Metric Black Hexagon Bolts, Screws, and Nuts Normal thickness Nut Type".

9.1.3.3 VALVES, APPURTENANCES AND EQUIPMENT

9.1.3.3.1 Standard Specification References

The following standards are referred to:

ISO 9000 series	Quality Assurance Standards
AWWA C500	Gate Valves -3-Inch through 48-Inch For Water and Other Liquids
AWWA C504	Rubber Seated Butterfly Valves

AWWA C509	Resilient-Seated Gate Valves 3 through 12 NPS, for Water and Sewerage System
ASTM A108	Steel Bars, Carbon, Cold-Finished, Standard, Quality
ASTM A126	Grey Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A276	Stainless and Hot-Resisting Steel Bars and Shapes
ASTM A307	Carbon Steel Externally Thread Standard Fasteners
ASTM A320	Alloy-Steel Bolting Materials for Low Temperature Service
ASTM B62	Composition Bronze or Ounce Metal Castings
BS 750:1984	Underground Fire Hydrant and surface box frames and covers
BS 5150	Cast and Gate valves.
BS 5155	Butterfly Valves
BS 5163	Pre Dominantly key operated Cast Iron Gate Valves for Water Works Purposes
BS 4504	Circular Flanges for Pipes, Valves, and Fittings
BS 21	Pipe treads for tube and fittings where pressure type joints are made
BS 5728	Measurement of flow of cold portable water in closed conduits
BS 3100:1991	Steel casting for general engineering purpose
BS 970	Wrought steel for mechanical and allied engineering purpose
BS EN 1561	Grey cast iron
BS EN 1563	Founding. Spheroidal graphite cast iron
BS EN 1564	Founding. Austempered ductile cast iron
BS EN 124:1994	Gully tops and manhole tops for vehicular and pedestrian areas
JIS B2062	Sluice Valves for Water Works
JIS B2063	Air Valves for Water Works
JIS G4303	Stainless Steel Bars
JIS G5501	Grey Iron Castings
JWWA K115	Tar Epoxy Resin Paints for Water Works and Method of Coating

9.1.3.3.2 Materials and Manufacture

All valves shall be of size and type as shown on the drawings or in the Bill of Quantities.

All valves, shall be from one manufacturer, unless approved by the Engineer in exceptional circumstances.

(1) Valves Ends

Valve ends shall be of flanged ends except where otherwise specifically called out on the drawings. Where flanged ends are used, mating dimensions and drilling shall be in accordance with BS4504. Class of flange shall be PN16 unless otherwise specified. Bolts and nuts shall be galvanised mild steel.

(2) Valve Marking

All valves shall have the direction arrow for opening; the name or mark of the manufacturer; the name of the Employer "NWSDB"; the valve size; year of manufacture; number of turns to open, and the working pressure for which they are designed cast in raised letters upon an appropriate part of the body. In addition, valves designed for one-way flow only shall have a direction arrow cast on the body.

(3) Interior Parts in Valves

All interior parts of valves manufactured of bronze (except valve stems) shall conform to the requirements of ASTM B62 or approved equivalent standards unless otherwise stated.

(4) Protective Interior Coating for all Valves

Ferrous surfaces in the water passages of the valves excluding those surfaces manufactured of corrosion resistant material) shall be non-toxic epoxy resin. The minimum coating thickness shall not be less than 100 microns.

(5) Protective Exterior Coating for Buried Valves

All buried valves shall be provided with an exterior protective coating against corrosive soil in accordance with JWWA K115 or BS 5163 :1974 or approved equivalent standard. The minimum coating thickness shall not be less than 200 microns.

(6) Valve Stem

The valve stem shall be stainless steel grade AISI 304.

(7) Direction to Closure

The valve shall be so constructed as to be closed by clockwise turning of the wrench nuts and valve operators and opened by counter clockwise turning.

(8) Underground Valves

All underground valves shall be furnished with surface boxes unless otherwise specified.

All underground valves shall be coated completely including flanges, all bolts and nuts except stem with Denso paste and primer, Denso mastic, Denso tape and PVC or Polyethylene outer wrapping.

(9) Spool Pieces

Testing and operation of the work is not to be delayed due to late delivery of valves. Contractor shall provide and install if required spool or spacer pieces equivalent in length and pressure rating to the valves to be installed in the work. The valves shall then be installed on arrival.

(10) Submittals

The Contractor shall submit manufacturer's certified drawings showing the principal dimensions, construction details and materials used for all parts of the valve and full details of valve stem extensions, including material, dimensions, fabrication, torque limits, method of connection to the valve and valve box and stem guides when required to avoid buckling.

(11) Maintenance Materials

The Contractor shall supply the following materials for use of the Employer as replacement parts for the valves furnished under this Contract in quantities of:

1) For every five (5) gate valves of the same size and type or fraction thereof:

1 set	stem seal
1 pc	stuffing box gasket with O-Ring
1 pc	bonnet gasket with O-Ring
1 pc	stem
1 pc	operating nut

2) For every five (5) butterfly valves of the same size and type or fraction thereof:

1 pc	shaft seal
1 pc	rubber sealing ring
1 pc	thrust bearing
1 pc	operating nut

3) For every five (5) fire hydrants of the same size and type or fraction thereof:

1 pc	shaft seal
1 pc	rubber sealing ring
1 pc	thrust bearing
1 pc	operating nut
1 pc	outlet stand pipe (1m high)

When each type of valve to be installed is less than five (5) sets, each one (1) set of the materials specified above shall be provided.

Costs of these maintenance materials shall be deemed to be included in the rate of each type of valve.

(12) Tee-Handle Valve Keys, Extension Spindles and Lifting Keys

The Contractor shall supply twenty four (24) tee-handle valve keys of sufficient length (inclusive extension spindles where required) for the operation of buried/below ground valves. The length of the key shafts shall vary according to the valve depths but shall project approximately one meter (1m) above ground level. Tee-Handle shall be of galvanised mild steel. The Contractor shall obtain Engineers prior approval before ordering these materials.

The Contractor shall also supply twenty four (24) lifting keys suitable for manhole covers and surface boxes.

9.1.3.3.3 Gate Valves (Resilient Seat Type)

(1) General

Valves 300 mm and smaller in diameter shall be gate valves (sluice valves) unless specified otherwise.

Unless otherwise specified or shown on the drawings, gate valve shall conform to AWWA C500, JIS B2062, BS5163 or AWWA C509. Gate valves shall be cast iron or ductile iron body, non-rising stem with solid wedge designed for a minimum working pressure of 16 kgf/sqcm.

Gate valves specified as PN16 shall conform to BS5163 PN16 designed for a minimum working pressure of 16 bar.

(2) Materials and Construction

In general, the underground type valve and the aboveground type valve shall be of the same construction with the stem collar made integral with the stem and the hand wheel shall be used instead of the wrench nut in case that the valve is the aboveground type. The valve shall be designed to be opened by counter clockwise turning and the arrow marks indicating the open and close directions shall be cast on the hand wheel or operating nut.

Stem sealing shall be in accordance with BS5163.

Resilient seat shall be bonded to either the gate or valve body. If the resilient seat is rubber material, the method used for bonding or vulcanising shall be proved by ASTM D429 "Tests for Rubber Property-Adhesion to Rigid Substrates-Method A or Method B". For Method A, the minimum strength shall not be less than 11.0 kgf/sq. cm and when Method B is applicable the peel strength shall not be less than 5.3 kgf/sq. cm.

(3) Specific Requirements

The maximum effort required to operate the valve against the maximum unbalanced head, applied at the circumstance of the hand wheel or end of the tee-key shall not exceed 26 kg.

(4) Testing

Each gate valve shall be subjected to operation, hydrostatic and proof-of-design tests at the manufacturer's plant as specified in the standard of JIS, BS or AWWA as applied at the appropriate test pressure.

9.1.3.3.4 Butterfly Valve (Resilient Seated Type)

Standard butterfly valves shall conform to BS 5155 for PN 16 pressure rating and shall give tight closure against unbalanced water pressure in either direction. The unbalanced water pressure shall be the design pressure rating of the valve.

The manufacturer's preferred direction of flow for the valve shall be clearly marked on it.

Valve shall be double flange cast iron or ductile iron resilient seated and shall be suitable for maximum velocity of 3 m/sec and for throttling service.

Valve body shall be designed to with stand the maximum working pressure specified and the maximum differential pressure of 0.6 Mpa. Minimum thickness of valve body shall be calculated with out exceeding a working stress equivalent to 20% of the tensile strength of the material used.

Valves shall be fitted with sleeve type bearings contained in the hub of the valve body and shall be equipped with either one or two trust bearings, which shall hold the valve disc securely in the centre of the valve. Sleeve and other bearings fitted in to the valve body proper shall be made of self lubricated material that do not have a harmful effect on potable water or resilient material.

Shaft shall be a one piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs. If of " stub"

construction, each stub shaft shall be inserted in to the valve disc hubs for a distance of at least 1.5 times the shaft diameter. Valve shaft shall be of high yield strength mantensitic series stainless steel such as type 403, 420, 431,and others and valve shafts made by precipitation series stainless steel also maybe acceptable. Allowable torsional sheer stress, not exceeding 25% of yield strength of material used shall be applied for design of valve shaft diameter.

A shaft seal shall be provided where shafts project through the valve bodies for actuator connection. Shaft seal shall be designed for the use standard V-Type packing ; O-ring seals; O-ring loaded U-cup seals; or a pull-down packing. If O-rings are used, they shall be contained in a stainless steel or bronze removable recesses. If stuffing box and pull-down packing are used, the design of the valve and stuffing box assembly shall permit adjustment or complete replacement of packing without disturbing any part of the valve or actuator assembly except packing gland follower. Gland or gland assemblies shall be made of stainless steel or bronze. Packing shall be made of resilient, non metallic material suitable for potable water service which shall not contain asbestos.

The valve seat shall be replaceable and be formed of approved resilient material. Seats shall be of a design that permits removal and replacement at the site of installation. The valve seat shall be securely clamped into a machined groove in the valve body or to the edge of the disc by seat retention members or other equivalent retention device, in such a manner as to prevent leakage of water under the seats and to hold the seat securely in position during opening and closing of the valve disc. The seat retention members shall be of stainless steel and shall be securely fastened to the body or disc with stainless steel fasteners. When all the seat retention members are in place, the finished edges shall fit closely and the surface shall be smooth with all fastenings set flush in the water passage so as to offer the least resistance possible to the flow of water through the valve.

Valve seats which extend over the face of the flanges to secure the seat in place, or which require surface grinding and/or hand fittings of the disc; or designs which require the adjoining pipe flange to retain the seat in place and resist line pressure, shall not be supplied.

Valve disc shall be made of cast iron or ductile iron or stainless steel casting and shall be of design with no external ribs transverse to the flow. The design of disc shall with-stand full differential pressure across the closed valve disc without exceeding the working stress, equivalent to 20% of tensile strength of the material used. Disc edges shall be machined with rounded corners and shall be polished to a smooth finish. The valve disc shall rotate through an angle of 90 degrees from the fully opened to the fully closed position and the seat shall be of such design as to allow the valve disc to seat at an angle normal to the axis of the pipe when the disc is in the fully closed position. Adjustable mechanical stops shall be provided in the valve body to prevent over-travel of the valve disc in both the open and closed positions.

Operating gear for butterfly valves shall be of the fully enclosed type. Valves shall be suitable for operation by on man at all pressure conditions that can apply. A valve position indicator shall be provided for butterfly valves in chambers. Where a hand wheel is used for operating such a valve, the indicator shall be clearly visible form the hand wheel operating position. Where a containing chamber is not shown, butterfly valves shall be specially adapted for buried use. In line valves shall be operated by means of a hand wheel or tee key and be provided with gearing to prevent rapid closure of the valve. Gear ratios shall be at least 20:1. The valve bodies shall be protected by a bitumen coating and the valve discs by a Nylon Coating similar.

All butterfly valves shall be tested at the manufacturer's works in accordance with BS 5155 and under 'open-end' conditions. The seat test shall be for tight closure under maximum unbalanced

water test pressure in either direction. The maximum permissible leakage for each valve shall be 0:05 litre per hour per 100 mm nominal diameter of the valve.

The word "CLOSE" or its abbreviation and the arrow mark indicating the direction of rotation to close the valve shall also be cast on the cover or the body.

The minimum size of letters shall be 25 mm and 3 mm raised from the surface.

9.1.3.3.5 Air Valve

Air valves shall be designed and manufactured in accordance with JIS B2063, or equivalent. Air valves shall meet the working pressure of 16 kgf/sq. cm respectively.

The valves shall be iron bodied, float actuated air valves.

Valve bodies, covers, bonnets and stuffing boxes shall be of cast-iron conforming to JIS G5501 FC200, ASTM A48 Class 35, or BS1452 Class 220, or equivalent.

Stainless steel conforming to AISI 304 may be used for stem, stud, bolts and nuts and main valve retaining units and plugs.

Air valves unless otherwise specifically indicated on the drawings shall be of the following type and size depending on the size of pipeline in which they are installed.

Type & Size of Pipe (mm)	Nominal Size of Air Valve (mm)		Type of Air Valve
	Body size	Flange size	
upto 225 PVC	25	Saddle	Single Orifice with an isolating cock, 1 inch BSP Threaded Male ferrule
250 - 300 DI	60	80	Double Orifice with flanged inlet and an isolating Gate valve, (type Stanton N2516 or equivalent)
400 – 600 DI	100	100	Double Orifice with flanged inlet and an isolating Gate valve, (type Stanton N2522 or equivalent)
800 - 1200	150	150	Double Orifice with flange inlet and an isolating gate valve, (type Stanton N2525 or equivalent)

(1) Single Orifice Type

Single orifice type air valves shall be designed to automatically operate so that they will exhaust accumulated air under pressure while the pipe is flowing full of water.

(2) Double Orifice Air Valve

Double orifice air valves shall be designed to automatically operate so that they will:

1) Positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;

2) Exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;
3) Not blow shut under high velocity air discharge; and
4) Exhaust accumulated air under pressure while the pipe is flowing full of water.

Air valves are performance tested to ISO 5208 at the shop.

Seat test 1.1 x working pressure.

Body test 1.5 x working pressure.

No leakage shall be allowed.

Coating of air valve shall be same as coating for gate valve.

(3) High Speed Air Valve (Quick Type)

Where shown on the drawing, high speed (quick type) air valve conforming to JIS B2063 Class 4, or equivalent shall be used. The valve shall have flanged end and to meet the maximum operating pressure of 16 kgf/sq. cm. Dimension of flange shall conform to the requirement of the pipe flange.

The valve shall be float actuated air valves with their inlets flanged. Valve bodies, covers, bonnets and stuffing boxes shall be of ductile iron conforming to JIS G5502 FCD 450, ASTM A536 65-45-12, or BS2789 500/7, or equivalent.

9.1.3.3.6 Flap Valves

Flaps and frames shall be ductile iron conforming to BS 2789. Mating surfaces of flaps and frames shall be of non-ferrous metal (excluding aluminium) accurately machined to ensure a watertight fit in the closed position.

Hinge pins shall be of tamper proof austenitic stainless steel; all flaps shall be double hung and seat off the vertical. Flanges shall be PN 16 conform to BS 4504.

Coated in either fusion bonded epoxy, minimum thickness 150 microns, or cold applied black bitumen.

9.1.3.3.7 Tilting Disc Check Valves

Tilting disc check shall be cast iron or ductile cast iron body and disc, and bronze or stainless steel seating. Valves shall be designed for a working pressure of 14.0 kg/cm2 and shall be suitable for operation in a horizontal pipe line.

Body shall be two (2) piece construction bolted together. Seat rings shall be mounted on both valve body and disc and shall be made of bronze casting conforming to JISH5111, Class 6 or type 304, 403, 420 or other stainless steel. Mating surfaces of body seat and disc seats shall be machine finished. Hinge pin shall be of stainless steel specified above. Bushing of hinge pin shall be bronze casting specified above or aluminium bronze casting conforming to JIS H5114, Class 2 or 3.

Body shall be provided with suitable holes for cleaning and by-pass pipe with valve. Pivot pin housing shall be fitted with ball check grease fittings.

Dash pots shall be furnished with valves and designed to have valve opening and closing speed control devices. Dash post shall be approved by the Engineer.

9.1.3.3.8 Toothed Vane Rotary Control Valves

(1) General

The valves and appurtenances shall be products of well established reputable firms with experience in the manufacture of the particular equipment hereinafter specified. The contractor shall show proof that the valve manufacturer has designed, built and supervised installation of toothed vane rotary control valve and shall be required to furnish a list of installations using the said valves manufactured and supplied by him.

Valves shall be rubber seated, toothed vane disc butterfly type rotary control valve and shall conform to all provision in the previous sub-section, (2) Butterfly Valves. Class NP 10, except the following items and in addition shall conform to the following requirements.

Valves shall be designed to be leak tight, in both directions at a maximum working pressure of 0.98 MPa and shall be suitable for a maximum velocity of 3.0 m/sec and for throttling service.

Valves shall have hydrodynamically designed, toothed vane which splits up the flow stream and reduces noise and cavitation effectively while providing precise flow control.

Valve bodies shall be of double flanged long body type and shall be made of ductile iron conforming to FCD 450, JIS 5001, Class 3. Flange drilling schedule shall conform to NP 10 Flange Drilling Schedule as specified in the sub-section 9.1.3.1.10 Flange Drilling Schedule, Section 9.1.3.1 GENERAL.

Shafts shall be of high yield strength mantensitic series stainless steel such as type 403, 420, 431 and others. Allowable torsional shear stress, not exceeding 25% of yield strength of the material used, shall be applied for design of valve shaft diameter.

Valve discs shall be designed to be centered.

Rubber seats shall be applied to the body and shall be clamped, mechanically secured, bonded, or vulcanized. Design of removal and replacement of rubber seats will not be required.

Any other type of flow control valve which is equivalent or superior to above may be proposed as an alternative.

9.1.3.3.9 Fire Hydrants

Fire hydrants shall be supplied and installed at the locations shown on Drawings. The exact locations of the fire hydrants shall be identified at site in the presence of the Engineer's Representative and approved by the Engineer.

Fire hydrants shall be wedge gate type in accordance with BS 750:1984. The fire hydrant shall consist of a screwed outlet 60 mm diameter round head.

The fire hydrants shall have a rated working pressure of 16 bars and flanges shall be drilled according to BS 4504 PN16. All the fire hydrants shall be supplied complete with pipes and specials required to connect the tee and the fire hydrants, manhole covers and frames etc. as per details given in the standard drawing, as specified under relevant item.

9.1.3.3.10 Manhole Cover and Frames

Manhole covers and frames shall be of ductile iron conform to EN 124-1994 Class D400 or to the approval of the Engineer. They shall be with circular opening of 600 mm, with captive hinge arrangement to deter vandals and with suitable water tight arrangement to prevent ingress of surface water into the manhole.

Fire hydrants – to comply with requirements of fire authority.
Air valves – ventilated type
Sluice valves – water tight
Washouts – ventilated type

The man hole covers shall have letter or words in English to indicate the function of the fitting, "FH, WO, SV, METER" and also the marking "NWSDB – WATER - 2000" in suitable size, cast in raised letters.

9.1.3.3.11 Surface Boxes

Surface boxes shall be of ductile iron, confirm to BS 5834:1983 Grade A or to the Engineer's
approval, with the following minimum clear opening of 120mm, unless otherwise specified.

They shall be with captive hinge arrangement to deter vandals and with suitable water tight arrangement to prevent ingress of surface water into the keyhole.

Surface boxes shall be painted before installation with two coats of bituminous paint.

The lids or covers of surface boxes shall have letters or words in English to indicate the function of the fitting "FH, WO, SV, METER" and also the marking "NWSDB – WATER - 2000" in suitable size, cast in raised letters.

9.1.3.3.12 Water Meters (in Distribution System)

(1) General

District meters and waste meters for the distribution system will be installed by the NWSDB.
Under this Contract provision shall be made with necessary fittings for the installation of meters at locations shown in the drawings.

9.1.3.3.13 Water meters (for House Connections)

The water meters shall be of nominal size 15 mm and 20 mm, with nominal capacity $2m^3/hr$ and $5m^3/hr$ respectively.

The meters shall conform to BS 5728 or ISO 4064/1, class D. It shall be rotary vane type and of dry dial construction.

The features shall be as follows ;

Meter Size / Feature	15mm	20mm
Continuos flow rate m^3/hr (±2%)	1.0	2.5
Maximum flow rate m^3/hr (±2%)	2.0	5.0
Minimum flow rate m^3/hr (±5%)	7.5	18.75
Maximum permissible working pressure (Bars)	10	10
Water temperature (Deg C)	0 -50	0 -50

The meter shall be calibrated to read in cubic meters.

The meters shall include all the necessary washers, nuts, connecting pieces as recommended by the manufacturer.

9.1.3.3.14 Materials for House Connections

The Contractor shall furnish all the specifications and relevant particulars for the materials for house connection he intend to supply, together with samples of the items to the Engineer for his approval, prior to placing the order.

(1) Brass Swivel Ferrules

Ferrules shall be standard screw down pattern brass ferrule with female BSP screwed single outlet for PVC pipes to BS 21 parallel thread. It shall have a main stem with 360° swivel outlet at 90° with control of water flow via a threaded inner plug. The inlet shall be male, with taper thread to BS 21 or ISO 7/1.

The ferrule shall be designed for underground installation, and to handle potable water with temperature upto 35° C, and also to withstand a working pressure of 15 - 20 bars.

The design of ferrule shall permit the installation of service pipe via conventional drilling and tapping machine, under pressure or dry, and with or without service saddles, into DI, or PVC pipes of different diameters.

The material of the stem, banjo, inner plug and top cap shall be Brass, conforming to BS 2872 - CS 122 or ISO RS 426.

The material of Banjo washers and top cap washer shall be Polypropylene or Nitrile rubber, and shall provide the sealing between the outer body and ferrule stem. The ingress of dirt shall be prevented by a Polypropylene top plug.

(2) Bib Taps, Stop Cocks and Gate Valves

Manufacturing standards shall be as follows;

(a)	Bib Taps	BS 1010 part 1972 or SLS 596 1982 Male Inlet BSP
(b)	Stop Cocks	BS 5433 : 1976 Medium Pattern Female End
(c)	Gate Valves	BS 5154 Medium Pattern Female End

The materials standards shall be

(i)	Hot forged brass	BS 2872
(ii)	Gunmetal	BS 1400-LG 2
(iii)	Spindles, Glands, Nuts & Washers	BS 2874
(iv)	Rubber Washers	BS 5454

All fittings shall be "water works" standard and shall be of a well proven robust design and manufacture and obtained from a reputed manufacturer.

The castings shall be close grained, sound, smooth and symmetrical and shall be carefully cleaned and dressed.

All castings shall be free of blow holes and other defects. No plugging will be permitted in the case of blow holes and other defects.

The spindles run shall be smooth and there should not be a noticeable play.

9.1.3.3.15 Under-Pressure Drilling & Tapping Machines (for Cast iron, Steel, Ductile iron)

The tapping machine shall be capable of drilling and tapping the Cast Iron, Steel and Ductile Iron pipes of different diameters upto at least 600mm and inserting ferrules directly into the wall of the pipe while the pipes are under pressure, without interrupting the water supply. It shall also be capable of tapping the pipe under dry conditions.

Tapping machines shall be of two sizes, based on the size of the tapping.

Size	Size of the Tapings
1	1/2" (12mm), 3/4" (20mm), 1" (25mm)
2	1 1/4" (30mm), 1 1/2" (40mm), 2" (50mm)

The feed screw, bridge, side links, drill spindle, ferrule spindle, drill taps, spanners, fixing chain, ferrule spindle adapters, drifts and ferrule keys shall be of high quality steel in conformity to BS 970 Part 1:1983 (ISO 683/1) or equivalent.

"O" rings for drill spindle, ferrule spindle and piston shall be of Nitrile Rubber in conformity to BS 2494 Type W and that for spindle buffers shall be of Nitrile or EPDM rubber in conformity to BS 2494 Type W.

The machine body shall be of Malleable Cast Iron in accordance with BS 6681: 1986 or Ductile Iron in accordance with BS 2789 grade 420/12 or equivalent or superior.

Bearings shall be of Stainless Steel in accordance with ASNI 420.
Rotating Table shall be of wear resistant Cast Iron in accordance with BS 1542 : 1977 (ISO/R 185).

The fixing shall be capable of withstanding a minimum load of 4000kg.
Each machine and its accessories shall be supplied in a robust lock up case.

Each machine shall be supplied with a set of spare parts recommended by the manufacturer for a minimum of 5 year normal operation.

In addition to that Contractor shall supply following cutter and spindles Tungsten drill bits.

12mm (1/2") cutters and spindles (Tungsten drill bits)	16 Nos.
20mm (3/4") cutters and spindles (Tungsten drill bits)	16 Nos.
25mm (1") cutters and spindles (Tungsten drill bits)	16 Nos.
50mm (2") cutters and spindles (Tungsten drill bits)	16 Nos.

9.1.3.3.16 Under Pressure Drilling Machine (for Asbestos and PVC)

The drilling machine shall be capable of drilling PVC pipes and Asbestos cement pipes of different diameters, and connecting ferrules to the water main through a saddle strap. (Clamp saddle) The machine shall be capable of doing this operation while the pipe is under pressure as well as under dry conditions. Saddle strap will be used with conventional swivel ferrules/service valves for service connections, and this combination shall be well suited with the equipment supplied.

The drilling machine shall be of two sizes, based on the size of the tapping;

Size	Size of the Tapping
1	1/2" (12mm), 3/4" (20mm), 1" (25mm)
2	1 1/4" (30mm), 1 1/2" (40mm), 2" (50mm)

The machine shall be capable of quickly adaptation for either PVC or AC pipes, and for different types of drilling, by inserting the appropriate size and type of cutter/integral spindle and correct ferrule adapters.

The "T" bar assembly, head works, inner sleeve, inner sleeve retaining screws, square plug adopter, spindles, ferrule adopter, ferrule keys shall be of high quality steel in accordance with BS 970 Part I : 1993 (ISO 683/1) or equivalent.

"O" Ring seals for spindle, inner sleeve and gate valve, shall be of Nitrile Rubber in accordance with BS 2494 Type W.

The gate valve shall be of gun metal in accordance with BS 5154 or bronze to BS 1400 LG2 DIN 1705.

Each machine and its accessories shall be supplied in a robust lock up case.

Each machine shall be supplied with a set of spare parts recommended by the manufacturer for a minimum of 5 years normal operation.

In addition to that Contractor shall supply following cutter and spindles Tungsten drill bits.

12mm (1/2") cutters and spindles (Tungsten drill bits)	16 Nos.
20mm (3/4") cutters and spindles (Tungsten drill bits)	16 Nos.
25mm (1") cutters and spindles (Tungsten drill bits)	16 Nos.
50mm (2") cutters and spindles (Tungsten drill bits)	16 Nos.