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KWSSIP

Request for Bids

Single Stage:
Two Envelope Bidding Procedure

K-IV AUGMENTATION WORKS

COMMON CORRIDOR WITH KBRT-2.7KM FROM NIPA TO HASAN SQUARE
TRANSMISSION MAIN AND APPURTENANCES FOR 96" & 72" DIA PIPELINE

Volume-II
Specifications

With Bank's Disqualification mechanism for non-compliance with SEA/SH obligations

December 2024

TECHNICAL SPECIFICATIONS

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1 INTRODUCTION

Karachi, a megacity, is Pakistan's premier Industrial and Financial centre and the economic capital of Pakistan. The city with its two seaports is responsible to handle 95% of Pakistan's foreign trade. Karachi is one of the ten largest cities in the world and its population is continuously increasing with a large number of citizens settling in informal settlements (Katchi Abadis). In addition, Karachi is also expanding horizontally and vertically, dovetailed with mushroom growth of commercial interventions.

Karachi, like all megacities, has grown so quickly that it struggles to deliver basic infrastructure services, including potable water. There is a huge unmet demand for water (550 MGD current capacity versus an estimated demand of 1200 MGD); and a high non-revenue water percentage (50-60 percent); Most of KWSB's 1.1 million customers get water through the piped network on an irregular basis, and some just 2-4 hours every other day.

1.1 Project Location and Access

The Site of the Works is the area for construction lying within the right-of-way lines, boundaries and limits shown on the drawings and such additional areas adjacent thereto as may be designated by the Engineer from time to time for the construction to be performed under the Contract Documents. All such areas and additional areas shall be comprised in the Site as defined in Sub-Clause 1.01 of the General Conditions of Contract. The Contractor shall not use the site for any purpose not required by the contract.

Within the areas, which may from time to time be defined as the Site, the Contractor shall carry out and perform the construction of the Works, and subject to the approval of the Engineer, will be permitted to construct temporary road ways, camps, buildings and Temporary Works which he may require for the construction of the Works. If the Contractor wishes to use any land other than as aforesaid for construction of camps or for any other Contract purposes, the Contractor shall make all necessary arrangements with the owner thereof and shall bear all rentals or other costs connected therewith.

The Employer will give to the Contractor possession of as much of the area designated and defined as the Site and shown on the Drawings, as may be required to implement the Works, starting from the Commencement Date.

The Contractor shall where necessary provide access to and through the site to adjacent properties as well as to other agencies/Contractors who might be executing any development work for any other agencies and coordinate his work with these agencies / Contractors.

Before the commencement of any part of the Works, the Contractor shall make temporary access tracks including temporary diversions, approach roads, temporary Roads for movement of vehicles, transporting Pipe lines and other Construction material during execution of the work with approval of the Engineer. The Contractor shall maintain such access tracks in a condition suitable for the safe and easy passage of plant, vehicles and pedestrians required for the purpose of the Contract.

1.2 Climate

The Contractor shall take account of the climatic conditions at the Site of the Works. The following information is provided as a guide to the climatic conditions likely to be encountered on the site to assist the Contractor, but this shall not relieve him of his responsibility under the Contract:

1 Monthly average temperatures:

(a) Maximum 35-degree C

(b) Minimum 19-degree C

2 Extreme Temperatures

(c) 41-degree C in June.

(d) 10-degree C in January.

3 Annual Average Rainfall

192 mm per year, the majority falling in the monsoon months of July and August. On average, there are 10 rainy days per year. Storm intensities can be high with storm totals reaching 200mm, with normal durations of 1 to 2 days.

4 Monthly Average Relative Humidity

(a) Maximum = 90%

(b) Minimum = 40%

The climatic data given above is based on limited records and their accuracy cannot therefore be guaranteed.

1.3 Scope of Works

KWSB currently has an approved quota to withdraw 650 million gallons per day (MGD) from the Indus River, but is effectively only using around 515 MDG of this allocation. This water is supplied to Karachi from Keenjhar Lake, a freshwater lake which supplies water to Karachi, through a network of open channels, conduits, pumping stations and pressurized transmission pipelines.

In order to over the water shortage, competent authorities have planned to provide additional 650 MGD water to Karachi from Keenjhar Lake. As a first phase of this project 260 MGD water is to be supplied to Karachi. This project commonly known as K-IV main project has been designed by M/s Techno Consult International and is to be executed under the supervision of WAPDA. K-IV is to bring water to three reservoirs at the outskirts of Karachi. These reservoirs (water treatment plants) are numbered as R-1 (Pipri for 65 MGD), R-2 (Hub Road for 130 MGD) and R-3 (Taiser Town for 65 MGD). Our scope of work involves the interconnection of these water treatment plants to the existing water network, significantly improve water supply by up to 260MGD, in water deficient areas of Karachi. This project is known as K-IV Augmentation Works project, which aims to improve water transmission to Karachi, has been divided into four main packages. Due to the Karachi Bus Rapid Transit (KBRT) project along University Road, a specific 2.7-kilometer segment of the pipeline, extending from Nipa to Hassan Square, has been extracted from the overall project for separate execution. The scope of work for this segment involves the installation of a gravity main water transmission pipeline with 96” & 72” inch diameter pipes, laid and jointed along the designated route, to transmit 130 MGD of water from Reservoir II to FUU. This adjustment ensures the integration of the water infrastructure with ongoing urban development projects.

1.4 Extent of Contract

The works specified under this contract shall include all general works preparatory to the construction of the works and materials and work of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the intent and meaning of the Drawings and this specifications and further Drawings and instructions that may be issued by the Engineer from time to time whether specifically mentioned or not in the clauses of this specifications.

1.5 Precedence of Contract Documents

Should the provisions of any clauses of any or all of the Contract Documents be shown to be mutually at variance or exclusive, the following order of precedence shall be applied in order to establish which of the said provisions, mutually at variance or exclusive, shall be deemed to be the true and correct intent of the Contract entered into by Employer, and the Contractor shall forthwith be absolved from any liability under the provisions not so proved to be the true and correct intent of the Contract, provided that in the execution of the Contract the Contractor has, or shall have complied with such true and correct intent.

i. Provisions of the Special Conditions of Contract shall take precedence over those of the General Conditions of Contract.

ii. Provisions of the Special Specifications shall take precedence over the Standard specifications unless otherwise indicated.

iii. Details shown or noted on the Contract drawings shall take precedence over the requirements of both the Standard and the Special Specifications.

iv. Detail Drawings shall take precedence over General Drawings.

v. Within the Standard Specifications, the provisions of any section particular to the provisions at variance shall take precedence over the General Section, and within any section, clauses particular to the provisions at variance shall take precedence over those not so particular. The foregoing Order of Precedence shall apply also to sections and clauses of the Special Specifications.

vi. Where there is conflict in units of measurement quoted in Standard Specifications and units quoted in Bills of Quantities the units in the latter will apply.

Notwithstanding any fore-written provisions, should the application of the foregoing order of precedence fail to resolve any variance or mutual exclusions as to the true and correct intent of the Contract to the satisfaction of the Engineer, the Engineer may exercise the right to arbitrarily give a ruling as to the true and correct intention of the Contract, and the Contractor shall have the right to claim additional payment for any additional expense incurred by him as a consequence of such variance or exclusion and arbitrary ruling.

1.6 Standards

In the Specifications, Bills of Quantities and Drawings, reference has been made to relevant British Standard Specifications and Codes of Practice - with which the materials and workmanship should comply. However, the materials and workmanship complying with equivalent International Standards Organization (I.S.O.) Standards for that particular material or workmanship will also be acceptable.

Mixture of different Standards in one trade will not be allowed. For instance, if pipes are to be provided to I.S.O Standard, then all the pipes in the works are to be to I.S.O. Standard.

Where the dimension in one standard does not completely correspond to the dimension of the other standard which is being used for construction of works, the ruling of the Engineer will be sought and any decision given by the Engineer will be final and binding upon the Contractor.

1.7 Quality of Materials and Workmanship

Materials and workmanship shall be of the best of their respective kinds and shall be to the approval of the Engineer. In reading of these Specifications, the words "to the approval of the Engineer" shall be deemed to be included in the description of all materials incorporated in the Works, whether manufactured or natural, and in the description of all operations for the due execution of the Works.

No materials of any description shall be used without prior approval by the Engineer and any material condemned as unfit for use in the works shall be removed immediately from the site by, and without recompense to the contractor. All works or parts thereof shall be in accordance with the latest edition of British Standard Specifications (BSS) and British Codes of Practice (CP) as published by British Standards Institution.

All materials shall be of approved manufacture and origin and the best quality of their respective kind, equal to sample and delivered on to the Site a sufficient period before they are required to be used in the Works to enable the Engineer to take such samples as he may require for testing or approval, and the Contractor shall furnish any information required by the Engineer as to the quality, weight, strength, description, etc. of the materials. No materials of any description shall be used without prior approval by the Engineer and any material condemned as unfit for use in the Works shall be removed immediately from the Site by, and without recompense to, the Contractor.

1.8 Trade Names

Trade Names and Catalogue References are given solely as the guide to the quality and alternative manufacturers of the materials or goods of equivalent quality will be accepted at the discretion of the Project Manager.

2 MOBILIZATION & PROCEDURES

2.1 Samples

Samples of all materials shall be deposited with the Engineer and approved prior to ordering or delivery to site. The Engineer reserves his right to test any sample to destruction and retain samples until the end of the maintenance period. No payment will be made for samples and the Contractor must allow for costs of samples in the rates of prices. All materials delivered to site shall be equal or better in all respects than the samples delivered to the Engineer.

All sampling of materials on the site must be done by or in the presence of the Engineer. All other samples will be deemed not to be valid under the Contract.

All material delivered to the site or intended for the works not equal or better than the samples approved by the Engineer shall be removed and replaced at the Contractor's expense.

2.2 Testing

As provided in Clause 36 of the Conditions of Contract and in accordance with the specification quoted for any material used on works of this contract, tests may be called by the Engineer to be carried out at the place of manufacture or on the site. The contractor may assume that the tests will be required on soils, workmanship, and materials whether natural or manufactured to verify their compliance with the specifications. Samples of all such materials and manufactured articles together with all necessary labour, materials, plant and apparatus for sampling and for carrying out of the tests shall be supplied by the Contractor at his own expense.

A Provisional Sum item has been included in Bills of quantities for testing of materials and workmanship as directed by the Engineer at an independent Laboratory.

The contractor will be reimbursed receipted costs of testing carried out by the laboratory as the work progresses.

2.3 Programme for the Execution of Works

i. In accordance with Clause 14 of the Conditions of Contract, the Contractor upon receiving Engineer’s order to commence shall within 14 days draw up a working programme setting out order in which the works are to be carried out with appropriate dates thereof together with delivery dates for materials. The Contractor shall together with his work programme supply an expenditure chart showing monthly anticipated expenditure.

ii. The programme shall be deemed to have taken into account normal variations in climatic conditions to provide for completion of the works in the order and within the times specified therein.

iii. The order in which it is proposed to execute the permanent works shall be subject to adjustment and approval by the Engineer, and Contractor's price shall be held to include for any reasonable and necessary adjustment required by the Engineer during the course of the works.

iv. The Contractor shall carry out the Contract in accordance with the programme agreed with the Engineer, but he shall in no manner be relieved by the Engineer's approval of the programme of his obligations to complete the Works in the prescribed order and by the prescribed completion date and he shall from time to time review his progress and make such amendments to his rate or executions of the works as may be necessary to fulfil these obligations.

v. Once the proposed programme is approved by the Engineer, the contractor shall not depart from the programme without the written consent of Engineer. In the event of unforeseen difficulties or disturbances arising, which forces the Contractor to depart from the approved programme of Works, he shall advise the Engineer in writing of such occurrences without delay and submit proposals for any necessary remedial measures, for which he shall obtain the Engineer's approval before putting such measures into effect.

vi. The contractor shall furnish the Engineer with a monthly statement of all works done on the contract and of all materials on site.

2.4 Substantial (Practical) Completion

Substantial or Practical Completion of Works is to be understood as a state of completion, which leaves out only minor outstanding items that can be readily completed within a period of less than 1 month without interfering with the normal operation of the Works.

The works will not be considered as substantially or practically completed without the works being capable of being used by the Employer in accordance with the purpose of the works. This means amongst other things, that all final tests to the works have been carried out, the electromechanical equipment and treatment processes are fully operational to the required capacity, operation manuals provided and clearance of the site upon completion of the works has been carried out, all to the satisfaction of the Engineer.

The Contractor shall allow for a period of one month for the completion by others of as-built drawings before the works are handed over to the Employer.

2.5 Nominated Sub-Contractors and Nominated Suppliers

The Contractor shall be responsible for the Nominated Sub-Contractor(s) in every respect. In particular, it shall be the Contractor's responsibility to ensure that each Sub-Contractor commences and completes the work in a manner so as to conform to the working programme, as specified above.

It is also the responsibility of the Contractor to ensure a satisfactory progress of the works and to ensure that the works are completed to a standard satisfactory to the Engineer.

The Contractor shall accept liability for and bear the cost of General and Specific Attendance on the Nominated Sub-Contractor(s) which shall be deemed to include for:-

i. Allowing the use of standing scaffolding, providing special scaffolding, maintenance and alteration of all scaffolding, retention of all scaffolding until such time as all relevant Sub-Contractor's works are complete and removal of all scaffolding on completion.

ii. Providing equipment and labour for unloading and hoisting sub-Contractor's materials.

iii. Providing space for office accommodation, and for storage of plant and materials; allowing use of sanitary accommodation; the supply of all necessary water, power, lighting and watching and clearing away all rubbish.

Cutting away for and making good after the work of Sub-Contractors as may be required will be measured and valued separately in the Bills of Quantities.

Before placing any orders with nominated Sub-Contractor(s) or nominated Supplier(s), the Contractor should enter into an agreement with the nominated Sub-Contractor(s)/nominated Supplier(s) to ensure that the conditions and delivery of materials to site comply with the Conditions of Contract and the working programme.

A particular clause should be inserted in the agreement with the nominated Supplier(s) ensuring the validity of the rates for the supply of materials as per the delivery schedule.

Nominated Supplier(s) who are unable to meet the delivery schedule will not be given allowance for any increases in prices incurred after the delivery time agreed in the delivery schedule.

2.6 Entry upon Land, Working Site and Adjoining Lands

The Employer shall provide land, right of ways and way leaves for the Works specified in the Contract.

If nothing else is mentioned, the Contractor will be allotted for execution of the works only the actual area as necessary for the extent of the construction.

The Contractor shall give notice to the Engineer at least 30 days before he wishes to enter onto the land required to carry out the Contract.

The Contractor shall not enter onto any land or commence any operations until such time as he receives formal confirmation from the Engineer that all necessary compensation formalities have been completed and that permission has been obtained from the landowner to enter the land and commence operations. Should the Contractor enter onto any land or commence operations without first obtaining this confirmation, he shall be liable in whole or in part, at the sole discretion of the Engineer, for all additional costs and/or legal charges which might arise therefore.

The Contractor shall on his own accord obtain rights of admission, and Rights of using all other areas which are necessary for storing and manufacturing or for setting up site offices and Resident Engineer's office or whatsoever will be necessary.

No separate payment will be made to the Contractor on account of these items and the Contractor must make due allowance for them in his rates.

The Contractor shall take care to prevent injury, damage and trespass on lands, fences and other properties near and adjacent to the Works and must in this connection make all necessary arrangements with adjoining landowners, or into the case of Government Property with officers appointed for this purpose, and ensure the Workmen's observance of all Government rules and Ordinances regarding game protection and other matters and provide, maintain and clear away on completion of the Works, all temporary fencing which may be required for execution of the Works.

Before completion of the Works, the Contractor must make good or compensate any such injury, damage or trespass on Lands, fences and other properties which have no otherwise been provided for in the Contract.

2.7 Preservation of Survey Beacons

Ordinance Survey Beacons, Bench marks, etc., or around the site of the Works shall not be disturbed unless permission has been obtained by the Project Manager from the Survey of Pakistan.

In the event of unauthorised disturbance of such beacons, bench marks, etc., in the course of the Works being carried out, the Contractor shall be responsible for reporting the same to the Engineer and The Survey and Mapping Department, and for payment of any fees due to said Survey and Mapping Department for replacement of such disturbed beacons, bench marks, etc. The contractor shall not replace such disturbed beacons bench marks, etc. on his own accord.

2.8 Land for Camp sites

The Employer shall make available free of charge to the Contractor all land on under or through which the works other than Temporary Works are to be executed or carried out all as indicated onto the Drawings or as detailed in the Specifications. Such land shall exclude land for Resident Engineer's offices and the land required by the Contractor for his own camps, offices, houses, temporary works or any other purpose.

2.9 Existing Services

Drains, pipes, cables and similar services encountered in the course of the Works shall be guarded from damage by the Contractor at his own costs to safeguard a continued uninterrupted use to the satisfaction of the owners thereof, and the Contractor shall not store materials or otherwise occupy any part of the site in a manner likely to hinder the operation of such services.

The Contractor shall on the Engineer's direction arrange for the construction of permanent or temporary diversions of the said drains etc., together with their reinstatement in liaison with the respective Departments, Bodies, Corporations or Authorities. The cost of such works or diversions including reinstatement shall be charged against the appropriate provisional Sum provided into the Bills of Quantities. The Contractor shall be at liberty, subject to the approval of the works, to bear the cost of reinstatement of additional diversions. No services may be tampered with by the Contractor, and all works in connection with any kind

of services shall be carried out by their respective owners. It is the responsibility of the contractor to inform the Engineer immediately any existing service is exposed.

2.10 Damage to Services

The Contractor shall be held liable for all damage and interference to mains and pipes, to electric cables or lines of any kind either above or below ground caused by him or his sub-Contractors in execution of the Works, whether such services are located on the Contract Drawings or not. The Contractor must make good or report to the appropriate authorities the same without delay and do any further work considered by the Engineer or owner. The contractor shall provide for these contingencies it the rates inserted in the Bills of Quantities.

If the Contractor fails to reinstate the damaged services within the time considered as reasonable by the Engineer's Representative, then the Engineer's Representative shall be empowered to get the damaged services reinstated by any other contractor and charges there-of shall be deducted from any money due to the Contractor.

2.11 Temporary Roads and Traffic Control

The Contractor shall provide and maintain all temporary roads, bridges and other work required for the construction of the Works including access to quarries, borrow-pits, accommodation etc.

The Contractor shall provide and in his rates allow for all necessary temporary traffic control signs, barricades, beacons, fragment, lighting and watching required for the normal control of traffic.

2.12 Road Closure

Where a road used by the Contractor for delivery of any material used in the works is closed under the Traffic Ordinance Act of Pakistan or amendments thereto, the Contractor shall obey such closure order and use alternative roads.

2.13 Road Crossing and Traffic Control

Wherever the pipelines cross classified roads, the Contractor will contact the relevant authorities in advance and obtain necessary permission to dig across the road in accordance with requirement of the authorities concerned and shall pay any royalties connected with this work, and the Contractor will provide temporary detour road together with any warning signs necessary. There will be no separate payment for this and cost of all expenses connected with road for which no separate items have been included in the Bills of Quantities.

2.14 Protection from Water

Unless otherwise mentioned, the Contractor shall keep the whole of the Works free from water and allow in his rates for all dams, coffer dams, pumping, piling, shoring, temporary drains, slumps, etc., necessary for this purpose and shall make good at his own costs all damage caused thereby.

2.15 Weather Conditions

The Contractor shall be deemed to take into account all possible weather conditions when preparing his tender and he shall not be entitled for extra payment by the reason of the occurrence or effect of high winds, excessive rainfall, temperature or any other meteorological phenomena.

2.16 Protection from Weather

All materials shall be stored on site in a manner approved by the Engineers Representative and the Contractor shall carefully protect from the weather all works and materials which may be affected thereby.

No separate payment will be made for this and Contractor will allow in his rates for this.

2.17 Liaison with Police, etc.

The Contractor shall keep himself in close contact with the Police, Labour Officers and other officials in the areas concerned regarding their requirements in the control of workmen, passage through townships, or other matters and shall provide all assistance and/or facilities which may be required by such officials in execution of their duties in connection with the Works.

Any instruction given by the Traffic Police concerning fencing off of open trenches or other excavations must be followed explicitly.

2.18 Provision of Water

The Contractor shall provide water for use in the Works. He shall supply all hydrants, hose, corks, vessels and appliances necessary for the distribution there-of and shall provide pumps, tanks, carts, vessels and appliances, transport and labour when and where-ever it is necessary for water to be carted for use at the Works. All water used in connection with the Works shall if possible be obtained from a public water supply and the Contractor shall make all necessary arrangements and pay all the charges for connections to main and for water used.

2.19 Temporary Lighting and Power

The contractor shall provide all artificial lighting and power for use on the Works, including all sub-contractors and Specialists' requirements and including all temporary connections, wiring, fittings, etc., and clear away on completion. The Contractor shall pay all fees and charges and obtain all permits in connection there-with.

2.20 Sanitation

The Medical Officer of Health or other Sanitary Authority shall be informed when Works are contemplated and when Works are about to commence. The instructions of the Medical Officer or other Sanitary Authority shall be complied with by the Contractor at his own expense.

The site shall be kept in a clean and proper sanitary condition. No nuisance shall be committed on or around the work, and latrines for the workmen and staff shall be provided in accordance with the requirements of the Medical Officer or Sanitary Authorities. The Contractor shall be responsible for the sanitary discipline of his labour.

The Engineer's Representative has the right to order any labourer, who in the opinion of the Engineer's Representative does not have a satisfactory sanitary discipline, off the site with immediate effect.

The Contractor shall make sure that his personnel working on the site are medically fit, and he shall bear the cost of any medical test required to determine that his personnel are free from infectious diseases.

The Contractor shall follow the safety rules set down by the Public Health Act.

2.21 Medical Facilities

Contractor's attention is drawn to the relevant sections of the Public Health Act and the Factory Ordinance Act which it is mandatory that every Contractor employing more than twenty people should appoint (in writing) a safety supervisor. A safety supervisor advices the management on all matters regarding safety, hygiene and welfare of the people affected by the Contractor's undertaking on the site. The safety officer may in addition carry out other duties.

The contractor shall provide adequate first-aid equipment on the site, and ensure that at least two of his site staff is competently trained in first aid.

2.22 Signboards

The Contractor shall erect signboards as shown on the drawings in prominent positions adjacent to the Works to the satisfaction of the Engineer. The location of the signboards shall be specified in the Special Specifications.

2.23 Setting Out and Survey Equipment

The Contractor must before commencing any construction works, make sure that levels shown on the drawings correspond with levels found on the site.

Should any discrepancy be discovered between the levels shown on the drawings and those found on the site, which may affect the levels and dimensions of any part of the Works, the Contractor shall notify the Engineer, who if necessary, will issue drawings showing the amended levels and dimensions.

The Contractor shall allow for in his rates, the cost of the necessary qualified and experienced staff to set out the works and during the continuance of the Contract for the sole use of the Engineer, provide approved new and accurate instruments together with all other requisites, all necessary chairmen and other attendance and transport required for setting out and checking the Works or purposes in connection therewith.

The major requirements are as a minimum but not limited to the following:

No.	Description
1	2 m ranging rods or reflectors
2	Modern Total Station or equivalent
3	Automatic Level and Tripod
4	4 m levelling staff with levelling bubble
5	100 m steel tape
6	50 m steel tape
7	3 m pocket tapes

The contractor shall clear the site and set out the Works well in advance to enable the Engineer to inspect and approve the setting out prior to commencement of the Works. The Contractor shall amend at his own cost any error due to inaccurate setting out.

Any checking or approval by the Engineer of the setting out, bench marks, plans or schedules will not relieve the Contractor of his responsibilities under the Contract.

The Contractor shall provide a site plan showing the position of his site offices, storage sheds, accommodation, Engineer's Representative's office etc., in relation to the permanent works for the approval of the Engineer before commencing erection of his camp.

2.24 Backfilling of Holes and Trenches

The contractor shall immediately upon approval of any work at his own expense and to the satisfaction of the Engineer backfill all holes, trenches and temporary quarries which have been made (except permanent borrow pits), level all mounds or heaps of earth that may have been raised or made and clear away all rubbish caused by the execution of the work. The Contractor shall bear and pay all costs, charges, damages, and expenses of any kind whatsoever which may occur by reason of holes and trenches connected with the Works or materials, tools or plant being left or placed in improper situation.

2.25 Normal Working Hours

The contractor shall inform the Engineer in writing, at the time of submitting the Work Programme, the normal working hours. The contractor shall respect all Public Holidays. Where the Contractor wishes to work outside these hours, he shall request the Engineer in writing at least 24 hours in advance for consideration.

2.26 Insurance

All buildings, furniture and equipment provided by the Contractor for the Engineer's representative shall be insured by the Contractor against loss or damage by accident, fire, theft and other risks ordinarily insured against for the duration of the Contract. The theft shall include personal belongings of the tenants in the Resident Engineer's staff houses.

2.27 Inspection of Works

No part of the Works shall be built in or covered over until it has been inspected and approved by the Engineer and the Contractor must give due notice in writing to the Engineer's Representative when any part of the Works are ready for inspection.

2.28 Method of Measurement

All measurements shall be taken jointly by the Contractor and the Engineer as and when the latter so directs and shall be made in accordance with the Specifications and Preamble to Bills of Quantities notwithstanding local or other customs.

2.29 Site Meetings

Site meetings will normally be held monthly, but will be called for whenever the progress of the works so require or when demanded by the Engineer.

The Contractor shall at all meetings be represented by a responsible representative other than the Site Agent, who has the powers to commit the Contractor in all matters concerning the Contract.

In the event, no responsible representative of the Contractor is present at the meetings; any decision taken by the Engineer at the meeting will be binding upon the Contractor.

3 SITE CLEARANCE AND REQUIREMENTS

3.1 Clearance of Trees, Bushes, Scrub, Huts, etc

The contractor shall unless otherwise directed cut down all trees, remove bushes, plantations, crops and other vegetable growth and grub up all roots, take down all huts, buildings, walls fence and any other obstruction except services mentioned in Clause 2. 3 and handle and transport salvaged usable materials, to a site approved by the Engineer. All salvaged and usable materials are the property of the respective owners. The clearing and demolition here-in described shall be carried out to a width of the minimum excavation plus 1.50 m on either side.

With exception of the salvaged material fore-mentioned, the Contractor shall destroy or otherwise remove the whole of the rubbish from the site to an approved tip or number of tips provided by him.

Trees shall be cut down to as near the ground level as possible and the rates entered in the Bill of Quantities shall include for cutting down, removing branches and foliage, cutting into suitable lengths, grubbing up stumps and roots, stacking up, burning or disposing of as directed.

Before commencing any site clearance, general clearance, clearance of pipelines etc., the Contractor shall inform the Engineer's Representative of his intention. The Engineer's representative will by visiting the section of works concerned, determine the extent of the clearance expressly required.

Payment for clearance will be authorised on the basis of what is expressly required and at the discretion of the Engineer's Representative.

3.2 Damage to Lands, etc.

Except where necessary for the proper execution of the Works, the Contractor shall not interfere with any fence, hedge, trees, land or crop forming the boundary of the site, or elsewhere. In the event of any interference, the Contractor shall make good any damage to such fence, hedges, tree, land or crop to the satisfaction of the Engineer and the owner thereof.

Where the work is to be executed in private land, the Employer will be responsible for negotiating and obtaining rights of way and the serving of all notices as may be required upon the owners and/or occupiers of the land and it shall be the obligation of the Contractor to keep the Employer and the Engineer fully informed concerning the rate of progress and of his intention to enter and begin work within any way leave as provided for under the Condition of Contract and required by this Specification.

3.3 Cleaning Up of Site

Before final acceptance upon the completion of the Works, the Contractor shall, at his own expense, remove and dispose of all rubbish and remove all equipment, surplus materials, camps and buildings, which the Contractor has provided, and temporary works ordered by the Engineer and shall leave the Site absolutely clear thereof and in good order and condition to the entire satisfaction of the Engineer.

3.4 Testing of Water-Retaining Structures

All water-retaining structures shall on completion be tested for water tightness in the following manner. The structure shall be filled with potable water in stages and held at each stage for such time as the Engineer may require. Should any dampness or leakage occur at any stage, the water shall be drained off and the defects made good. The procedure shall be continued and finally the structure shall after a period allowed for absorption remain full for seven days. Within those seven days, the level of the surface of the water should be recorded and measurements made at intervals of 24 hours. The total leak must not exceed 0.3% of the total volume of water in the tested structure.

If the structure does not satisfy the conditions of the test, and the daily drop in water lever is decreasing, the period of test may be extended for a further 7 days, and if the specified limit is then not exceeded, the structure may be considered as satisfactory.

Should any dampness or leakages or other defects occur they shall be made good and the structures re-tested until the water tightness is approved by the Engineer. Faces of submerged structures may not be covered before testing. The Contractor shall allow in his rates for all expenses and shall provide water and all necessary labour and materials for testing the structures.

3.5 Cleaning and Sterilizing Water-Retaining Structures

The interior of all potable water-retaining structures shall be thoroughly cleaned and washed after the water-tightness test has been approved by the Engineer in order to remove all contamination.

The structure shall then be filled to overflow level with clean water containing 50 parts per million of chlorine and left for a period of at least 24 hours. The chlorinated water shall then be drained away and the structures refilled with clean water from which samples shall be taken for bacteriological examination and for tests of residual chlorine. If any of the results of the tests are unsatisfactory when compared with those of the control sample of the supply water, the sterilizing process shall be repeated until the results of the tests are satisfactory.

The costs of the initial sampling, analyses and preparing reports on the bacteriological quality of the water shall be borne by the Employer, but should the initial reports be unsatisfactory, the costs of any subsequent sampling analysis and preparing reports shall be borne by the Contractor.

The Contractor shall allow for - in his rates: providing water, all labour, materials, chemicals and other things necessary for cleaning and sterilizing the water-retaining structures.

3.6 Storage Spaces and Sheds

Suitable temporary stores and workshops shall be erected and later removed on completion of the works. All buildings shall be adequate for protection of the equipment or materials to be kept there-in and shall be constructed and located to the satisfaction of the Engineer.

3.7 Removal of Camps

On the completion of the Contract, the Contractor shall if so requested take down and remove all structures connected with his camp, and shall take up all pipes, drains and culverts, backfill trenches, fill up all latrine pits, soakways and other sewage disposal excavations and shall restore the site as far as practicable to its origin condition and leave it neat and tidy to the satisfaction of the Engineer.

3.8 Clearing the Site on Completion

On completion of the Works, the Contractor shall clear the Site of all plant, building, spoils, dumps, rubbish, etc. and leave the Site to the satisfaction of the Engineer.

Borrow pits and temporary quarries shall be made good and covered with vegetable soil. Dumps for waste material shall be covered with at least 0.5 m of soil of which at least a 0.10 m layer in top shall be vegetable soil.

4 EARTHWORK

4.1 General

Excavation shall be made to such lengths, depths and inclinations as may be necessary for the construction of the works or as stated in the BOQ or as shown on the drawings or as the Engineer may direct.

4.2 Definitions of Materials

The following definitions of materials encountered in excavations shall be used. The opinion of the Engineer shall be final.

4.2.1 Topsoil for Re-use

This shall include any of the “red soils” and shall be taken as being uniformly 250mm thick. This material shall be stored in heaps not exceeding 2m in height and shall be spread over the excavated areas during reinstatement and replanted with plants, trees, bushes etc., at least equal to those existing before the ground was disturbed.

4.2.2 Topsoil for Disposal

This shall include any highly organic clay or silt, any clay having a liquid limit exceeding 80 and / or a plasticity index exceeding 55; any material which is susceptible to spontaneous combustion; or material consisting of such domestic refuse which by virtue of its physical or chemical composition or moisture content will not compact to form a stable fill such as material shall be removed to the Contractor’s tip and reinstatement shall be made with any of the materials defined as topsoil for re-use. The quantity to be provided shall be based a uniform depth of 250mm and the surface shall be restored by planting as already described. Should there be insufficient suitable material on the site for use as reinstatement topsoil the Contractor shall obtain the material from elsewhere and pay all charges in connection therewith and the Contractor shall be reimbursed at the rates show in the Bill of Quantities.

4.2.3 All Other Surfaces

These shall be specified in the Bill of Quantities.

4.2.4 Material for Re-use

This shall comprise any material which is not top-soil, surface material, material for disposal, rock or artificial hard materials.

4.2.5 Material for Disposal

This shall comprise any material from swamps or marshes, silt, organic material, slurry or mud, clay having a liquid limit exceeding 80 and / or a plasticity index exceeding 55, any material which is susceptible to spontaneous combustion, domestic refuse of any kind; such material shall be removed to the Contractor’s tip and shall be replaced with materials specified for re-use. Should there be insufficient suitable material on the site for use as replacement the Contractor shall obtain the material from elsewhere and pay all charges in connection therewith and the Contractor shall be reimbursed at the rates shown in the Bill of Quantities.

4.2.6 Rock

Rock excavation includes all solid rock in place which cannot be removed until loosened by blasting, barring, wedging, and all boulders or detached pieces of solid rock more than 0.25 cubic metres in volume. Solid rock under this class is defined as sound rock of such hardness and texture that it cannot be loosened or broken down by hand-drifting picks.

All materials containing more than 50 per cent by volume of boulders exceeding 0.25 cubic metres in volume shall be classified as rock excavation.

4.3 Classification of Excavation

The Engineer or his Representative and the Contractor or his Representative shall be present during classification of materials. Where the terms "rock excavation" and "common excavation" or "excavation" are used in these specifications, the definitions stated above shall apply.

4.4 Measurement

Payments will be made in accordance with the above classifications, and no additional allowance will be made for materials being wet or dry.

4.5 Stripping of Topsoil

4.5.1 Stripping

Stripping shall consist of removing transporting and disposing of topsoil, stumps, roots, buried logs, debris, humus and similar objectionable matter.

Areas to be stripped are all areas required for permanent constructional works, borrow-pits and embankment fills.

The limits of stripping shall extend 2 metres beyond the limits of excavation or toes of fills.

The depth of stripping shall normally be 0.2 m, but deeper stripping might be needed to remove stumps.

4.5.2 Disposal

Materials from stripping suitable as topsoil shall be spread in approved areas. All other non-combustible materials shall be buried in approved disposal area; covered with a minimum of 0.5 m of excavation spoil. These disposal areas shall be left with neatly graded surfaces and stable slopes that assure drainage. Alternatively, the non-combustible material shall be removed from the area by the Contractor.

4.5.3 Measurement

Stripping is measured as horizontally stripped area in cubic metres.

4.6 Excavation in open-cut

4.6.1 General

All open cut excavation shall be performed in accordance with this section to the lines, grades and dimensions shown on the drawings or as directed by the Engineer. The Engineer reserves his right to at any time during the progress of the work to vary the slopes or dimensions of the excavations from those previously specified.

All necessary precautions shall be taken to preserve the material below and beyond the lines of all excavation in the soundest possible condition. Any damage to the works due to the Contractor's operations, including shattering of the material beyond the required excavation lines, shall be repaired at the expense of and by the Contractor. Any and all excess excavation for the convenience of the Contractor for any purpose or reason, except as may be ordered in writing by the Engineer and whether or not due to the fault of the contractor shall be at the expense of the Contractor. Where required to complete the work, all such excess excavation and over-excavation shall be filled with compacted concrete Grade 10 furnished and placed at the expense of and by the Contractor.

All excavation for structure foundations shall be performed in the dry. If excavations are carried out in roads, footpaths, separators, or within 5 m of buildings, the contractor is requested to execute the work in a way that will minimise damage and disturbances.

In general vertically sided excavations will be required in such places and the necessary timbering or other support must be provided. Undercutting of excavation sides will not be permitted.

The Engineer reserves his right to direct the contractor as to the lengths of trenches or parts of bulk excavations which shall be opened up at any one time.

In the case of excavations in roads, and in other cases which in the opinion of the Engineer are likely to cause interference to the public, the Contractor shall organise his operations in such a way as to reduce to a minimum the interval between opening up and backfilling the excavations.

No permanent work shall commence until the Engineer has inspected and approved the excavation

Arrange shoring, sheeting and bracing so as not to place any strain on portions of completed work until the general construction has proceeded far enough to provide ample strength.

If ENGINEER is of the opinion that at any point the shoring, sheeting or bracing are inadequate or unsuited for the purpose, resubmission of design calculations and working drawings for that point may be ordered, taking into consideration the observed field conditions. If the new calculations show the need for additional shoring, sheeting and bracing, it should be installed immediately.

DEWATERING

The Contractor shall keep all excavations, including those for footings, sub structures and conduits, clear of water at all times during construction. Where structures are constructed in ground with saline groundwater, the contractor shall avoid any concrete being submerged in such saline groundwater, within 3 days of the concrete being placed. The method of keeping excavations clear of water, dewatering, and disposal of water, shall be subject to the approval of the Engineer the Contractor shall ensure that sufficient standby plant is on Site at all times to avoid any interruption in continuity of the dewatering. In the vicinity of the existing structures, dewatering shall be carried out by establishing well points, lowering of the groundwater level to below the required excavation level and maintaining the same in dry condition till concrete is cast and is minimum 3 days old. The well points for dewatering, shall be located at safe distance from the foundation of existing structures to avoid any settlement or other damage to the same. The contractor shall ensure continuous dewatering where required till all the concreting and backfilling operation is completed in all respect as per drawing. Under no circumstances dewatering shall discontinue even for a short period of time during the entire course of work. The contractor shall submit his dewatering plan with details of equipment, for approval of the Engineer minimum 28 days in advance of excavation work.

4.6.2 Mechanical Excavation

A mechanical excavator shall be employed only if the sub-soil is suitable and will allow timbering of trenches or other excavations to be kept sufficiently closed up to ensure that no slips fall or disturbance of the ground takes place or there are no pipes, cables, mains or other services or property which may be disturbed or damaged by its use.

When mechanical excavators are used, a sufficient depth of material shall be left over the bottom of the excavation to ensure that the ground at finished excavation level is not damaged or disturbed in any way. The excavations shall then be completed by hand to the finished levels required.

4.6.3 Rock Excavation

The Contractor shall notify the Engineer on each occasion when he considers that he is entitled to payment of excavation in rock and shall not fill in any excavation concerned, until it has been inspected by the Engineer.

No payment for excavation in rock shall be made unless the Engineer has inspected the excavation and certified in writing the quantities involved.

The Contractor shall trim all rock faces in cuttings according to the dimensions shown on the drawings and upon completion leave them safe from rock falls to the satisfaction of the Engineer.

On any work requiring the use of explosives, the Contractor shall employ men experienced in blasting - and these men must be in possession of a current blasting certificate. The purchase, transport, storage and use of explosives shall be carried out in accordance with the most recent Explosives Ordinance and Rules issued by the Government, and the Contractor shall allow in his rates for excavation and quarrying, for all expenses incurred in meeting these operations shall be carried out with as little interference as possible to traffic or persons and the rates shall include for all flagging, watching, barricades and clearance of debris, and the Contractor shall take all practical precautions for the protection of persons, properties and the Works.

Slopes shattered or loosened by blasting shall be taken down at the expense of and by the Contractor.

The Contractor's blasting and other operations in excavation shall be such that they will yield as much suitable material as possible for the construction.

4.6.4 Foundation for structures

a) **Common material**: The bottom and side slopes of common material upon or against which concrete is to be placed shall be finished accurately to the established lines and grades, and loose materials on surfaces so prepared shall be moistened with water and tamped or rolled with suitable tools and equipment to form a firm foundation for the concrete structure. If, at any point in common material, material is excavated beyond the established excavation lines, for any reason except by written orders from the Engineer, then the over-excavation resulting voids shall be filled with consolidated concrete Grade 10 at the Contractors expense or as per Engineer’s instruction.

b) If the excavation is carried out in advance, a protective layer of 150 mm thickness shall be left above the foundation level until immediately before the Contractor is ready to pour the blinding concrete.

c) **Rock Materials**: The bottom and side slopes of rock material upon or against which concrete is to be placed shall be excavated to the required dimensions as shown on the drawings or established by the Engineer. No material will be permitted to extend within the neat lines of the structure. If, at any point in the rock material, material is excavated beyond the limits required to receive the structure, the additional excavation shall be filled solidly with concrete Grade 10 or as per Engineer’s instruction.

d) All soft or loose material shall be removed by the use of stiff, brooms, picks, hammer or jets and any cavities backfilled with concrete Grade 10, grout or compacted rockfill as directed.

e) **Levels and Dimensions of foundations**: Levels and dimensions of foundations shown on the drawings may be changed by the Engineer to suit actual site conditions.

f) The additional volume shall be measured net and paid according to the rates in the Bills of Quantities.

4.6.5 Trench Excavations for Pipe laying

All surface material including top soil which differs in any nature whatsoever from the sub-strata shall in every case be carefully set aside and stored separately from other excavated material. No extra claim will be allowed for setting aside surface matter or topsoil for later use.

Trench excavation shall be carried out with great care, true to line and gradient and as near as practicable to the size required for construction of the permanent work. Nowhere shall the external dimensions of the excavations be less than the dimensions of the permanent work shown on the Drawings or directed by the Engineer.

If the bottom of the excavation becomes weathered prior to pipe laying, due to fault of the contractor, the weathered soil shall be replaced with suitable compacted material to the original formation level at the contractor's expense. The pipe trench shall be excavated to a depth of 150 mm below the invert level of the pipe and refilled with sand, gravel or other selected materials free from stones and well rammed in order to provide a smooth bed for the pipes.

Where concrete pipes are laid in concrete, the pipe trench shall be excavated to a depth of 150 mm below the invert level or the pipe and the width shall be equal to the breadth of concrete bedding for the pipes plus 150 mm on either side.

Excavation for pipe trenches shall be of sufficient depth to give a minimum cover of 0.9 m over the top of the pipe or as specified in the Drawings. Where pipes/sewers cross under roads, minimum cover shall be 1.2 m or as specified in the Drawings, or such cover as may be directed by the Road Authority.

Where the pipeline is required to be laid at depth, which does not satisfy the minimum cover conditions set out above, the ground surface shall be brought up to the required level by banking the backfill or as directed by the Engineer.

No pipes shall be laid and no excavation filled in or covered with concrete until the formation has been inspected and permission to proceed with the work obtained.

The width of the trench to be excavated will depend on the size and type of pipe being laid as specified on the drawings. Sufficient width must be excavated to allow the pipe to be correctly bedded and aligned, and to allow for the joints to be correctly made. Generally, the grade of the pipe will conform to the grade of the ground, but the excavation must be deepened where necessary to avoid backfills in any section.

Any excavated material stored on site for backfilling or other purposes shall be deposited alongside the excavation at a minimum distance of 0.5 m in such a manner that it will cause no damage and as little inconvenience as possible.

4.6.6 Timbering of Excavations

The Contractor shall supply and fix outside the limits of the permanent Works all the timber necessary for support of sides and bottoms of the excavations, for the security of adjacent structures and properties and for every other purpose for which it may be required, all to the satisfaction of the Engineer. The Contractor shall maintain such supports until in the opinion of the Engineer, the works is sufficiently advanced to permit the withdrawal of the support. Such withdrawal shall be executed only under the personal supervision of a competent foreman.

The Engineer may order excavations to be timbered or to be close timbered or may order timbering to be driven ahead of the excavation, or may order the adoption of any other method of supporting the sides and bottoms of the excavations as may appear to be necessary, and the Contractor shall adopt and shall make no charge for executing the adopted method.

The Contractor shall be responsible for any injury to the work and any consequential damage caused by or arising out of the insufficiency of the support he provides for his excavations or caused by or arising out of the removal of that support, and any advice, permission, approval or instruction given by the Engineer relative to that support or removal thereof shall not relieve the Contractor of his responsibility.

Any instruction given by the Engineer will be directed to the provision of stronger support than that proposed by the Contractor, and will be given only when, in the opinion of the Engineer, the support proposed by the Contractor is insufficient.

Where timber has been used in excavations any such timber left in position shall be at the expense of the contractor except where the Engineer has ordered the timber to be left in place or if any timber should be left in place with the prior approval of the Engineer. The timber approved or ordered to be left in place will be paid for at the rates entered in the Bills of Quantities.

For the purpose of this clause the words "timber" and timbering" shall be construed to include trench sheeting and steel or concrete sheet pilling or any other means adopted by the Contractor for supporting excavations.

4.6.7 Excavation to be kept Free from Water

Where excavations are required below the existing water level, the Contractor shall make arrangements to keep the excavation dry and shall produce drawings and written explanations of the method to be used to enable the Engineer to determine the adequacy of the method, before commencing the excavation.

The Contractor shall give due regard to the possibility of floods and provide all pumps, timbering, coffer dams, sheet piling and other equipment necessary or keeping the excavations free from water.

Every precaution shall be taken not to diminish the bearing capacity of the soil below foundation level. Well points or pump pits are to be outside the foundation area to prevent flows in upward direction.

All slumps and drains are to be filled in or otherwise made good as directed by the Engineer on completion of the relevant part of the Works.

The costs of all the above precautions shall be allowed for in the rates inserted in the Bills of Quantities.

4.6.8 Refilling Excavations

No backfilling or refilling shall commence without the Engineer's approval.

The refilling of excavations shall be commenced as shown as practicable after the permanent works have been tested where so required and inspected and approved by the Engineer. In particular, the back filling of trenches shall be carried out expeditiously to reduce lengths of trenches open at any one time.

Joints must be left open for inspection until the pressure test is completed.

Backfilling shall be executed with selected materials in 150 mm layers (for a 300 mm layers, a mechanical hammer are used) each layer being well rammed and watered to obtain the maximum compaction. Care shall be taken to ensure that no stone or other material, which could damage pipes or other work, is placed within 300 mm of such work.

Water in excess shall not be used in settling of the backfilling.

Backfilling over steel pipes shall be generally as described above, except that the initial protective filling around the pipe is not necessary.

Regardless of the means of backfilling adopted, it is the Contractor's responsibility to ensure that he satisfactorily backfills all excavations and causes no damage to permanent work or adjacent structures, and he shall at his own expense take all steps necessary to comply with this obligation.

The Contractor shall at all times be responsible for damage caused to permanent work through his backfilling operations or throughout he premature opening to traffic of a backfilled surface.

4.6.9 Reinstatement of Surfaces

Generally, all trenches and backfilled excavations shall be reinstated to equal surface as before excavation.

Trenches in any existing road shall be refilled to the level of natural soil below the road with sub-soil in 75 mm layers or as per Engineer’s instruction, each layer being carefully tamped with rammers. The remaining top layer shall be filled to the road surface with materials equal in type, quantity and compaction to materials used for the existing road.

The trench shall then be left to settle for 30 days. At the expiration of this period, the surface shall be made up to level and tamped or rolled to the approval of the Engineer, who will decide on the particular surfacing employed in accordance with the existing surface of the road.

Before expiration of the maintenance period, the Contractor shall make good any defaults in reinstatements.

4.6.10 Removal of surplus excavated material

Excavated material, which is not needed either for backfilling trenches or other excavations or use in embankments or otherwise, shall be removed and disposed of to tipping places obtained by the Contractor. All rubbish and waste material shall similarly be removed by the Contractor. All Surplus excavated material shall be spread and levelled in the tipping places in accordance with such directions as the Engineer may give, and the Contractor's rates for disposal shall include for the costs of such operations.

The contactor shall take every practical precaution against causing any nuisance, damage, injury or inconvenience in the handling, stacking, carting or disposal of excavated materials or any other operation matter or thing in connection therewith.

No excavated material shall be placed in any position here it may be washed away or may be liable to fall or spread into any private property or across a road or footpath, should such occur, the Contractor Shall forthwith remove the same at his own costs.

Should the Engineer direct the Contractor to tip certain surplus excavated materials in a particular place (other than the tipping places obtained by the Contractor) the Contractor shall abide by such instruction and shall make no charge in consequence thereof unless the place specified entails a longer haul than what would be incurred by tipping at the place or places obtained by the Contractor.

4.6.11 Measurement of excavation work

Excavated material will be measure, in cubic metres in excavation to the lines shown on the drawings or described in these specifications and will include only material that is actually removed at the direction of the Engineer.

Where excavation lines are not shown on the drawings, the excavation will be measured to the most practicable lines, grades, and dimensions as directed by the Engineer.

In the case of bulk excavations, the Contractor shall unless otherwise directed by the Engineer prior to the commencement of any excavation prepare grid plans of the various sites showing the existing ground levels at intervals of not more than 10 m. For any particular part of excavation the mean ground level shall be determined from the aforesaid grid plan and the depth shall be calculated from the above mean ground level.

Pipe trenches are measured in linear metres as one item for each pipe size with a minimum width and depth as indicated on the drawings. Extra excavation for deeper trenches will be measured on cubic metres and paid for where ordered by the Engineer.

Rates for excavation shall include for all labour, equipment; preparation of bottoms for receiving concrete or granular soil beds; for forming joint holes where applicable, for preserving surfaces of excavation; for returning excavated material as rammed backfill and for carting away surplus to dump.

Rates for excavation shall also include for working in a manner that causes no interference with the stability of adjacent structures and properties; for the cost of all timber or other support left in place unless ordered or approved to be left in place by the Engineer: for ground stabilization by means of de-watering, chemical processes or other approved method whether affected by floods, storms or otherwise; for the provision and sealing of temporary channels, drains and dumps; for temporarily storing excavated materials required for backfill or other purposes; for temporarily supporting, protecting, diverting, maintaining utility services; for maintaining flows in sewers and water found necessary for the proper execution and safety of the works.

Further, the rates in the Bills of Quantities for excavation in open cut shall include the entire cost of:

a) Transportation of materials from the excavation to points of final use, to disposal areas, to temporary stockpiles, and from temporarily stockpiles to points of final use.

b) Re-handling the excavated materials which have been deposited temporarily in stockpiles.

c) Removal of oversize materials from otherwise suitable materials and disposal of the same.

No extra payment shall be made to the Contractor for working in confined space or if the position of the Works as set out or ordered will not allow the use of mechanical excavators.

50% of the rate for excavation, backfilling and disposal of surplus materials will become due for payment when trenches have been backfilled to a dept of 150 mm over the pipe barrel. Excavation for structure foundations will be authorized for payment of 50 % of the rate, when the excavation has been approved and the surface blinded.

4.6.12 Borrow Pits

No borrow pits will be allowed to be opened on the site unless permission in writing has been obtained from the Engineer.

Before the excavation of an approved borrow area is commenced, the Contractor shall clear the surface and strip the topsoil in accordance with Clauses 3.4.1 and 3.4.2.

Borrow excavations shall be regular in width and shape and shall be properly graded and drained and finished with neatly trimmed slopes, and if so directed soiled and grassed.

The Contractor shall not be entitled to any additional allowance above the unit prices on account of any changes ordered by the Engineer in the amounts of materials to be secured from any borrow area, or on account of the designation by the Engineer of the various portions of the borrow areas from which materials are to be obtained, or on account of the depths of cut which are required to be made.

Measurement for payment of excavation in borrows areas will only include for the quantities of materials utilized for construction of embankments etc. Any costs of excess excavated material, except if directed by the Engineer shall be borne fully by the Contractor.

4.6.13 Hardcore Filling

Hardcore fill shall consist of clean hard broken stone or rubble with measurements not exceeding 150 mm in any one direction with sufficient murram added to fill the interstices. The hardcore shall be well packed, rammed and where possible rolled with a 5 ton roller. Where rolling is impossible, compaction shall be by hand or by mechanical tampers. Before any concrete is laid on hardcore, the hardcore shall be levelled and blinded with fine stone chipping, rolled and watered as necessary. Hardcore filling is measured after compaction.

4.7 Earth Filling

4.7.1 General

Earth not suitable to be used in filling may at any time be rejected by the Engineer. If there is a deficit of soil, the Contractor shall from approved borrow pits supply selected material in the ordered amount.

Before commencement of filling, the topsoil shall be removed, if so ordered by the Engineer. The removal of this layer will be separately priced in the Bills of Quantities. The contractor shall carry out the forming of embankments in accordance with the drawings and shall adhere to the slopes, levels, depths and heights shown thereof.

Before earth filling, the sand or gravel bedding of the pipes, according to the drawings shall be made. Soil filled to 500 mm over the top of pipes shall be free from stones and be filled in by hand with the utmost care to avoid replacement of pipes

4.7.2 Compaction of Fill

The 500 mm fill over the pipe shall be compacted carefully by hand. In other areas, after removal of topsoil as specified, fill material shall be spread in even layers over the full width of the area to be filled. Each layer shall not exceed 300 mm in thickness after compaction or as specified in the BOQ.

The water content of the earth fill material prior to and during compaction shall be distributed uniformly throughout each layer of the material. The allowable ranges of placement water content are based on design considerations. In general, the average placement water content will be required to be maintained at the Proctor Laboratory standard optimum condition. This standard optimum water content is defined as, "That water content which will result in a maximum dry unit weight of the soil when subjected to the standard Proctor Compaction Test".

Proctor compaction tests are to be carried out in accordance with BS 1377 and the Contractor shall provide the Engineer with facilities to carry out such tests, or cover the cost of tests carried out elsewhere.

As far as practicable, the material shall be brought to the proper water content in the borrow pit before excavation. Supplementary water, if required, shall be added to the material by sprinkling on the earth fill and shall be mixed uniformly throughout the layer.

Compaction of fill shall be carried out to 95 per cent standard proctor if not otherwise indicated on the drawings. In case of unsatisfactory compaction test results, the Contractor shall re-compact or remove the fill to the satisfaction of the Engineer.

The number of tests to be made shall be agreed upon by the Engineer and the Contractor at commencement of the work.

The machinery the Contractor intends to use for compaction (pneumatic, vibrating, static or other rollers) must be approved by the Engineer before employment.

The Contractor shall take care that each separate layer is formed with side slopes to ensure that water cannot gather on the surface, thus causing softening of the soil. Compaction shall start from the side of the embankment and continue towards the middle.

On completion of the embankment to formation level and stipulated side slopes, the layer of topsoil mentioned in Clause 4.9 shall be applied.

Earth fill is measured after compaction.

4.8 Grass planting and top soil

Top soil shall be selected vegetable soil, well compacted and except where otherwise specified by of 150 mm thickness.

The Contractor shall trim the faces of the side slopes to open channels and elsewhere where directed to the dimensions, inclinations and curves shown on the Drawings, remove all excess material and make good all depressions with suitable material.

Where instructed by the Engineer, the Contractor shall plant approved grass at the rate of 16 plants per m^2 corresponding to 250 mm c/c. The Engineer shall satisfy himself that natural growth of grass will not take place within a reasonable time before instructing the Contractor to grass specified areas.

The Contractor shall be responsible for obtaining suitable grass plants and for making all necessary arrangements with the owners and/or occupiers of the land from which they are to be obtained. The Contractor shall be responsible for the preparation of the embankment for planting, and for maintaining adequate grass cover and necessary watering during the Contract and Maintenance Period.

Top soiling and grassing are measured in square metres.

4.9 Ant- termite proofing

Where an ant- termite proof course has been specified, it should be made by application of approved concentrate diluted one part concentrate to forty pars water (by weight) at the rate of 5 litres solution to 1 sq. metre to the whole area of the building immediately before (36 hours maximum) the concrete is poured. Additionally to all critical areas, i.e. both sides of wall foundations, piers and porches the application should be 5 litres per running metre. Treatment should not be made when the soil is excessively wet. Precautions should be taken to prevent disturbance of the treated areas before they are covered.

Ant- termite proofing is measured in square metres.

4.10 Gabion protection works

4.10.1 Gabions

Where shown on the Drawings or directed by the Engineer, the Contractor shall excavate for, trim to line and level, provide and erect gabions including providing selected rock, crushed if necessary, packed and compacted inside the gabions.

Gabions shall include gabion mattresses and gabion boxes and for the purpose construction and method measurement and payment no distinction shall be made between them.

Gabions shall be of the hexagonal wire mesh type. The maximum mesh size shall be 100 mm x 120 mm for boxes and 60 mm x 80 mm for mattresses. The wire used for the construction of gabions shall unless otherwise instructed by the Engineer comply with the requirements set out in the table below:

	Diameter (m)	**Galvanising (g/m)**
Mesh		
Box	3.4	275
Mattress	2.7	260
Binder		
Box	2.2	240
Mattress	2.2	240
Selvedge		
Box	3.9	290
Mattress	3.4	275

All wire shall be to B.S 1052 having a tensile strength of not less than 40 kg/mm^2.

Gabions shall be constructed to the shapes and dimensions as show on the drawings given in the Special Specifications or as directed by the Engineer. Galvanising shall comply with the requirements of B.S 443. Gabions, as constructed shall be within a tolerance of ± 3% on the length instructed.

All wire used in the fabrication of gabions and in the wiring operations during construction shall after galvanising, have extruded onto it a coating of polyvinyl chloride compound referred to as PVC. The coating shall be black in colour, not less than 0.4 mm thickness and shall be capable of resisting deleterious effects of exposure.

The alignment of the gabion shall be correct within a tolerance of 100 mm of the instructed alignment and level of any course of gabion shall be correct to within 50 mm of instructed level. In addition adjacent gabions shall not vary by more than 25 mm in line and /or level from each other.

The surface upon which gabions are to be laid shall be compacted to a minimum dry density of 95% MDD (AASHTO T99) and trimmed to the specified kevel or shape.

Joints in gabions shall be stitched together with 600 mm minimum lengths of binder wire, with at least one stitch per 50 mm, and each end of the wire shall be fixed with at least two turns upon itself.

Adjacent gabions shall be touching edges.

Gabion boxes shall be laid with broken bond throughout to avoid continuous joints both horizontally and vertically. Pre-tensioning of gabions shall be subject to the approval of the Engineer.

Gabions shall be hand packed with broken rock of 150 m minimum dimension and 300 mm maximum dimension. The sides shall be packed first in the form of a wall, using the largest pieces, with the majority placed as headers with broken joints to present a neat outside face. The interior of the gabion shall be hand packed with smaller pieces and the top layers shall be finished off with larger pieces. The whole interior and top layers shall be hand packed tight and hammered into place.

Where instructed by the Engineer the Contractor shall place filter fabric (“Terram” or similar approved) behind gabion faces in contact with existing or backfilled ground. The Contractor shall ensure that the filter

fabric is not damaged during the construction or backfilling around the gabion works and any damaged or torn fabric shall be replaced at the contractor's expense. The filter fabric shall be installed in accordance with the manufacturer's instructions and the filter fabric shall not be left exposed to sunlight for than 3 weeks.

At the back face and ends of the completed gabion works or where on the Drawings or instructed by the Engineer the existing soil shall be backfilled, thoroughly compacted against the sides of the gabions and finished flush with the top of the gabion.

On completion of the gabion construction the exposed joints shall be painted with thick bitumen to the approval of the Engineer to discourage vandalism.

5 CONCRETE WORKS

5.1 General

All materials and workmanship for concrete shall comply with BS 8110 and BS 8007 where applicable.

5.2 Materials and Tests

5.2.1 Cement

Cement shall be ordinary Portland cement complying with BS 12. The cement shall be delivered in properly sealed, unbroken bags.

Rapid hardening Portland cement complying with BS 12 may be used with the approval of the Engineer.

Quantities in excess of one ton shall be stored in a water-proof shed with a raised floor. The cement shall be used in the order in which it has been received.

Quantities of less than one tone for early use may be stored on a raised floor and covered by a water-proof tarpaulin.

Any cement damaged by water or proving defective shall be removed from the site immediately.

5.2.2 Aggregates for Concrete

The aggregates shall comply in all respects with the requirements of BS 882.

The aggregates shall be free from dust, decomposed material, clay, earthy matter, foreign substances or friable, or laminated material. The fine aggregate shall be of approved river sand.

Coarse and fine aggregates shall be stored on the sites in separate heaps so that no possibility of any intermixing of the two shall occur. Any materials, which have become intermixed, shall be removed by the Contractor forthwith.

A sample of all aggregates shall be delivered to the site for the approval of the Engineer, and it shall remain on the site until all concrete work is finished.

Should the Engineer so require, the Contractor shall furnish a certificate from an approved testing laboratory in connection with each source of fine and coarse aggregates showing that materials comply with the specifications? All such testing shall be carried out at the Contractor's expense.

5.2.3 Water

All water to be used for concrete, mortar and curing shall be of good drinkable quality, free from humus acid, chemicals, salts or other matters that in any way whatsoever, may be harmful to the concrete, either by diminishing the strength or causing a discolouration of the concrete.

Generally, water from Public mains shall be used, but if this is not possible, the contractor shall obtain water from other sources approved by the Engineer. The contractor may be requested to provide test analysis according to BS 3148 from an approved laboratory.

5.2.4 Admixture

Admixture of any kind of accelerating the setting of cement, plasticizers, water proffers, etc. shall not be used except by written permission of the Engineer. The Contractor must by request supply all details of any admixture.

5.2.5 Concrete Mixes

Concrete shall be "Designed mixes" for reinforced concrete and "Nominal Mixes for Mass Concrete" to BS 8110 and used as shown on the drawings and in the Bills of Quantities. The concrete mixes, maximum aggregate sizes, maximum water/cement ratio and minimum cement content shall be in accordance with the following table.

Concrete Grade	Maximum size of Coarse Aggregate	Minimum Cement Content	Maximum Water/Cement Ratio
10	40 mm	210 kg/m^3	-
15	40 mm	250 kg/m^3	-
20	20 mm	320 kg/m^3	0.5
25	14 mm	390 kg/m^3	0.5

5.2.6 Trial Mixes

The actual concrete mixes shall be determined prior to starting of concrete works according to BS 8110.

For each grade of concrete three separate batches shall be made using the actual aggregates.

The workability of each of the trial batches should be determined and two times three cubes made from each batch for test at 7 days and 28 days.

The average strength of the nine cubes shall exceed the following values:

Concrete grade	Minimum average strength of 9 cubes	
	At 7 days	At 28 days
20	21 N/mm^2	31.5 N/mm^2
25	24.5 N/mm^2	36.5 N/mm^2

For the trial mixes the mix proportions shall be as specified under clause 6.3 of BS 8110

5.2.7 Testing of Concrete

Testing of concrete shall comply with BS 8110. All test cubes shall be manufactured, cured and tested as detailed in BS 1881.

The Contractor shall provide at his own expense all the necessary labour, equipment, moulds, transport, etc., required for manufacture of the test cubes. All test cubes requested by the Engineer shall be tested by Ministry of Works, Materials Branch, and the Contractor shall allow in his rates for concrete for all costs in relation with test cubes.

Should the Contractor require independent tests, he shall make them at his own expense, and the results of such tests shall not be valid unless test cubes are manufactured in the presence of the Engineer and tested by an approved agency and to the requirements in all details of the BS mentioned above.

Sufficient moulds and equipment shall be provided to enable a minimum of six test cubes to be prepared on each day when concrete is being mixed or such other number as the Engineer may direct. The Contractor shall be responsible for delivery of the test cubes to the Ministry of Works and Communication, or other approved testing laboratory.

The precise location of the concrete, which the test cubes represent and the time of Placing, shall be noted on the drawings or elsewhere.

Where the concrete in the work is compacted by mechanical vibration, the test cubes shall be compacted by mechanical vibration, and where the concrete in the work is compacted by hand, the test cubes shall also be compacted by hand as specified in BS 1881.

The Engineer may in the Laboratory make test cubes for any purpose from site materials, and the Contractor shall supply such materials as required free of charge.

The test cubes shall be stored at the site of construction at a place free from vibration under damp sacks for 24 hours after which time they shall be removed from their moulds, marked and buried in damp sand or under water until the time for delivery to the testing laboratory.

The cubes shall then be paced in damp sand or other suitable damp material and sent to the testing laboratory, where they shall be similarly stored until the date of test. Test cubes shall be kept on the Site for as long as practicable but for at least three-fourths of the period before testing, except for tests at ages less than seven days.

5.2.8 Standards for Acceptance of Cube Tests

The result of all cube tests shall be accepted by the Contractor and Engineer as true results of the crushing strength of the cubes. The cube strength shall be calculated from the maximum load sustained by the cube at failure.

The appropriate strength required may be considered to be satisfied if the requirements in BS 5328: Part 4, clause 3.16, is fulfilled.

If the tests fail to give the required strength, further testing of the Concrete shall be carried out. If these tests fail to prove the strength of the concrete used, the Contractor shall at his own expense remove and replace all such concrete as directed by the Engineer.

5.2.9 Slump Tests

Concrete consistency shall be determined by a slump test carried out in accordance with BS 1881 and at the Contractor's expense.

Unless otherwise specified by the Engineer, the following are the slumps for the particular class of work.

	Compaction by vibrator	**Compaction by hand**
Reinforced Concrete	30 to 60 mm	-
Mass Concrete	0 to 30 mm	30 to 80 mm

Concrete having a slump test value exceeding the values here-in specified may be rejected by the Engineer.

5.2.10 Steel Reinforcement

Steel for reinforced concrete shall be stored under cover clear of the ground and shall comply with BS 4449, BS 4461 and BS 4483.

All steel reinforcement shall be supplied by an approved manufacturer, and the Contractor may be required to obtain a manufacturer's test certificate in respect of steel reinforcement supplied. In the absence of such a test certificate, the Contractor may be required to submit samples to be tested at the Contractors expense in such a manner as the Engineer may determine.

5.2.11 Pre-cast Concrete Units

Pre-cast concrete shall be cast in properly made strong moulds true to the shapes required. For work described "Finished fair" the moulds shall be lined with hardboard, sheet metal or other approved material.

The Concrete shall be thoroughly tamped in the moulds and shall not be removed from then until 7 days after placing the concrete, but the sides may be removed after 3 days, provided the moulds are such that the sides are easily removable without damaging the concrete.

The pre-cast work shall be cast under sheds and shall remain under same for 7 days in the moulds and a further 7 days after removal from the moulds. During the whole of this period the concrete shall be shielded by sacking or other approved material kept wet. It shall then be removed from the sheds and stacked in the open for at least 7 days to season.

All pre-cast work shall be cast in lengths convenient for handling unless otherwise described.

Prices are to include for handling reinforcement, hoisting and fixing and bedding in cement mortar, and for finishing exposed surfaces fair where described.

5.3 Workmanship

5.3.1 Inspection of Reinforcement and Formwork

No concreting shall commence until the reinforcement and formwork have been inspected and approved by the Engineer, Reinforcement in walls and columns shall be inspected and approved before being enclosed in the formwork. Before concreting any part of the Work, the Contractor shall give at least 24 hours' notice in writing to the Engineer and obtain his approval.

5.3.2 Mixing of Concrete

Concrete for grade 20 and grade 25 shall be mixed by weight batching only, unless approval has been obtained from the Engineer for the concrete materials to be mixed by volume. Concrete for grade 10 and 15 can be mixed by volume.

The weight of coarse and fine aggregates in each batch shall be so computed that each batch contains one or more full 50 kg bags of cement.

All concrete is to be mechanically mixed in a batch mixer of an approved type. The dry materials for concrete shall be mixed in the mixer until a uniform colour is obtained after which the gauged quantity of water shall be gradually added. After all the water has been added, the mixer shall continue to mix for a period of not less than two minutes.

The mixers shall be equipped with an adjustable device capable of supplying a predetermined amount of water.

On the completion of each mixed batch of concrete, the mixer drum shall be completely emptied before a fresh batch is placed therein. On the cessation of work, the mixer ad all handling plant shall be washed out and shall always be left clean and free from hardened concrete.

Any mix considered to be unsatisfactory by the Engineer for any reason, will be discharged to waste at the Contractor's expense, as and where directed by the Engineer, well clear of all mixed and placing operations in such a manner as to avoid the risk of defective concrete being incorporated in the Works.

The mixer shall be maintained in a first class condition throughout the Contract and any mixer or plant, which is faulty in any respect, shall not be used. The drums of all mixers shall revolve at the speed recommended by the makers. A mixer which has been out of use for more than 20 minutes shall be thoroughly cleaned out before any fresh concrete is mixed.

The Contractor shall always have one spare mixer ready on the site to avoid interruption in the mixing and casting of concrete.

5.3.3 Transportation and placing of concrete

Concrete shall be transported in a manner which will avoid a segregation of the constituent material, and placing in the forms shall be completed before the concrete has taken its initial set. In no case shall concrete be placed in the Works more than 30 minutes after mixing.

Concrete shall not be dropped through a height greater than 1.2 m. Chutes may be used if they are constantly kept free from coatings of hardened concrete or other obstructions. Pumping of concrete through delivery pipes may be used, but only with the prior approval of the Engineer.

Concrete of any unit or section of the work shall be carried out in one continuous operation, and no interruption of the concreting will be allowed without the approval of the Engineer.

The concrete shall be placed in layers as directed by the Engineer over the whole area to be concreted and the second layer shall not be commenced until the first is completed. Sloping beds will not be allowed when placing concrete. Should any accidental segregation occur, the affected area shall be thoroughly turned over by hand until a homogeneous mix has been obtained.

When concreting walls and columns, the mix proportions of the first 250 mm depth of concrete placed in contact with the horizontal joint should be adjusted by reducing the amount of coarse aggregate.

5.3.4 Compaction

After the concrete has been placed in a position it shall be compacted by vibration with a rigid poker type with internal vibrator approved by the Engineer. The Concrete shall be worked well up against the form, joints and around the reinforcement and be free from voids and other imperfections. Under no circumstances shall the concrete be shifted or transported inside the form with vibrator.

The Contractor shall always have one spare vibrator ready on the site to avoid interruption in the mixing, casting and vibrating of concrete.

In the case of reinforced concrete, a competent steel fixer shall be in constant attendance during the placing of concrete to adjust and correct the position of the reinforcement, if so required, immediately before the concrete is placed. In no case shall the vibrators be attached to or be allowed to come into contact with the reinforcement.

Each freshly placed layer of concrete must be thoroughly compacted and worked into the preceding one but care shall be taken that no damage is done to previous work that has already set. Excessive compaction of concrete shall be avoided.

The upper surface of slabs shall be compacted by an approved external vibrator.

5.3.5 Placing of concrete under water

Concrete shall only be placed under water with the prior approval of the Engineer who shall likewise approve the method to be used and the precautions necessary to prevent loss of material. In no circumstances shall concrete be dropped or placed in water in a loose condition or be placed in flowing water. In all cases the cement content shall be increased by 25 per cent for each class of concrete at the Contractor's Expense.

5.3.6 Placing of concrete on earth surfaces

Earth surfaces on which concrete is to be placed shall be clean, firm and free from standing or flowing water. After the excavation has been completed to the approved lines, levels and dimensions it shall be kept as damp as practicable to reduce absorption of water from the concrete to a minimum.

No concrete shall be placed until the prepared earth surface has been approved by the Engineer.

5.3.7 Construction and expansion joints

The position and arrangement of construction and expansion joints shall be as shown on the drawings. Where additional joints are requested, the positions must be approved by the Engineer.

All construction joints shall be rebated to form a key with subsequent work. Concreting of any unit or section of the work shall be carried out in one continuous operation up to construction joints and no interruption of the concreting will be allowed without approval.

Where shown on the drawings construction and expansion joints shall be provided with water bars of P.V.C. or other approved material. The widths and shapes of the water bars shall be as specified on the drawings and all joints shall be used. The trade mark of the water bars shall be approved by the Engineer before commencement of work, and fixing and jointing of water bars shall be approved by the Engineer before commencement of work, and fixing and jointing of water bars shall be approved by the Engineer before casting.

The fusing of water bars shall be performed in a way so as to secure that the two bars are joined over the entire width. The fused joint shall be able to withstand tension and shall be intact after 10 consecutive bendings. The Engineer may request that the fusing is carried out by specialists.

Where shown on the drawings, joints shall be provided with a joint sealing compound. The sealing compound shall be a two component poly-sulphide rubber sealing compound complying with BS 4254, and the trade mark shall be approved by the Engineer. The compound shall be placed in a chase made by a fillet strip in the formwork. The concrete shall be dry and a suitable primer shall be applied to the joint before applying the sealant. The procedure for the workmanship shall be approved by the Engineer before commencement of work, but the Contractor shall have the full responsibility for the water tightness of the joints.

It should be noted that the lower part of the concrete walls shall be cast together with the floor slab and no joint directly on the slab will be permitted.

Before depositing fresh concrete against concrete which has already set, the face of the latter shall be roughened to expose the coarse aggregate, all cement latency removed whilst the concrete is still green and the surface thoroughly wetted with water and cleared of foreign matter. Cement mortar grout mixed in the proportion of one part of cement to two parts of sand shall be spread to a thickness of 5 mm over the face of the set concrete before the fresh concrete is deposited.

5.3.8 Curing and protection of concrete

Curing shall begin as soon as the surface of the concrete has hardened sufficiently. All exposed concrete surfaces shall be cured for a period of seven days by covering them with a layer of sand, Hessian canvas or other approved material kept damp. Concrete shall be protected from sun, wind, heavy rains and flowing water for at least three days after placing.

5.3.9 Finishes of horizontal surfaces

Concrete surfaces for floors shall be true to level and falls as shown on the drawings. Water coming to the surface when vibrating shall be removed.

After casting the surface shall be smoothened with a wooden flat. After some hours, when the surface has dried up, the surface shall be trowelled smooth with a steel trowel. All other horizontal surfaces shall have the same surface finish except for the final trowelling with steel trowel.

5.3.10 Finishes of vertical surfaces

The shuttering for exposed concrete faces shall be so constructed that the latter shall be true to line and surface. The concrete shall be consolidated as specified against the shuttering to keep the face of the work free from honeycombing and other blemishes.

After removal of the shuttering, no concrete surfaces shall be treated in any way until they have been inspected by the Engineer.

If upon removal of the shuttering, the line or surface of the work is, in the opinion of the Engineer, unsightly and not in accordance with the requirements of the Contract, the Contractor shall at his own expense cut out and make good such portions of the work as the Engineer directs.

Rendering over defective surfaces shall not be permitted. Areas of honeycombing shall with the approval of the Engineer be made good immediately upon removal of the shuttering, and isolated superficial air and water holes shall be filled. Care shall be taken not to leave mortar or cement on parts f the surface which have been cast smooth and without pores.

Unless otherwise instructed, the face of exposed concrete placed against shuttering shall after removal of the shuttering be rubbed down with a carborundum stone or in other approved manner to remove fins and other irregularities, and washed perfectly clean.

Concealed concrete faces shall be left as from the shuttering, except that surfaces with honeycombing shall be made good.

5.3.11 Accuracy of Finish

The arrangement of all formwork shall be made in such a way that all dimensions shall comply as exactly as possible with those given on the drawings. The following tolerances shall be respected:

Foundations		50 mm
Position of columns and Walls	_	5 mm
Thickness of walls	_	5 mm
Lateral dimensions of columns	_	5 mm
Level of slabs, beams	_	5 mm
Slab thickness	_	5 mm
Lateral dimension of beams	_	5 mm
Plumb of columns and walls	_	3 mm in each storey (non/accumulative)
Window and door opening sizes	_	5 mm

Surfaces and edges must not show any noticeable warping. On a length of less than 10 m the deviation may be 10 mm at the most.

The Contractor shall be responsible for the cost of all corrective measurers required by the Engineer to rectify work which is not constructed within the tolerance set out above.

5.3.12 Construction of formwork

All formwork shall be substantially and rigidly constructed of timber or steel or pre-cast concrete or other approved material and shall be true to the shape, line, level and dimensions shown on the Drawings.

Timber shall be well seasoned, free from loose knots and or Formwork of exposed concrete faces be planned to thickness. Faces in contact with concrete shall be free from adhering grout, projecting nails, splits, or other defects that will mark the concrete surface. Formwork for foundations and other concealed work may be undressed or rough timber.

All joints shall be sufficiently tight to prevent leakage of cement grout and to avoid the formation of fins or other blemishes, and all faulty joints shall be caulked.

All formwork shall be thoroughly cleaned and coated with an approved type of oil before it is fixed in position. Immediately before concreting the formwork shall be watered thoroughly and washed out to remove saw-dust, shavings or other rubbish. Where the appearance of the concrete face is important, the position and direction of the joints shall be as directed.

Fillet strips shall be fixed in the formwork to form a chamfer 20 mm by 20 mm on all external corners of the concrete.

Openings for inspection of the inside of the formwork for walls, beams and similar work and for the escape of wash water shall be formed in such a way that they can be conveniently closed before starting to place the concrete.

Connections between formwork elements shall be constructed to allow for easy removal of the formwork, and shall be either nailed, screwed, bolted, clamped, braced or otherwise fixed securing a sufficient strength to retain the correct shape and line during compaction of the concrete.

Bracing members placed in the formwork to keep two sides of formwork in exact position shall be approved by the Engineer. Holes in the concrete after bracing arrangement shall be made good by plugging with approved material.

Top formwork shall be provided to concrete faces where the slope exceeds 1 vertical to 2 1/2 horizontal. Such formwork shall be counter-weighed or otherwise anchored against floating.

The formwork shall be so designed that the formwork for soffits of slabs and for sides of beams, columns and walls may be removed first leaving the formwork for the soffits of beams and their supports in position. Wedging or other suitable ways of adjustment shall be provided to allow accurate adjustments of the form-work and to allow a gradual removal of the same without jarring the concrete.

On demand the Contractor shall provide such drawings and calculations as necessary for determination of the structural strength of the form-work. The Engineer's approval of such drawings and calculations will not relieve the Contractor of his responsibilities under the Contract.

Formwork shall be erected true to line and braced and strutted to prevent deformation under the weight and pressure of the wet concrete, construction loads, wind pressure or other forces. Forming for beam soffits shall be erected with an upward camber as shown on the Drawings or as directed by the Engineer or of 2 mm for each 1 m of horizontal span.

Re-propping of beams will not be approved except when props are re-instated to relieve the beams of loads in excess of the design load. Vertical props shall be supported on folding wedges on sole-plates, or other measures shall be taken whereby the props can be gently lowered vertically when commencing to remove the formwork.

If, in the opinion of the Engineer, the formwork is faulty, inadequate or does not comply with the specifications, then the Contractor shall at his own cost modify the formwork until it meets the approval of the Engineer.

5.3.13 Mould Oil

All faces of formwork that will come in contact with wet concrete shall be treated with approved mould oil or other coating to prevent adherence to the concrete. Such coatings shall be insoluble in water, non-staining, nor injurious to the concrete, shall not become flaky and shall not be removable by rain or wash-water. Liquids that retard the setting of cement shall only be applied to the shuttering when approved. Mould oils and similar coatings shall be kept free from contact with the reinforcement.

5.3.14 Holes for Pipes, Cast-in items etc.

5.3.14.1 *General*

The Contractor shall be responsible for the co-ordination with the Sub-contractors for the setting out and fixing of all pipes and holes, pockets and chases for pipes. Sleeves provided by the sub-contractors are to be accurately set out and cast in and cutting away in completed concrete work is to be minimized.

Details of all holes etc. required in a structural work for services must be submitted to the Engineer who will assess the necessity for extra trimming reinforcement.

No openings, holes, chases, etc., are to be formed in the concrete without the approval of the Engineer and details of fixtures or fixings to be cast in must be approved.

5.3.14.2 *Pipes through Water Retaining Walls*

Pipes passing through water retaining walls and floors shall, wherever possible, be built into the structure in-situ. Shuttering shall be formed closely to the outside of the pipe, and concrete shall be placed and compacted thoroughly round the pipe.

Pipes, bolts or other steel items cast into the concrete in water retaining structures must not in any way be in contact with the steel reinforcement.

When not possible to build in place, pipes shall pass through preformed holes. Holes shall be formed with formwork which shall be stripped cleanly and without shock to the concrete. As soon as the shuttering is stripped, the hole shall be thoroughly wire brushed to expose the aggregate. The hole shall be as neat as possible to allow the pipe to be passed through the wall, while the corners shall be chamfered or rounded.

The pipe shall be set and the hole filled up as soon as possible. Immediately before filling, the hole shall be continuously soaked so as to saturate the concrete, and the surface coated with a stiff mix of 1:1 sand grout. Shutters shall be fixed true to the faces of the wall, and a stiff mix of concrete packed in until the hold is completely filled, particular care to be taken to ensure that the spaces beneath the invert of the pipe and beneath the slopping soffit of the hole are completely filled. Shuttering shall be stripped as soon as possible and the filling rubbed smooth. The filling and the surrounding concrete shall be kept wet for 7 days after filling.

5.3.15 Removal of Formwork

Formwork shall be left in position until the concrete has attained sufficient strength to be self-supporting. The Contractor shall be responsible for the safe removal of the formwork without shock or vibration - which would damage the concrete.

Any work showing sign of damage through premature removal of formwork or through premature loading shall be entirely reconstructed at the Contractor's expense. The Engineer may delay the time of removal of formwork if necessary. Subject to the above, the minimum period for removal of formwork shall generally be as follows:

Slabs	Soffits (props left under)	7 days
Beams	Props	21 days
	Sides	3 days
Walls and Columns	Soffits(unloaded)	21 days,3 days

When formwork is removed after 3 days, it will be necessary to ensure that the exposed surfaces of the concrete are kept thoroughly wet for the period of curing.

5.3.16 Steel Reinforcement

All bending, cutting and fixing to comply with BS 8110 and BS 4466. Normally Bending schedules are incorporated in the Contract Drawings, but the Contractor shall satisfy himself about their accuracy and about their complete coverage of the work involved. Any omission, inaccuracy or other errors observed by the Contractor shall be reported to the Engineer before commencement of the work.

In case of errors in Bending Schedules, no extra payment will be approved, provided the reinforcement is shown correctly on the Contract Drawings. The number, size, shape and position of all the reinforcement shall, unless otherwise directed or permitted by the Engineer, be strictly in accordance with the drawings. Bars shall be of the shown lengths, and lapping, except where indicated on the Drawings, is not permitted unless approved by the Engineer.

Spacing between bars shall not differ more than 5 mm from the required spacing. Any inaccuracy in the total length of a bar as cut shall be compensated for in the end hooks or other approved parts of the bar.

The internal radius of a bend shall neither be less than allowed by BS 4466 nor less than the radius given in the Bending Schedule. The steel reinforcement shall be assembled and fixed in the form of a rigid case. To prevent displacement before or during concreting the bars shall be secured one to the other with approved binding wire at each intersection. In slabs and walls binding at every second intersection is sufficient.

Concrete cover blocks (mix 1:3) shall unless otherwise directed be used between the reinforcement, the bottoms and sides of the forms to ensure the specified concrete cover to the bars. Variations of cover shall be kept within plus/minus 3 mm from the specified cover.

The minimum clear horizontal distance between adjacent bars shall be of 25 mm or the diameter of the bar whichever is the biggest, and 25 mm vertically. Space bars shall be inserted at such intervals that the bars do not perceptibly sag. Projecting bars shall be adequately protected against displacement both during and after concreting.

At the time of fixing and when concrete is being placed, all reinforcement shall be free from oil, painting, grease, dust and scale or any other coating which would destroy and bond with the concrete. The Contractor must obtain the Engineer's approval of the reinforcement when places, before any concreting is commenced.

6 WATER SUPPLY- PIPELINE MATERIALS AND WORKS

6.1 Application

This Section shall apply to the pressurized conveyance system comprising of MS transmission mains, washout pipelines and appurtenances. Where necessary transmission mains will be provided with air valves, washouts and other appurtenances which will be connected in steel pipeline.

6.1.1 Definitions

The following words and expressions shall have the meanings hereby assigned to them except where the context otherwise requires:

'Pipeline' shall have the definition assigned to it in BS PD 8010 and means a line of pipes having an appreciable length, it may have branch line, but these would not normally be numerous. It does not include piping systems such as process plant piping within refineries, factories or treatment plant, short connections between adjacent plant and distribution and service mains which are characterized by numerous branch connections. Pipework shall mean all pipes excluded from the definition pipeline.

'**Pressure pipelines'** shall mean pipelines in which the nominal internal working pressure exceeds 3 m of water (0.3 bar) and such other pipework as may be so designated.

'Pipes' shall mean straight tubes having beveled ends or ends shaped to form joints.

'Fittings' shall mean bends, junctions, reducers, tapers, joint adaptors and similar items which are not joints or flow control equipment.

'Internal' shall mean those parts of pipes or fittings which are to be in contact with the liquid being conveyed.

'Dismantling joints' shall mean joints made with factory made double flanged fittings that accommodate longitudinal adjustments and can be locked at the required length with the tie bars. This system are particularly suitable for simplifying the installation and removal of valves and fittings.

'Chamber' shall mean structures on the pipeline housing pipes, fittings and valves, including fittings through the chamber walls.

'Welding Procedure Specification (WPS)' A written procedure, based on applicable codes, standards and good engineering practice, listing the materials, detailed method and parameters to be employed during welding of a joint

'**Procedure Qualification (PQ)'** A demonstration of welding a joint (qualification weld) by using approved equipment and methods, utilizing the parameters outlined in the proposed WPS to demonstrate that the given weld will have suitable mechanical properties and soundness. The qualification weld has to be subjected to non-destructive and destructive testing.

'**Procedure Qualification Record (PQR**)' A document containing all information concerning the welding of the qualification joint (as run parameters, detailed methods and conditions) as well as the results of the subsequent tests, material certificates, calibration certificates etc. Welder Qualification Demonstration of the abilities of the welder to produce a weld that meets the requirements of the applicable qualified WPS. The qualification weld has to be subjected to nondestructive testing

6.1.2 General

Pipes and fittings of any one material shall not be supplied by more than one manufacturer except with the approval of the Engineer.

The manufacturer shall have a facility licensed by the American Petroleum Institute (API) and is intended to supply line pipe up to OD 2438mm bearing the API Monogram. The factory shall have facility at manufacturer's work for internal hydraulic pressure test rating not less than the pressure rating as defined in the API 5L Specifications.

No pipes or fittings shall be ordered without the approval of the Engineer.

Materials used in the Works which are or can be in contact with the untreated or treated water shall not contain any matter which could impart taste or odor or toxicity or otherwise be harmful to health or adversely affect the water conveyed.

Approval by the US Environmental Protection Agency or any other recognized body will generally be regarded as satisfactory evidence of suitability.

6.1.3 Test Certificates

Each consignment of pipes and fittings delivered to the Site shall have been tested at the manufacturer's works or other approved place in accordance with the acceptance criteria of Clause 9 of API 5L specification or other approved standard (such test being referred to here as Works tests). The manufacturer should have Quality Management System API Q1 certification.

The Contractor shall provide to the Engineer with the manufacturer's test report for each such consignment before delivery to Site begins and also regularly maintain record of material test reports and delivery of pipes at site.

The Engineer reserves the right to inspect the pipes and fittings to be supplied for the Works at the place of manufacturer and to witness works tests at all contractor cost.

6.1.4 Procurement Plan

The Contractor shall submit detailed procurement plan of steel pipe line and fittings for identifying and consolidating requirements by determining their time frames for approval of the Engineer.

The contractor shall report his quality management plan carried out during procurement process and conformity checks on approved supplier at following stages.

(a) Pipeline and fittings manufacturer qualification and check audits by contractor.

(b) Delivery documents along with Material Quality & Certification documents

(c) Surveillance of manufacturer's production process for quality control and output.

(d) Pipe line fabrication and coating process must be covered for inspection.

The contractor shall carry out audit on purchase order to reaffirm specifications, third party inspection protocols and certifications.

The contractor shall maintain quality control checks at factory prior to shipment of steel pipes for installation including dia. wall thickness, material test reports, signing of forms for shipment / road transportation and maintaining complete record for submission as proof to the Engineer.

The contactor shall confirm that pipe delivery notification of being free from defects due to transport and handling and contractor shall resolve noncompliance directly with the manufacturer.

6.1.5 Quality Control & Safety Management Plan

The Contractor shall operate a Quality Management System in compliance with requirements of ISO 9000 Series.

The contractor shall submit a comprehensive Quality Control and safety management plan for manufacturing & handling of MS Pipe & Fittings, welding of joints, etc. in view of the requirement as per API 5L & API 1104 specifications along with resources to be deployed for the construction of MS Line Pipe . This system would be managed by an experienced and qualified staff and would include but not limited to the following activities.

(a) Quality Control surveillance and monitoring
(b) Health Safety & Environmental management
(c) NCR Procedures
(d) Safety Check List
(e) On Site Inspecting & testing prorformas in compliance with specification.
(f) Third Party Inspection Protocols

The Contractor Shall carry out all welding process under the well-recognized and an experienced third party inspection agencies having certification of NDT personnel as Clause 8.4 of API 1104 specification for inspection and radiographic examination of welding joints of MS Pipe Line with the approval of the Engineer.

The Contractor Shall be required to Carry out his own quality control measures backed by regular internal audits on his site team to ensure proper functioning of key tasks of Pipe Line construction;

(a) Pipe Handling
(b) Welding of Joints
(c) NDT Test
(d) Cement Mortar lining
(e) Coating
(f) Hydrostatic testing
(g) Backfilling
(h) Operation and maintenance.

The contractor shall ensure quality control and safety management plan during the construction activities stated hereinabove are conforming to codes and standards.

All procedures for testing and inspection shall be subject to the approval of the Engineer prior to commencement of work.

Measuring and test equipment, as well as qualification, inspection and test personnel, shall be in accordance with the requirements of the applicable Codes and Standards.

The project material and the welding consumables shall be furnished with material test certificates according to the requirements of the applicable Codes and Standards and the relevant Project Specifications.

All project materials and welding work shall be inspected and tested in accordance with the requirements of the applicable design codes and as described in detail in this specification.

6.1.6 Pipeline Materials

Unless otherwise specified or shown on the drawings, **pipelines shall be manufactured from steel of grade X42 - PSL2.**

6.1.6.1 Steel Pipe and Fittings

(i) Pipes

Steel pipes of grade X42-PSL2 for the pipeline shall be of spiral welded construction complying with API 5L, specification for Line Pipe product specification level PSL2, with outer diameter up to 1829 mm of thickness 12.7mm and above 1829 mm dia. will be 20.6mm, having minimum yield stress of 290 MN/m^2

Cross-bar stiffeners will be provided where required and as directed by the Engineer to provide a minimum cross-bar stiffness of 10,000 N/m^2 per meter length of pipe.

Steel pipes for the washouts shall be grade X42-PSL2 with a yield stress of 290 MN/m^2 and of **welded** construction complying with API5L specifications for Line Pipe Product Specification level PSL2 having nominal diameter as indicated on drawings,

The process of manufacture shall be as stated by the Contractor in **Appendix to the Tender** at the time of tender. Pipes shall be manufactured at a reputed and recognized factory approved by the Engineer.

Full length pipes shall be supplied in uniform nominal length of 6 / 12 m each. 'Nominal length' shall be as defined in API 5L specification.

'Half-length' and 'quarter-length' pipes shall be supplied in case shorter pipe length is needed as per site requirement.

Tests and test certificates will be required for the pipes and Fittings supplied under this Contract in accordance with API 5L Specification for line pipe PSL2 including ladle and check analyses of the steel.

The pipe manufacturer shall carry out inspection standards, chemical composition and mechanical strength requirements including Charpy impact test in accordance with API 5L Specification PSL2 and shall provide test certificate to confirm that the pipe is suitable for use under the operating conditions specified herein operating temperatures between –50 C and 400 C.

(ii) Circular Pipes

Pipes intended for fabrication at Site by welding and for cutting into closing lengths shall be referred to as 'circular pipes' and shall be truly circular and sized uniform throughout their length, within the tolerance applicable to their outside diameter in accordance with API 5L Specification enabling them to be suitable for use in jointing of line pipe and fittings.

They shall be marked 'circular' and identified by painting a 25 mm wide red stripe along each of two diametrically opposite locations throughout the external surface of the pipe length.

(iii) Fittings

Steel Fittings for butt-welding shall comply with AWWA C208. All Fittings shall have the same strength and be compatible in all other respects with the line pipe with which they are to be used.

Flat tapers shall have one side of the taper at right angles to the ends so that they may be laid with level invert or level crown as required.

Concentric reducer shall be used to join MS Pipe sections on the same axis and it reduces the size of pipe in the pipe system from one size to another. The minimum length of reducer shall be calculated by the formula Lr = 4(DL-DS).

Bends shall be of even curvature type only unless otherwise approved by the Engineer.

Fittings shall be hydraulically tested in accordance with ASME 31.4 or AWWA M11

(iv) Marking

The marking of pipes and fittings specified in Section 11 of API 5L Specification shall be given in metric units. Suitable marks indicating lateral symmetry of flat tapers shall be scribed at the larger end.

(v) Certification

The manufacturer shall upon request by the Engineer furnish a certificate compliance stating that the material has been manufactured, sampled, tested and inspected and supplied according to specification and has been found to meet the requirements.

Material test certificates shall be according to EN10204" type 3.1" showing all chemical analysis required, results of mechanical tests with reference to coil and corresponding heat numbers.

A material test report certificate of compliance or similar documents, Hydrostatic pressure test at mill shall be attached at the time of supply of API-5L grade X-42 steel line pipe.

(vi) Preparation of Pipe Ends

The preparation of pipe ends for Butt Welded type joints shall be ends beveled in accordance with the requirements of clause 15.12.5.2 of API 5L Specification unless otherwise specified in the drawings.

6.1.7 Welded Joints

All Welded joints in the pipeline shall be butt welded as shown on drawings. Welded joints for the washout pipework shall also be butt welded. All welding in joints of pipe line and related facilities shall comply with API 1104 Specification.

All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15° apart around the joint circumference.

The butt welds for pipes of larger diameter shall comprise several passes including root pass followed immediately by the hot pass to provide reinforcement and then filler and capping runs with back pass from inside as per welding procedure specification Clause 5.3 of API 1104 and approved by the Engineer.

The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the weld shall have an even contour with regular finish and shall indicate proper fusion with the parent material. All slag shall be thoroughly removed after depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap onto the parent metal without proper fusion or containing any other defects whatsoever shall be cut out and re-welded to the satisfaction of the Engineer at the Contractors expense.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Engineer.

Non-destructive testing personnel shall hold a valid qualification for the visual inspection of welds interpretation of radiography results.

Contractor shall employ or appoint at least one Level III qualified NDT operator/interpreter at each sections to establish and control Contractor's NDT procedures and to be available to interpret doubtful indications.

The Contractor shall submit his proposals and welding procedures for Engineer's approval before commencing the jointing work.

6.1.8 Flanged Joints

Flanged joints shall be as mentioned on the drawings with raised face type and complying with EN 1092 as detailed on the drawings or directed by the Engineer.

Blank flanges of PN 25 and PN 40 flanges shall comply with EN 1092.

Flanges connecting to valves and Fittings shall be compatible with the flanges attached to them.

One complete set of bolts and nuts conforming to EN 1092 together with gaskets shall be supplied with each flange for welding, each flange ended pipe or each flange end of a special or valve. Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

After cleaning the flanges, the gasket shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using spanners of a type approved by the Engineer.

Graphite grease shall be applied to the threads of bolts before joints are made. All flanged joints which are buried or in chamber shall be protected with denso mastic and denso tape wrapping, applied in accordance with manufacturer's recommendations.

Flanges shall wherever practicable be attached in the factory and field welding of flanges will only be allowed with the approval of the Engineer.

6.1.9 Flange Gaskets

Gaskets for flanges shall be of rubber gasket or rubber gasket with metal support ring or other of the recommended materials complying with EN 1514 and suitable for potable water. Gaskets shall be designed to withstand gasket pressure of at least 2.5 times the normal operating pressure as specified or as detailed on the Drawings of the pipes, fittings or valves to which they are attached.

6.1.10 Welding Process

The metal arc process shall be employed for the welding of joints to pipes and Fittings and shall comply with API 1104 specification.

Before commencing the welding of pipe joints in the works the Contractor shall submit to the Engineer for approval details of the plant, materials, and the method he proposes to employ including make and size of electrodes, number of runs, current strength as per welding procedure specification (WPS) and arrangement for testing of joints including visual inspection, destructive and non-destructive (NDT) testing as per Clause 6.4, 6.5 and 6.6 of API 1104 specification. When required by the Engineer, the Contractor shall carry out Site trials in demonstration of his method, to prove the suitability of the materials and the adequacy of his plant.

The welding of joints shall be carried out automatic GMAW or manual by welders qualified for all position as per welder qualification test Clause 6 of API 1104 specification and the Contractor shall submit to the Engineer details of all welders whom he proposes to employ with evidence that they have passed the qualifying tests prescribed in API 1104 specification. The Engineer may further require any such welders to perform satisfactory test welds under site conditions and on pipes similar to those for use in the works before approving his employment as a welder. The Engineer's approval for any welder will only be given after the welder has satisfied the requirements of the welder tests prescribed by API 1104 specification.

The Contractor shall furnish each of his welders with indelible crayons for marking the pipe with his unique identification number, adjacent to each weld run by him. No marking made by indenting with a steel stamp will be permitted.

The approval of a welder may be revoked by the Engineer at any time if he considers the welder's workmanship is inconsistent or below a reasonable standard.

The throat thickness of full fillet welds shall be not less than 0.7 times the pipe wall thickness and the throat thickness of butt welds shall not be less than the pipe wall thickness.

Spiral welded pipes shall be laid such that the manufacturer’s spiral welds shall not coincide at the ends of the adjacent pipes but shall be opposed by at least 45 degrees.

No welding shall be carried out until the portion of the pipeline to be jointed has been properly prepared and set up, and inspected and approved by the Engineer.

Welded joints shall be welded on Site by the metal arc process, using portable welding sets of 300/400 A, 30/35 V capacity.

The type of welding electrodes to be adopted on Site and the site welding procedure specification shall be as stated in Appendix to the Form of Bid and approved by the Engineer.

6.1.11 Welding Inspection

All welding and in particular the deposition of the root run, will be subject to stringent examination by the Engineer. The inspection and testing of production weld shall be carried out as per Clause 8 of API 1104 specification. The Contractor shall give adequate advance advice of welding operations and provide test equipment for the welds. Radiographic inspection of welds shall be made by the Contractor in the presence of the Engineer in accordance with Clause 6.6 of API 1104.

All tie-in welds, repair welds, welds to be enclosed in casings or concrete weighting, welds between pipes of different thickness and welds for joining special parts as bends, tees, reducers, valves, etc. shall be subject to 100% radiographic examination by the Contractor's qualified NDT personnel

At the start of production welding the first 100 joints of each pipeline shall be subjected to 100% RT. In case satisfactory performance of welders/operators, radiographic examination shall be 10% of the total run of each weld joint.

If, in the opinion of the Engineer, excessive repair work is necessary the radiographic inspection may be increased beyond 10% of the total run of each welded joint.

The acceptance or rejection of any weld shall be mentioned in the radiographic inspection report. The format of the report has to be approved by the Engineer in advance.

Each joint to be radiographed shall be cleaned, and weld spatter removed. Any defective weld shall be repaired by approved means or cut out if necessary. The acceptance standards for NDT test of welding joints shall be as per Clause 9 of API 1104 specification. In case of doubt, inspection of welding joints shall be made additional by ultrasonic test (UT) as per Clause 11 of API 1104 specification with the approval of the Engineer.

Magnetic Particle test (MT) or Liquid Penetrant test (PT) inspection shall be made by the contractor for Fillet weld of Flanged joint in the presence of the Engineer in accordance with API 1104.

All visual inspection shall be performed under acceptable conditions with regard to light, access to the weld, etc. The weld surface and the adjacent pipe surface shall be clean and dry. To perform his task the operator/interpreter shall be equipped with all necessary gauges, mirror, digital thermometer, etc. Only equipment of recognized commercial quality shall be used.

Cracks, craters, pinholes, weld spatter, residual slag or arc strikes shall not be acceptable. Undercuts shall be acceptable to the criteria given in API 1104. If cracks have been found, the reason/cause of the crack shall be thoroughly investigated and the WPS immediately reviewed or modified such that they do not reoccur. This may result in halt of welding until resolved. The external weld reinforcement shall merge smoothly with the adjacent surfaces of the parent material. The thickness of the external weld reinforcement shall not exceed the limits of API 1104.

6.1.12 Safety

The Contractor shall have detailed written procedures and work instructions in place, covering all aspects of health, safety and environmental impacts due to the use of NDT equipment, especially radiation protection. Same have to be approved by the Engineer prior to commencement of work.

6.2 Pipe Protection

6.2.1 Internal Pipe Protection

For the internal epoxy lining of a 72 & 96-inch diameter MS (Mild Steel) water supply pipeline, the specification would be more detailed due to the large scale, environmental exposure, and operational demands of such a system. Internally liquid epoxy as per American water works association (ANSI/AWWA C210) Specification, heat shrinkage or alternative, cathodic protection, if required and jointing with helical welding in trenches i/c cost of all fittings, bend, tee, yee of any degree & reducer (if required). With all flanges and testing with water specified pressure for different diameter of pipes, including Durable Marking tapes to be normally placed 12" below grade (ground surface), and no closer than 12" from the pipe.

6.2.1.1 Scope of Work

- The internal surface of the MS water supply pipeline shall be lined with a high-performance epoxy coating to protect it from corrosion, scaling, and biological growth, ensuring a smooth surface for efficient water flow and long-term durability.

- This specification covers the surface preparation, application of the epoxy lining, testing, and quality control measures.

6.2.1.2 Materials and Standards

- **Pipe Material:** The pipeline shall be made from Mild Steel (MS) conforming to the relevant standards (e.g., IS 1239, ASTM A53, or equivalent) and shall be of the required thickness and strength to withstand the operational pressures and mechanical stresses.

- **Epoxy Coating Material:**
  - The epoxy resin used for lining must meet the following:
    - Type: Two-component, solvent-free, high-build epoxy coating designed for potable water use.
    - Standards: The epoxy must conform to standards such as ASTM D6610 (for potable water) or ISO 12944 (for corrosion protection).
    - Curing Type: Ambient temperature curing or heat-assisted curing depending on product specification.
    - Color: Typically light or off-white color for visibility and aesthetic uniformity.
    - Viscosity: The epoxy resin should have a viscosity suitable for spray application, ensuring a uniform coat on the pipe's interior.

6.2.1.3 Surface Preparation

- **Internal Cleaning:**
  - The pipe's internal surface must be cleaned to remove any dirt, grease, oil, scale, rust, or other contaminants.
  - Methods include mechanical cleaning (e.g., wire brushing), water blasting, or abrasive blasting to ensure the surface is suitable for bonding.
  - **Abrasive Blasting:** The internal surface should be prepared by abrasive blasting (e.g., **sandblasting**) to an **SA 2.5** or **near white blast** standard (ISO 8501-1) to create a clean, rough surface profile for maximum adhesion.
  - **Surface Profile:** The internal surface should have a roughness of **50-75 microns** (2-3 mils) to ensure optimal bonding of the epoxy coating.

6.2.1.4 Epoxy Lining Application

- **Application Method:**

  - The epoxy lining should be applied using airless spray equipment for consistency across the large diameter of the pipe. Alternatively, roller or brush methods may be used for smaller or hard-to-reach areas.
  - The epoxy should be applied in multiple thin coats to achieve the desired thickness.
- **Dry Film Thickness (DFT):**
  - The minimum DFT for the epoxy coating should be 250 microns (10 mils) and up to 400 microns (15 mils) depending on the service conditions (e.g., water quality, internal pressure, temperature).
  - Total Coating Thickness: The total applied epoxy lining should generally not exceed 400 microns (15 mils) to avoid issues such as cracking or delamination during curing.
- **Curing:**
  - The epoxy should cure according to the manufacturer's instructions. In general, curing is at ambient temperature (typically 10-25°C) for a period of 24-72 hours depending on the product specifications and temperature.
  - If needed, a heat-assisted curing method (up to 60°C) can be employed to accelerate curing, particularly for large pipes.

6.2.1.5 Properties of Epoxy Lining

- **Adhesion:** The epoxy must achieve **strong adhesion** to the steel surface, typically in the range of **1000 psi** or higher, as tested by a **pull-off test** (ASTM D4541).
- **Chemical Resistance:** The epoxy must demonstrate resistance to:
  - **Chlorinated water**
  - **Alkaline and acidic conditions** commonly encountered in potable water systems.
  - **Sulfur, organic compounds**, and other chemical agents often found in industrial or agricultural water supplies.
- **Abrasion Resistance:** The coating should withstand abrasion from the flow of water and any particles or sediment it carries.
- **Impact Resistance:** The epoxy should show **high impact resistance**, particularly against the mechanical stresses during pipe installation and operation.
- **Thermal Resistance:** The epoxy should handle operational temperatures within the range of **-20°C to +80°C** (or as specified), ensuring no degradation over time.
- **Water Compatibility:** The epoxy lining must be certified for **potable water** applications, ensuring that it does not leach harmful substances into the water supply.

6.2.1.6 Inspection and Testing

- **Visual Inspection:** The internal surface of the pipe should be visually inspected after the application of the epoxy coating to ensure uniformity, thickness, and smoothness.
- **Dry Film Thickness (DFT) Measurement:** A **coating thickness gauge** should be used to measure the DFT across different sections of the pipeline. Ensure that the coating is applied uniformly, meeting the specified thickness.
- **Adhesion Testing:** Conduct **adhesion tests** on selected pipe sections to verify the strength of the bond between the steel surface and the epoxy lining.
- **Holiday Testing:** Use a **high-voltage holiday detector** to inspect the interior for any pinholes or discontinuities in the coating.

- **Curing Test:** Ensure the epoxy has fully cured according to the manufacturer's specifications, achieving the required hardness and performance properties.

6.2.1.7 Quality Control

- The contractor or applicator shall provide a **quality assurance plan** outlining the materials, methods, and equipment used.
- The applicator must demonstrate experience and qualification for handling large-scale applications of epoxy linings.
- **Documentation:** Provide certification of compliance with relevant standards and the results of inspections and tests performed during the project.

6.2.1.8 Health, Safety, and Environmental Considerations

- **Personal Protective Equipment (PPE):** Workers should use appropriate PPE, including gloves, safety goggles, respirators, and protective clothing when applying the epoxy.

- **Ventilation:** Ensure proper ventilation during the application and curing phases to prevent exposure to fumes.

- **Environmental Impact:** Ensure proper disposal of waste materials, including solvents and other chemicals, in accordance with environmental regulations.

6.2.1.9 Service Life and Warranty

- The epoxy lining should be designed to last for a minimum of **15-20 years** under normal service conditions.

- The applicator should offer a warranty period, typically **1–2 years**, for the integrity of the coating, covering issues such as peeling, cracking, or delamination.

6.2.1.10 Inspection of Internal Lining

Prior to commencement of hydrostatic testing the completed lining has to be inspected.

For the inspection of the internal lining the Specification M03 as well as the below stipulations have to be observed. It is the obligation of the Contractor to provide adequate equipment and qualified personnel. Following two methods for the inspection are acceptable:

(a) Visual inspection for large diameter pipes.

(b) TV-inspection for small pipe diameter below 36”

The equipment and methods used will be subject to approval by the Engineer. Visual inspection has to be done before hydrostatic testing of the pipeline sections by independent "third party" inspectors to be approved by the Engineer. For TV-inspection, the inspection device shall consist of several heads (each of them adjustable) to get an overview over the whole circumference. The TV-inspection has to be done continuously with respect to the progress of joint lining and curing of the laid pipe sections.

6.2.2 External Pipe Protection

The external protection against corrosion will be applied on line pipes, fittings, including bends and valves. Pipeline will be externally coated by factory-applied three-layer extruded polyethylene-based coatings as per standard DIN 30670 and as directed by the Engineer. The welded joints and fittings will be coated by using heat-shrinkable sleeves at site as per standard ISO-21809-3 and suitable for protection of buried

steel pipes at design temperature up to 80 degree centigrade. While the valves and appurtenances will be externally epoxy resin coated with application of electrostatic process “EKB” by the valve manufacturer.

6.2.2.1 Three Layer Polyethylene Coating (3LPE)

External anti-corrosion Coating of Pipes by using three 3-Layer Polyethylene (3LPE) conforming to DIN 30670 shall be multilayer coating composed of three functional components: A high performance Fusion Bonded Epoxy (FBE) primer, followed by a copolymer adhesive and an outer layer of high density polyethylene which provides tough, durable protection for small and large diameter pipelines against any physical damage of the pipes, as well as chemical and biological protection in all site conditions and suitable for the service condition and the pipe sizes involved.

The contractor shall be responsible for complying with all applicable requirements of DIN 30670 at the factory. The Engineer shall make necessary investigation in case of doubt and conduct additional testing, batch sampling and manufacturing inspection in order to satisfy and compliance by the applicator at factory. Any materials/coating that does not comply with the requirements shall be rejected.

Three Layer polyethylene coating, inspection and testing shall be carried out as per DIN 30670 standards. 3LPE Coating shall be done in pipe factory, while joint in pipes shall be coated by suitable heat shrinkable sleeves in accordance with IS0-21809 -3 (“Field coating materials for corrosion protection of buried pipelines”) as per approval of the Engineer.

The coatings shall be stopped 150±20 mm from the both ends (“cut back”) of all pipes to be field welded in accordance with the standards and heat shrinkable wrapping shall be applied to cover this section after welding of joint.

The Contractor shall provide detail of facilities available at factory for external coating of Pipe line by 3 LPE including size of coating plant(s) after evaluating the scale of work, detailed procedure of the Applicator’s method, material proposed and the time schedule required for the work. Also the contractor shall make sure that Plant equipment, machinery and facilities are in finest operating condition to meet the job requirements of quality and production.

The factory proposed by contractor shall be its own fully equipped laboratory and test facilities with adequate inventory to carry out tests required for the procedure qualification and regular production. The Quality System shall be based upon ISO 9001/2 or equivalent. In addition to manufacturer's Certificate, the factory applicator shall draw samples from each batch of epoxy, adhesive and polyethylene in the presence of Engineer’s Representative and test for the following properties at the coating yard at least one week prior to its use, to establish compliance with the manufacturer's Test Certificates.

a. Epoxy Powder

(i) Gel Time

(ii) Cure time

(iii) Moisture content

(iv) Thermal Characteristics (T91, T92, ΔH)

b. Adhesive

(i) Density

(ii) Melt flow rate

(iii) Vicat softening temperature

(iv) Water content

c. Polyethylene

(i) Melt flow rate (MFR)

(ii) Density

(iii) Water content

(iv) Thermal stabilization (as per ASTM D3895)

The contractor shall ensure that all coating materials are properly stored at factory in accordance with the Manufacturer's recommendation at all times, to prevent damage and deterioration in quality prior to use.

6.2.2.2 Coating Application Stages

The principle stages of pipe coating shall be as follows:

(a) Solvent cleaning followed by steam or hot bath cleaning (if required)
(b) Abrasive blasting
(c) Application of fusion bonded epoxy (FBE) layer
(d) Application of adhesive layer
(e) Application of polyethylene layer
(f) Modifications depending on the Pipe Coating Contractor’s equipment and standard factory procedures are possible but shall be approved by the Engineer

6.2.2.3 Cleaning Prior to Abrasive Blasting

All surface contaminants such as oil, grease, tar, salt, or other contaminants on the pipe shall be removed by solvent cleaning followed by steam or hot bath cleaning, in accordance with a procedure approved by the Engineer

Following the steam or hot bath cleaning the pipe shall be tested for salt and chloride contamination in accordance with the requirements of DIN EN ISO 8502- 2, ISO 8502-5 or DIN EN ISO 8502-9.

All water used for rinsing or cleaning purposes shall be potable with less than 200 ppm total dissolved solids and 50 ppm chlorides

6.2.2.4 Coating Application

The application of the coating shall be in accordance with the material manufacturer recommendations and the procedure outlined below.

Prior to start of production, the Applicator shall carry out a coating Procedure Qualification Tests (PQT) at factory as per approved procedures, for each pipe diameter on max. wall thickness, to prove that his plant,

materials, and coating procedures result in a quality of end product conforming to the properties stated in specification, relevant standards, specifications and materials manufacturer's recommendations.

a. FBE Layer

The FBE shall be applied to a minimum thickness of 200 microns and a maximum of 350 microns. The pipe shall be uniformly preheated in accordance with the FBE manufacturer's instructions. This temperature shall have been confirmed during PQT. The surface temperature shall not exceed 260 °C in accordance with AWWA C213, section "4.4.3.1 Preheating".

The coating shall be applied by electrostatic spray with the pipe at earth potential and the epoxy powder charged to high potential.

During application, the beveled ends and pipe bore shall be protected against mechanical damage and from contamination with coating material

The Pipe Coating Contractor shall perform coating procedure qualification testing (PQT) prior to commencing production or on his own risk at the start of production in accordance with this specification. Prior to startup of the coating process the powder application and recovery systems shall be thoroughly cleaned to remove any powder other than that in use, minimum once per day and the collected powder shall be disposed of.

b. Adhesive Layer

The adhesive shall be applied to a thickness of 150 to 250 microns. The adhesive layer shall be applied before gel time of the FBE has expired. Application of the adhesive shall not be permitted after the FBE has fully cured. The Contractor shall state the proposed minimum and maximum time interval between FBE and adhesive applications at the proposed pre-heat temperature.

c. Polyethylene Layer

The polyethylene layer shall be applied to a minimum thickness of 3.5 mm over the pipe body and to a minimum of 3.25 mm over the production welds for pipe diameters greater than 500 mm and to a minimum thickness of 3.0 mm over the pipe body and to a minimum of 2.75 mm over the production welds for pipe diameters less than 500 mm. The polyethylene shall be applied over the adhesive within the time limits established during pre-production testing.

The coating shall be cooled to below 60°C before handling. Immediately after the coating is fully cured, pipe identification marks shall be re-applied to the coated pipe using a method approved by the Engineer.

d. Cut back of Coating

A length of 120 mm +10/-0 mm from the pipe end shall be free from any coating material. A polyethylene layer cut back of 150 mm (+10/-10 mm) shall be provided at pipe ends.

The FBE layer shall protrude the polyethylene layer by min.10 mm but shall not extend further than 120 mm from the pipe end. The ends of the layers shall be chamfered and beveled at 30 to 45°.

6.2.2.5 Inspection, Testing and Certification

In order to demonstrate that the manufacturer's proposed coating application procedure is capable of meeting the specification, the Contractor shall undertake coating procedure qualification testing (PQT) prior to commencing production, or at his own risk at the start of production. The Contractor shall also be required to test the finished coating during production to demonstrate continued compliance with this specification.

Details of all inspections and testing shall be fully documented in accordance with the requirements of standards DIN 30670. All stages of the surface preparation, coating and testing shall be subject to 100% inspection by the Contractor. The Engineer shall be informed at least two weeks prior to the start of surface preparation to allow scheduling of inspection supervision work.

6.2.2.6 Coating Procedure Qualification Testing (PQT)

Prior to commencing or at the start of full production one pipe joints of each diameter coated with FBE only and one pipe joints of each diameter with the full coating system shall be selected for PQT. All coating shall be in accordance with the coating procedure specifications and shall be witnessed by the Engineer or its representative.

The produced pipes will not be released until the successful results of the PQT can be provided. Any failure in meeting the specified acceptance criteria for the PQT will result in rejection of the coated pipes. Engineer shall approve any remedial action, repairs or re-use.

The test methods for all tests required for PQT on the FBE and the complete coating system shall be performed in the same manner as the production tests described in this specification.

6.2.2.7 PQT Inspection and Test Summary

Inspection and testing summary for procedure qualification test (PQT) for three layer coating system for each pipe diameter:

Property	**Acceptable Values**	**Frequency of**
• Pipe Damage	Minor damage/grinding <3 per pipe	Each pipe
Chloride Oil Salt	2 .1g/cm^2 No contamination3 .1g/cm^2	Each pipe
• Cleanliness • Profile • Contamination	SA 2.5 according to ISO 8501 50 - 100 .1mg No contamination	Each pipe Each pipe Each pipe

• Visual Inspec-tion • Holidays • Thickness	No surface defects No holidays Min/max	Each pipe Each pipe 10 per pipe 2 per pipe
Coating Thickness • minimum		16 per pipe
Visual Inspection		
Coating Bare steel at pipe ends Protruding FBE	No surface defects 120 +10/-0 mm width 10 to 40 mm width, chamfered 150 +10/-10 mm, bevel 30° to 45°	Each pipe Each pipe Each pipe Each pipe
• Peel Test	>100 N/cm at 20°C ±5°C > 50 N/cm at 50°C ±5°C	2 per pipe 2 per pipe
Impact Resistance		1 per pipe
% Elongation at Failure		2 per pipe
Cathodic disbond-ment		2 per pipe
Other Tests as per DIN		1 per pipe

6.3 Pipe Production Testing

Pipe production testing shall be performed at the frequency shown below:

Property	**Acceptable Values**	**Minimum Frequency**
Bare steel pipes		
Pipe Damage	Minor damage/ grinding <3 per pipe	Each Pipe

Chloride Oil Salt	2 .1g/cm^2 No contamination 3 .1g/cm^2	1 per 100 pipe 1 per 100 pipe 1 per 100 pipe
Cleanliness Profile Contamination Pipe Damage	ISO-SA 2.5 50-100.1mg No contamination	Each pipe 1 pipe per 100 1 pipe per 100 Each pipe
Pipes with FBE only		
Visual Inspection Thickness Adhesion	No surface defects Min/max	One pipe per day and one pipe when FBE batch changes
Holidays	No holidays	At each batch change and at any stop of FBE application
Pipes with full coating system		
Final Coating (minimum)		Each pipe
Visual Inspection Coating Bare steel at pipe ends Protruding FBE	No surface defects 120 +10/-0 mm width 10 to 40mm width, chamfered 150 +10/-10 mm, bevel 30° to 45^0	Each pipe Each pipe Each pipe Each pipe
Peel Test	>100 N/cm at 20°C ±5°C	1 pipe per 100

The frequency of tests shown in the table above will be for normal production.

The frequency of tests shown in the table above will be for normal production operations. This frequency of tests is subject to change at the discretion of the Engineer as a result of change of materials or consistent poor production performance.

The contractor's quality control system shall include the following, as a minimum:

(a) Monitoring of blasting grit and shot size –

(b) Visual checks, in good light, of the surface of the blasted pipe –

(c) Temperature control of the pipe surface –

(d) Coating testing as detailed in this Specification

(e) Supervision of the adequate and proper repair of all defects

The contractor shall, prior to the commencement of work, prepare and submit a Quality Plan for all of the activities required satisfying the requirements of this specification. The contractor shall submit manufacture's test reports of materials involved in 3LP coating. The three layer coating shall be Class "S" and minimum overall thickness of finished coating shall be 3.85mm and minimum 3.60mm over the manufacturing weld. The permissible minimum thickness can be tolerated on the condition that it does not attain a total extent of more than 5 cm2 per meter length of coated pipe, and the actual coating thickness does not drop more than 10% below the permissible minimum coating thickness at these locations.

The contractor shall submit detailed qualification procedure of epoxy powder application & Recycling, Pipe preheating surface preparation, coating application for approval of the Engineer.

The contractor shall establish and maintain such quality assurance system as are necessary to ensure that coated pipes supplied comply in all respects with the requirements of this specification. The minimum inspection and testing to be performed shall be as indicated herein.

i. Visual Inspection
ii. Coating Thickness
iii. Holiday detection test
iv. Impact resistance test.
v. Indention Hardness
vi. Air Entrapment Test.
vii. Degree of Cure
viii. Dry Adhesion Test (For Epoxy)
ix. Cathodic Disbandment test
x. Elongation at break

6.3.1 Coating Thickness

The total coating system shall be applied to the following minimum thickness requirements:

PIPE DIAMETER	PIPE BODY	OVER THE
<500mm	3.35mm	3.10mm
≤500mm	3.85mm	3.60mm

The thickness of the cooled polyethylene coating system shall be checked using Engineer approved equipment in accordance with the requirements of DIN 30670.

At least 3 of the measured points per pipe length shall be on the welds. Any individual reading less than the values above shall be cause for the coated pipe length concerned to be quarantined. The pipe shall be held for further review by the Engineer.

6.3.2 Holiday Detection

Holiday testing of the FBE coating shall be carried out on 100 % of the coated surface with a pulse type DC holiday detector equipped with audible signaling device. The test shall be carried out in accordance with NACE RP0490 or equivalent:

Each fully coated pipe shall be inspected for holidays over 100 percent of its coated surface using a high voltage DC detector.

The Pipe Coating Contractor shall demonstrate to the Engineer that the setting of the detector is satisfactory for detecting pinhole defect.

The correct travel speed shall be determined by consistent detection of an artificial pinhole made in a good coating sample but shall not exceed 300 mm/s.

All holidays and other defects shall be marked for subsequent repair and re-testing. On re-testing, no holidays shall be permitted in the final coating. The number of holidays for each pipe length shall be recorded. Coated pipe having holidays in excess of 1 per 1 square meter shall be stripped and re-coated. If there is an excess occurrence of holidays on successive pipes, the Pipe Coating Contractor shall immediately stop the coating operation to determine the cause and remedy it.

6.3.3 Adhesion (Peel) Test

The adhesion for the complete coating shall be determined in accordance with the requirements for bond strength in DIN 30670.

6.3.4 Impact Test

A sample of coated pipe shall be impact tested in accordance with the procedures and acceptance criteria of DIN 30670.

Coated pipe shall be handled in a manner that avoids damage to the pipe, pipe ends and coating. The Contractor shall submit details of the handling procedures. Any defects shall be made good in a manner in accordance with the requirements of the applicable pipe specification or standard and to the satisfaction of the Engineer.

6.3.5 Coating Repairs

The Pipe Coating Contractor shall submit detailed coating repair procedures for approval by Engineer. These shall include procedures for repair of ‘pin-hole’, ‘small area’ and ‘large area’ defects.

6.4 Preservation, Marking and Shipping

6.4.1 Preservation

The bare ends of each pipe shall be painted outside with a removable varnish as temporary corrosion protection during transportation and storage. Bevel protectors of a type to be approved by the Engineer shall protect the bare ends of each pipe.

6.4.2 Marking

In addition to the marking required by API 5L, the Contractor's unique coating number shall be marked to the internal surface of the pipe with synthetic resin paint. Further, marking details like colour coding etc. shall be agreed upon with the Engineer. The marking shall have at least a distance of 150 mm to the pipe end.

6.4.3 Shipping

Shipping and Loading preparation shall be in accordance with API Specification 5L or otherwise stated in the contract documents. The Pipe Coating Contractor shall submit detailed loading, stacking and shipping procedures for approval by the Engineer.

6.4.4 Pre-Production Documentation

The Contractor shall submit the following documentation to the Engineer for approval prior to commencing production:

(a) The manufacturer's trade name and data sheets for all proposed coating materials. This includes cleaning and abrasive blasting consumables.

(b) Procedure for identifying, or maintaining the identification of each coated item.

(c) Handling procedure.

(d) Stacking procedure

(e) Materials control and traceability procedure for the batches of coating materials.

(f) Materials storage procedure (pipe and coating materials).

(g) Procedure for steel surface preparation including materials, cleaning, inspection, verification of cleanliness and surface profile.

(h) Coating application procedures, including fusion bonded epoxy (FBE), adhesive and polyethylene layers.

(i) The results of the batch tests for batches to be used for pre-qualification tests.

(j) Details of testing methods including instrument types and copies of current calibration certificates.

(k) Details of inspection methods for bare and coated pipe.

(l) Full test results from the coating Procedure Qualification Test (PQT).

(m) Repair procedure and results of tests on demonstration of repairs.

(n) Project specific Quality Plan.

Work shall not commence until these procedures have been reviewed and approved by the Engineer. The selection of proposed coating materials shall be subject to Engineer's approval.

6.4.5 Production Records

A daily log containing the following data shall be maintained and be available for inspection by the Engineer during and/or after production. Data shall be recorded against the pipe unique identification number.

(a) Bare pipe inspection data.

(b) Ambient temperature.

(c) Humidity.

(d) Coating progress (no. of items coated, including item serial numbers).

(e) Blast pipe surface amplitude.

(f) Tests for cleanliness of blast surface.

(g) Tests for cleanliness of blast medium.

(h) Film thickness measurements

(i) Average, maximum and minimum coating thickness during each shift.

(j) Details of any coating defects recorded and defect density on respective pipe lengths.

(k) Details of any coating repairs

(l) The unique identification number of all items that are stripped for recoating

(m) Pipe coating test results

The log shall be available to the Engineer throughout all coating operations.

6.4.6 Release Documentation

The Pipe Coating Contractor shall submit to the Engineer the following documentation in hard copy and softcopy (format to be agreed upon with the Engineer) with each batch of pipes released:

(a) Mill certificates for line pipe

(b) Production listing for each batch

(c) Unique pipe identification numbers

(d) Unique coating identification number (if different) e) Pipe length

(e) Length of the coated portion of each pipe and total coated lengths of all pipes.

(f) Reductions in lengths due to us

(g) Date of coating

(h) Batch numbers of coating materials used

This shall be followed within two weeks by the following:

(a) Manufacturer's certificates for each batch of coating materials

(b) Certification/calibration certificates for all testing and coating equipment.

(c) Inspection and test records, results, and other documentation of all materials and coating test

6.5 Coating of Joints and Fittings

The Contractor shall apply the protective coating on welded joints, special parts and fittings and other metallic installations according to the type and sequence defined in the specification.

Coating of buried joints, fittings, etc. shall be performed with Heat Shrinkable Sleeves. Above ground pipeline joints and components shall be coated with liquid epoxy.

6.5.1 Epoxy and Sleeve Properties

The corrosion coating shall consist of a high build epoxy applied to the steel surface, followed by a wrap-around heat shrinkable sleeve, and shall be suitable for an operating temperature not exceeding 80° C in wet conditions.

As one of the requirements for Quality Control of proper shrinking of sleeve, the shrink sleeve backing shall have a built-in permanent change indicator. This shall be in the form of a special pattern on the backing. Prior to shrinking the pattern shall be clearly visible and feel able to the touch. Once the sleeve has been shrunk down properly, the pattern shall disappear and the sleeve surface shall become completely smooth.

6.5.2 Epoxy and Sleeve Thickness

The first layer of the joint coating system shall be a 100 % solids two component epoxy of a minimum dry-film thickness of 150 microns when applied on the steel surface. The epoxy layer shall be the primary anti-corrosion barrier and shall be capable of corrosion protecting the steel surface on a standalone basis.

The heat shrink sleeve shall provide mechanical protection to the epoxy layer and shall seal onto the epoxy layer and the adjacent line coating. It shall have the following minimum thickness:

Backing: > 1.4 mm

Adhesive: > 1.6 mm

Total sleeve (Backing + Adhesive): > 3.4 mm

To prevent damage to the adjacent 3LPE line coating, the pre-heat of the weld area prior to epoxy application shall not exceed 800C. After application of epoxy to joint area, the shrink sleeve shall be shrunk over the epoxied surface while the epoxy is still in a gel state and shall not require post curing of the epoxy layer prior to sleeve shrinking. This is to prevent contamination of the epoxy surface caused by direct flame.

6.5.3 Sleeve Width

The sleeves on the weld joint shall be wide enough so as to overlap onto the mainline coating by a minimum of 50 mm on each side of the weld joint once installed. The installed sleeve width shall be considered as the edge-to-edge width of the backing of the sleeve once fully shrunk down.

The sleeves on field bends may be wider and shall overlap onto each other by a minimum of 50 mm once installed.

6.5.4 Coating Performance Requirements

(a) Contractor shall ensure that all material proposed for field joint coating has been tested and meet the requirements of ISO21809-3 Std. for physical, chemical and electrical properties as detailed in the table below.

(b) The Shrink Sleeves Materials to be supplied shall have a track record of satisfactory performance for a period of at least ten years worldwide on projects of equal or larger size than this project.

(c) Contractor shall provide independent laboratory test certificates and reports in compliance to ISO 21809-3 Std. for a temperature of 80°C for all accepted materials, detailing the information as required in this Specification.

(d) The self-adhesive layer of the coating shall be homogeneous, free from flaws, defects, pinholes, bubbles, cracks and inclusions.

(e) The corrosion coat shall be resistant to bacterial attack and shall not deteriorate during the design life of the pipeline.

(f) The sleeve shall be resistant to the high Ultra Violet light occurring in summer without requiring any sort of painting or covering. To confirm suitability, the sleeve shall be tested for UV resistance as per EN 12068 standard. An independent lab test report shall be provided to confirm compliance.

(g) To ensure that the sleeve is applicable in the high ambient temperature and Black Body temperatures in the summer at the location of installation, the backing and adhesive shall be of a high enough temperature rating (80°C) such that it shall be fully installable without damage. It shall not be necessary, nor will it be allowed, to paint or cover the installed shrink sleeve with any protective cover during the peak of the summer. At this time, under the direct sun in the summer and without any protective coating, the sleeve and adhesive

shall not become soft and the adhesive shall not flow. Any sleeve which exhibits such softness or flow of adhesive when directly exposed to the sun shall be considered unsuitable and rejected.

The performance requirements for the physical, chemical and electrical properties have to be proven by the test methods shown in the below table.

Performance Parameter	**Test method**	**Required Result**
		≥150 micron
Pull off adhesion strength to steel at 23°C	ASTM D4541	≥15 MPa
Shrink Sleeve Backing		
Sleeve Backing thickness	-	≥ 1.4 mm
Density	ASTM D792	≥0.95 gm/cc
Hardness of backing	ASTM D2240	≥55 Shore D
Shrink Sleeve Adhesive		
Sleeve adhesive thickness	-	≥ 1.6 mm

Ring and Ball Softening Point of adhesive	ASTM E-28	≥120°C
Lap Shear Strength of adhesive	ASTM D-1002	> 0.35 MPa (50 psi) @ 80°C
Peel Strength of installed sleeve at 80°C (pull rate of 10 mm/min) to pipe surface (steel) to factory coating (PE coating)	EN 12068	 > 2 N/cm > 2 N/cm
Penetration resistance @ 80°C for 24 hours	ASTM G-17	No holiday at
Impact Resistance at 23°C	EN 12068 Class C	Pass
Ultraviolet resistance	EN 12068 – Annex F	Pass
Moisture Vapor Transmission of sleeve at 38°C, 90 % RH	ASTM E-398	<0.08 gm/ 24 hrs/100 sq.in
Cathodic disbondment of installed sleeve at 80°C after 30 days	ASTM G-42	< 15 mm
Soil Stress Creep Resistance of installed sleeve at 80°C	TP-206	< 0.1 inch after 24 hours

Hot Water Immersion resistance of installed sleeve at 80°C for 120 days	ASTM D-870	No blisters or determination. No water under
Holidays Detection		Pass at 5kV/mm + 5kV

6.5.5 Coating Application

Installation of shrinkable sleeves must be done according to regulations and usual safety precautions.

Joint coating shall be carried out only by qualified staff that have been trained and certified by the manufacturer of the shrink sleeves.

6.5.6 Joint Coating Applicator and Procedure Qualification

The Contractor in presence of the Engineer shall prequalify the application procedure and each member of the joint coating application crew. Each member of the application crew shall apply coating to a minimum of three joints in the presence of the manufacturer who will certify the procedure and the applicator as acceptable for carrying out the coating application. Any joint coating or mainline coating repair applied by a team or team member that has not been qualified shall be completely removed and re-applied by a qualified team.

Procedure Qualification Testing (PQT) shall be carried out by the Contractor, of the supplied sleeves as per the requirements of ISO 21809-3 standard for PQT prior to start of construction.

Contractor shall provide factory test procedures prior to purchasing of shrink sleeve materials. In addition, test results of factory testing shall be provided for each batch of material.

6.5.7 Joint Coating Procedure

The inspectors at site shall spot check the application procedure without any limitation. Any non-compliance with the agreed procedure shall constitute reason for rejection of heat shrink sleeves and their replacement by Contractor at no cost.

The coating application sequence should be as follows:

(a) The exposed steel area and adjacent pipe coating shall be cleaned of all dust dirt, moisture, salts, grease or other contaminants, if necessary using a non-contaminant solvent, Xylene or equal.

(b) Weld area shall be thoroughly abraded to a near white metal finish, SIS SA 2 1/2 to yield an anchor pattern of 50-100 microns. Anchor pattern shall be checked using Testex Press-o-film tape. Blasting material shall be either industrial grade grit or copper slag, approved by the Engineer prior to its use at site. Sand shall not be used for blast cleaning of joints. No blasting shall be carried out if Relative Humidity is above 80 %. The line coating adjacent to the weld area shall also be sweep blasted and should be beveled to less than a 30° angle. The exposed steel and coated areas should be wiped clear of all foreign materials. Grit/slag used shall be free of any slat contaminants and shall be sieved to give the required anchor pattern.

(c) Adjacent line coating over which the shrink sleeve shall be shrunk, shall be sweep blasted to give it a rough finish. The sweep blasting shall extend 25 mm beyond the edge of the shrink sleeve.

(d) Just prior to sleeve shrinking, the surface of the blast cleaned joint steel area shall be tested for salt contamination using an Elcometer Salt contamination test instrument. The level of salt contamination on the joint steel shall not exceed 4 microgram/sq.cm. If the contamination level exceeds this value, the joint shall be cleaned with clean stilled water and re-blasted. Contamination of the blasting medium may also have to check to ensure that the 4 microgram/sq.cm level is not exceeded.

(e) After blasting and as soon as possible (within 1/2 hour of blasting), joint area shall be pre-heated to the manufacturer's recommended minimum temperature. A pyrometer shall be used to ensure that correct temperature is reached on steel and the line coating. As a minimum, pre-heating of the steel surface 5 degree C above dew points is required.

The total elapsed time between the start of blasting of any pipe bend or fitting and the heating of that pipe to the specified temperature shall not exceed the following time-humidity table:

Percent Relative Humidity	(Elapsed Time Hours)
85	0.5
80	1.0
70	1.5
60	1.75
50	2.0

Any pipe surface not processed within the above time-humidity table shall be completely re-cleaned and re-blasted before coating.

(a) The two component epoxy shall be mixed together thoroughly in the ratio recommended by the manufacturer and brush, pad, roller or airless spray applied to the bare steel surface to yield a Dry Film Thickness of minimum 150 microns. Runs, sags, or other application defects shall be removed and coating reapplied.

(b) The heat shrink sleeve shall be wrapped loosely around the pipe, centered over the epoxied weld area and evenly overlapping the adjacent pipe coating by 50 mm or more.

(c) Using a torch, the flame length shall be adjusted to approximately 500 mm to produce a yellow flame at the end. Using the yellow portion of the flame, the closure shall be heated evenly until the pattern of the fabric reinforcement is visible. The closure shall then be put down with gloved hand and any wrinkles shall be smoothened by gently working them outward from the center of the closure.

(d) A small hand roller shall be run over the closure to push out any trapped air.

(e) Using a torch heating shall start at the center of the sleeve and move circumferentially around the pipe, using a constant paintbrush motion.

(f) Heating shall be continued toward one end of the sleeve, followed by the other, starting at the shrunk down weld bead area and continue to the other end of the sleeve.

(g) Alternatively, shrinking may be started from one end and continued to the other end of the sleeve.

(h) During shrink-down, adhesive flow shall be occasionally checked with finger. Wrinkles should disappear automatically.

(i) When the sleeve has been shrunk onto the joint area and is still hot and soft, a small hand roller may be run over the sleeve to push out any trapped air. Particular attention

shall be paid to the weld and cutback area. If necessary, areas may be reheated to roll out air.

6.5.8 Inspection and Testing procedure

The inspection of the joint shall only be done after the cool down of the sleeve and the substrate to ambient temperature. The sleeve shall be visually inspected for the following points:

(a) The QC permanent change indicator shall have disappeared completely and the sleeve shall be completely smooth to the touch.

(b) The weld bead profile contour shall be visible through the sleeve.

(c) The ends of the sleeve shall be firmly bonded to the mainline coating.

(d) There shall be no upstanding edges.

(e) Adhesive flow shall be evident at both edges of sleeve.

(f) The sleeve shall be smooth; there shall not be any dimples, cold spots, bubbles, punctures, burn holes or any signs of holidays.

(g) There shall be no signs of entrapment of foreign materials in the underlying adhesive.

(h) The sleeve shall overlap the adjacent mill coating for at least 50 mm each side.

All coating material containers shall be kept in suitable cabins/rooms so as to avoid to be submitted to hot temperatures. After drawing the necessary quantities, the containers shall be immediately closed in order to avoid contamination of dirt, dust or water and solvent leaks due to evaporation. Containers shall never be opened in the presence of open flames.

6.5.9 Coating Thickness

The thickness of the cooled, field joint coating shall be checked using an approved Electrometer ultrasonic or electro-magnetic type thickness gauge. Measurements shall be made as follows:

(a) 4 readings of the installed sleeve thickness shall be taken, 1 each at the 12, 3, 6 and 9 o'clock positions of the installed shrink sleeves on the main body of the pipe away from the girth weld and the closure patch.

(b) 4 readings of the installed sleeve thickness shall be taken, 1 each at the 12, 3, 6 and 9 o'clock position, over the weld bead but not on the closure patch.

(c) The average of each of the four readings shall result in an average min. thickness of 3.25 mm and no individual reading shall be less than 3.0 mm.

If required, a weld bead filler tape may be used to achieve the required coating thickness on the weld bead.

A sleeve which does not meet the above thickness requirements shall be rejected and replaced.

6.5.10 Holiday inspection

(a) After complete cooling down, holiday inspection shall be done.

(b) Holiday inspection shall be done using a voltage setting of minimum 5 kV/mm + 5 kV with a full encirclement contact electrode for every joint.

6.5.11 Adhesion (Peel) Test

(a) One out of every 50 sleeves or alternatively one out of a two day's production (whichever is lower) shall be subjected to a manual peel test.

(b) Peel strength inspection shall be done at a sleeve temperature of up to 40° C; both the substrate and the sleeve shall be at this temperature.

(c) Strips of 25 mm x 200 mm shall be cut perpendicular to the pipe axis either at 9 or 3 o'clock positions as per DIN 30672 halfway between the circumferential weld bead and the mill coating.

(d) Manually remove the first 30-40 mm of the leading edge of the strip by using a screw-driver, make sure that the initial adhesive bond line cut is essentially centered within the adhesive layer.

(e) Attach the peel strength test gauge to the leading edge of the test strip and fasten clamp.

(f) Holding the test gauge with both hands exert a steady force with a slow pulling speed of 100 mm/min., and at an angle of 90° to the circumference of the pipe.

(g) At this point the peel strength shall be greater than 30 N/cm, and the bulk of the adhesive shall remain on the epoxied pipe.

6.5.12 Air voids

(a) Window testing can be carried out on one sleeve out of 100

(b) Window testing shall be done at a sleeve temperature of 23° c; both sleeve and substrate shall be at this temperature.

(c) On each sleeve tested, at least one window each shall be cut in the patch overlap area, across the field girth weld, and in the body of the sleeve.

(d) There shall be no evidence either of voids extending to bare metal or areas of no adhesive wetting.

(e) If any defects are found, their extent shall be determined, if necessary by removing the entire sleeve backing.

(f) The sleeve installation shall be acceptable if both of the following requirements are met:

i. The maximum dimension of voids extending to bare metal does not exceed 50 mm.

ii. At least 99 % of the metal surface is free of voids extending to bare metal.

iii. The maximum dimension of voids extending to bare epoxy does not exceed 10 cm2.

At least 97 % of the adhesive layer is free of voids and/or lack of adhesive wetting.

(a) Defective areas shall be repaired in accordance with the manufacturer recommended installation procedure.

(b) If the sleeve does not meet the acceptance criteria above, the adjacent sleeves shall be tested until acceptable installations are found on both sides of the defective installation.

(c) Normal testing frequency can then be re-established.

6.5.13 Dismantling Joints

Dismantling Joints shall be provided to enable all fittings in the form of valves, flow meters etc. to be removed without disturbing built-in pipes or any other built-in items. They shall be pressure rated in accordance with the class and type of pipes being jointed.

The nominal pressure rating shall be PN 40 and PN 25 as indicated on Drawings and in accordance with AWWA C 219.

Flanges of the valves shall be raised face type in accordance with EN 1092-2.

This work shall consist of providing, installing, testing, commissioning furnish all labor, equipment, materials, tools, supplies, fittings, nuts, bolts & washer and appurtenances required for the support, installation, and testing of Dismantling Joints at the locations shown on drawing, and all appurtenant work, for a complete and workable installation as specified herein, in accordance with the requirements of the Contract Documents in accordance with these specifications and to the layouts and details, shown on the Drawings and/or as directed by the Engineer.

The Contractor shall furnish shop drawings of all items and accessories in accordance with the General Requirements. Shop drawings shall include detailed design calculations stamped by a registered engineer, bill of materials listing all Dismantling Joints components, materials, tools, supplies, fittings, and appurtenances, etc., with manufacturer's name, trade and identification marks.

All manufactured items provided shall be new, of current manufacture, and shall be the products of reputable manufacturers specializing in the manufacture of such products; such manufacturers shall have had previous experience in such manufacture and shall, upon request of the Engineer, furnish the names of not less than 5 successful installations of comparable nature to that offered under this contract.

All combinations of manufactured equipment which are provided under these Specifications shall be entirely compatible, and the Contractor’s listed manufacturer shall be responsible for the compatible and successful operation of the various components of the unit con- forming to specified requirements. All necessary mountings and appurtenances shall be included. Dismantling Joints shall be capable of accommodating material movements due to temperature variations or differences and the angular deflections all without leakage.

Dismantling Joints shall be manufactured from the following materials:

1 Body and gland/seal ring - mild steel to BS EN 10025:1990 FE430B and coated with Non –Toxic fusion bonded epoxy.
2 Studs and tie bars shall be min. Grade 8.8, zinc plated and passivated.
3 Nuts and washers shall be min. Grade 8.8, zinc plated and passivated.
4 Seals shall be EPDM Class E to BS EN 681-1. Compatible with Potable water.

Where the Dismantling Joint has to accommodate thrust it shall be fitted with suitable adjustable tie bars to restrain any likely movement.

7 WATER SUPPLY - PIPELINE PROVIDING / LAYING & TESTING (AWWA C604)

7.1 Pipe Shipment and Transportation

7.1.1 Marking and Protection of Pipetations and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works.

7.1.2 Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than 4 pipes high or 2 pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

7.1.3 Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Additional precautions shall be taken to avoid deformation of pipes to maintain their circular cross ─section. Internal struts shall be fitted in the pipes and shall be retained in position until laying and jointing have been completed. At least two struts shall be used in each full length of pipe. They shall be adjustable in length having the ends suitably shaped.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept

at a minimum. Under no circumstance shall pipes be dropped, be allowed to strike one another, be rolled freely of dragged along the ground.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded. Under no circumstances shall pipes be dropped, be allowed to strike one another, be rolled freely or dragged along the ground.

7.1.4 Inspection of Pipes and Fittings

Transportation of pipes to Site over extremely rough terrain may give rise to a high proportion arriving damaged. Before incorporating into the pipeline each pipe shall be brushed out and carefully examined for soundless. Damaged pipes which in the opinion of the Engineer cannot be satisfactorily repaired, shall be rejected and removed from Site.

If under line test, the Engineer considers that an unacceptable proportion of the pipes within a test length has failed the Contractor may be required to test hydraulically to the Site test pressure each pipe and joint before pipe laying. In this event, test results shall be submitted to and approved by the Engineer before any further pipes are laid.

The cost of such individual pipe testing shall be borne by the Contractor.

7.2 Laying of Pipelines

7.2.1 Survey of the Pipeline Routes

The Contractor in conjunction with the Engineer will set out and agree the final pipeline route and shall undertake a detailed joint survey of the agreed route prior to the commencement of construction work. The Contractor shall submit the results of the survey to the Engineer in the form of plan and longitudinal sections drawn to a scale to be decided by the Engineer. They shall conform to the following:

(a) The length of the route shall be accurately measured and approved type chainage markers fixed at 50 m intervals and clearly marked with the chainage at that point.

(b) Using modern survey equipment approved by the Engineer, ground levels shall be taken at intervals agreed with the Engineer. Generally, a 25 m interval will be acceptable though this is to be reduced as necessary to ensure any abrupt changes in ground level are recorded.

(c) Levels shall relate to an approved datum, and permanent bench marks shall be established, clear of the proposed pipeline, at intervals along the pipeline route.

The Engineer will review the pipeline routing in plan (Horizontal arrangement), profile and amend it where necessary including any revisions to the number and positions of air valves and washouts.

At all times the route surveying shall he sufficiently ahead of excavation and pipe laying by at least one further week's work to permit the Engineer's review to be carried out and revisions to be issued to the Contractor on the pipeline between high and low points on the section under construction and the next section to be opened up for construction.

7.2.2 Earthwork

In addition to the requirements of Chapter- 1 “Earth Works”, the following sub-clauses shall apply:

7.2.2.1 Excavation

Where trenches for pipelines are constructed with vertical, sloping or stepped sides, that portion of the trench which extends from the formation level to not less than 300 mm above the crown of the pipe when laid in its correct position, shall, unless otherwise specified or ordered by the Engineer be formed with vertical sides the minimum practicable distance apart and shall be such that the distance between the side of the trench and the barrel of the pipe does not exceed 900 mm inclusive of any allowances required for temporary supports.

7.2.2.2 Backfilling

The excavation for pipelines shall be backfilled in two stages. Trench supports shall be withdrawn gradually in accordance with the progress of the fill subject at all times to the provision that such withdrawal will not prejudice the safely of the Works.

It is the Contractor's responsibility to provide suitable material for backfilling in accordance with the Specifications.

(a) First Stage

The pipe and pipe bedding (Class S) or concrete surround (if any) shall be carefully covered to a depth of 300mm above the crown of the pipe leaving the joints exposed at the Contractor's discretion. Selected fill materials with particle size not exceeding 20 mm shall be evenly placed and compacted in layers not exceeding 150 mm thick after compaction.

The layers shall be compacted by hand controlled vibration on each side of the pipe only and not over the top of the pipe.

The backfill shall be compacted to achieve not less than 95% of the modified Proctor maximum dry density as specified in B. 1377, Test 13. This work shall commence as soon as possible after pipe laying and bedding is complete in the section or length concerned. Initially Site tests shall be made to prove the effectiveness of the method of compaction and thereafter at intervals of approximately 250 m.

Concrete bedding or surround (if any) shall be at least 72 hours old before backfilling commences.

(b) Second Stage

After the section of pipeline concerned has passed the preliminary test, any holes left at exposed joints shall be filled and compacted to achieve not less than 95% maximum dry density as specified for the appropriate levels.

The remainder of the trench shall then be filled with excavated material with particle size not exceeding 100 mm evenly placed and compacted in layers not exceeding 150 mm thick after compaction. The method of compaction shall achieve not less than 95% maximum dry density as specified in BS 1377.

This work shall be commenced and completed without delay.

7.2.3 Underground Warning Tape & Fiber Optic Cable

The underground warning tape shall be colored as specified, non-adhesive film, manufactured from high grade low density polyethylene polymers (LDPE), and shall be printed with a message to warn of the presence of buried transmission lines and for Fiber optic cable conduit. The warning tape shall be installed at 600mm above the transmission lines at specified distance so that any future excavators will be aware of the cable or pipeline further below.

The warning tape shall be resistance to most soil types including alkalies and acid soils conforming to EN technical specification 12-23 issue 13, 2013.

The warning tape shall be 100-micron nominal thickness in the width of 300mm and length of each tape in one roll shall be min.350 meter. For all water pipelines, the warning tape shall be blue in color and for Fiber Optic PVC conduit, the tape shall be in green color for identification purpose. It shall be printed in English language with the words "Caution: Buried Waterline Below" for water pipeline, and "Caution: Buried Fiber Optic Cable Below" for Fiber Optic conduit.

The conduit for laying and protecting the fiber optic cables shall be high density Polyethylene (HDPE), flexible, durable and chemical resistance 75mm diameter pipe of minimum. wall thickness 4 mm. The Pipe shall be in long real lengths to reduce joints and installation time. The fibre optic of 12 core MMS/Armored 50/125 outdoor fiber cable in conduit shall be used for operation and monitoring of bulk water supply system between Pumping complex and water storage reservoir. The contractor shall provide pull boxes at equal interval as per contractor’s approved shop drawing.

The contractor shall submit samples of warning tapes, conduit, and armored cables with method statement and shop drawings for approval of the Engineer.

7.2.4 Pipe laying

Pipe shall be laid in accordance with BS PD 8010 unless otherwise specified herein.

The pipeline shall be constructed in sections with a separate full time gang working on each section. The work on the sections may proceed concurrently. The program for pipe laying shall be submitted to and be approved by the Engineer, at the start of the Contract. Any subsequent change in program shall be submitted to and approved by the Engineer, before work to a different program is started. Excavation for the pipeline in any one section shall not at any time proceed more than 5 km beyond the end of a tested, completed and backfilled length of pipeline unless otherwise approved by the Engineer. The exposed joints between test sections shall be disregarded in the above definition.

No metal tools or heavy objects shall be permitted to come into contact with the pipes or fittings. Externally coated pipe shall be handled at all times with wide nonabrasive canvas, rubber or leather belts or other equipment designed to prevent damage to the coating. The use of chains, wire slings, or any other handling equipment found to be injurious to the coating shall not be permitted. The timbers or skids used to support the coated pipe prior to lowering into the trench shall be properly padded with sufficient bags stuffed with sand or straw for the purpose of protecting the coating.

Alternatively, the pipe may be supported alongside the trench on mounds of sand. Any injury to the protective coating from any cause must be repaired before the pipes are tested. Every precaution shall be taken to prevent foreign material from entering the pipes or fittings. During laying operations, no debris, tools, cloth or other material shall be placed in the pipe. Pipes and fittings shall be lowered into the trench by crane with lifting beam suitable for the weight of the pipes and fittings, and in such a manner to ensure that the pipe is not laid in a stressed condition.

Pipes shall be laid accurately to the line and levels shown on drawings within a tolerance of ± 5mm.

Pipe alignments shall be straight except at bends or when laid to curves.

On Controlled Sections as defined in Clause 4.32 properly painted sight rails shall be supplied and erected, with boning rods of predetermined length for the boning in of individual pipes to the correct gradient. The sight rails shall be situated immediately adjacent to the line of the pipe, and there shall at no time be less than three sight rails in position on each length of pipeline under construction to any one gradient.

The Contractor may submit to the Engineer for his approval an alternative method for the control of pipe laying to the correct levels and alignment, for example: on Non-Controlled Sections as 1 m long properly graduated bubble level may be used to ensure minimum gradients and a measuring rod and cross straight edge used to determine minimum cover.

A 'badger' or 'bung' about 5 mm smaller than the internal diameter of the pipe shall be kept in the pipe of all times and pulled forward as the work progresses. When pipe laying is not in progress, including over-night, the open end of the pipeline shall be blanked off with a temporary watertight fitting approved by the Engineer. The pipe shall be suitably held down so that the pipe does not become buoyant in the event of the trench becoming flooded.

To restrict the flow of rain runoff along the trench the Contractor shall plug the trench with backfill material at distances not exceeding 250 m until the pipeline can be filled in. The plugs shall be removed when trench filling is taking place.

7.2.5 Pipe laying - Controlled and Non-Controlled Section

The criteria for the level and gradient to which pipes shall be laid are divided into two categories as follows:

'Controlled Sections' shall comprise the sections so designated on the Drawings, and such extra sections which shall be determined from the Contractor's detailed survey of the route, and approved by the Engineer.

'Non-controlled Sections' comprise the remaining sections of the pipeline where pipe gradients will normally correspond to ground slope and be subject to the following:

(a) The cover above the crown of the pipe to ground level shall normally be a minimum of 1200 except where the pipe is in a situation requiring a greater depth of cover as shown on the Drawings.

(b) The upward gradient shall be steeper than 1 in 500 with flow, or steeper than 1 in 300 against the flow;

(c) The position of high and low points shall be determined from the Contractor's detailed route survey and shall be as far apart as ground levels permit, with the depth of the pipe being increased from the minimum by as much as 500 mm to avoid high points at small undulations.

The Contractor shall ensure that the required pipe levels and gradients along 'Non-controlled Sections' comply with the above criteria. If after the route survey he considers that high or low points additional to those on the Drawings are essential the Engineer must be informed immediately. Failure to inform the Engineer of proposed variations may result in the Contractor being required to excavation to extra depths to avoid additional high points without any extra payment.

7.2.6 Pipe Laying to Curves

Lengths of line pipe laid to curves shall only be allowed where shown on the Drawings. The miter bend shall be prepared in accordance with approved shop drawings as per AWWA C208 or ASME B31.4. Pipes shall not be laid to a curve with a radius less than 130 m.

7.2.7 Indicator plates and marker posts

Precast concrete indicator plates to the dimensions indicated on the Drawing shall be installed at all sluice valves, single-air valves, double air valves, fire hydrants and washouts, with letters SV, SAV, DAV, FH, WO, respectively, indented in them. The plates shall be painted with at least two coats of all-weather plastic emulsion paint of approved colour.

Marker posts to the dimensions indicated on Drawings shall be installed at 100 m spacing along the pipe-lines installed in open country or as directed by the Engineer. Marker posts shall be painted with at least two coats of all-weather plastic emulsion paint of approved colour.

7.2.8 Tie in works between existing and new pipelines

This specification clause shall apply to any tie in works between existing operational and new pipelines which involve closing down of any main which is in service supplying water, either Raw or Treated, within the existing water supply system. It shall further apply to any new fitting that has to be inserted into an existing operational pipeline.

The Contractor shall be responsible for the execution of the works except under circumstances where the execution of the tie in operation is assumed by Engineer as mentioned under (f) below, from the date of the Engineer's instruction to perform described under (g) below. The Engineer's instruction to perform the tie in will be given at least 14 days before the date on which the tie in is to be executed.

7.2.9 Personnel

The Contractor shall ensure that at least one senior member of his field supervisory staff who has proven experience of such operations and fluent in English, Portuguese or the language of his labourers is on site throughout the whole duration of the tie in operation.

The Contractor shall also ensure that all necessary skilled artisans for the operation of all his plant are on site for the whole duration of the tie-in operation.

The Contractor shall furnish the Engineer's Representative a list of the key personnel to be involved in the tie in exercise at least 48 hours before the commencement of the exercise and shall get the Engineer's approval at least 24 hours before the commencement in respect of such personnel. To gain this approval the Engineer may require that operative is tested in the performance of his duties in the operation of the plant for which he is in attendance.

In particular this requirement shall apply to all welders, pipe cutters using either mechanical or flame cutting equipment and lifting plant operators.

The Contractor shall ensure that an adequate number of labourers are in attendance upon the site during the period of the tie in operation.

7.2.10 Pre Tie-in Works

The Contractor shall execute all works possible before the commencement of the operations which shall include:-

7.2.11 Excavation and supports to the excavation

Blinding with concrete the bottom of the excavation and (where instructed by the Engineer) immediate working areas.

Provision of any required drains a sump of adequate size from which any accumulating water is to be pumped out.

Casting of the floor of any chamber which is to be constructed around such tie-in works.

Casting of any thrust blocks or thrust walls or any other works necessary for effective execution of the tie-in works as may be required by the Engineer.

The Contractor shall complete these works at least 96 hours before the commencement of the tie-in operation or within a period that may be otherwise set by the Engineer upon issue of the Engineer's instruction to perform the tie-in works, and obtain the Engineer's approval not less than 24 hours before commencement of the tie-in operations.

7.2.12 Plant

The Contractor shall prepare a schedule of the plant which he proposes to have on site either to use, or on standby, or for emergency use and shall obtain the approval of the Engineer not less than 48 hours before the commencement of the tie-in operations.

Such Plant shall include

- Excavation plant
- Cutting equipment
- Lifting equipment
- Pumping equipment (unless a drain is provided)
- Concrete Mixer
- All tools necessary for the erection and assembly of the plant.

The Contractor shall also ensure that all plant is on site not less than 24 hours before the commencement of the tie-in operation and shall inform the Engineer who shall check the plant against the schedule as approved where he deems this necessary.

7.2.13 Actual tie-in works

The Contractor shall prepare a programme giving details of the proposed scheduling and sequencing of tie-in works necessary for minimising the interruption to the existing water supply. Approval of such programme by the Engineer shall be obtained not less than 72 hours before commencement of the tie-in operation.

The Contractor, unless relieved of the responsibility by the Client or the Engineer, shall first empty the section of the main on which the tie-in is to be made and shall ensure that the nearest air valves and washouts immediately upstream and downstream are all open and the washout dry.

Where the Contractor is relieved of this operation, which shall be notified to him by the Engineer not less than 96 hours before the tie-in operation is due to commence, he shall check that air-valves and washouts mentioned above are in the state described.

When the Engineer is also satisfied that the main is empty of water he shall verbally give the order to commence the works from which time the Contractor shall be solely responsible for the execution and completion of the tie-in works unless relieved of such responsibility by the Engineer.

In event that the Engineer directs that the required tie-in works be carried out during the night for purposes of minimising the effect of such tie-in on the Municipality consumer community, the Contractor shall make all required preparation for provision of lighting (including standby and emergency) and any other measures as the Engineer may direct.

The Contractor shall provide all the insurance normally required by the Engineer and the operating F.I.D.I.C. Condition of Contract and shall obtain an endorsement if necessary to ensure that the insurances remain valid in the event that the Engineer takes over the direction of the works.

When the Engineer is satisfied that the tie-in works are completed he shall give notice for the main to be re- commissioned, when this has been satisfactorily accomplished the Contractor shall re-deploy his staff on the Engineer's verbal instructions of completion of the tie-in.

7.3 Pipe Bedding

7.3.1 Classes of Bedding Materials

The Classes of bedding to be used are indicated below:

Classes of bedding	Description of bedding Material
A	Mass Concrete
A2	Reinforced Concrete
B	Granular material
S	Granular material (bed &surround)

Class 'B' **and Class 'S'** bedding shall be used on all pipelines unless otherwise specified

7.3.2 Material for Class A Bedding and Class A2 Bedding

The concrete to be used in Class A bedding shall be mass concrete "Class C". The concrete to be used in the reinforced concrete class A2 bedding shall Class A.

7.3.3 Construction of Class A and A2 Pipe Bedding

Before placing concrete, the pipes shall be supported near each joint with a padding of compressive material on a precast concrete block. Concrete shall not be placed until the pipes have been jointed and inspected. The concrete shall be placed to ensure full Contact with the underside of the barrel of the pipe throughout its length. Concrete shall be made discontinuous at flexible pipe joints by a diaphragm of fibre board or other compressible material of at least 20mm thickness to the full section of the concrete bed.

7.3.4 Material for Class B Bedding and Class S Bedding and Surround

The granular material shall consist of durable gravel to the approval; of the Engineer. Not more than 10% of such material shall pass a BS test sieve with 5mm apertures and all the material shall pass a BS test sieve having an aperture listed below:

Nominal internal diameter of pipe (mm)	Aperture
450 or less	14.0
525 to 750	20.0
Over 750	28.0

When ordered by the Engineer, one part of free draining sand shall be added to and well mixed with each two parts of the granular material specified above. Alternatively, where approved by the Engineer the granular material may be 'all-in' gravel mixture of similar size or comprise a layer of coarse sand on the formation covered by granular material as specified. In all cases the soluble sulphate and chloride content of the granular material shall not exceed 0.5% and 0.06% by weight respectively.

The granular class “B” bedding for lower surround shall be Class S2 and upper surround shall be Class S4 as per BS EN 1295-1 as specified in the drawing and as directed by the Engineer.

7.3.5 Construction of Class B Pipe Bedding:

Class B pipe beds shall be constructed as indicated on the drawings.

The granular material shall be evenly spread over the full width of the formation and lightly hand compacted to a level slightly higher than the level corresponding to the underside of the pipe barrel to allow for settlement of the pipe to the correct level.

Further granular material shall be placed in the trench, special care being taken to fill under the sides of the pipes to ensure full contact with the barrel of the pipe but leaving the joints exposed for a length of approx-imately 200mm on each side of the joint. The granular material shall then be compacted evenly on both sides and between the pipes to an overall thickness as shown on the Drawings and to provide a bedding angle not less than 120 degrees.

The contractor shall ensure that the material to the sides of the pipes is adequately compacted and the method of compaction used will be required to achieve not less than 95% of the maximum dry density as determined from BS 1377: Part 4.

7.3.6 Construction of Class S Pipe Bedding and Surround

Class S pipe bedding shall be constructed as indicated on the Drawings.

The granular material shall be evenly spread over the full width of the formation and lightly hand compacted to a level slightly higher than the level corresponding to the underside of the pipe barrel to allow for settlement of the pipe to the correct level.

Further granular material shall be placed in the trench, special care being taken to fill under the sides of the pipes to ensure full contact with the barrel of the pipe. The granular material shall then be compacted evenly on both sides and over the pipes to an overall thickness as shown on the Drawings.

The Contractor shall ensure that the material to the sides of pipes is adequately compacted, and the method of compaction used will be required to achieve not less than 95% of the modified Proctor maximum dry density as specified in BS 1377, Test 13.

Pipe cut-off structures as shown on the Drawings shall be constructed to limit the uninterrupted length of a granular bed to a maximum of 500 m, and the cost of this provision shall be deemed to be included in the granular bedding.

Where Cut-off structures arc not opposite pipeline markers, additional markers shall be placed opposite cut-off structures.

7.3.7 Pipework Surrounded by Concrete

When pipework is surrounded by concrete at thrust blocks, anchor blocks, road and valley crossings, etc. the pipes shall be given the normal external protection and shall be wrapped with at least two layers of waterproof paper to BS 1521, Grade BIF securely fixed with waterproof tape. The concrete Class C to be used in the pipe work surrounded by concrete.

7.3.8 Pipework Built into Concrete

The external protection to pipes built into concrete walls of chambers and structures shall extend at least 75 mm in to the wall from the concrete face.

7.3.9 Anchor Blocks

Anchor blocks or thrust blocks shall be provided at horizontal bends, vertical bends or /and intervals on pipe lines with gradients in excess of 1in 6 noted on the drawings and at other locations ordered by the |Engineer. The anchorages shall be made from concrete and constructed to the dimensions shown on the drawings. The concrete Class C to be used in the anchor blocks and thrust blocks on pipeline.

7.3.10 Flexible joints at Chambers and structures

Pipe lines entering and leaving chambers and structures shall include two flexible joints with harnessed dresser couplings at distances from the face of the chamber or structures as shown on the drawings. The contractor shall submit shop drawings for approval of the Engineer.

7.3.11 Pipelines under Existing Roads

The contractor shall program the works to reduce disruption to road traffic to a minimum, and before any work commences in existing roads shall:

(a) Obtain the full permission and approval of all authorities concerned serving notices of intent to start work as may be necessary and observing all the local laws and regulations.

(b) Submit details of proposals, and obtain approval from the Engineer. Pipe lines shall cross roads at the angles shown on drawings

The bedding and jointing shall be specified but the first stage of trench refilling shall be carried out using granular bedding material and compacted at the sides not less the 95% of the maximum dry density as determined from BS 1377: Part 4. Above this layer of Class C concrete shall be placed to bring the level of backfilling up to the underside of the road sub-base. This method of the backfilling shall extend at least 5m either side of the surfaced road carriageway.

The roadway shall be reinstated using the form of construction and material as ordered by the relevant authority.

7.3.12 Reinstatement of Roads

The replacement of the road structures shall be carried out as soon as practicable after backfilling has been completed. Suitable excavated road pavement which complies with the requirements of the Engineer may be used at the sub base levels. Compaction shall be carried out with approved mechanical equipment.

The edges of the trench shall be cut to form a uniform line consistent with the varying width of the trench and the agreed trimming allowances. Any part of the structure of the road which has been damaged beyond the width of the trench must be cut out and made good. The Engineer’s prior agreement for such additional work must be obtained before additional payment can be considered in cases where damage was beyond the contractors’ control.

A vertical joint shall be formed between the new work and the existing road surface and shall be painted with as approved by the Engineer and the base course and wearing course stepped 75mm.

The finished levels of the completed reinstatement shall confirm with the adjoining carriage surface.

Reinstatement of wearing courses shall match as nearly as practicable the colour or other characteristics of the existing surface.

Where the carriageway surface adjoining the trench is of rolled asphalt the contractor shall lay an interim wearing course of bitumen macadam 40mm thick.

At a later date, to be decided by the Engineer, the temporary wearing course may be removed and replaced with 40mm of rolled asphalt.

7.4 Hydrostatic Testing

7.4.1 General

Hydrostatic testing shall be performed on the basis of VdTUEV Leaflet 1051.

Contractor shall schedule the high pressure test sufficiently in advance and shall develop the following for approval to the Engineer:

(a) a detailed method statement, with particular reference to sectioning of line sections with which every single test is concerned, including a hydrostatic test profile and a hydrostatic test section map,

(b) a complete list of envisaged equipment, material and installations, safety measures including safety relief valves.

(c) a list of personnel charged with carrying out testing operations, including names and CV's of the responsible personnel

(d) filling and testing record forms, structure of final hydrostatic testing report.

Besides personnel, Contractor shall supply all equipment, materials, instruments and necessary installations to perform the tests including but not limited to the following:

(a) prescribed test heads

(b) provisional scraper launching and receiving traps

(c) cleaning scrapers and calibration scraper.

(d) all valves, test flanges, head, pipe fittings, safety valves, etc.

(e) pumps for filling, capable to produce high flow rate and low pressure

(f) calibrated tanks

(g) test pumps, capable to produce a pressure approx. 20% higher than that of test, with small flow rate

(h) dial gauges, recorder gauges and temperature measuring devices with high class accuracy capable to record values higher than specified test values

(i) Digital pressure calibrator

(j) communication along the pipeline routes

(k) means of transport for working, observation and supervision personnel

(l) every other installation, supply or temporary work connected with testing operations

(m) Compressor and foam scrapers for drainage of tested pipeline.

Any pressure testing activity shall only be allowed after completed civil works, welding, coating, lining and backfilling along the pipeline section to be tested.

The accuracy of measuring devices shall be in accordance with VdTUEV 1051.

In addition, all safety measures defined by the manufacturer of the internal cement mortar lining shall be observed.

7.4.2 Hydrostatic Test Sections and Test Pressures

The test pressure at the lowest point of a test section shall correspond to 1.25 times the design pressure. The design pressure is depicted in the Hydraulic Profile Drawing. The minimum test pressure shall be not less than 5 bar above maximum water level of a reservoir, if this reservoir is located at a highpoint of the pipeline. No pressure may occur (e.g. developed due to a temperature increase during testing) which exceeds 95% of the specified minimum yield strength.

The maximum length of a test section shall be 50 km.

Adjacent test sections shall be constructed without overlap but with a gap to permit a two-weld tie-in. All tie-in welds are to be tested as per this specification.

The following sections may be individually tested:

(a) major road crossings

(b) main Railway line crossings

7.4.3 Test Team Composition

Contractor shall provide at least one experienced Test Engineer to head the hydrostatic testing, assisted by one foreman. The crew shall comprise of fitters, riggers, helpers and other skilled workers to guarantee an optimal performance of the test and a high safety level.

7.4.4 Testing-Safety

Contractor will make sure that all safety measures are implemented during testing activities. He shall provide the necessary safety equipment, communication equipment, access barriers, etc.

All local and statutory authorities, residents in the vicinity of the pipeline and all personnel shall be notified of the proposed dates of testing and shall be advised of any extension.

Contractor shall issue a statement to all persons connected with testing, warning of the hazards of failure under pressure.

Safety signboards both in English and Urdu language shall be posted at appropriate locations during testing. The display shall be as follows:

“WATER TRANSMISSION MAIN – KEEP AWAY”.

Areas where test equipment is being used shall be clearly marked and entry of unauthorized persons shall not be permitted.

Before pressurization the Contractor shall put in place appropriate measures to avoid danger to personnel resulting from pipe failure under test, and any damage, disruption or pollution to land, roads, railways, waterways and any other service or installation along or close to the pipeline route.

No work shall be permitted on sections under test.

The Contractor shall provide patrols to watch special points of hazard during test, in particular road, rail and water crossings and points of public access.

All safety measures shall be described in detail in Contractor's written method statement.

7.4.5 Pipe Cleaning and inspection of CM lining

Before commencement of test water filling, the pipeline sections shall be pre-cleaned from any construction debris.

Cleaning shall be carried out before the automatic vent valves are installed. Pipe line shall be cleaned manually in sections between each automatic vent station. All drain and automatic and manual vents valves of the section to be cleaned will be opened one or two days in advance of cleaning day to drain any remaining CM lining curing water and to aerate the pipeline interior to prepare for personnel entry. Fresh air shall be blown into the pipeline by fans and large flexible hoses, before and during the period when cleaning crews are working inside the pipeline.

Internal cleaning crews shall carry emergency breathing apparatus with them. Spare breathing apparatus units shall be kept at site, and regular safety precautions shall be observed.

The pipeline interior surface shall be cleaned by using water, brooms and squeegees. The cleaning crew shall be trained and shall not take any foreign material into the pipeline.

After cleaning the final inspection of the pipeline including the CM lining shall take place. Inspection is visual and is done by inspectors walking through the entire length of the pipeline.

7.4.6 Quality of Filling Water

Water shall be fresh, clear and clean and shall be comparable to drinking water quality according to WHO standard.

Filling water for testing shall be chlorinated to a level of approximately 5 ppm.

Disinfection shall be performed during start up and line fill activities and shall be based on the guidelines of AWWA C 651 "Disinfecting Water Mains".

7.4.7 General Set-up of Pipeline Test Sections

Test water shall be filled into the pipeline in sections.

The filling and cleaning operations shall be performed through the test heads (launcher and receiver) on each test section. Test heads shall be prefabricated and welded to the test sections as per approved welding procedures. Fittings and valves used in test headers shall be of required pressure rating.

The test heads shall be designed to accommodate the required number of scrapers. One scraper shall remain in the launcher of each section for de-watering/cleaning after hydrostatic testing if so required.

Scraper discs shall be made of urethane or of other suitable material. Blades and brushes shall not be used as they may damage the CM lining.

The final type of cleaning and the system set-up shall be agreed between the Contractor and the Engineer as a part of Contractor's hydrostatic test procedure.

Pressure gauges and pressure recorders shall be installed to the test heads. All instruments shall have valid calibration certificates issued by an accredited testing laboratory.

Pressure safety device shall be installed to ensure that the pressure providing a hoop stress corresponding to 95% of the specified minimum yield strength will not be exceeded during the testing.

Automatic air vents shall be installed during testing at all distinct highpoints, but minimum one air vent per test section. For the design pressure of the automatic air vents installed during hydro-testing the hydrostatic test pressure shall be considered.

7.4.8 Calibration

Calibration is the geometrical proof that at no location or point along the pipeline the internal diameter deviates by more than 3% from the pipe diameter as recommended by AWWA M11.

If there are dents and/or ovalities detected on the calibration survey the location of the defective points shall be found and proper repair shall be carried out.

Dents and/or ovalities beyond the allowable range shall generally be cut out as a cylinder and replaced by a pipe section as described in clause 451.6.2.9 of ASME B31.4.

7.4.9 Filling

Filling shall be performed according to the procedures described below. Establish communication with receiver end

(i) A quantity of water corresponding to the capacity of 300 to 5,000 linear meters of line shall be introduced into the pipeline and then the first scraper, the cleaning scraper, shall be launched into the line. When determining the front water quantity, it shall be observed that no scraper is allowed to run on dry CM surface. A scraper speed between 500 and 1000 linear m/h shall be maintained.

(ii) A quantity of water sufficient to flush and clean the line, but not less than corresponding to a capacity of 100 linear meters of pipeline shall be introduced in order to move the cleaning scraper away from the launching trap. Next the second scraper shall be launched into the line.

(iii) After this the calibration scraper shall be launched at an appropriate distance.

(iv) Filling operation shall proceed without interruption. The above instructions aim to produce inside the pipeline the movement of a full cross section liquid mass to remove air. Movement of scrapers, flow rates, volume of water introduced, temperatures etc., shall be recorded on a special graph at the test point.

(v) The drains along the pipeline shall be opened prior to passing of the scrapers and shall be closed after the last scraper has passed. In this way it is ensured that dirt and debris is flushed out and clean water is in the drainage pipes.

(vi) The vents installed at each highpoint shall be used to release the air from the pipeline.

(vii) Filling shall continue until all scrapers have run the whole length of the line and been recovered at the temporary receiver. After completion of the hydro test the temporary test ends shall be cut out of the test sections. The recovered scrapers shall be carefully examined in order to ascertain the degree and regularity of wear of cups. The crew at the filling end has to be informed and filling shall be stopped. Blocking of one or more scrapers at any point of line shall entail suspension of filling operations. In this case Contractor shall locate the position of the blocked scraper, recover it, ascertain causes which

stopped its course and make necessary substitutions and repairs to restore the line to testing condition. These works shall be carried out in complete accordance with directions contained in the preceding paragraphs. After this, Contractor shall start filling the line again.

(viii) The dirty water which comes out in front of the filling scrapers shall be drained as per approved procedures and in accordance with local legislation and authority requirements.

(ix) Evaluation of the calibration scraper readings shall be carried out.

7.4.10 Performance of Hydrostatic Testing

Once filling has been completed, Contractor shall isolate the line from any parts which are not to be tested, and shall connect the test pump for raising the internal pressure. Moreover, he shall check conditions of pressure and temperature measuring instruments, and make sure that all preparatory operations and other installations required have been completed. In particular, dial and recording gauges shall be calibrated.

Tests shall commence not earlier than 96 hours from completion of filling so that thermal equilibrium is established between filled pipeline and soil temperature and to provide enough time for soaking of the CM lining. During this period all parameters shall be recorded continuously. For soaking purposes, a pressure of around 50% of the test pressure shall be applied.

During pressurization, the pressure and volume readings shall be recorded at an interval of 100 kPa. Digital pressure calibrator shall be used as the primary pressure measurement device and shall be connected continuously to the test section.

After the soaking period the pressure shall be increased continuously and checked by means of two gauges of which one shall be a recorder. The rate of pressurization shall be in accordance with the cement mortar lining manufacturer's requirements but shall not exceed 100 KPa per minute. At this stage the air content shall be checked in accordance with VdTUEV-leaflet 1051.

If the air content does not meet the criteria set out in VdTUEV 1051 the pressure shall be brought down to 100 kPa above static head. Air shall be vented from all available points. After repetition of pressurization the air content shall be checked again. This shall be repeated until the criteria are met. If there is no improvement, after various attempts the line might be filled again.

If the air content is less than specified in VdTUEV 1051 pressurization shall continue up to the specified test pressure at a rate of max. 50 kPa/min. and held for four hours to identify any significant pressure losses.

If no pressure drop occurs during this interval, pressure shall be lowered to 50% of test value. Then another interval of two hours shall elapse, after which the pressure shall be set again at test value and maintained constantly for a period of 24 hours. Should pressure drops occur during the above intervals the aforesaid operations shall be repeated not more than twice, after which the line shall not be considered fit for testing until Contractor has established and eliminated the cause of tightness failure.

The 24h test shall be carried out in accordance with and applying the acceptance criteria of VdTUEV leaflet 1051.

Throughout testing, pressure and temperatures are to be systematically recorded for the various schedule times (generally every 30 minutes).

In case of pipeline internal pressure is exceeding, as a result of significant thermal variations, the maximum value specified above, Contractor shall partially bleed the line so as to bring pressure back to initial test values. In such case the test shall be started again after bleeding.

Filling of water into the test section will only be allowed after interruption of the test.

The hydrostatic testing is considered successful if the pressure has remained constant during the test period with the exception of variations due to temperature differences on test water and steel pipes, compression of test water under pressure and expansion of steel pipes under pressure.

The impact of above listed variables shall be calculated based on formulae listed in VdTUEV leaflet 1051. The test shall be considered accepted if the actual final pressure at the end of the 24-hour test does not deviate from the calculated final pressure by 0.2 bar.

For conducting the hydrostatic test in line pipe as per AWWA M11, the pipeline shall be filled slowly to prevent possible water hammer, and care shall be exercised to allow all of the air to escape during the filling operation. After filling the line, a pump may be necessary to raise and maintain the desired test pressure.

The hydrostatic test pressure is usually applied for 24 hours before the test begins, principally to allow for the lining material to absorb as much water as possible. After that, the pipeline shall be carefully inspected for evidence of leakage.

In the hydrostatic testing of line pipe, the water pressure shall be raised (based on the elevation at the lowest point in the section of the line under test) to a level such that the test section is subjected to not more than 125 percent of the actual (or design) operating pressure or pipe class, whichever is the greater. The test pressure should be maintained for at least 2 hours. There should be no significant leakage in an all-welded pipeline or one that has been joined with properly installed mechanical couplings. A leakage of 10 gals (37.85 L) per in. (25.4 mm) of diameter per mile per 24 hours is usually permitted. Pinhole leaks that develop in welded joints should not be stopped by peening; instead, they should be marked for proper repair by welding. Such welding frequently can be accomplished without emptying the pipeline, providing pressure can be relieved.

If a section fails to pass the hydrostatic field test, it will be necessary to locate, uncover, and repair or replace any defective pipe, valve, joint, or fitting. The pipeline must then be retested.

7.4.11 Evaluation of Results and Final Report

Should test finally fail, Contractor will seek the cause, and in case of pipeline leakage, he will locate the defective point. The Contractor shall then effect complete repair in accordance with approved procedures and perform the necessary works in accordance with the clauses contained in this specification. On completion of repair, the Contractor shall repeat the entire hydrostatic test according to the procedures described previously.

Contractor shall prepare a report at the end of the test

This report shall be signed by the Engineer, by relevant Authorities (if any), and by the Contractor

7.4.12 De-watering after Hydro testing

Contractor's detailed program shall include whether the pipeline sections will be emptied or not.

If the pipeline section after hydro test will be emptied and/or the water used for the hydro test of the next section, the pipeline may have to be completely emptied. Where all sections of pipe are laid at a convenient altimetry, drainage may be achieved by gravity.

During drainage operations, Contractor shall take the necessary arrangements for the drained water to be suitably disposed, in order to avoid pollution, damage to crops and/or land, to existing works and obstruction to traffic. Contractor shall therefore bear in mind provisions of this point during scheduling stage of hydro tests.

If a pipeline section will be emptied, the Contractor has to ensure that cement mortar lining will not be negatively affected. Some water shall remain in the pipe to maintain humidity to avoid cracks in the cement mortar lining. The quantity of water shall be as per Contractor's detailed program, which shall be approved by SWCC and the Engineer.

At the end of testing operations, Contractor shall also remove provisional test heads as well as other temporary installations connected with the test. He shall also effect the tie-in of the pipe section to the previously tested line in accordance with the approved procedures.

7.4.13 Testing Structures on pipelines

Unless otherwise approved by the Engineer, water retaining structures on the pipelines which are not tested with the pipelines shall be separately tested in the presence of the Engineer for water tightness.

The structures shall be filled with water to ground level, the underside of the cover slab, or to give a head over the pipeline of 2 m whichever is the less. After a period to the approval of the Engineer to allow for absorption of water by the structure, there shall be no discernible loss of water over a period of 30 minutes as measures by a Vernier gauge or other approved device.

After depressurizing the test section shall be carefully emptied and the water disposed of to the Engineer's approval.

7.5 Pipeline Disinfection

7.5.1 General

The internal surfaces of all pipelines and pipework including all equipment incorporated in a pipeline or pipework through which water will pass shall be disinfected after they have been hydro tested to the satisfaction to the Engineer.

7.5.2 Disinfection Process

Disinfection of line pipe shall be performed after hydro testing as per AWWA C651 and as per method statement approved by the Engineer.

Disinfection shall be effected by filling the pipeline with water heavily dosed with chlorine, and shall be carried out when filling the pipeline with water for carrying out the hydraulic test on completion. Alternative methods may be adopted with the approval to the Engineer.

The level of chlorine dosing shall be such as specified in AWWA C651 to make available of free chlorine throughout the pipelines.

The water, heavily dosed with chlorine, shall stand in the pipeline for a period of 24 hours or for such longer period as the Engineer shall require and all valves in the system shall be operated at least once during this period.

At the termination of the required period, chlorine residual tests shall be taken at the end of the pipeline farthest from the point of injection and the test shall be repeated if necessary until the residual is less than as specified in AWWA C651.

The Contractor shall obtain the Engineer's approval to the method to be adopted for disposing of the chlorinated water and the time when such disposal shall take place on completion of disinfection.

7.5.3 Pipeline Markers

Marker Posts shall be of precast concrete Class C to the dimensions and locations shown on the Drawings, reinforced with 4 Nr 10 mm diameter high yield steel reinforcing bars tied to give 25 mm cover to each face.

Marker plates shall be 5 mm thick mild steel plate with dressed and beveled face edges engraved to a depth of 2 mm x 3 mm x 150 mm mild steel fish tail plates shall be provided bent, split and welded to the back of the plate and the whole hot dip galvanized before casting into the marker post.

7.6 Cathodic Protection System

7.6.1 Scope

This document outlines the minimum requirements for detailed design, manufacturing, supply, construction, installation, testing and commissioning of an Impressed Current Cathodic Protection System (ICCP) for pressurized water transmission pipe line.

Supply of sweet raw water shall be through MS pipe line of 84” & 52” diameter from pumping stations to reservoir located at R2-B1 near Pipri for treatment at Filtration plant.

The pipelines are to be provided passive corrosion protection externally by 3-layer Polyethylene coating (3LPE) with active corrosion protection by means of cathodic protection system.

The pipe segments will be welded together and the welding seam will be coated on site with HDPE heat shrink sleeves. The pipes shall be internally lined with cement mortar (CM) lining.

All buried pipe line shall be protected from corrosion by using impressed current type cathodic protection (ICCP) method as per guidelines set forth in applicable international codes and standards and local regulations. Any possible high voltage interference from nearby overhead lines, power cables or other HV installations in the vicinity of the pipe and structures must be considered and limited.

The Pipeline Cathodic Protection System (CPS) shall be separated from the Pumping Station and Reservoir Stations or between the pipe line sections and neighboring structures by means of insulating joints/ isolation joints. The Line Valve Stations are an integrated part of the pipeline cathodic protection system.

The number of Cathodic protection system feeder stations along the pipelines shall be optimized under consideration of low ground resistance for the anode beds and availability of electrical power supply connections.

The necessary site investigation and detailed corrosion protection survey including soil resistivity survey at every one KM and collection of data by considering all crossings /parallel structures with the proposed pipe

line shall be carried out by the contractor for detailed engineering and design. The contractor shall also prepare and submit operational maintenance manuals for approval of the Engineer.

The detailed engineering and design of impressed current cathodic protection system including fabrication and installation drawings, calculations, cable sizing, voltage drop calculations and other detailed calculations, types and quantity of anodes and anodes beds etc. as required and as per NACE International standards and code of practice for buried pipe line shall be submitted to the Engineer for approval prior to execution of work.

Implementation of sacrificial anode and ICC Cathodic Protection systems including erection by interpretation of survey data, detailed design, engineering, getting approval of survey data/ engineering documents , manufacturing, fabrication, assembly, inspection and testing at manufacturer's works as per approved documents, ,packing and delivery at site, unloading and storage at site, execution of all associated civil works, supply and installation of various equipment, inspection, field testing & commissioning as per the approved commissioning procedure, performance testing and handing over to the Employer.

Monitoring of the protection level of the pipelines and structures, interference testing & mitigation is required during post commissioning period and submission of complete documents to Employer for record.

All other materials which may be necessary but not mentioned herein specifically to complete the cathodic protection system in all respects to the best engineering practices shall be in the contractor's scope.

All associated civil, structural and electrical materials for installation of cathodic protection CP system as elaborated elsewhere.

All materials, consumables, special tools and tackle, testing instruments and machines required for execution of the work are also included in contractor's scope.

All instruments and consumables required during erection/ pre-commissioning, performance testing and monitoring shall be arranged by the contractor.

The contractor shall visit the site in order to acquaint himself with all the necessary information such as soil conditions, transportation facilities, data of similar pipelines and underground cables & cable trench/corridor in the adjacent pipe corridor, transmission line/railway line interferences, etc. for proper design and execution of the work. Ignorance of the site conditions will not be accepted as a basis of claim for any compensation whatsoever.

It is not the intent to specify herein all the details of design and manufacture. However, the equipment shall conform in all respects to high standards of design engineering and workmanship and shall be capable of performing in continuous commercial operation up to contractors' functional guarantee.

7.6.2 Codes and Standards

The design, manufacturing, construction, installation, test and commissioning of cathodic protection systems shall be in accordance with the following codes and standards, at least. The latest revision of the publication referred to shall apply.

1.	**NACE SP-0169**	Control of external corrosion on underground and submerged piping systems

2.	**NACE SP-0572**	Standard practice design, installation, operation and maintenance of impressed current deep grounded
3.	**NACE SP-0177**	Mitigation of alternating current and lightning effects on metallic structures and corrosion control systems
4.	**NACE SP-0200**	Cased steel pipeline practices
5.	**NACE Standard TM0497**	Measurement Techniques Related to criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
6.	**NACE Publication No. 54276**	Cathodic Protection Monitoring for Buried Pipelines
7.	**IS 8062**	Cathodic protection of buried pipeline/ structure for transportation of natural gas, oil and liquids-code of practice
8.	**NACE SP-0286 Standard Practice**	Electrical Isolation of Catholically Protected Pipelines
9.	**NACE SP-0187**	Design considerations For corrosion Control Of Reinforcing Steel In Concrete
10.	**DNV RP-B043**	Recommended Practice monitoring of Cathodic protection systems.
11.	**DNV RP-B401**	recommended practice cathodic protection design
12.	**NACE SP-0308**	Inspection Methods For Corrosion Evaluation Of conventionally reinforced concrete structures
13.	**BS 7361 Part 1**	cathodic protection code practice for land and marine application
14.	**IEC 61439**	Low-voltage switchgear and control gear Assemblies
15.	**IEC 60529**	Degrees of protection provided by enclosures (IP code)
16.	**IEC 60989**	Separating transformers, autotransformers, variable transformers and reactors

17.	**IEC 61558**	Safety of power transformers
18	--	latest international practices, acts and regulations.

As far as the power supply authority and permits of other authorities require additional codes and standards, respectively impose additional requirements, these are also part of the contract. For crossings and parallel routing with foreign pipeline their particular requirements and standards shall be considered.

7.6.3 Environmental Conditions

7.6.3.1 Design Requirements

All components of the cathodic protection systems shall be designed and constructed for continuous operation at full load under the local climatic and environmental conditions.

The impressed current cathodic protection systems shall be designed to provide sufficient current to achieve an “OFF” potential over the equipment and/or material to be protected, equal to or more negative than -1 V (measured against a Cu/CuSO4 reference electrode). “OFF” potentials with a value more negative than - 1.5 V should be avoided.

For calculations of the permanent CP system, the current density value shall be considered, according to the respective system:

7.6.3.2 Cathodic Protection

i. A current density of 0.015 mA/m^2 shall be considered. b) Local Cathodic Protection

ii. A current density of 1 mA/m2 shall be considered for coated, reinforced concrete foundations with foundation earthing.

iii. A current density of 100 mA/m2 shall be considered for copper earthing electrodes in soil.

In all cases, DC current rating of transformer rectifier is considered to be 1.5 times greater than the actual design current. Special care is required to avoid any negative influence from CP installations to other existing pipes or foreign installations and vice versa. Also the possible high voltage interference from overhead lines, power cables or other HV installations in the vicinity of the new pipes and structures must be considered and limited.

The pipeline cathodic protection systems shall be separated from the station cathodic protection systems by means of isolation couplings, the line valve stations are an integrated part of the pipeline cathodic protection.

The transition from CML to FBE lining shall be a certain distance upstream of the isolation coupling as CML would bridge the isolation and lead to a faulty and inactive CP system at the pipeline section.

The design life of system shall be minimum twenty five (25) years.

The specifications for equipment given in this document are those preferred by the Engineer. In the event that the Contractor, after carrying out final design, proposes to use other equipment, he shall detail the differences between his recommended equipment and the equipment given herein and such different equipment may only be used on the written approval of the Engineer.

Suitable measures as per national / international practice will be taken to mitigate any interference current and cross currents from any source.

Special protection shall be provided at cased-crossing (Road-crossing/ Rail crossing etc.). Additional sacrificial anodes for casings/ carrier pipes within casings shall be provided by the contractor

The design, installation, and testing of cathodic protection systems shall be performed by well experienced and approved company having core team of renowned NACE certified CP specialists with diversified and rich experience in water, oil and gas sector not less than 20 years in system design, installation and commissioning of CP system for pipe lines.

7.6.4 Cathodic Protection of Pipeline

The cathodic protection systems of pipelines made out of welded steel pipes shall mainly consist of cathodic protection feeder stations, test stations, bonding stations and devices for mitigation of high voltage interference.

Each cathodic protection feeder station includes the following main parts:

(i) Rectifier unit,

(ii) Anode ground bed,

(iii) Minus connection on pipe,

(iv) Potential measuring connection on pipe (including reference electrode),

(v) Current measuring connection on pipe,

(vi) Cable connections,

(vii) Surge protection, polarization cells, etc.

The rectifier units shall be placed within station areas with power supply, preferably. The locations and the distances between the cathodic protection feeder stations (lengths of cathodic protection sections) are subject of a respective calculation during detail design.

The kind of anode ground bed per cathodic protection feeder station (horizontal or deep well) shall be selected according to the soil resistivity and possible land acquisition.

The current measuring connection shall be performed at the downstream side of negative connection. Measuring connections and negative connections on pipe must be installed in a distance of minimum 1 m.

Test stations shall be located as follows:

(i) At isolation couplings,

(ii) At foreign line crossings or parallelism with foreign lines,

(iii) At crossings of large roads,

(iv) At crossings of above ground and underground railways,

(v) At locations of steel cases.

Wherever there are not already located one of the above mentioned test stations, potential test stations shall be installed all 1.5 to 2 km. From these potential test stations each fifth or sixth test station will be a current test point. All test stations shall be easy accessible from existing roads, ways, etc. A placement of test stations in the middle of fields or other agricultural useable areas shall be avoided.

7.6.4.1 Survey

The Contractor shall carry out a complete survey along the pipeline routes and at stations to be cathodically protected and shall prepare the respective reports which are subject to Engineer's approval.

The main purpose of the site survey is to inspect and investigate the selected pipeline route, to make detailed soil resistivity measurements and to identify special points, foreign lines, crossings, HV installations and other existing particularities, which may have any impact for the design of the cathodic protection system. A further purpose is the pre-selection of possible ground bed and rectifier locations. Third party systems being under construction shall be considered in the report. It is necessary to perform the site survey before commencement of the pipeline or station construction works on the original terrain.

7.6.4.2 Soil Resistivity

The soil resistivity, apart from other factors such as pH, chloride and sulphide ion concentrations, soil acidity and anaerobic bacteria, is the most important and easy to measure representation of the soil corrosiveness. It must be noted that the soil resistivity varies as a function of moisture content and temperature, therefore it is important to record the environmental conditions during the measurement session. Soil resistivity measurements shall be taken at the following locations:

(i) at 1 km intervals along the pipeline route,

(ii) at intermediate location between two points when results show change of classification,

(iii) at areas where visual observation indicates a change of ground conditions,

(iv) at station areas,

(v) at possible location of anode beds,

(vi) at all other locations deemed necessary by the Contractor.

For the soil resistivity measurements, the Wenner four-pin method shall be used, preferably for shallow ground bed while Geonics EM-34 is suitable for Deep Ground Bed The measurements along pipes shall be carried out with a pin spacing about the pipe depth, half the pipe depth and twice the pipe depth. For horizontal ground beds the soil resistivity is to be measured at a depth of 1.5 m, 3 m and 6 m at minimum 4 points along the ground bed location.

Soil resistivity measurements for deep well anode ground beds shall be performed from ground level down to 100 m in steps of 5 to 10 m. In addition to the recording of the soil resistivity at each chosen location, the following information have to be recorded:

(i) date of measurement,

(ii) method, instrument assembly,

(iii) name of technician,

(iv) ground conditions,

(v) weather conditions,

(vi) other particular remarks or findings.

The soil resistivity measurement results shall be part of the survey report, to be presented in tabulated form and in a resistivity profile together with the aggressiveness determination and all other details.

7.6.4.3 Investigation of High Voltage Installations

The pipeline routes cross high voltage overhead lines with voltages of 110 kV and above or run in parallel to these overhead lines. The Contractor shall investigate the locations and the data of these overhead lines (proximity less than 1000 m). Based on this investigation the Contractor shall prepare a detailed survey and investigation report which must also include the high voltage interference calculation.

Further, the report must contain the description of the required measures and protective devices in order to reduce the interference voltage below the allowed limits. Long term as well as short term interference shall be considered and all measures must be provided to reduce the induced voltages to safe values. For long term interference the induced voltage must be below 4 VAC.

7.6.4.4 Neighbouring Lines and Structures

Cathodic protection systems applied to buried metallic pipes or structures might cause direct current flow in neighboring lines or structures, which could result in increase of the corrosion rate of those neighboring pipes and/or structures if they are unprotected or their protection potential is less negative. Special care is required in order to minimize these stray current effect. The Contractor must investigate all neighboring pipes and structures in the near vicinity of the new installations and if the foreign installations will be influenced or the foreign installation will influence the new system. It is the responsibility of Contractor to notify all owners of neighboring structures and to gather all requested information. The results of the investigations as also the notification and all proposed measures must be part of an interference report. All remedial measures, if already considered during design or required additionally after execution of the interaction tests must be coordinated with the respective owners/operators of the neighboring structures.

7.6.4.5 Cathodic Protection Controller

CPC shall be designed and manufactured for industrial “Off-Grid” application with an operational life expectancy of >25 years without maintenance.

Suitable for non-hazardous location supplied with an independent enclosure suitable for IP-66, Painted Steel, lockable enclosure with detachable gland plate on the bottom edge for cable entry.

System controller shall be independently adjustable constant current, constant potential and constant voltage parameters. GPS synchronizable and adjustable current interruption from 0.1 second to 99.0 seconds. Should be supplied calibrated to the battery bank. Capable of steeples output control from zero to 100%.

Alarms and monitoring facilities shall be provided minimum for the following: Low/High Current, Low Voltage etc.

Communication shall be USB RS-232 supplied complete with all required cables, conduits, conduit adaptors, crimp connectors, cable ties and cable labeling.

Circuit breakers for input/output DC cables and all incoming/outgoing cable shall be via appropriate glands and all connections within the enclosure shall be via clearly labeled DIN rail-mounted terminals.

7.6.5 Measurement and Payment

7.6.5.1 Pipes and Fitting

All pipes and pipe fittings shall be supplied by the Contractor.

(i) Construction of pipelines and pipe fittings unless otherwise specified, shall be measured by length of single pipes, laid as specified including fittings up to 22.5 degree bends. The rate shall be inclusive of all pipe and pipe fitting material grade X-42, cutting, beveling, laying, welding and jointing, welding procedure specification, welder's qualification test, testing of welding joints, outside protective 3 LPE coating, 13mm internal cement mortar lining shop applied and all manufacturing costs including any taxes, and transportation from the place of manufacture to the Site. It shall not include excavation in all materials, to the maximum bottom width of trench permitted under the Specification up to the required depth, dewatering the trench where necessary, the provision and placing of suitable material for backfilling of pipe trench as specified but include hydrostatic testing and sterilization of the pipeline. The cutting of pipes to form bevel joints in pipes, and articulation pieces or as otherwise dictated by the Works shall also be allowed for within this rate. For pipelines laid above ground the rates shall not include for excavation in all materials including rock for the pipe line and supports. The rates shall include for the laying, jointing and welding of Pipes and pipe fittings at pipe supports, the provision and installation of all materials for the supports including straps, bolts and nuts, saddles, bituminous paint etc. The rates shall also include external joint coating by shrinkage sleeves as per DIN 30672 and internal joints by cement mortar lining as per AWWA C602.

(ii) Pipe fittings, such as, bends, elbows and reducers in pipelines (more than 22.5 degree), tees with flanges and blank flanges shall only be measured by numbers supplied according to type and size. Installation shall be included in the rate for laying of type of pipes fittings except as otherwise stated. The rates include pipe fitting materials, fabrication of miter bends and fittings as per approved shop drawings include cutting, beveling, laying and jointing in trenches, testing of welding joints external shrinkage sleeves at coating and inside cement hydro testing.

(iii) Valves, flow meters, taps, dismantling joints and similar items in pipelines shall be measured by number supplied according to specified type, materials and size. Installation shall be included in the rate of laying of pipes and fittings except as otherwise stated in accordance with the approved Drawings or directions of the Engineer. The unit rates tendered shall be deemed to be inclusive of but not limited to the following:

Providing, installing, comprising mainly their support structure, all fixing & installation accessories including bolts, nuts, washers, gasket, fittings, and leveling materials;

(a) All sorts of transportation involved in the process

(b) All sorts of wastages

(c) Carrying out designs and preparing shop drawings

(d) Carrying out all sampling and testing

(e) All other operations, procedures and requirements necessary to complete the work in accordance with these specifications

7.6.5.2 Cathodic Protection

1 The detailed design report for the requirement of Cathodic protection system for MS pipe lines complete, including, carrying out required corrosion survey, Soil resistivity survey at every 1 km and collection of data by considering all crossings/ parallel structures and pipeline, overhead high tension line with the proposed pipeline for design and engineering ICC CP system including fabrication/ installation drawings, cable sizing, voltage drop calculation, test station and other detail calculations as required and as per NACE International standards code of Practice for buried pipeline and structures to the satisfaction and approval of the Engineer.

2 Implementation of Impressed Current Cathodic Protection System (ICCP) including erection by interpretation of survey data ,detailed design engineering, manufacturing & fabrication , assembly, inspection and testing at manufacturer's work as per approved document, proper packing and delivery at site, proper storage, execution of all associated civil works, supply and installation of required number of anode beds with anodes and with canister and backfill material, anode junction box/cathode junction per TR unit, Transformer rectifier unit (TRU), Cabling and Cable connections to pipeline, Surge diverters, insulating/ isolation joints etc. as per approved detailed design and engineering of CP system, inspection, field testing, commissioning as per the approved commissioning procedures and performance testing and submission of O&M manual to the satisfaction and approval of the Engineer. Temporary Sacrificial CP system is required only for the construction phase and there shall be no separate payment for temporary sacrificial CP system and its cost is deemed to be included in relevant B.O.Q item.

7.7 References

The following standards are applicable to the quality control and test procedures:

1. ASTM C 29 : Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregates
2. ASTM C 40 : Standard Test Method for Organic Impurities in Fine Aggregates for Concretes
3. ASTM C 88 : Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
4. ASTM C 117 : Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
5. ASTM C 128 : Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
6. ASTM C 136 : Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
7. ASTM C 142 : Standard Test Method for Clay Lumps and Friable Particles in Aggregates
8. ASTM C 150 : Standard Specification for Flow Table for Use in the Test of Hydraulic Cement
9. ASTM C 289 : Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
10. ASTM C 490 : Standard Practice for Use of Apparatus for the Determination of Length Changes of Hardened Cement Paste, Mortar, and Concrete

11. ASTM C 1240 : Standard Specification for Silica Fume Used in Cementitious Mixtures
12. BS EN 1744-1: Tests for chemical properties of aggregates. Chemical analysis
13. BS 1881, Part 124 : Testing Concrete. Method for Analysis of Hardened Concrete
14. BS EN 480-1 : Admixtures for concrete, mortar and grout.

    Test methods. Reference concrete and reference mortar for testing
15. BS EN 480-2 : Admixtures for concrete, mortar and grout - Test methods – Determination of setting time
16. BS EN 480-4 : Admixtures for concrete, mortar and grout – Test methods – Determination of bleeding of concrete
17. BS EN 480-5 : Admixtures for concrete, mortar and grout – Test methods – Determination of capillary absorption
18. BS EN 480-6 : Admixtures for concrete, mortar and grout – Test methods – Infrared analysis
19. BS EN 480-8 : Admixtures for concrete, mortar and grout.

    Test methods. Determination of the conventional dry material content
20. BS EN 480-10 : Admixtures for concrete, mortar and grout. Test methods. Determination of water soluble chloride content
21. BS EN 480-11: Admixtures for concrete, mortar and grout – Test methods – Determination of air void characteristics in hardened concrete
22. BS EN 480-12: Admixtures for concrete, mortar and grout - Test methods Determination of the alkali content of admixtures
23. BS EN 934: Admixtures for concrete, mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labelling
24. BS EN 934-6: Admixtures for concrete, mortar and grout – Sampling, conformity control and evaluation of conformity
25. BS EN 12350: Testing fresh concrete
26. BS EN 12390 : Testing hardened concrete
27. BS EN 12504: Testing Concrete in Structures
28. BS EN 13791: Assessment of in-situ compressive strength in structures and precast concrete components
29. BS EN 196-1 : Methods of Testing Cement, Part 1 – Determination of Strength
30. AASHTO T 277: Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride

8 MECHANICAL WORKS - VALVES

8.1 Gate Valves (High Pressure Type)

Gate valves of PN40 and PN25 shall be steel wedge type complying with BS 1414.The pressure/temperature rating shall be in accordance with Table PE-1 of BS 1560: Part 2.

The wedge shall be plain solid wedge type. Shell materials shall be selected from those listed in Table PE-1 of BS 1560: Part 2.

Trim materials, except the stem shall be bronze to BS 1499-LG2 as listed in Table-2 of BS 1414.The stem shall be stainless steel of 18-8 Ti as listed in Table 2 of BS 1414.

Flanged ends shall be raised face type complying with EN 1092 and Butt welded ends shall be in accordance with Clause 8.7 of BS 1414.

Operation shall be by hand wheel or square head and tee key as shown on the Drawings.

One body tapping shall be provided in the bottom of the valve in accordance with Clause 8.9 of BS 1414 for drainage. Tapings shall be provided with plugs. A valve by-pass shall be provided in accordance with Clause 17.2 of BS 1414. The materials of the by-pass shall be at least of the same standard as those specified for the main valve.

8.2 Check Valves (High Pressure Type)

Check valves of PN40 and PN25 shall be piston type horizontal flow valves complying with BS 1868. They shall be designed for rapid closing, without slamming, on cessation of forward flow. The pressure/temperature rating shall be in accordance with Table PE-1 in BS 1560: Part 2.

Shell materials shall be from those listed in Table PE-1 of BS 1560: Part 2 and the trim material shall be bronze to BS 1400 - LG2 as listed in Table 2 of BS 1868.

Flanged ends shall be raised face type complying with EN 1092. Butt welded ends shall be in accordance with Section 8 of BS 1868.

The valves shall be provided with an equalizer. One body tapping shall be provided in the bottom of the valve in accordance with Clause 8.10 of BS 1808 for drainage. Tapping shall be provided with plugs.

8.3 Butterfly Valves

Butterfly valves of PN40 and PN 25 shall be of the double flanged droplight closure offset, rubber sealed type generally in accordance with AWWA, C 504.

Double flanged butterfly valves made of ductile iron EN-GJS-450 material, designed to BS 5155, with a polyurethane coating (thickness 80 µm, color: RAL 5002), standard epoxy coating , allowing for Operating Pressures of 25 bar with options for higher velocities and various actuator/valve combinations. Manual actuation is available via manual gearboxes key & Labour.

Valves seats shall be gunmetal to BS 1400 secured to the valve body by corrosion resistant screws.

Bypass valves and air release plugs shall be fitted on all valves of 200mm or larger. Valves shall be designed for watertight and airtight shut off and shall be suitable for mounting in any position.

Valves shall be mounted with shafts horizontal unless otherwise specified or shown on the drawings. Manually operated valves over 350mm bore shall be provide with hand wheels and bevel gearing. All valves shall be fitted with indicators to show the position of the disc.

In general, the material of construction chosen shall be corrosion resistant to the source water referred to in the specification. All bolts, nuts and other fixings which will be in contact with the flow or with the ground, shall be of stainless steel.

Valves shall be suitable for frequent operation as well as for operation after long periods of idealness in any position.

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 designed so as to allow the valve disc to close to an angle normal to the axis of the pipe. Adjustable mechanical stops shall be provided to prevent over travel of the valve disc. The stops, shaft, and disc fixing shall be capable of absorbing full operating torque, with a minimum design safety factor of five.

The shaft shall be made of stainless steel. Shafts seals shall be nitrite rubber O-ring type. Packing shall be either rubber O-ring or self –adjusting chevron type.

Finished edges of seal retention members shall fit closely and the surface shall lie smooth, with all fastenings set flush in the water passage to minimize flow resistance.

Valves Seats which extend over the face of the flanges to secure the seal in place will not be acceptable. Each valve shall be tested in accordance with the requirements of BS 5155, for body test, seat test and disc strength test. Seats tests shall be carried out in each direction and the valve shall be drop tight. Disc strength tests shall also be carried out in each direction.

Valves of 600mm and above shall be metal faced. It shall be possible to adjust the seat clearance to obtain as near a watertight condition as possible, without the need to remove the valve body from the pipework in which it is fitted. The valves shall have metal to metal seating. Body mounted replaceable stainless steel face rings shall be fitted and disc rims shall be hard metal plated where they contact the face rings.

Unless otherwise provided for, valves shall be rated to 25 bar working pressure with the bodies capable of withstanding a test pressure of 1.5 times of working pressure and the seat 25 bar without leaking.

Bypass for valves 400mm diameter shall be provided with integral by pass as follows with the approval of the Engineer:

DN 400: 50mm dia. By pass

DN 600: 80mm dia. By pass

DN 800: 100mm dia. By pass

8.4 Ball / Plunger Valves

Ball valves shall be of the full-bore asymmetric split-body type. The ball shall be trunnion mounted. Valves shall comply with BS ISO 7121 / EN 1983:2013.

The line valve bore shall have a diameter as to meet the inside diameter of the adjoining pipework.

End flanges shall be cast or forged integral with the body shall comply BS EN 1092.

The valve body shall be of cast Iron or better and incorporate a drain tapping complete with drain tap. The ball shall be forged steel ASTM A 105 with chrome or nickel plated surface finish.

Internal wetted valve parts shall be protected with a fusion bonded epoxy coating system suitable for potable water; other parts shall be of stainless steel AISI 304 or better. The internal bore of the ball valve shall be chromium plated.

The nominal pressure rating shall be PN 25 and PN 40 having diameter of DN100, DN150, DN 200, DN 250, DN 300, DN 400, and DN 600 or as indicated on drawings.

The design shall be such that the stem shall not be capable of ejecting whilst under pressure. Except for valves below 50mm, glands shall be of the one piece bushed or two-pieced self-aligning type.

Body seal ring assemblies shall be designed to be renewable. Ball ports shall be cylindrical. Valves shall be operated by hand wheels, wrench or actuator and arranged for clockwise closure. Maximum force required to open/close valve shall not exceed 350N.

Valve seals shall be designed for minimal maintenance. Where valves are very infrequently operated (pipeline isolation applications), seal life shall be similar to the design life of the valve as a whole.

Hand wheels shall be marked to show direction of closing. Valves arranged for manual control shall incorporate a valve position indicator.

Stops shall be provided at both the fully open and fully close position.

Ball valves shall be designed when open to permit the free passage of pipeline scraper equipment.

The sealing between ball and body at both sides of the valve shall be accomplished by elastomeric material suitable for the medium being shut-off.

Designs with seal greases will not be acceptable.

The seal surface shall be perfectly spherical and lapped. Chromium plating shall be perfectly applied and the Contractor will be responsible for any spalling.

The sealing between the stem and the cover shall be accomplished by means of O-rings, neck bushing and additional secondary sealant or equivalent. The O-rings shall be of a material suitable for the pressure and the temperature.

8.5 Air Release Valves

Air release valves shall be designed to meet the following conditions and complying with AWWA C512.

(a) Discharge air during charging of the pipeline.

(b) Admit air during emptying of the pipe.

(c) Discharge air accumulated at local peaks along the pipeline under normal operating conditions.

Conditions (a) and (b) shall be met by the employment of a large orifice capable of handling large volumes of air at a high flow rate, and condition (c) by a small orifice capable of discharging small quantities of air as they accumulate.

Valves with air intake or exhaust facilities shall have approved screening arrangements to prevent the ingress of air borne sand.

A float consisting double body, double orifce air release valves with isolation valves made ductile iron EN-GJS-450 material, designed to AWWA C512 (14), with nominal pressures and a maximum permissible pressure of 25 bar. Includes packing, key, and labor.

8.6 Double Acting Air Valves

These shall combine both large and small orifices within one valve. The large orifice shall be sealed by a buoyant rigid ball and the chamber housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. The small orifice shall be sealed by a buoyant ball al all pressures above atmospheric except when air accumulates in the valve chamber.

The nominal pressure rating shall be PN40 and PN25 having diameter of DN 50, DN 100 and DN 150 as indicated on Drawings.

Flanges shall be raised face type complying with EN 1092.

Each valve shall be provided with its own isolating gate valve, which will permit the removal of the entire valve whilst the pipeline is 'live'.

Valves shall be factory finished with a two-pack epoxy paint system to the approval of the Engineer.

8.7 Non Slam Air Valve

Non Slam air valves shall be designed in compliance to the requirements given in section 4 of EN 1074-4 to prevent water hammer from occurring:

(a) When column separation occurs the large orifice introduces large quantities of air into the vacuum bubble and reduces the sub-atmospheric pressure.

(b) When the water columns change direction and start moving back towards collision, air is exhausted rapidly through the air valve, creating a differential pressure higher than 1.0 meter across the Air Valve orifice.

(c) The Non Slam first stage partially closes the air outlet, allow only a slow discharge of air entrapped in the pipe. This air pockets dampens the velocity of approaching water columns, and acts as a shock absorber that prevents water hammer.

Non Slam air valves shall consist of a cast iron body which shall be coated with blue color polyester resins. The floating lever shall be a sphere of stainless steel and materials of elastomeric sealing rings shall comply with the requirements of EN 681-1. The contractor shall submit certificates in conformity to EN 10204 and material of air valve that are in contact with water shall be of sufficient resistance against corrosion and

ageing. The mechanical strength and resistance against internal pressure of the shells and also other pressure containing components shall be according to section 5.1.1 and Annex A of EN 1074 -1. The resistance to disinfection products shall be according to section 5.4 and Annex E of EN 1074 -1.

The nominal pressure rating shall be PN 25 and PN 40 having diameter of DN 100 as indicated on Drawings.

The air valves shall be designed for a service temperature range of 0°C up to 60 °C and a storage temperature range of -20 °C up to 70 °C.

The design of the air valves shall ensure a safety factor against short and long term rupture.

Flanges of the valves shall be in accordance with EN 1092-2.

The air valves shall be designed for maximum water velocities of 5m/sec with PN 25 in accordance with table 2 of EN 1074-1 and performance requirements shall be in accordance with section 5 of EN 1074 -4.

The marking on Non Slam air valve shall be according to section 7 of EN 1074-4.

8.8 Washouts

The design and locations of washout are shown on the Drawings. Exact positioning shall be determined with regard to topography and be to the approval of the Engineer. At least 3m of the washout pipework, inclusive for the isolating valve, measured from the Centre line of the pipeline shall be laid at the same time as the pipeline and suitably capped to prevent ingress of foreign material. The minimum gradient for the washout pipework shall be 1 in 100.

Washout pipework shall be steel complying with API 5L Specification for line pipe, Grade X-42, having an outside diameter and minimum wall thickness as shown on the drawings.

The pipe shall be protected externally in accordance with Clause 4.17.

8.9 Flow Meters

For bulk flow meters for diameters greater than 150 mm, they shall be inclined in-line turbine type meters to BS 5728 / mechanical flow meter or equivalent, suitable for installation in horizontal or vertical mains. Each meter shall have a register calibrated in cubic metres, with straight reading counters. They shall be capable of measuring accurately +/- 2.5%. For diameters of 150 mm and less, and if so specified, then a combination water meter shall be provided so as to give an accuracy of +/- 2.0%. All meters shall be supplied complete with a removable strainer, and if so indicated on the Drawings with extended registers of the nearest but shorter standard length to that indicated.

End flanges shall be drilled to BS 4504 NP10 or equivalent and shall be supplied complete with flange gaskets, bolts, nuts and washers.

8.10 Fittings of Valves

The Contractor shall take delivery of any fittings and valves required at the Works not less than 96 hours before the commencement of the tie in operations. He shall provide all the necessary watching to ensure that such fittings do not get misplaced or stolen. The Contractor shall, check the suitability of such fittings including checking of all dimensions, particularly the external diameter of the pipe into which the connection is being made and the internal diameter(s) of couplings which are to be used for such connection. This shall be done by measuring diameter at 4 positions to a tolerance of 0.25 mm. The Contractor shall certify

the suitability of such materials to Engineer not less than 48 hours before the commencement of tie-in operations.

The Contractor shall prepare a schedule of fittings including those on existing pipes that are to be used for such tie-in or redeployed elsewhere as instructed on the drawings and shall obtain approval of the Engineer not less than 48 hours before the commencement of tie in operations of such schedule.

The Contractor shall ensure that all materials are at the site of the works not less than 24 hours before the commencement of the tie-in operation and shall inform the Engineer who shall check the materials against the schedule as approved where he deems this necessary

Any non-standard fittings which are required for the execution of the tie-in works shall be fabricated under the Engineer's supervision and shall be hydro statically tested to at least one and a half times the maximum working pressure.