Project Implementation Unit (PIU), KWSSIP, Karachi Water and Sewerage Corporation (KW&SC)

Project Number: P171422

K-IV Augmentation Works

Laying of MS Pipelines for:

Lot 1: 72-inch diameter MS pipeline, approximately 28 km from Reservoir 1 to Y-Junction

Lot 2: 96-inch diameter MS pipeline, approximately 24.5 km from Reservoir 2 to Sir Syed University near NIPA.

Lot 3: 72-inch diameter MS pipeline, approximately 12.5 km from Hassan Square to Gul Bai.

Lot 4: 72-inch diameter MS pipeline, approximately 29 km from Reservoir 3 to Banaras Chowk

Bidding Documents
VOLUME 3 OF 4 – TECHNICAL SPECIFICATIONS

Issued on: 10 August 2026

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PART – I

SPECIAL PROVISIONS

CHAPTER 1 – SPECIAL PROVISIONS

SP-01 THE SITE

1.10 Background and Location of the Works

Karachi, a megacity, is Pakistan's premier Industrial and Financial center, and the economic capital of Pakistan. With its two seaports, the City handles about 95% of Pakistan's foreign trade. Ranked among the ten largest cities globally, Karachi continues to experience rapid population growth, with a significant portion of its residents settling in informal settlements (Katchi Abadis). At the same time, Karachi is expanding horizontally and vertically, accompanied by a rapid and often unregulated proliferation of commercial developments.

With rapid population growth, Karachi 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 Karachi Water and Sewerage Corporation (KW&SC)'s 1.1 million customers get water through the piped network on an irregular basis, and some just 2-4 hours every other day.

KW&SC 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, and pressurized transmission pipelines.

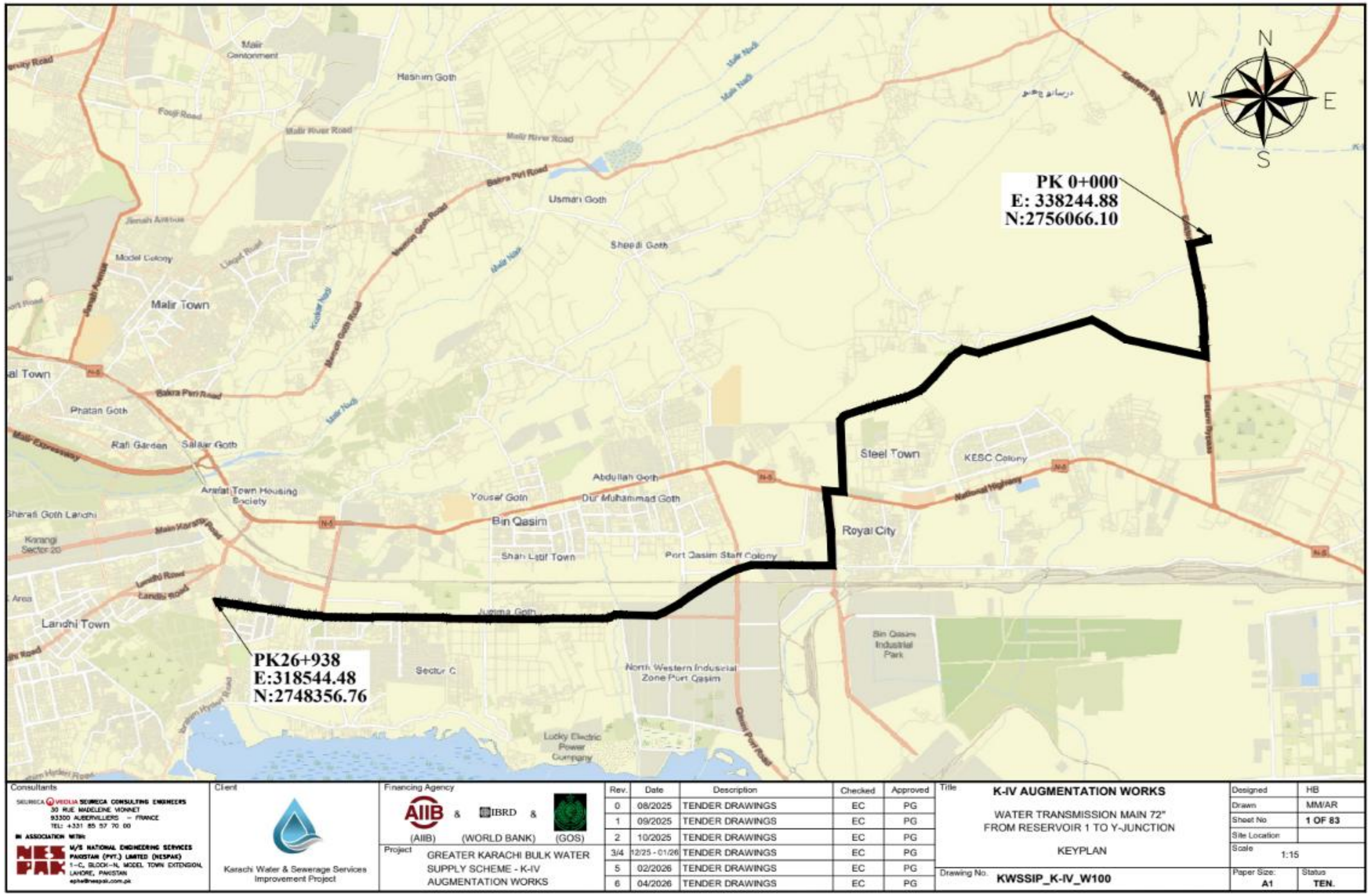
To overcome the existing water shortage, competent authorities have planned to provide additional 650 MGD water to Karachi from Keenjhar Lake. As a first phase of this project 260 MGD water is to be supplied to Karachi. This project commonly known as K-IV main project has been designed by M/s Techno 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).

Scope of this contract involves the interconnection of these water treatment plants to the existing water network, significantly improving water supply by up to 260MGD, in water deficient areas of Karachi. This project is known as K-IV Augmentation Works. The project has been divided into four lots: Lot1 from R1 to Y-junction, Lot 2 from R2 to SSU, Lot 3 from Hasan Square to Gul Bai and Lot 4 from R3 to Banaras Chowk.

Package Descriptions

Lot 1: Reservoir 1 to Y-Junction

- Scope: Laying of a 72-inch diameter mild steel (MS) pipeline.
- Pipe Specifications: X-42 grade steel with 12.7 mm wall thickness.
- Length: Approximately 28 km.
- Purpose: Conveyance of 65 MGD of treated water to Y-Junction.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Steel Town
KESC Colony
Royal City
Bin Qasim
Landhi Town
Shah Latif Town
Port Qasim Staff Colony
Bin Qasim Industrial Park
North Western Industrial Zone Port Qasim
Sector C
Lucky Electric Power Company
Abdullah Goth
Yousaf Goth
Usmani Goth
Hashim Goth
National Highway
Eastern Bypass
Bakra Pirri Road
Malir River Road
Consultants
SEURECA CONSULTING ENGINEERS
IN ASSOCIATION WITH:
M/S NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED (NESPAK)
Client
Karachi Water & Sewerage Services Improvement Project
Financing Agency
AIIB & IBRD &
(AIIB) (WORLD BANK) (GOS)
Project
GREATER KARACHI BULK WATER SUPPLY SCHEME - K-IV AUGMENTATION WORKS
Rev. Date Description Checked Approved
0 08/2025 TENDER DRAWINGS EC PG
1 09/2025 TENDER DRAWINGS EC PG
2 10/2025 TENDER DRAWINGS EC PG
3/4 12/25 - 01/26 TENDER DRAWINGS EC PG
5 02/2026 TENDER DRAWINGS EC PG
6 04/2026 TENDER DRAWINGS EC PG
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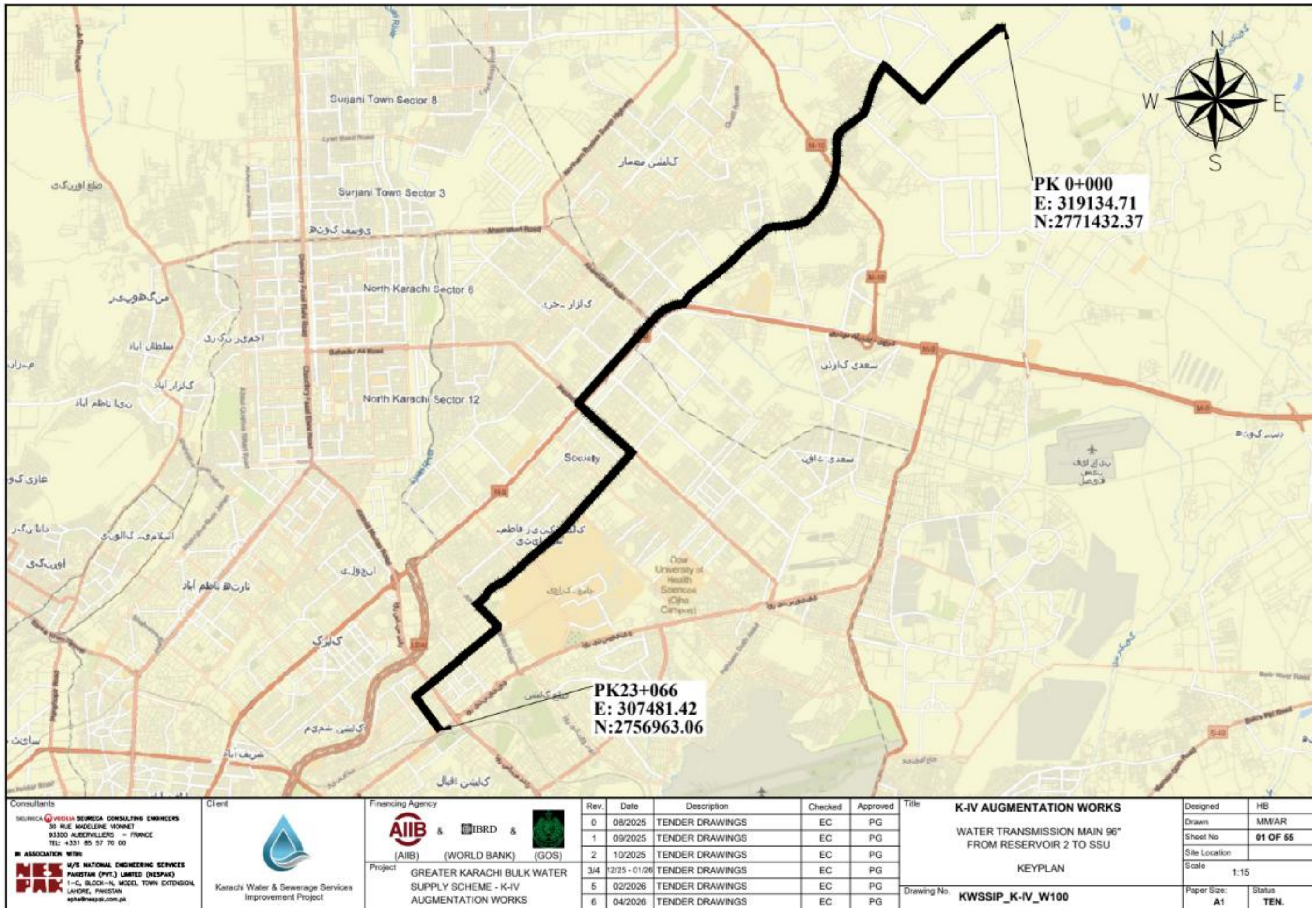
K-IV AUGMENTATION WORKS
WATER TRANSMISSION MAIN 72" FROM RESERVOIR 1 TO Y-JUNCTION
KEYPLAN
Drawing No. KWSSIP_K-IV_W100
Designed HB
Drawn MM/AR
Sheet No 1 OF 83
Site Location
Scale 1:15
Paper Size: A1
Status TEN.

Lot 2: Reservoir 2 to Sir Syed University (near NIPA)

- Scope: Laying of a 96-inch diameter MS pipeline.
- Pipe Specifications: X-42 grade steel with 20.6 mm wall thickness.
- Length: Approximately 24.5 km.
- Purpose: First segment of the 130 MGD conveyance to Sir Syed University.



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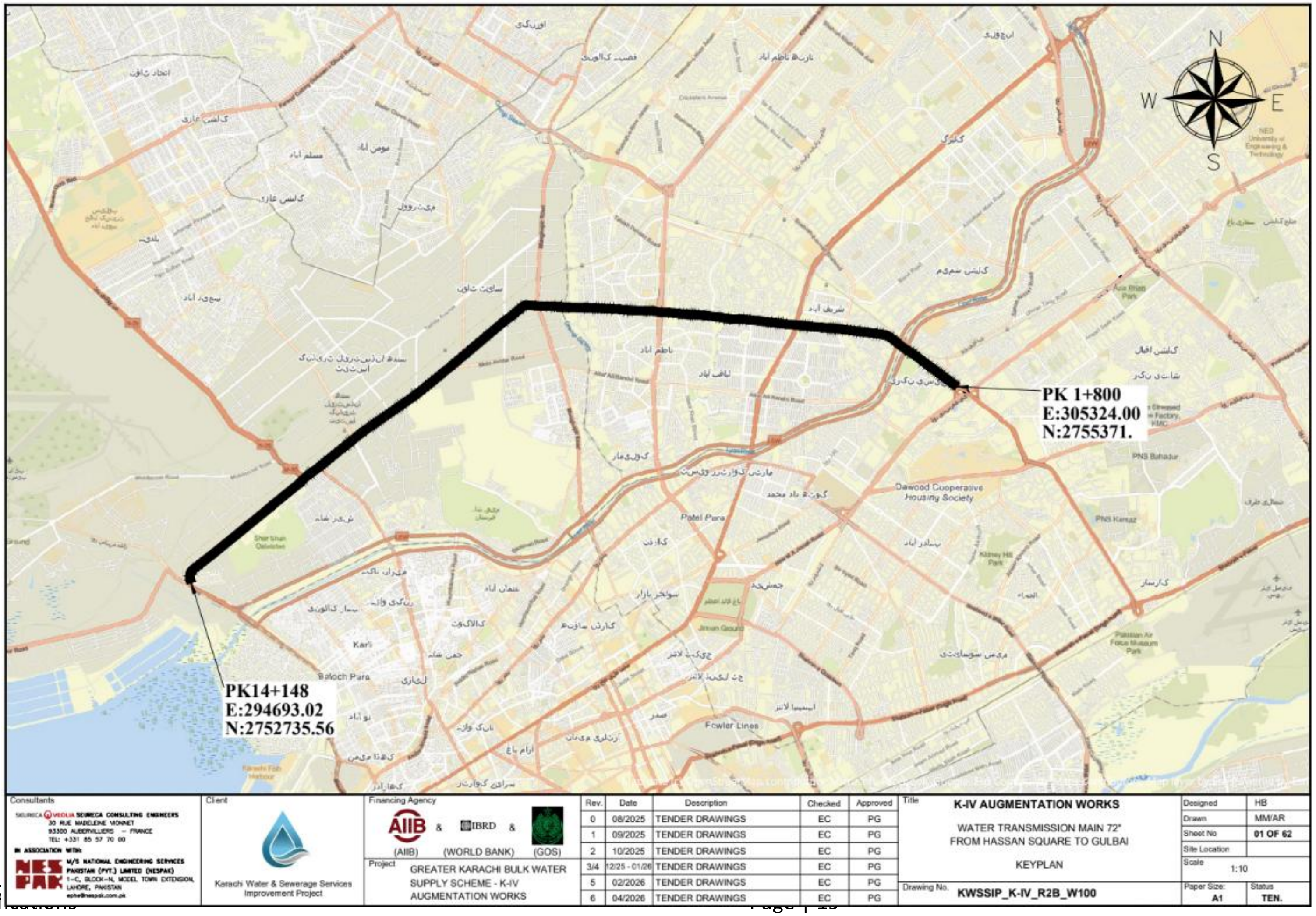
3/4	12/25 - 01/26	TENDER DRAWINGS	EC	PG
5	02/2026	TENDER DRAWINGS	EC	PG
6	04/2026	TENDER DRAWINGS	EC	PG

Lot 3: Hassan Square to Gul Bai (Continuation of Lot 2 pipeline)

- Scope: Laying of a 72-inch diameter MS pipeline.
- Pipe Specifications: X-42 grade steel with 12.7 mm wall thickness.
- Length: Approximately 12.5 km.
- Purpose: Continuation of transmission from Sir Syed University to Gul Bai.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PK 1+800
E:305324.00
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PK14+148
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N:2752735.56
Patel Para
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Karachi Water & Sewerage Services Improvement Project
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AIIB & IBRD &
(AIIB) (WORLD BANK) (GOS)
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Rev. | Date | Description | Checked | Approved
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1 | 09/2025 | TENDER DRAWINGS | EC | PG
2 | 10/2025 | TENDER DRAWINGS | EC | PG
3/4 | 12/25 - 01/26 | TENDER DRAWINGS | EC | PG
5 | 02/2026 | TENDER DRAWINGS | EC | PG
6 | 04/2026 | TENDER DRAWINGS | EC | PG
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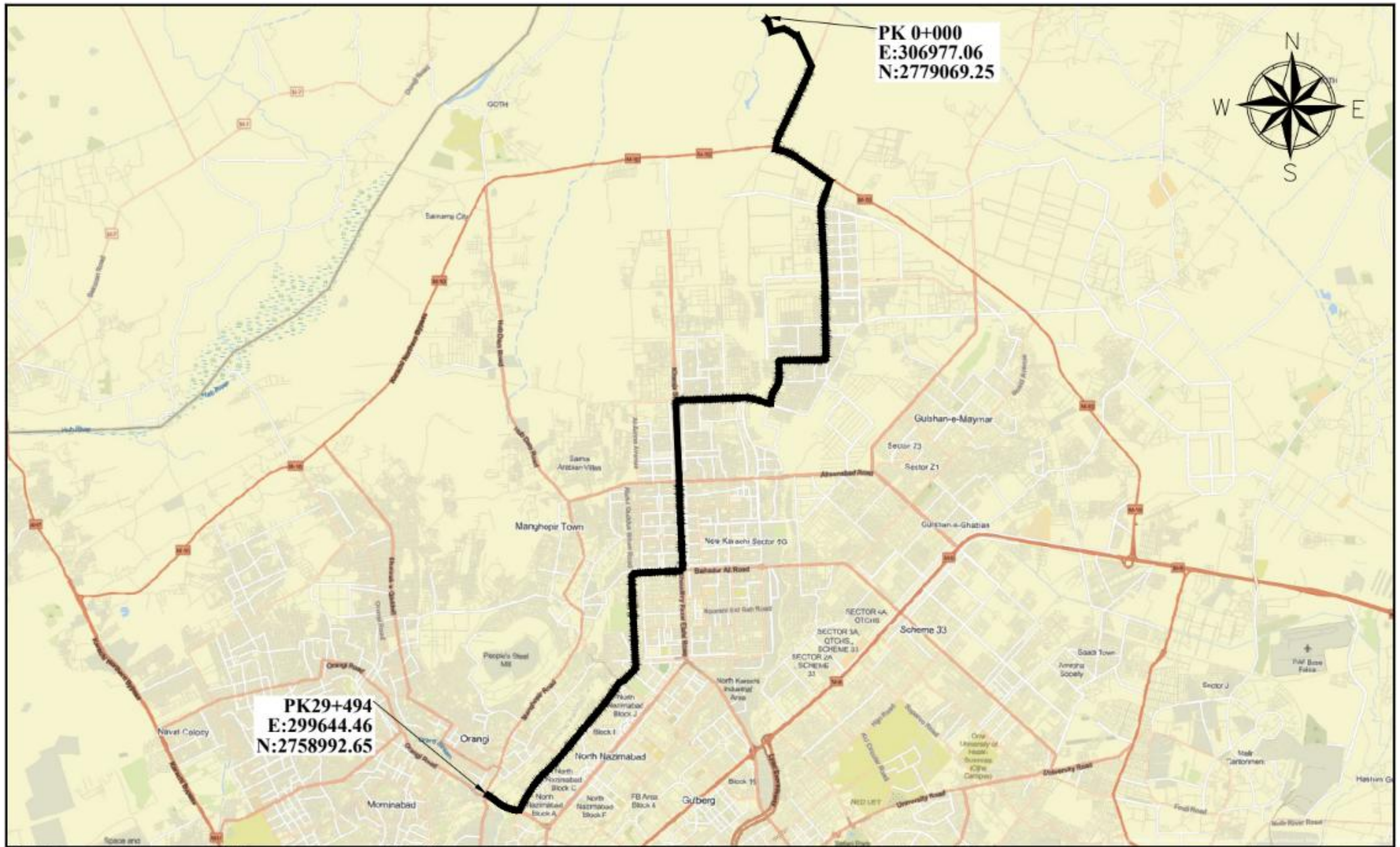
K-IV AUGMENTATION WORKS
WATER TRANSMISSION MAIN 72" FROM HASSAN SQUARE TO GULBAI
KEYPLAN
Drawing No. KWSSIP_K-IV_R2B_W100
Designed HB
Drawn MM/AR
Sheet No 01 OF 62
Site Location
Scale 1:10
Paper Size: A1
Status TEN.

Lot 4: Reservoir 3 to Banaras Chowk

- Scope: Laying of a 72-inch diameter MS pipeline.
- Pipe Specifications: X-42 grade steel with 12.7 mm wall thickness.
- Length: Approximately 29 km.
- Purpose: Conveyance of 65 MGD to Banaras Chowk



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Client

Karachi Water & Sewerage Services Improvement Project

Financing Agency

AIIB & IBRD &
(AIIB) (WORLD BANK) (GOS)

Project

GREATER KARACHI BULK WATER SUPPLY SCHEME - K-IV AUGMENTATION WORKS

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1	09/2025	TENDER DRAWINGS	EC	PG
2	10/2025	TENDER DRAWINGS	EC	PG
3/4	12/25 - 01/26	TENDER DRAWINGS	EC	PG
5	02/2026	TENDER DRAWINGS	EC	PG
6	04/2026	TENDER DRAWINGS	EC	PG

Title

K-IV AUGMENTATION WORKS

WATER TRANSMISSION MAIN 72"
FROM RESERVOIR 3 TO BANARAS CHOWK

KEYPLAN

Drawing No. **KWSSIP_K-IV_W100**

Designed	HB
Drawn	MM/AR
Sheet No	01 of 87
Site Location	
Scale	1:20
Paper Size: A1	Status TEN.

1.20 Site of Works

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 included 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.

1.30 Access to Site

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. The Employer, through the Engineer, shall assist the Contractor in identifying major roads around the pipeline route that can be used to access the site along with indication/highlighting of nearby facilities such as hospitals, rescue, firebrigade etc.

1.40 Clearance and Reinstatement of Site

Before beginning clearance within any way leave the Contractor shall give seven days written notice of his intention to the Engineer who will determine the extent and limits of such clearance having regard to the Contractor's requirements, the rate of Contract progress, the reasonable wishes of owners and occupiers, weather conditions and other factors which in the opinion of the Engineer may affect or be affected by the Contractor's proposals.

The Contractor shall prepare the Site, or other areas where indicated on the Drawings or ordered by the Engineer by carrying out a general clearance of the ground and by removing trees and other vegetation to permit the proper execution of the Works.

The Contractor shall clear the Site of all vegetation, trees, hutments, obstructions etc. to the extent required by the Engineer for checking the setting out. The Contractor shall also ensure that the parts of the Site to be occupied by the Permanent Works are clear and maintain the remainder of the Site as may be required for access and Temporary Works areas.

General clearing and grubbing work shall be carried out over the areas to be occupied by the permanent Works before beginning excavation or other work, and shall include the clearance of all trees of girth less than 0.15m, stumps, bushes and other vegetation and the grubbing out of all roots and the removal of all boulders between 0.01 and 0.2m3 volume and disposal as directed. Trees shall be defined as having a girth exceeding 500 mm measured 600 mm above ground level except where a tree has buttresses when measurement shall be taken immediately above the buttresses. The limits of the areas to be cleared shall be as indicated on the drawings or as will be defined by the Engineer.

Where shown on the drawings, indicated or directed by the Engineer, trees shall be uprooted or cut down as near to the ground level as possible and all timber shall be deemed to become the property of the Employer. The Contractor shall cut and stack such timber that is salvageable as directed by the Engineer.

Bushes, undergrowth, small trees, stumps and tree roots shall, where directed by the Engineer, be grubbed out, burnt and deposited off the site in dumps to be provided by the Contractor. All holes left by the stumps or roots shall be backfilled with suitable material in a manner approved by the Engineer.

The Engineer may require that individual trees, shrubs and hedges are to be preserved and the Contractor shall take all necessary precautions to prevent their damage

Stumps and major roots shall be grubbed out and all combustible material arising shall be stockpiled at sites designated by the Engineer. Noncombustible material shall be removed by the Contractor to approved tips. The holes shall be backfilled with approved material and rammed in 30 cm layers. The Engineer may order certain trees to be left standing, shrubs and hedges be preserved and the Contractor shall take all necessary precautions to prevent their damage.

Stumps and major roots shall be grubbed out and all combustible material arising shall be stockpiled at sites designated by the Engineer. Noncombustible material shall be removed by the Contractor to approved tips. The holes shall be backfilled with approved material and rammed in 30 cm layers. The Engineer may order certain trees to be left standing, shrubs and hedges be preserved and the Contractor shall take all necessary precautions to prevent their damage.

The Contractor shall maintain the Site in a neat, tidy and healthy condition for the whole of such time as he is responsible for the care of the Works.

The Contractor shall remove the material arising from such clearance and dispose of it in a manner and at a location on or off the site, to the approval and satisfaction of the Engineer.

No heavy equipment/ plant whether mobile or stationery shall be allowed to come nearer than 1.5 m of the existing conveyance and other structures. For this purpose, such structures and pipelines shall be protected by erecting warning fences or barricades.

The Contractor shall fill and make good with appropriate materials those cavities and losses of soil which result from clearing the parts of the Site not subsequently to be occupied by the Permanent Works.

The Contractor shall not clear the Site of any structure without the prior written permission of the Engineer.

1.50 Surface Levels

After the area of any section of the Works has been cleared and after trees have been felled and stumps removed to the satisfaction of the Engineer, but before any other work is commenced, surface levels of the ground shall be taken. The levels shall be taken at spacing agreed with the Engineer. Levels shall similarly be taken on the surface of the ground after the removal of unsuitable overburden prior to placing fill and at the interface between natural ground, rock or artificial hard material layers. The levels shall be agreed with the Engineer. If the Contractor should fail to make such an agreement, the ground levels shown on the Drawings or determined by the Engineer shall be taken as correct. The Contractor shall prepare plans and sections which shall, when finally and mutually agreed, be signed by the Engineer and Contractor as truly representing the configurations of the areas in question at the commencement of excavation or fill construction.

1.60 Location and Levels of Existing Services

The location and levels of any existing services shown on the drawings is approximate only. Before carrying out any demolition or excavation for construction purposes the Contractor shall accurately locate in both line and level all existing services within the Site whether indicated on the drawings or not, and furnish the Engineer with three (3) copies of the relevant information immediately.

The Contractor shall excavate, refill and restore in advance of his programme all such trial holes as he may require for the location of existing services (sewers, water supply pipe, sand cables, etc). The cost of these trial holes shall be included in his excavation rates.

1.70 Site Records

The Contractor shall make records jointly of the position and extent in the excavations of every type of service, stratum and obstruction encountered during the construction of the Works. These records shall form part of the as-built data to be submitted in accordance with Clause 3.50.

1.80 Climatic Data

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 36-degree C
   (b) Minimum 13-degree C

2 Extreme Temperatures
   (c) 48-degree C in June.
   (d) 6-degree C in January.

3 Annual Average Rainfall

250-330mm per year, the majority falling in the monsoon months of July and August. On average, there are 15-24 rainy days per year. Storm intensities can be high with storm totals reaching 230mm, with normal durations of 1 to 3 days.

4 Monthly Average Relative Humidity
   (a) Maximum = 90%
   (b) Minimum = 15%

The climatic data given above is based on the latest data from the Pakistan Meteorological Department (PMD) and recent climatic trends.

1.80 Preliminary geotechnical information

Preliminary exploratory logs along the project route indicate that the native stratigraphy primarily consists of sand, shale, and conglomerate formations. The subsoil layer at foundation depth is generally composed of variable sandy and clayey soils , underlain by dense gravelly sand , fractured limestone , and laminated shale. A superficial layer of loose backfilled material is widely present across the site, typically extending to depths between 1.0 and 2.0 meters. Groundwater levels observed during preliminary field investigations fluctuated significantly; water was encountered at shallow depths between 1.80 meters and 1.95 meters at certain central locations , while other outlying sections of the alignment were logged as entirely dry.

The geotechnical data, stratigraphy descriptions, and groundwater observations provided in this section or any attached reference documents are furnished strictly for informational purposes only.

The Contractor must independently verify all soil parameters, bearing capacities, lateral pressures, and dewatering requirements necessary to ensure the safe design and safe execution.

1.90 Reference Datum

All project references to elevations are based on Survey of Pakistan (SOP) Datum i.e. above mean sea level (msl). The contractor shall be responsible to establish a permanent site datum for the purposes of executing the works. The horizontal coordinate system to be used for the Works shall be proposed by the Contractor and approved by the Engineer, ensuring compatibility with the existing data. The Local Engineering Standard: UTM84-42N is used for the design stage.

1.100 Contract Signboard

The Contractor shall supply and erect two or more contract signboards at locations agreed by the Engineer. The signboards shall be of substantial construction to the approval / satisfaction of the Engineer and the lettering, in both English and Urdu shall be black on a yellow fluorescent background.

The project signboards shall start 150 cm high above the ground and 240 cm wide and shall be lettered according to instructions provided by the Engineer. Direction signboards shall be erected in sufficient numbers, as directed by the Engineer. No advertisements shall be placed on any boarding, fencing or scaffolding erected for any purpose connected with the Contract without the written permission of the Engineer.

1.110 Permits

The Contractor shall be fully responsible for obtaining necessary permits and permissions, prior to commencement of the Works. This will include responsibility for all permissions for the contractor's site operations with regard to work adjacent to and under the following agencies not limited to:

- Karachi Water and Sewerage Corporation (KW&SC)
- National Highway Authority (NHA)
- Pakistan Railway (PR)
- Karachi Electric (KE)
- Sui Southern Gas Company (SSGC)
- Pakistan Telecommunication Limited (PTCL)
- National Telecommunication Corporation (NTC)
- Karachi Metropolitan Corporation (KMC)
- Karachi Development Authority (KDA)
- Pakistan Steel Mills (PSM)
- Port Qasim Authority (PQA)
- Pakistan Arab Refinery Limited (PARCO)
- Sindh Infrastructure Development Company Limited (SIDCL)
- Headquarters Signals 5 Corps

- Naval Signal Center (NSC)
- Malir Development Authority (MDA)

The aforementioned list of agencies is non-exhaustive. Compliance requires obtaining all requisite authorizations from any and all applicable regulatory authorities.

1.111 Advertising

The contractor shall not use any part of the site for any form of advertising without the written approval of the Engineer.

SP-02 WORK UNDER THE CONTRACT

2.10 General Description of the Works

The Contract comprises the construction, completion and remedying of damages and defects in the Works , both during the execution of the Works and during the Defects Liability Period as defined in the Conditions of Contract, and, except in so far as the Contract otherwise provides, the provisions of all labor, materials, Constructional Plant, Temporary Works and everything whether of a temporary or permanent nature required in and for such construction completion and maintenance so far as the necessity for providing the same is specified in or can reasonably be inferred from the Contract, shall be deemed as forming work under the Contract.

The following description of the works to be performed under this Contract is general in nature and is not intended to describe all of the facilities to be provided under this Contract:

The work under this contract comprises Construction of Water Transmission Pipeline (gravity main) by laying and jointing 72-inch diameter MS pipeline, from R1 to Y-Junction, 96-inch diameter MS pipeline from R2 to SSU, 72-inch diameter MS pipeline from Hasan Square to Gul Bai and 72-inch diameter MS pipeline from R3 to Banaras Chowk. The Allied works include washout & valve chambers, crossings under main railway line and roads and other utility services and protection works at Nullahs etc. Some features of the scope of permanent and temporary works are given under the Clause SP-02.

The Works shall also include external coating, internal lining, cathodic protection, supply & installation of valves, washout, fittings, dismantling joints etc. testing and commissioning of transmission pipelines and all electrical and mechanical works under this Contract.

The description of Works to be performed under the Contract are general in nature and do not necessarily describe all of the facilities to be provided under this Contract.

Main components of the contract are listed below, which are briefly described subsequently:

(a) Water Transmission Pipeline

(b) Valve Chambers

(c) Flowmeter Chambers

(d) Washout Chambers

(e) Air Valve Chambers

(f) Crossings

(g) Allied Works

2.10.1 Water Transmission MS Pipeline:

The pipelines will 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 by butt welding and the field seams will be coated on site with HDPE heat shrink sleeves. The pipes shall be internally lined with fusion bonded epoxy lining applied in the factory according to AWWA C213 standards or equivalent. The internal field welded joint sections shall be lined on site with an approved liquid epoxy coating system suitable for potable water, in accordance with AWWA C210 with ANSI/NSF 61 for potable water or an equivalent approved standard, ensuring continuity with the factory-applied epoxy lining.

The internal pressure will vary depending upon the distance of disposal point. However, the maximal allowable transient pressure considered is 12 bars in each pipe.

2.10.2 RCC Chambers

All chambers and structural works shall be carried out by the Contractor on a complete design-and-build basis. This includes site investigations, structural design calculations, selection of construction materials, preparation of shop drawings, formwork and reinforcement detailing, execution of civil works, concrete pouring, waterproofing, access provisions, and finishing. The Contractor shall ensure full compliance with project specifications, relevant standards (such as EN 1992 for concrete structures and EN 1997 for geotechnical design), and local authority requirements. Prior to commencement, all technical submissions including method statements, risk assessments, quality control procedures, and material data sheets shall be submitted to the Engineer for approval. Final deliverables shall include certified as-built drawings, inspection records, and operations and maintenance manuals.

All Chamber of Washout and Air Valves shall be Reinforced cement concrete structures with all fittings and installation of washout pipes and Valves as shown on drawings. The Concrete class of all Chambers shall be Class “A” of 35 MPa (5000 PSI) Cylindrical/Cube Strength.

2.10.3 Crossings Under Main Railway Line, Roads, Lyari and other services

All thrust boring and utility crossing works shall be executed by the Contractor on a full design-and-build basis. This scope includes subsurface (geotechnical and geophysical) investigations, detailed bore alignment and profile design, selection and procurement of all pipe, casing, lubrication, grout and ancillary materials, pilot bore drilling, reaming and product pipe pull-back operations, verification testing, surface reinstatement and restoration. The Contractor shall submit geotechnical reports, design calculations, risk assessments, method statements, shop drawings and manufacturer data sheets for review and approval before mobilization. Following this, the Contractor shall ensure all endorsed documents are submitted to the relevant authorities for final approval prior to the start of construction.

All activities must comply with project specifications, health and safety requirements, and applicable international standards, and the Contractor shall deliver complete as-built drawings, test certificates and operation, maintenance and warranty manuals at project handover.

The crossings under Main Railway Line, Roads and other services mentioned above shall be constructed by use of trench-less methods (Micro-Tunneling / Pipe Jacking) as detailed in Chapter 6 - Micro-Tunneling / Pipe Jacking Specific Codes & Specifications and as shown on drawings. The Contractor shall carry out the design and works as per the approval of the Engineer and strictly in accordance with the requirements of the concerned department of all agencies. The contractor shall execute the work and protection of existing installations and utility services as per Sub Clause 2.40 of Special Provision of Contract.

Utility crossing (including but not limited to water, wastewater, electricity, telecommunication, storm water drainages, etc…) shall also follow the design-and-build model with precise geographic location (x,y,z). The contractor shall carry out the designs and works as per the approval of the Engineer and strictly in accordance with the requirements of the concerned stakeholder and agencies. The Contractor shall execute the works to allow for minimal disruptions and give the necessary protections required to protect the surrounding utilities.

2.10.4 Protection Works

The protection works for the pipeline shall consist of Gabion Mattress, Concrete Encasement, Stone pitching with grouting etc. to protect against scouring at crossings of all river streams and Nullahs, if any. Additionally, where the pipeline crosses existing utilities (such as sewers, gas lines, cables…) and the minimum required vertical and/or horizontal separation distance as per applicable regulations or as directed by the Engineer cannot be achieved, specific protection measures such as concrete encasement, installation of protection slabs, or other approved methods shall be implemented by the Contractor to ensure the integrity of both the new pipeline and the existing utilities. Such protection measures shall be subject to the Engineer's approval. The contractor shall verify through confirmatory bore holes the soil characteristics and erosion potential to confirm the extent of protection works of pressurized pipelines.

The unit of measurement shall be cubic metre as indicated in the Bills of Quantities.

The rate shall be comprehensive and include all costs for the provision, transport, and installation of materials; all formwork, strutting, curing, and protection; geotechnical verification and confirmatory boreholes; coordination with utility authorities; and all labor, tools, specialized plant, supervision, overheads, and profit necessary to complete the works as specified.

2.10.5 Operation of Components

After completion of the Works, during the testing and commissioning phase and for any specific period as may be required for performance demonstration tests defined herein or instructed by the Engineer/Employer the contractor shall operate all components in such a manner as is required to demonstrate the proper performance and functioning of the components and appurtenant structures and to complete any specific tests required by the Engineer/Employer. The duration and specific requirements for such operation will be as detailed in the commissioning plan or as instructed by the Engineer.

2.20 Temporary Works

Not less than fourteen days before commencing any portion of the Works, the Contractor shall, if ordered, submit to the Engineer for his approval complete drawings and calculations for all Temporary Works the Contractor may be proposing for the construction of that part of the Works.

Notwithstanding approval by the Engineer of any design for the Temporary Works, the Contractor shall be entirely responsible for their efficiency, security and maintenance and compliance with all Health, Safety and Environmental (HSE) requirements and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

2.20.1 Water and Electricity Supply

The Contractor shall at his own cost make arrangements for the supply of water and electricity required for the purposes of the carrying out and completion of the Works.

2.20.2 Disposal off Water and Waste

Water and wastewater derived from the construction, testing and completion of the Works shall be disposed of clear of the Site to the satisfaction of the Engineer so as to cause no damage or complaint. The Contractor shall prepare and submit for the Engineer’s approval a comprehensive Waste Management Plan detailing the procedure for collection, handling, storage, transportation, and disposal of all types of waste generated by the Works, including but not limited to construction debris, excavated material, chemical waste, and domestic waste from site facilities, in accordance with applicable regulations and the environmental protection requirements of this Contract (refer to Clause SP-11).

2.20.3 Contractor's Facilities

The Contractor shall provide all site facilities including offices with telephone, workshops, stores, accommodation, washing, latrines etc. necessary for use by his own staff.

The Contractor shall be responsible for making all arrangements for drainage from his site facilities and shall be responsible for payment of all charges in connection therewith. Arrangements for the supply of electricity, water and gas shall be the responsibility of the

Contractor. Works Areas for the Contract in addition to those defined as Site of the Works shall be decided in consultation with the Engineer.

2.20.4 Latrines

Throughout the period of construction of the Works the Contractor shall provide, maintain and cleanse suitable and sufficient latrines for use by his employees; which may include specialized mobile units to ensure proximity to active work areas. Where practicable the latrines shall be connected to the nearest sewer, or if this is not possible, the Contractor shall provide an adequately sized septic tank and soak pit, or contract a licensed service provider for the regular maintenance of portable chemical toilets. The Contractor shall ensure all employees make proper use of these facilities and do not foul the Site.

2.30 Maintenance of Existing Access Track during the Works

On commencement of the Contract the Contractor shall be solely responsible for the maintenance of the existing access roads within the Site. This responsibility shall continue until the contract completion date, or until such earlier date as the Engineer may advise the Contractor in writing. Such maintenance work shall include general upkeep, and any necessary repairs to damaged road surfaces, pavement, drainage, associated slopes, etc. (whether caused by the Contractor's activities or not) to a standard no worse than the original condition. During the carrying out of such maintenance work, the Contractor shall make arrangements to maintain through passage for the Employer’s and his, staff’s vehicles and also those of other Contractors over these access roads, which may comprise temporary diversions all to the approval and satisfaction of the Engineer.

2.40 Protection of Existing Installations

The Contractor shall execute the Works in such a manner as to avoid interruption and interference with the operation of the existing water and sewerage conveyance system, facilities, utility services and to minimize disturbance to the surrounding area within and adjacent to the Site. Access to the existing facilities shall be maintained, to the satisfaction of the Engineer, at all times.

The Contractor shall apply to the Engineer in writing at least 28 days before starting any work which involves interference with existing structures, equipment, etc. or otherwise interfere with or interrupt the normal operation of the existing conveyance system, pumping and treatment works, and distribution system. The Contractor shall not execute such work until he has received permission to proceed, in writing from the Engineer and / or the responsible authority or owner.

The Contractor shall ensure that no earth, debris or rock is deposited on existing structures, conduits, public or private roads or right of ways as a result of the Works and all vehicles leaving the Site shall be cleaned accordingly.

The Contractor shall be responsible for the safety and security of existing services encountered during the course of execution of works and any damage to existing installation and services due to Contractor's operations shall be made good at his risk and cost, if they fall within the area of works, from SSGC, PTCL, KW&SC, NTC, KE, PARCO, NTC, PTCL and any other agencies.

The Contractor shall submit detailed methodology along with a work program for crossing public utility services as per their requirement to take approval and to protect the services during the construction of pipe line and other works. The Contractor shall strictly comply with the safety and precautions requirements as deemed necessary by the concerned agencies.

The Payment for protection of public utility services at each crossing location shall be made as per item rate quoted in the bill of quantities

2.40.1 Protection of Existing Public and Private Services

The Contractor shall notify all public authorities, utility companies and private owners, of proposed works that will affect them not less than one week before commencing the works.

The contractor shall adequately protect, uphold, maintain and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utility companies, private owners, or the Engineer as appropriate.

If any damage to services results from the execution of the Works, the Contractor shall immediately:

(a) Notify the Engineer and appropriate public authority, utility company or private owner.

(b) Make arrangements for the damage to be made good without delay to the satisfaction of the public authorities, utility company or private owner as the case may be. The Contractor shall be liable for all costs for making such damage.

The Engineer may issue instructions or make other such arrangements, as he deems necessary, to repair rapidly any essential services damaged during the execution of the Contract. Such arrangements shall not affect any liability to pay for making good the damage

2.50 Site Investigation Records

The site investigations deemed necessary by the Engineer, during the execution of the work shall be carried out by the Contractor at his own cost.

Before commencement of work at site, the Contractor shall carry out the trial pits up to the required formation level to locate any existing underground services and utility lines. The precise location (horizontal and vertical coordinates), nature, dimensions, and condition of all services and utilities encountered shall be accurately recorded. This information shall be incorporated into the As-Built Drawings and, if required by the Engineer, into GIS database, to be submitted to the Employer/Operator in accordance with Clause 3.50.

2.60 Other Works and Services

For all other works and services specified in the Specifications or shown on Drawings and for which there is no separate item in the Bill of Quantities, no payment shall be made directly and the cost thereof shall be deemed to be included in the unit rates of other items of BOQ

2.70 Notice of Operations

The Contractor shall give full and complete written notice of all important operations to the Engineer sufficiently in advance to enable the Engineer to make such arrangements as he may consider necessary for inspection or for any other purpose. The Contractor shall not commence any important operation without the written approval of the Engineer.

2.80 Protection

The Contractor shall take care to protect the work from any damage, of whatsoever nature, during the construction period. In case of any damage done to the work, the Contractor shall remove, replace, or rectify such work at his own cost, without any additional compensation.

2.80.1 Protection of Works against Flooding

The Contractor shall ensure the protection of all temporary and permanent works including plants, materials and equipment against flooding and any other extreme weather events from any cause, natural or otherwise, as well as recurrent rains or any other reasons, during the course of execution of works. Before the commencement of works the Contractor will submit his detailed work methodology including diversion plan, for Engineer's approval, showing manners to protect the work area in an orderly state. The Contractor shall maintain such protective works in part or as a whole till the works have been completed or covered in accordance with drawings, specifications or as directed by the Engineer. The cost of complying with this section is deemed to be included in other items of BOQ, unless expressly specified otherwise.

2.90 Sub-Soil Investigation

The Contractor shall carry out Geotechnical investigation of site by employing specialist geotechnical contractor in accordance with contract specifications and as directed by the Engineer prior to proceeding with the construction of Contract Works at site to confirm the sub soil investigations provided by the Employer.

It is the responsibility of the contractor to ascertain the soil conditions on his own as the information provided is for preliminary information and for reference only. The Employer takes no responsibility for any miscalculation, omission or error in the bidding process and tender pricing due to use of available subsurface information.

No separate payment shall be made for geotechnical investigation of site, laboratory testing and submission of geotechnical investigation report and its cost shall be deemed to have been included in the contract price.

SP 03 DRAWINGS

3.10 Tender Drawings

The Tender Drawings issued with the Tender Documents show the scope of the work to be performed by the Contractor. The Drawings are generally in sufficient detail so as to be used as a basis for fabrication or construction and for placing preliminary orders for materials, subject to corrections based on the future issue of Drawings as provided under Sub-Clause 3.20 hereof issued for Construction.

One set of tender Drawings will be issued to the Contractor. Additional sets of the Bid Drawings will be provided at the cost of reproduction upon written request of the Contractor.

3.20 Drawings Issued for Construction

The term Construction Drawings as used in the Specifications means Drawings Issued for Construction as described under this Sub –Clause.

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Following the award of Contract, the Engineer shall issue Construction Drawings which shall supersede the Tender Drawings and constitute "Instructions of the Engineer" per Sub-Clause 3.3; these Construction Drawings represent a refinement of the previous comprehensive tender design, updated specifically to incorporate exact site parameters, including but not limited to verified utility invert levels, existing interconnections, and confirmatory geotechnical data, which the Contractor is mandated to physically verify and conduct during the mobilization phase. While the Engineer retains responsibility for the issue of the Construction Drawings to ensure project integrity and mitigate speculative variations, it is required that pipe laying, profiles, chambers civil and structural drawings, thrust/anchor blocks drawings interconnections and crossings drawings shall, where so instructed by the Engineer, be prepared by the Contractor based on site investigations and submitted for approval by the Engineer. The Contractor shall also be responsible for preparing all derivative Shop Drawings (including bar bending schedules, fabrication details, and temporary works…) to provide the necessary fine detailing for execution. No permanent works shall commence until the Contractor has verified all existing utility crossings and interconnections, completed necessary surveys and necessary additional designs related to the site specific data..

The Contractor shall check all Construction Drawings carefully as soon as practicable after receipt thereof, and shall promptly advise the Engineer of any errors / omissions discovered.

One set of Construction Drawings will be issued to the Contractor. Additional sets of Construction Drawings will be provided at the cost of reproduction upon written request of the Contractor.

3.30 Drawings to be Furnished by the Contractor

3.30.1 Shop drawings and Reinforcement Details

All shop drawings required for the works including reinforcing steel detailing, bending and cutting drawings, field erection, fabrication details, layout and construction detailed drawings shall be furnished by the Contractor for approval of the Engineer. If more detailed drawings are necessary to complete any part of the work, such detailed drawings shall be prepared by the Contractor and submitted to the Engineer for approval. All drawings shall be complete and shall be submitted to the Engineer in due time and in logical order to facilitate proper coordination of this work.

All drawings prepared by the Contractor shall be in metric units and in English language and where necessary in both metric and fps Systems.

3.30.2 Lift and Placement Drawings

At least twenty-eight calendar days prior to starting construction of any concrete lift or other placement, the Contractor shall submit lift or other placement drawings to the Engineer for approval. Lift or other placement drawings shall be to such scale as to clearly show all recesses, openings, and embedded work, including embedded structural, mechanical, and electrical items, in each lift in sufficient detail for proper installation and for execution of the work.

3.30.3 Construction Camps Layout Drawings

Three prints of drawings and a soft copy showing the layout of the construction camps shall be provided by the Contractor in advance for review of the Engineer. The drawings shall show the locations of the principal components of the construction plant; offices; shops and storage buildings; housing facilities. These submittals must demonstrate strict adherence to Environmental and Social Safeguard (ESS) protocols. The Layout shall detail as well as storage areas and yards which the Contractor proposes to construct at the site of the work and elsewhere. Such housing must include specific provisions for adequate sanitation, potable water supply, waste management, emergency medical facilities, and gender-segregated accommodations to ensure the health, safety, and dignity of the workforce. The drawings shall also show the unloading facilities for materials and equipment that the Contractor proposes to provide at the work site.

The drawings shall show appropriately the capacity of each major feature of the concrete batching plant, including the rated capacity of the aggregate processing, transporting, storage and reclaiming facilities; volume of aggregate storage; capacity of cement storage rated capacity of concrete pumps; and chiller arrangement to control temperature of concrete at batching plant.

Drawings showing any changes made in construction camps during the design and erection or after the plant is in operation shall be submitted to the Engineer for review. The Engineer will retain Two (2) sets of the drawings and one set will be returned to the Contractor with comments. The Contractor will amend and modify the drawings as necessary and resubmit three (3) hard copies and one electronic copy.

3.30.4 Other Drawings

Drawings showing proposed methods of construction and other drawings additional to those referred to hereinabove, required by the Specifications, and shall be submitted to the Engineer for approval.

3.40 Submissions and Approvals

3.40.1 Except as otherwise specified, two (2) prints of each drawing for approval or review shall be furnished as herein required. Transmittals shall be made in accordance with the written instructions of the Engineer within fifteen (15) days after receiving a notice to Commence the works. The Engineer will send one copy to the Contractor marked Approved, Approved Except as Noted, or Returned for Correction Within fifteen (15) days calendar days after receipt. The notations Approved and Approved Except as Noted will authorize the Contractor to proceed with the fabrication of the materials and equipment covered by such drawings subject to the corrections, if any, indicated thereon. When prints of drawings have been Returned for Correction, the Contractor shall make the necessary revisions on the drawings and shall resubmit prints for approval in the same manner as for new drawings. Every revision made during the life of the Contract shall be shown by number, date and subject in a revision block.

3.40.2 Upon receipt of prints which have been Approved or Approved Except as Noted, the Contractor (after duly incorporating the indicated changes in case of drawings marked Approved Except as Noted) shall furnish four prints plus one soft copy of each drawing to the address as instructed above unless otherwise directed.

3.40.3 All of the applicable requirements of this Clause with reference to drawings to be prepared by the Contractor shall apply equally to catalogs, illustrations, specifications, or other data submitted for approval.

3.40.4 Any work done prior to the approval of drawings shall be at the Contractor's risk. The Engineer will have the right to request any additional details and to require the Contractor to make any changes in the design which are necessary to conform to the provisions and intent of these Specifications and such changes shall be made without any additional cost to the Employer. The approval of the drawings by the Engineer shall not be construed as a complete check but will indicate only that the general method of construction and detailing is satisfactory. Approval by the Engineer of the Contractor's drawings shall not be held to relieve the Contractor of the obligation to meet all the requirements of these Specifications or of the responsibility for the correctness of the Contractor's drawings or of the responsibility for correct fit of assembled parts in final position or of responsibility for the adequacy of the method of construction.

3.50 As-Built Drawings

During construction, the Contractor shall keep an accurate and up to date record of work as executed. Any changes or deviations shall be marked on copies of the approved Drawings including shop drawings. As the work progresses two (2) copies each of all marked-up drawings and an electronic copy shall be submitted to the Engineer for his verification / approval. One copy of each drawing approved by the Engineer shall be returned to the Contractor and these shall be used for subsequent preparation of As-Built Drawings for the Works. The cost of compliance with this requirement shall be deemed to be included in the Contract Price.

The Contractor shall furnish to the Engineer four (4) complete sets of all As-built Drawings prior to issuance of the Taking-Over Certificate. In addition, the Contractor shall provide digital copies of all As-built Drawings in both PDF format and the original editable CAD format (DWG). Also, the Contractor shall submit a georeferenced GIS database (shapefile format) containing all relevant asset information for the installed pipeline and appurtenances, including but not limited to pipe diameter, material, invert elevations, ground elevations, coordinates of fittings, valves, chambers, and other features. The Contractor shall also furnish to the Engineer one mylar polyester base full size reproducible of each As-built and other Drawings, which, in the opinion of the Engineer, may be required for operation, maintenance, dismantling and re-assembly, for identification of parts; and for ordering replacement parts and materials. The mylar shall be 0.1 mm thick, double matte film, wash off film, printed on the front.

3.60 Data and Information

Subsurface and other physical information contained in the Tender Documents or otherwise made available to the Contractor by the Employer shall be deemed not to be representations or warranties. It is expressly understood that the Employer will not be responsible for the accuracy thereof nor for any deduction, interpretation or conclusion drawn therefrom. If the Contractor needs any further data from any other Agency, he will procure the same at his own cost.

SP - 04 LAYOUT OF WORK AND SURVEYS

4.10 Setting Out of Work

The Contractor shall set out the Work himself as per drawing by deploying a competent survey team and if any discrepancy is found, he shall report the matter to the Engineer and shall act as directed. The Contractor shall rectify or make it good, at his own cost and expense, any defective setting out, carried out by him.

The Contractor shall establish bench marks and / or reference lines at the site in accordance with the instructions of the Engineer. The Contractor shall set out its work from these bench marks and / or lines.

4.20 Verification

The Engineer may make checks as the work progresses to verify lines and levels established by the Contractor and to determine the conformance of the work as it progresses with the requirements of Contract Specifications and Drawings. Such checking by the Engineer shall not relieve the Contractor of his responsibility to perform all work in accordance with the Drawings and Specifications and the lines and grades given therein.

Any work done beyond the lines and levels shown on the plans or established by the Engineer, or any extra work done without written approval of the Engineer will be considered as unauthorized work and will not be paid for Upon order of the Engineer, unauthorized work shall be remedied, removed, or replaced at the Contractor's expenses.

4.30 Survey Instruments

The Contractor shall maintain at the site the requisite surveying instruments in perfect working conditions for the sole use of the Engineer's Representative to check levels and lines of the work at all times. These instruments shall include but not be limited to one Total Station, at least one dual-frequency precision GNSS/GPS system capable of RTK surveying, adequate number of automatic levels, Theodolites, calibrated steel tapes, and other necessary surveying accessories.

4.40 No work Without Joint Survey

Before commencing any excavation works, a joint survey shall be carried out by the Engineer and the Contractor to verify the existing ground levels, reference benchmarks, and general site conditions. The results of this joint survey shall be recorded in a signed joint measurement record forming the agreed baseline for subsequent measurement and payment.

The Contractor shall not start the excavation or embankment works or dredging work until the Joint Survey has been carried out to establish and record the existing levels.

4.50 Utility Lines

The Contractor shall conduct his operations, make necessary arrangements, take suitable precautions and perform all required work incidental to the protection of and avoidance of interference with power transmission, telegraph/telephone and natural gas lines and other utilities within the areas of his operations in connection with the Contract and the cost therefore shall be borne by the Contractor. The Contractor shall avoid any damages and indemnify the Employer in respect of all claims, demands, proceedings, damages, costs charges and expenses whatsoever arising out of or in relation to any such interferences.

4.60 Stone Quarries

The Contractor shall be responsible for developing the quarries to obtain the rock fill and riprap, as specified in the Technical Specifications, for use in connection with the work under the Contract. The Contractor may, at his option, and with no additional cost to the Employer, explore, locate, investigate and develop these or other quarry sites that he may require to meet his requirements under the Contract. Such development of quarries shall include, where applicable, construction, operation and maintenance of the required haul/access roads and haulage arrangements, all with no additional cost to the Employer.

SP - 05 MATERIALS AND WORKMANSHIP

5.10 Standard Specifications

Except where otherwise specified plant, Each and every part of the Works shall be designed, manufactured, tested and installed in accordance with an internationally recognised Standard, Code of Practice, or Regulation applicable to that part of the Works.

Such standards, etc. shall include:

(a) International Organisation for Standardisation (ISO).

(b) British Standard (BS).

(c) South African Bureau of Standards (SABS)

(d) European Standards (EN)

(e) Deutsches Institut für Normung (DIN)

(f) American Water Works Association (AWWA)

(g) International Electro-technical Commission, where applicable (IEC).

(h) Other national or international or other authoritative standards equivalent or superior to those designated in the Specifications. The Contractor shall demonstrate to the Engineer's satisfaction the equivalence or superiority of any item of Plant supplied to such alternative standards.

All standards shall be the latest published and shall include amendments, which are current at the date of manufacture or construction (as applicable). In the case of category (h) approval must be given in writing by the Engineer, and the Contractor shall familiarise himself with the requirements of these standards. The Contractor shall supply to the Engineer one original copy in the English language of all such standards, prior to approval by the Engineer. These standards and reference works shall be supplied to the Engineer within 30 days of the Engineer's order to commence the Work.

All materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable to the climate in the project area, for which Engineer’s decision is a binding.

A list of standards and other publications referred to in the Specification is given in respective sections.

When alternatives are offered, the Contractor shall submit to the Engineer for approval a statement detailing the alternatives, and shall include full technical descriptions, drawings, and specifications, and shall provide such full information as is required to enable the Contractor to demonstrate to the Engineer that the alternative is equivalent to the item specified. Any further information that the Engineer may require shall be produced by the Contractor when called for.

Electrical diagrams and symbols on drawings shall comply with IEC 617." with "Electrical diagrams and symbols on drawings shall comply with IEC 60617.

Electrical systems shall comply with requirements and regulations of the public electricity supply authority. Electrical installations in buildings shall comply with the local regulations pertaining to such installations. The Contractor shall be deemed to have acquainted himself with such requirements and ensured that all electrical systems comply therewith.

The electrical installation shall additionally comply with the Regulations of the Institution of Electrical Engineers (Great Britain) for the Electrical Equipment of Buildings (BS 7671 or equivalent) with amendments. In the case of conflict between the various regulations, the regulations of the appropriate authority in Pakistan shall take precedence.

5.20 Supplier of Materials

At least thirty (30) days before ordering material of any description intended for the Permanent Works, the Contractor shall submit for the approval of the Engineer's approval, the names of the manufacturer or maker or supplier proposed, technical datasheet, a specification of the material and certificates of the place of origin or manufacture and a traceability plan. Proposed manufacturers for the necessary equipment and materials required for the project (as per the following specifications and the tender drawings) shall demonstrate documentary evidence of a quality management system compliant with ISO 9001, an environmental management system compliant with ISO 14001, and an occupational health and safety management system compliant with ISO 45001, or equivalent approved standards. The Engineer reserves the right to require Factory Acceptance Tests (FAT) for specific materials or equipment (for pipelines and accessories) at the manufacturer's plant or an ISO/IEC 17025 accredited laboratory to verify compliance with the specifications before shipment. Such FATs shall be carried out in accordance with approved procedures and will be reviewed by the Engineer or his representative and witnessed by the Employer's representative at the Contractor's cost. All costs (incl. flights for 5 persons, accommodation, transport, subsistence allowance) incurred during witness testing shall be borne by the Contractor and paid for under the relevant bill item. If it is found necessary, tests regarding its compatibility with specifications be carried out at an external facility. If requested by the Engineer the Contractor shall supply to the Engineer for his retention, a copy of any such order placed.

If a test failure occurs, the Contractor shall submit a Non-Conformance Report (NCR) and bear all costs for re-testing; furthermore, Engineer approval of any material or test shall not relieve the Contractor of their sole responsibility for contract compliance.

In particular, materials on contact with potable water, or with raw water which is to be treated to render it potable, shall have satisfactorily passed the appropriate tests as laid down by BS 6920 or an equivalent approved standard or code of practice in operation in the country of manufacture.

The Contractor is responsible for formal site receipt inspections, specialized storage, and preservation in accordance with manufacturer specifications until final incorporation into the Works.

All materials, fixtures, fittings, and supplies furnished under the Contract shall be new and unused, of standard first-grade quality and of the best workmanship and design. No inferior or low grade materials, supplies or articles will be either approved or accepted, and all work of assembly and construction shall be done in a first-class and workmanlike manner. The Engineer may ask for prices on materials intended for delivery to the site and incorporation in the Works under any portion of these Specifications, the Contractor shall provide the manufacturer or supplier with complete information as may, in any case be necessary to secure compliance to this Clause and, in every case, he shall quote this Clause in full to each such manufacturer or supplier.

5.30 Submission of Technical DataSheet

As soon as practicable after the award of Contract, the Contractor shall submit for the approval of the Engineer, drawings, catalogs, diagrams and other descriptive data for all mechanical, electrical, architectural, and such other materials and equipment designated by the Engineer, which the Contractor proposes for use under this Contract. For certain materials and equipment, data may be required to be submitted in accordance with a detailed Standard Material Submittal form furnished by the Engineer. The form will require ,at a minimum: manufacturer traceability, a comparative matrix of technical properties vs. contract standards, laboratory accreditation credentials (ISO/IEC 17025), and a comprehensive checklist of mandatory certificates of conformity.

The Contractor is specifically required to provide comprehensive technical datasheets and the aforementioned submittal documents for or all primary components including, but not limited to, Steel pipes and fittings, Valves and accessories, Cement types and brands

5.40 Natural Materials

The Contractor shall make all arrangements for locating, selecting, and processing natural materials to comply with the Specification and shall submit to the Engineer for approval full information regarding the proposed location well in advance of incorporation of proposed material into permanent works. Approval of a location shall not imply that all material at that location is approved.

5.40.1 Sampling

Before the supply of any materials or articles which he intends to incorporate into the Permanent Works, the Contractor shall submit to the Engineers Representative for his approval a sample of each respective material or article, and such samples shall be delivered to and kept at his Office for reference. All samples rejected by the Engineer shall be removed from Site. All approved samples shall be stored on Site by the Contractor for the duration of the Contract, and any materials or manufactured items subsequently delivered to Site for incorporation to the Permanent Works shall be of a quality equal to the approved sample.

Should the samples be considered by the Engineer's Representative to be unsuitable for the purpose intended, or not to comply with the Specification or the nominated Standard Specification the Contractor shall submit samples of the materials or articles from a different source for approval. All the respective kinds of materials and articles used in and upon the Works, shall be at least equal in quality to the approved samples. Each and every sample shall be a fair average of the bulk material or of the article it represents. The Engineer's Representative may decide the method by which each sample to be taken from the bulk shall be obtained and the number of such samples. The Contractor shall allow for complying with the provisions of this Clause within his rates.

In addition to technical data sheets, the Contractor shall specifically provide the following physical samples for approval:

- Steel pipes and fittings: A representative section of the pipe (minimum A4 surface area) to allow for the inspection of the internal and external coatings and the verification of the steel wall thickness.
- Natural materials: A sample for each of the following:
    - Sand bedding
    - Imported backfill material
    - Concrete sand
    - Fine aggregate (small gravel) for concrete
    - Coarse aggregate (large gravel) for concrete

5.40.2 Rejected Material

Should any materials or manufactured articles be brought on to the Site of the Works by the Contractor which are in the judgement of the Engineer unsound or of inferior quality including defects or damage sustained in transit or in any way unsuited for the Works in which it is proposed to employ them, such materials or manufactured articles shall not be used upon the Works but shall be branded if, in the opinion of the Engineer this is necessary, and shall forthwith be removed from the Site of the Works, all at the Contractor's expense and in each case as the Engineer shall direct.

5.50 Testing

The Engineer will make such tests on concrete, concrete aggregates, embankment materials, filter pack materials and other materials as he may from time to time select at an independent accredited laboratory, and the Contractor shall provide such samples or assistance in sampling materials at the Site as the Engineer may reasonably require. Testing by the Engineer shall in no way relieve the Contractor of his responsibility to test materials to ensure that they meet all the specified requirements and to control their quality.

The Contractor shall keep a complete record of all quality tests programs performed on Site.

Samples of materials and manufactured articles together with all the necessary labour, materials, equipment and apparatus for sampling and carrying out of tests on the Site shall be supplied by the Contractor at his own expense.

The Contractor shall provide facilities for the Engineer to take samples for testing of any of the concrete or other materials to be incorporated in the Works. Such samples may be taken before or after incorporation into the Works or at any stage during construction at the discretion of the Engineer.

The Contractor shall provide two sets of equipment for carrying out site testing and inspection of materials, plant and equipment. In particular the Contractor shall provide equipment for carrying out pipe site inspection and measurements of electric voltage, current etc.

5.50.1 Manufacturer's Certificate of Compliance

In the case of standard labeled stock products of standard manufacture which have a record of satisfactory performance in similar work, the Engineer may accept a notarized statement from the manufacturer certifying that the product conforms to the applicable Specifications.

Notwithstanding the acceptance of such certification, the Engineer reserves the right to request additional independent laboratory tests or field trials to verify the performance of the product. Such tests shall be witnessed by the Engineer or his representative, and the Contractor shall provide all necessary assistance and access to facilitate this verification.

5.50.2 Mill Certificates

Regarding materials for which such practice is usual, the Engineer may accept the manufacturer's certified mill and laboratory test certificate.

Notwithstanding the acceptance of such certification, the Engineer reserves the right to request additional independent laboratory tests or field trials to verify the performance of the product. Such tests shall be witnessed by the Engineer or his representative, and the Contractor shall provide all necessary assistance and access to facilitate this verification.

5.50.3 Testing Laboratory Certificates

The Engineer may accept a certificate from a reputable commercial testing laboratory, satisfactory to him, certifying that the product has been tested within a period acceptable to the Engineer and that it conforms to the requirements of the Specifications.

Notwithstanding the acceptance of such certification, the Engineer reserves the right to request additional independent laboratory tests or field trials to verify the performance of the product. Such tests shall be witnessed by the Engineer or his representative, and the Contractor shall provide all necessary assistance and access to facilitate this verification.

5.60 Contractor’s Laboratory Facilities

The Contractor shall, for the duration of the Contract, supply, maintain and operate a materials testing laboratory at site necessary for sampling, preparing and testing materials as specified. The Contractor may also use an off-site testing laboratory to perform certain of the specified tests. Both the laboratory and the tests shall be to the approval / satisfaction of the Engineer, such approval shall not be given if significant delays in obtaining results are likely, or if the results may be unreliable. The Contractor shall make all the necessary arrangements and provide all transport and labor for conveying the samples to the approved laboratory, and shall ensure that results are conveyed to the Engineer's Representative promptly. The Engineer's approval will be withdrawn if the service proves in any way are found unsatisfactory.

The Contractor shall provide trained and qualified Material Engineer, technicians and skilled labor to carry out specified tests to the satisfaction of the Engineer’s representative. The Material Engineer and technicians shall be approved by the Engineer. In case of unsatisfactory performance such approval will be withdrawn and the Contractor shall arrange for suitable replacements for approval by the Engineer’s representative.

The Engineer and his supervisory staff shall have access to the laboratory to supervise testing and to witness verification tests ordered by the Engineer or his staff.

The Contractor shall keep records of all tests he conducts in connection with compliance with, and as required by, the specifications, and shall supply copies of the results of such tests to the Engineer's Representative as soon as practicable after each test is made.

Notwithstanding the above the Contractor shall supply, maintain and operate all the necessary apparatus for certain tests which shall be carried out within the Permanent Works or elsewhere on the Site as directed by the Engineer; these tests are as follows:

5.60.1 Concrete Tests

(a) Slump test to ASTM C-143

(b) Aggregate moisture test (For determination of water/cement ratio) to ASTM C-566

(c)	Concrete cylinder compressive strength test	to ASTM C-39
(d)	Elongation and flakiness of aggregate	to ASTM D-4791
(e)	Gradation of Aggregates	to ASTM C-136
(f)	Soundness of the aggregates	to ASTM C 88

The Contractor shall be responsible for making and curing test cylinders in accordance with ASTM C-31 and for measuring the temperature of atmosphere, formwork, concrete constituents and concrete itself as directed by the Engineer from time to time, and shall provide and maintain the equipment for so doing.

5.60.2 Earthwork Tests

(a) Determination of the dry density/moisture Content relationship of soil to AASHTO T-180

(b) Determination of the dry Density of soil to AASHTO T-191

(c) Determination of moisture, organic matter Content in soil to ASTM D 2974

(d) Atterberg Limit tests to ASTM D 4318

(e) Soil gradation analysis by mechanically Vibrated sieves to ASTM D 421

(f) Soil gradation by Hydrometer (Long stem type calibrated at 20^{o} C) to ASTM D 422

(g) Determination of sulphates content as SO_3 to ASTM D 2974

(h) Testing of water samples for electrical Conductivity, soluble Cations and Anions, pH and dissolved solids etc. to ASTMD1125, ASTM5464&ASTM 5907

5.70 Inspection

All materials and equipment furnished and all work performed under this Contract will be subject to inspection by the Engineer at all times and in all states of completion both off-site and on-site. The Contractor shall furnish promptly without additional charge, all facilities, labor and material reasonably needed for performing such inspections and tests as may be required by the Engineer. Inspection at the source, e.g. borrow area, manufacturer's plant, etc., will be made of selected materials and equipment in addition to the inspection at the site. The Contractor shall give adequate information to the Engineer when materials and equipment are available for inspection. Acceptance of materials and equipment or the waiving of inspection thereof shall in no way relieve the Contractor of his responsibility for furnishing materials and equipment meeting the requirements of the Contract Documents.

5.80 Cost

Further to the Provisions of Sub-Clause 7.4 of the General Conditions of contract, the cost of any additional laboratory, field and shop tests required through the resubmission of samples because of failure of compliance with Specifications shall be borne by the Contractor and will be deducted from any money due to him under this Contract.

SP – 06 CONTRACTOR’S RECORDS AND SUBMITTALS

6.10 Initial Submittals

Before commencing the Works, the Contractor shall submit to the Engineer for his approval a program in accordance with Sub-Clause 8.3 of the General Conditions of Contract showing the order in which he proposes to carry out the Works. This program shall include, to a level of detail approved by the Engineer, a comprehensive Work Breakdown Structure (WBS) identifying all key activities and deliverables.

6.20 Requirements

Each submittal shall consist of schedules based on an approved project management software, and narrative descriptions of the proposed construction program.

6.20.1 The program shall be in the form of a detailed Gantt Chart, developed using the adequate project management software as specified in Clause 6.20, or another planning software approved by the Engineer. The program shall clearly show, as a minimum: defined milestones, the critical path, critical tasks, and the float for each activity. The program shall show the order and interdependence of activities planned by the Contractor, and shall be time-scaled according to calendar dates. Activities shown on the work program shall consist not only of the actual construction operations but shall also include the submittal and approval of shop drawings and samples, procurement plan of line Pipe, materials and equipment and installation and testing of major and critical items. Related activities shall be grouped on the network for simplification and critical path shall also be clearly delineated on the network.

The program of work shall clearly indicate the following:

(a) The sequence of each activity, the proposed start and completion dates of each activity, the rate of progress and the cumulative quantity or percentage of work expected to be achieved on each activity by the end of each month;

(b) The time allocated for work by others, including those of the Employer and by utility undertakings; including a detailed schedule of resource requirements and allocations (e.g., specific personnel, equipment…) required from these parties to support the planned activities.

(c) Cash flow program and Resources management.

The program shall also include details of the following:

(a) A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled workers to be employed on the Works.

(b) A list and type of major Constructional Plant (including vehicles) which the Contractor proposes to employ on the Works.

(c) Details of the Contractor’s methods of working for all operations.

(d) A statement giving the proposals for location or locations and sizes of base camps, accommodation, offices, workshops and stores.

(e) Details of the program for the Works from the date of receipt of the Engineer's order to commence the Works including a complete resources allocation showing the number of units and allotted times for each unit of Construction Plant, materials and labor allocated to each part of the works.

(f) Details of the Public Utility Services to be encountered during the progress of works and their methodology to locate and protect these services.

The narrative report accompanying the construction schedule shall describe the construction methods, plant and equipment proposed to be used and shall explain the expected production rates that are the basis of the scheduled durations.

6.30 Operation and maintenance manual

The Contractor shall provide comprehensive technical documentation in two hard copies in English and in an agreed-on searchable digital format for all new pipes and accessories, materials, and all related components. This submission shall include, but not be limited to: manufacturers' brochures, as-built drawings, operations and maintenance protocols, and a categorized spare parts list.

The Engineer will utilize this data to compile the final Operation and Maintenance manuals for the Employer's staff. Final approval of the Works is contingent upon the delivery of these complete and verified data sets.

6.40 Training for the Client or Operator's personnel

The Contractor shall provide training to a number not exceeding 10 No for the KW&SC staff, nominated by the Engineer during the construction of the Works. This shall include but not necessarily be limited to: - provision of a work crew or crew supervisors or foreman to work alongside the Contractors staff in the fields pipeline; installation and repair of large-bore steel pipelines, specialized welding, 3LPE coating application, and the mechanical installation of heavy-duty valves and flowmeters. The Contractor shall also train the Operator's nominated personnel, as well as supervise the operation of the Works until the operators are fully conversant with the system. This training phase shall be conducted by a English speaking instructor(s) and shall include instructions in the operations and maintenance of the Works in accordance with a programme previously submitted to and approved by the Engineer.

6.50 Resubmittals

If changes in the planned program of construction operations modify the logic of the approved schedule or if the progress of the work differs from that scheduled to such an extent that the time-scaled networks are not representative of the project schedule, but in any event not less often than once a year, the schedules shall be redrawn to show actual progress up to the date of preparation and scheduled progress thereafter. If this revised schedule affects the interfaces with subsequent stages, the schedules for those subsequent stages shall also be revised. These revised schedules and network analysis tabulations based thereon shall be submitted for approval, together with a narrative report explaining the changes and the reasons therefore and describing any new or modified construction procedures proposed and, if applicable, any steps being taken to improve and accelerate progress to ensure completion of works within the time of completion.

SP – 07 CONSTRUCTION CAMPS

7.10 General

The Contractor shall provide or rent a sufficient area for the construction of all offices, site installations, workshops, warehouses, mosque and other camp and sub-camp facilities. The Contractor shall provide, construct, and maintain a fully equipped camp suitable for the accommodation and welfare of all project personnel. The camp shall include sleeping quarters, sanitary facilities, kitchen and dining areas, recreation spaces, administrative offices, board/meeting rooms, first-aid or clinic facilities, workshops, and storage areas as required for the proper execution of the works.

The total built-up floor area shall be sufficient to meet the functional requirements of the workforce, and is expected to be in the range of **2,400–2,500 m²**, providing adequate space for accommodation (approximately 4.0 m² per person) together with necessary areas for sanitation, catering, storage, and administration. All temporary offices, store-rooms, canteens, sanitary premises, and other required facilities shall be provided with approved water supply, sanitary arrangements, and sewerage systems leading to a septic tank or other approved treatment facilities.

The Contractor shall also provide suitable fencing or boundary walls around the camp and construction site to ensure safety, security, and controlled access.

All temporary offices, store-rooms, canteens, sanitary premise, and other temporary constructions, necessary for use of Contractor must be provided. Corresponding water supply, sanitary arrangements, and sewerage system, leading to septic tank or other cleaning means, shall be presented in the form, approved by the Engineer.

The Contractor shall design, install, and maintain high-quality temporary fencing and solid hoarding walls around the entire perimeter of the construction site and camp areas.

The facilities to be provided by the Contractor will include but are not necessarily limited to the construction of:

(a) Building / camp;

(b) site grading, drainage, landscaping and other area improvements;

(c) water and electric power supply and distribution systems;

(d) telephone and other intra-communication systems including local road network;

(e) waste disposal and sewage collection;

(f) solid waste collection and disposal systems; and

(g) fire protection facilities

(h) Miscellaneous facilities.

(i) Medical facilities

The facilities to be provided in camps and temporary sub-camps, to the extent to which such are required, shall be commensurate with those required at the main camp within the practicable limits as determined by the Engineer.

7.20 Site Work

7.20.1 Grading, Drainage and Pavements

All camp areas constructed by the Contractor shall be graded and provided with proper drainage works to protect the facilities from surface run-off and flooding, Low areas shall be filled with excavated material and the entire area laid out and provided with facilities for adequate collection, conveyance and removal of storm waters. Streets and roadways shall be at least 5 meters in width inclusive of shoulders and shall be graded and paved with tuff tiles or surfaced with surface treatment, as approved by the Engineer. Roadway dust control measures shall be instituted as necessary. Sidewalks, where provided, shall be not less than one meter-wide and of concrete except as otherwise approved by the Engineer.

7.20.2 Areas Adjacent to Camps

Camp sites shall be stripped of all debris and organic material to the satisfaction of the Engineer. The ground around the buildings shall be graded to slope away from building perimeters so as to provide adequate drainage and shall be thoroughly compacted. Excavated material shall be disposed off by filling in low areas or as otherwise directed by the Engineer. The Contractor shall landscape the area around each building and facility to provide a pleasant community atmosphere. Existing trees shall be protected from damage as far as is reasonably practical. Any trees removed shall be replaced elsewhere in the vicinity.

7.20.3 Utilities

The utility systems shall be of sufficient size and capacity to serve all normal requirements of the camp facilities, including the Engineer's and Employer's headquarters and camp facilities where applicable.

7.20.4 Landscaping

The Contractor shall landscape all areas in the vicinity of the offices, camps and facilities constructed by him and in the vicinity of his camps and sub-camps with grass, shrubs and trees as required to provide an attractive and pleasant area and to control erosion and local dust. Landscaped areas shall be watered and fertilized as required to maintain plants in an attractive and healthy condition at all times.

7.20.5 Fences

All headquarters, construction camps, colonies and sites shall be completely enclosed with a 2.5 meters fencing wall as approved by the Engineer. All fences, gates, braces, concrete, bricks and other items required for a complete installation shall be furnished and installed by the Contractor as directed by the Engineer.

7.20.6 Maintenance of Facilities

The Contractor shall furnish, make arrangements for and carry out proper and adequate maintenance of the facilities required to be constructed by him so as to provide neat, well-kept, pleasant, healthful surroundings and conditions for all occupants. All areas shall be kept clean, well-graded, free from undergrowth and bush and adequately drained. All landscaping shall be properly trimmed and cut. Roads and streets shall be kept in good repair, patched and sprinkled if and as necessary to keep down dust or a palliative may be employed as approved by the Engineer. Qualified operators and repairmen shall be provided for the operation and maintenance of all utilities. Utilities shall be adequately and properly operated and maintained to provide service and conditions meeting the requirements of these Specifications and accepted good practices. Camps shall be adequately and properly maintained. Janitorial services for public buildings shall be regularly provided. Equipment shall be checked periodically in accordance with the manufacturers' instructions and defective equipment shall be replaced at the Contractor's expense.

SP - 08 OCCUPATIONAL HEALTH AND SAFETY (OHS)

8.10 General

In executing the work of this Contract, the Contractor shall provide working conditions on each operation that shall be as safe and not injurious to the worker's health and safety. The work shall be carried out in compliance with the "Occupational Health and Safety Plan" prepared by the Contractor in the light of guidelines provided in the Environmental & Social Impact Assessment (ESIA). In all rock excavation operations, the Contractor shall install, maintain and effectively operate appliances and use methods approved by the Engineer which will effectively reduce the amount of harmful dust and he shall exercise good practice in the control of silica dust in rock drilling. The crushing of rock, the dumping of stone, the mixing of concrete and the handling of cement, steel and other materials shall be so conducted that these operations will not be injurious to life, limb or health. All work shall be performed in accordance with applicable local and National laws, codes, requirements and regulations including safety, health, welfare of persons and others. The Contractor shall in general be fully conversant and comply with the relevant sections of all construction regulations relating to health and safety in construction and its recommendations.

The Contractor shall employ a full-time OHS Specialist and five OHS Officers to help accomplish the purposes of this Clause SP-08: OHS. The Contractor shall comply with the provisions of the ESIA Report regarding OHS mitigation, monitoring and management measures proposed for the worker’s health and safety.

The Contractor shall submit his detailed OHS Plan for approval of the Engineer, which shall upon approval be strictly followed for all work at the Project site.

The Contractor shall comply with all statutory and other regulations concerning the safety of his site staff, operatives, staff of the Employer and Engineer and members of the public and protection of Environment, as a result of his operations. He shall obtain copies of all the relevant regulations, and shall make them available for inspection by the Engineer.

8.20 Accident and Fire Prevention

The Contractor shall enforce all necessary rules and regulations for the safe prosecution of the work in order to avoid preventable accidents and to minimize injuries to his employees and those of other concerned entities. Work areas shall be adequately posted with safety signs and posters.

Machinery and equipment shall be guarded and all hazards eliminated in accordance with the "Occupational Health and Safety Plan” prepared by the Contractor in the light of guidelines provided in the ESIA. He shall maintain a satisfactory system of inspection and scaling in all open cut excavations. All reasonable precautions shall be taken against fire, and provisions shall be made for the expeditious extinguishing thereof.

8.20.1 In addition to the reports which the Contractor may be required to submit under the law to the Engineer on or before the tenth day of each month a report giving the total force employed on this Contract in man-days during the previous calendar month, the number and character of all near accidents, and accidents resulting in injury and loss of time, and any other information on classification of employees, injuries received on the work and disabilities arising therefrom that may be required by the Engineer.

8.20.2 The Contractor shall, during the entire period of his operation at the construction site, provide emergency facilities with adequate medical and surgical equipment for first aid treatment and approved qualified personnel to administer such treatment to all injured persons, including the Employer's and Engineer's personnel. The Contractor shall designate competent personnel having OHS related experience who shall at all times be in readiness to answer calls to supply medical and surgical services.

Ambulance services to the hospital at the Contractor's camp shall be available at all times.

8.20.3 No payment will be made for the services required in sub clauses of SP-11 other than those made under the Contract Items applicable to the first aid and fire protection facilities required to be provided by the Contractor under Clause SP-07, Construction Camps and Colonies.

8.30 Safety Devices

Safety devices shall be used, as required, and shall include but not be limited to those described hereinafter. Efficient safety helmets, safety gloves, safety boots, safety goggles, safety masks, safety screens, artificial breathing apparatus, fire proof clothing, safety harnesses etc., and shall be provided, as necessary, for all the personnel including all authorized visitors to the Site. Excavated areas shall be properly guarded from the beginning of excavation untill the status of the work removes all possible elements of danger. The efficiency of all safety devices shall be established by satisfactory tests acceptable to the Engineer at least once every three months thereafter.

SP - 9 TRAFFIC FACILITIES

9.10 General

The Contractor shall provide and maintain traffic facilities in the construction area as covered in these Specifications and in areas adjacent thereto, as is necessary for the safe and adequate crossings for pedestrians and equipment. The Contractor shall submit a plan of traffic operation, maintenance and protection for the approval of the Engineer. The Employer will facilitate and liaise with various Agencies like District Authorities, NHA, PSM, PQA, KE, SSGC etc. should the Contractor require assistance for matters relating to these Agencies. After the completion of the Contract, all roads, and other facilities provided by the Contractor shall become the property of the Employer.

9.20 Haul and Construction Roads

The Contractor shall provide and maintain such haul and construction roads and standard safety sign board arrangements where required and as are necessary for the conduct of the work. Construction and maintenance of such roads will not be measured for payment under a separate Contract Item.

To ensure compliance, the Contractor shall submit a comprehensive Haul Road Management Plan for the Engineer’s approval, detailing dust suppression measures, and safety signage placement. The Engineer shall conduct weekly inspections to verify these standards, and any non-compliance not rectified within 24 hours of notice will grant the Employer the right to perform the maintenance using third-party services, with all associated costs deducted from the Contractor's next payment certificate.

9.30 Existing Roads

The Contractor shall maintain in suitable condition, as instructed by the Engineer, existing roads within the Project area and in the vicinity of the construction camp areas for the performance of the Contract.

9.40 Access Road to the Site

Shortly after the receipt by the Contractor of Notice to Commence the work under this Contract, the Contractor shall assume all responsibility for preparation of earthen graded access track in the width of 5 meter along the alignment of gravity pipeline and also for the maintenance of the all access road including shoulders, ditches, and drainage structures throughout their entire lengths and shall continue such maintenance during the specified Contract completion time plus authorized extensions thereof.

SP - 10 ENVIRONMENTAL PROTECTION

10.10 General

The Contractor shall take all reasonable precautions not to cause unnecessary environmental disturbance or damage by his construction activities. This applies to all the construction sites, roads and borrow areas, and also to the surrounding area with communities, which may be adversely affected by the Contractor's operations. In particular, his measures shall include, but not be limited to the instructions for work performance given in the following sub-clauses.

As regards protection of the environmental damage, Sindh Environmental Protection Act (SEPA), 2014 and the Rules made thereafter shall be complied with.

10.20 Erosion Protection

Where there is a risk of severe erosion occurring on the slopes of the temporary or permanent works, the contractor shall implement measures to safely carry water away from such areas to minimize erosion and protect the embankment.

10.30 Waste Disposal

Waste disposal shall be carried out on locations approved by the Engineer and in such a manner as to protect the ground water and any streams from being contaminated.

10.40 Water Pollution

The Contractor shall take all reasonable precautions to avoid contamination of the groundwater or release of pollutants to creeks, streams and rivers. Such pollutants include untreated sewage, petroleum products, biocides and any chemical product foreign to the natural environment. Fuel and oil storage shall be located well away from the water bodies. All waste oil shall be stored and disposed off as per appropriate waste handling standards.

Gravel, screening and concrete batching plants shall be provided with settling ponds, filters or other treatment to avoid processed wastewater entering directly into creeks and water bodies.

10.50 Air and Noise

Dust suppression measures may be taken and environmental monitoring should be conducted on a regular basis along with other measures specified in the ESIA and ESMP.

10.70 Reinstatement of the Site

Before completion of the Works, the Contractor shall remove all temporary access roads or tracks and temporary stockpiles, if required by the Engineer, and shall restore all disturbed areas by shaping such areas to fit in with the local topography, as appropriate, by ripping, filling, top soiling and grassing.

On completion of the Works, the Contractor shall remove from the Site or dispose of in accordance with the Contract all temporary Site installations and structures, surplus materials, construction plant and equipment, and all rubbish, debris and scrap. The Contractor shall leave the Site in a clean and tidy condition in all respects to the approval / satisfaction of the Engineer.

Should the Contractor fail to complete this work within 70 days of the issue of the Taking -Over Certificate, the Employer may decide to have the work carried out by others and the expense incurred by the Employer in doing so shall be deducted from the Contractor's final payment.

SP - 11 TRANSPORT AND HANDLING OF CARGO

11.10 General

The Contractor shall be solely responsible for the shipment of materials, plant, equipment and all other things necessary for the completion of the Works including the selection of routes and carriers to ensure that all shipments are safely and expeditiously transported. It may, however, be noted that carriers of certain nationalities may from time to time be prohibited from delivery to Pakistani Ports. The Contractor shall not consign any shipment to any prohibited carriers and shall be responsible for complying with any such regulation of the Government of Pakistan.

11.20 Transportation Route

The Contractor shall make his own enquiries to ensure that adequate unloading and other facilities are available at the Port of Karachi/Port Qasim. He is warned that for heavier loads it may be necessary to use ships tackle and he may, therefore, wish to impose limits on his loads.

The Contractor shall be solely responsible for satisfying himself at the time of shipment as to the clearance gauges, suitability and availability of trailer trucks, availability of cranes and costs and charges incurred for transportation of MS Pipes and other equipment.

Prior to the dispatch of any materials, pipes, or equipment, the Contractor shall submit a comprehensive transport and handling methodology to the Engineer for formal review and approval. The Contractor shall coordinate all critical logistical phases with the Engineer and provide advanced notification to allow the Engineer or his representative to witness the cargo handling operations.

11.30 Port Charges and Port Congestion

The Contractor shall be deemed to have obtained all information as to port clearance facilities/charges, loading and unloading facilities/costs, storage facilities/charges, transportation facilities/costs and congestion at Karachi Port and Port Qasim and shall be deemed to have confirmed the requirements thereof at his own cost and responsibility. The Contractor shall be deemed to have included all clearing, forwarding and any other incidental costs in this regard in his Tender. The Contractor has the option to use either the Karachi Port or Port Qasim or both at his own risk and costs. All charges, costs and expenses incurred by the Contractor, shall not be separately reimbursable.

11.40 Unloading and Storage at the Site

The Contractor shall unload all MS Pipes , Valves and fittings , Equipment, Sluice Gates and other material at the Site. Items for permanent installations shall be properly stored in areas designated by the Employer and shall be protected as required to prevent damage or deterioration of MS Pipes, valves and fittings, Plant & Equipment, Sluice Gates and other material. Storage shall comply with the requirements of the Specifications or the approval of the Engineer.

SP - 12 DIRECTED AND REQUIRED

Unless otherwise stated, wherever in the Specifications, or the Drawings, the words "directed", "required", "permitted", "ordered", "designated", "prescribed", "instructed" or words of like meaning are used, it shall be understood that the direction, requirement, permission, order, designation, or prescription of the Engineer is intended, and similarly the words "approved", "acceptable", "Satisfactory", or words of like import shall mean approved by or acceptable or satisfactory to the Engineer.

SP - 13 COMMUNICATIONS TO THE ENGINEER

Pursuant to the definition of Engineer in Sub-Clause 1.1 of the Conditions of Contract, the Engineer has an office in Karachi to which the Contractor shall, except when otherwise directed, address all communications. The address is: B-27, Block-16, Gulistan e Johar, Karachi

SP - 14 MEASUREMENT AND PAYMENTS GENERAL

14.10 Bill of Quantities

The Bill of Quantities (Volume II to Bid) contains the following Bills for which payment will be made to the Contractor as per contract:

Bill No. 1 – Preliminary & General Items

Bill No.2 – Provisional Sums

Bill No. 3 - Water Transmission Main MS pipeline

Bill No. 4 – ESMP Implementation Cost

Bill No. 5 – Day Works

14.20 Payments - General

Payments will be made as provided in "**Clause 14 Contract Price and Payment**", Conditions of Contract and as specified hereinafter.

Except as stated herein or specifically stated elsewhere in the Contract, the Items under each Bill are the only Items under which measurement and payment will be made for work performed for that Project Feature. If some work required by these Specifications or by the Drawings for a Project Feature is not included in the payment items in the Bill of Quantities for that Project Feature, no separate payment will be made for that work; notwithstanding that a payment item for similar work may appear in other Bills.

The Bills divide the work under different features of the project. The work items contained in the Special Provisions are provided in Bills No.1 & No.2. Other work items are contained in the respective Bill Nos. from 3 to 5. This separation is for convenience only, and does not in any way limit the applicability of any Section of Specifications.

The payment clauses in the last part of each Section of the Specifications includes lists of items to which the various payment clauses apply. These lists are included for guidance and convenience, and should they differ in any respect from the items listed in the Bill of Quantities, the latter shall take precedence.

14.30 Measurement - General

The Engineer will measure the actual quantities of work performed or items furnished in accordance with the specified methods of measurement. In all cases where a quantity under one Item measured for payment is contiguous to the quantity under another Item measured for payment the division lines marking the beginning and end of the quantity under each Item shall be as indicated on the Drawings or as defined in the Specifications. If any question arises as to the location of any such line, it shall be determined by the Engineer. Unless otherwise specified, measurement for payment will be made only for material removed or placed, accepted and required as part of the Permanent Works. Excavations for construction plant and other purposes of the Contractor's choice will not be measured for payment unless such excavations are required for the Permanent Works.

No separate payment will be made for any work required to be performed under the whole of Special Provisions, except as specified in this Clause. Where maintenance, repair, operation or other work in connection with a particular facility is not specifically included under an item, the cost thereof shall be considered to be included in the prices for the various items of the Contract. No measurement for payment will be made for work required by this Section under such items of the Bill of Quantities as concrete, cement, earthwork and similar items.

14.40 Measurement by Weight

The weights of materials and equipment, the installing, handling or placing of which is to be paid for on the basis of weight, will be determined by the Engineer from information furnished by the Contractor. The weights shall be determined as defined in the relevant Measurement and Payment clauses. Unless otherwise specified, the Contractor will not be required to provide scales for actually weighing these materials and equipment; the Engineer will determine the weight of each part or item involved in the most practicable manner and he may use for that purpose railroad shipping weights, manufacturer's weights, catalog weights, scale weights if available, or computed theoretical weights at the Engineer's discretion. Net weights only will be paid for and the weight of all tare, packing and blocking will be deducted. No extra allowance will be made for paint coatings.

14.50 Compensation Included

Payment to the Contractor of the amounts based on the actual quantities of work as measured by the Engineer in accordance with the specified methods of measurement and the prices stipulated in the accepted Tender, will constitute complete compensation for all work shown on the Drawings, provided in the Specifications or other Contract Documents, or reasonably inferable from any of the Contract Documents, and all expense incidental thereto; and all costs of accepting the general risks, liabilities and obligations set forth or implied in the Contract Documents. The Contractor will be required to perform such work for such payment whether the work is specifically referred to or otherwise included in a specific item in the Bill of Quantities or not. Payment under all items shall include, but not necessarily be limited to compensation for furnishing all plant, supervision, labor, equipment, overhead, profit, materials and services, and performing all work required to accomplish and complete the work specified under each item and all other work required by the Contract Documents. No payments will be made on account of anticipated profits for work covered by the Contract which is not performed. The Contractor shall have no claim for further payment in respect of any work, or method of execution described in the Contract for which apparently no corresponding item is given in the Bill of Quantities and the cost of any such work or method of execution shall be deemed to be included in and covered by the Contract Rates.

14.60 Provisional Sum Items

Payment for the Provisional Sum items listed in the Bill of Quantities will be made in accordance with the requirements of the General Conditions, applicable to provisional sums. Payment will cover only such work incidental to these items as are not included under other items. Payment will be made only for work performed in accordance with the Drawings, Specifications and procedures approved or established by the Engineer. The indirect cost of contractor’s overhead shall not be more than five percent. Also, payment will not be made for such indirect costs as are compensated for under the Contract prices for other items.

14.70 Unit of Weights and Measurements

The tender drawings and technical specifications and existing data and information pertaining to civil engineering works of the project are based on metric system. However, some of the drawings are in both metric and FPS (Foot, Pound, Second) systems.

The unit for all measurement and payment in this Contract shall be in MKS system (Meter, Kilogram, Second). All the items in the BOQ and measurement and payment clauses have therefore been provided accordingly. Conversion factors wherever required for conversion of quantities from one system to another shall be as per ACI code. Some of the conversion factors are as follows:

One linear meter	=	3.28	linear feet
One square meter	=	10.76	square feet
One cubic meter	=	35.31	cubic feet
One gallon (Imp)	=	4.546	liters
One US gallon	=	0.832702	Imp. Gallon
		3.785	Liters
One kilogram	=	2.2046	pounds
One ton	=	1000	kilograms

Unless otherwise specified, a gallon means an Imperial gallon.

PART – II

PARTICULAR SPECIFICATIONS

CHAPTER 1 - EARTHWORKS

1.01 General

The Contractor shall make excavations and embankments and dispose of excavated materials all as specified herein shown on Drawings or ordered by the Engineer and referred to herein as earthworks.

1.02 Notice of Earthworks

Before commencing any earthworks on the Site the Contractor shall give the Engineer at least 7 days written notice of the proposed date, which shall not be less than 7 days after the appropriate part of the site has been cleared. Within this period the Contractor shall make a record of the ground levels and topography to the satisfaction of the Engineer. The contractor shall provide the Engineer with a copy of the original ground level survey drawings including the existing infrastructure located within and adjacent to the construction corridor and the existing underground utilities using pipe locators, electrical and telecom locators and Ground Penetrating Radar GRP. The survey outcome and drawings shall be signed by the contractor and the Engineer as agreed and which will be used for measurement purposes.

1.03 Existing / Original Ground Level

For the purpose of the specification the terms “existing ground level” and “original ground level” shall refer to the ground surface before the start of earthwork operation but after site clearance as per Clause 1.40 of Part I, Special Provisions.

The excavated material from previous construction work if disposed along the alignment of proposed Pipelines and structures shall be removed by the contractor and shall be disposed of outside the limit of works to an approved dump site as approved by the Engineer and as provided for in clause 1.16 hereof. Cost of this work shall be deemed to have been included in the quoted rates.

1.04 Excavation of Unsound Material

If any unsound material occurs in the bottom of any excavation, or on the foundation to an embankment, the Contractor shall remove it and dispose of it to the satisfaction of the Engineer. Unless otherwise specified or ordered by the Engineer, the Contractor shall fill the voids so formed with concrete Class D in the formation to structures. In case of pipeline, the same material may be used to backfill the formation to embankments and with suitable granular material to the approval of the Engineer.

If the Contractor encounters material which to his opinion may be unsound, he shall immediately inform the Engineer, who will instruct the Contractor in writing as to whether the said material shall be treated as unsound, provided that the Engineer will give no such instruction except in accordance with Conditions of Contract. The omission by the Engineer to give an instruction shall not relieve the Contractor from any responsibility for defects in the work, if, prior to construction, the Contractor shall have failed to request the Engineer in writing to inspect the exposed foundation.

If in the opinion of the Engineer, the soil encountered at the base level is considered unsound, the Engineer may order sampling and testing of the material to ascertain the nature of material and its compaction characteristics. On the conclusion of such sampling and testing for classification of soil as per AASHTO M-145, the unsoundness of the material shall be decided by the Engineer.

The material shall be declared unsound or unsuitable if it falls under A-6 or A-7 of AASHTO soil classification.

Unsuitable or surplus material arising from excavation shall require being disposed as per contract.

Unsuitable material shall be removed up to the depth of 200mm falling under construction of roads, structures and Pipe line etc. and be replaced with suitable borrowed earth work

1.05 Safety of Excavation and Adjacent Structures

The Contractor shall provide support necessary to ensure the stability of the excavation and adjacent structures. The Contractor shall be responsible for the safety and security of all excavations at all times during the execution of the contract and where necessary shall provide soldier piling system or other measures required and approved by the Engineer to prevent movement or loss of ground outside the boundaries, settlement of or damage to property, or injury to persons. The Contractor shall make good any damage to structures, services or other properties caused by such movement, loss of ground and settlement. The Contractor shall also take precautions to route his plant in such a manner as to minimize the likelihood of slips occurring due to vibration or surcharge from the working or movement of heavy machinery.

The sides of all excavations shall be kept true and shall where necessary be adequately supported by means of soldier piling or other safety system approved by the Engineer. All supports shall be of sound design and construction and shall be sufficiently watertight to permit excavation, concreting and other work to be completed satisfactorily. The Contractor will be permitted, subject to the approval of the Engineer, and based on the geotechnical design to adjust side slopes of excavations in soft materials, which are to remain open temporarily in preference to shoring or strutting. However, no payment shall be made for extra excavation volume as a result of these measures. Excavations shall be kept free from water and it shall be the Contractor's responsibility to construct and maintain temporary diversion and drainage works and to carry out pumping and to take all measures necessary to comply with this requirement.

Sufficient numbers of suitable barricades, flood lights, warning lights, signs and similar items shall be provided and installed by the Contractor prior to proceeding any earthwork operation.

Any excavations made, by the Contractor, for his convenience or due to his fault, beyond the prescribed limits, shall be re-filled by the Contractor, by suitable material, at his own cost, as directed or approved by the Engineer.

The Contractor shall be responsible for any personal injury or property damage due to his negligence.

Wherever necessary or required for the convenience of the public or individual residents, the Contractor shall provide suitable temporary bridges over unfilled excavations. All such bridges shall be maintained in service until backfilling has been completed.

Where necessary, during the progress of excavation works, the Contractor shall make proper detour for the traffic and shall install proper signs, indicating the detour, in accordance with the instructions of the Engineer

The maximum length of open and unbackfilled trench is to be considered as 300 m. The Contractor shall be solely responsible for the security, safety, and stability of all open excavations. This responsibility includes, but is not limited to, the provision of continuous heavy-duty safety barriers, nighttime warning lights, pedestrian crossings, and 24-hour site surveillance where necessary. The Contractor shall ensure that all open sections are managed to prevent public hazard or unmanaged soil collapse.

- Bracing and Shoring

The Contractor shall supply, fix and maintain necessary soldier piling or other similar safety system at the required spacing and embedment, as may be required to support the sides of the excavation, to protect workmen in the trench and to prevent any trench movement which might any way injure or delay the work, change the required width of the trench, make unsafe condition for adjacent pavements, utilities, buildings or other structures above or below ground.

The Contractor shall be responsible for the design of the shoring system, including pile spacing and embedment, based on soil conditions, surcharge loads, excavation depth, and the proposed construction sequence.

Soldier piling shall be withdrawn and removed as the backfilling is being done, except when the Engineer may agree that such shall be left in place, at the Contractor's request. In any case, the Contractor shall cut off any such sheathing at least 600 mm below the surface and shall remove the cut off material from the trench.

All sheathing, shoring and bracing which is left in place under the foregoing provisions shall be removed in a manner so as to not endanger the completed work or other structures, utilities or property, whether public or private.

1.06 Slips, Falls and Excess Excavation

The Contractor shall take great care to prevent slips and falls of material from the sides of the excavation and embankments.

In the event of slips or falls occurring in the excavations, and where excavations are made in excess of the dimensions of the permanent works, the voids so formed shall be filled by the Contractor. When such voids, in the opinion of the Engineer, may affect the stability of the ground for the support of the works, or of the adjacent structures and services, the Contractor shall fill the void solid with concrete Class D. In other cases, the Contractor shall fill the voids with selected excavated material placed and compacted to the approval of the Engineer. This shall be at no extra cost to the Employer.

Contractor shall exercise due diligence and care and shall ensure that excavation for intake structures and conduits is precisely carried out up to the required trench levels as specified in the drawings.

Particular care shall be exercised by the contractor to ensure that over excavation beyond specified levels is not carried out. In case of over excavation, the volume excavated shall be replaced by Concrete of class D at his cost. Filling of voids due to over excavation shall be in accordance with para 1.04 hereof.

1.07 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 a 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.

1.08 Preparation of Formations for Structures

Where the formation of any excavation, being other than rock, is to support the foundations or base of a structure, the bottom 150 mm thereof, shall be carefully excavated and trimmed immediately before placing the permanent work upon it. Formation in granular material shall be compacted using suitable type compactors. Foundation of proposed structures shall be compacted to 95% of the modified proctor density determined in accordance with AASHTO T-180. (Modified). Where the foundation is at or above existing ground level a depth of 150 mm shall be excavated below original ground level and replaced by granular material. Formation in granular material shall be compacted using a vibrating type compactor. Where the formation of any excavation in rock is to support the foundation or floor of structure, shattered or loosen material shall be removed from the rock formation and the resulting over break shall be replaced with Class D concrete at the contractors own expense.

Before start of concreting work, the Contractor will also carry out confirmatory tests to reconfirm the bearing capacity of soil at the base of structures. Results of the tests shall be timely reported to the Engineer before proceeding with any concreting work. Cost of these tests shall be deemed to be included in the quoted rates.

1.09 Backfill and Fill

Unless otherwise specified or approved the material used for backfill and fill shall be material selected from the excavated material of particle size not exceeding 100 mm.

Backfilling against the permanent work shall be selected, and free from boulders, cobbles, rock fragments and the like greater than 50 mm nominal size, unless otherwise specified or approved. After approval has been given by the Engineer in accordance with the contract for filling or backfilling to commence, the operation shall start with the minimum delay and shall continue until the work is completed in the part of the Works for which the approval is given.

The Contractor shall ensure that soil depth of backfill material or overburden material on proposed structures and conduits for any other reason does not exceed as specified in the drawings.

1.10 Scarification

The Contractor shall scarify to a depth of 200mm the ground upon which compaction of fill is specified. He shall ensure that no vegetation remains in the area to be covered by the Works, and shall if necessary bring the moisture content of the specified surface material to its optimum value before placing and compacting any fill thereon.

The Contractor shall similarly treat the surface of any fill which in the opinion of the Engineer has been exposed too long before the placing of subsequent fill thereon.

1.11 Compaction of Fill and Backfill

Unless otherwise specified or shown on the drawing, the Contractor shall deposit fill or backfill in layers of uniform depth not exceeding 200 mm thick and shall compact it by methods and with the use of such Construction Plant as are necessary to achieve the degree of compaction specified. The layers shall have a slight cross-fall away from the permanent work. Where no degree of compaction is specified the fill or backfill shall be compacted by the even distribution over it of the passage of earthmoving plant and labor.

Where the degree of compaction is expressed as a percentage, it is the percent ratio of the dry density of the compacted material to the maximum dry density as determined by the modified compaction test (AASHTO T-180 Method D-modified). At least one month before commencing such compaction of the fill in the Works, the Contractor shall submit to the Engineer details of the method and Constructional Plant proposed to be used, and shall make such tests of the materials before and after compaction as the Engineer considers necessary, both of the trials and of the permanent work, to ascertain to his satisfaction that the degree of compaction specified is achieved. The modified compaction requirement will be 95% of Maximum Dry Density unless otherwise specified or shown on the drawing. All testing shall be in accordance with AASHTO T-191 and according to Modified Proctor Test.

The Contractor shall if necessary wet the fill material prior to and during compaction so that its moisture content lies within a range of values suitable for the fill material and the adopted method of compaction as may be established by prior trials on Site.

1.12 Hardcore Filling

Hardcore shall be clean, broken stone that will pass in all directions through a 100 mm ring. Hardcore shall be well packed and compacted to a CBR value of at least 25% as measured in accordance with Test Nr 16 of BS 1377. Sand may be added to hardcore to achieve this degree of compaction.

1.13 Allowance for Settlement

The Contractor shall make due allowance for consolidation and settlement of fill and compacted fill such that the levels and dimensions of the finished surfaces at the end of the Period of Maintenance are not less than those specified, shown on Drawings or ordered by the Engineer.

1.14 Borrow Areas

Should there be insufficient selected excavated material from the works for the purpose of filling, the contractor may submit for the Engineer's approval his proposed sites of borrow pits from within the sites or other areas.

The contractor shall apply in writing for the approval of the Engineer given detail of his proposal for the use of borrow pits at least 1 month before the proposed date of starting earthwork at the site of each borrow pit.

Such approval shall be contingent upon the Contractor obtaining all necessary permits, licenses, and clearances from the relevant statutory authorities, including but not limited to, the Environmental Management Agency and local government bodies. The Contractor shall be responsible for all costs and delays associated with securing these legal requirements and shall provide copies of all valid permits to the Engineer prior to the commencement of any excavation at the borrow site.

1.15 Works at Borrow Pits

The Contractor shall excavate at the site of borrow pits to expose the material required for fill and shall select and excavate the said material. After the required amount of material has been excavated from each borrow pit, the Contractor shall reinstate its site by spreading the previously removed superficial materials in layers not exceeding 0.25 m deep over the area of the excavation and by grading and trimming the surfaces all to the satisfaction of the Engineer and the relevant authority including the environmental agency. Where practicable such grading shall be made to prevent accumulation of surface water.

Where the water table is encountered most of the material from borrow areas may have to be excavated from below the water table. The Contractor must include this in his rates and allow suitable drainage periods before the material can be reworked to form embankments.

Geotextile shall be placed where required or as instructed by the Engineer in order to prevent sand from migrating outside their confined area, whilst allowing water to drain. The geotextile shall be a non-woven needle punched and thermally bonded polymer and be manufactured in accordance with ISO 10319. The minimum tensile strength and maximum elongation at maximum tensile strength in accordance with ISO 10319 shall be 9 kN/m and 40% respectively. Puncture resistance in accordance with ISO 12236 shall be 1500 N, whilst the effective opening size and permeability, in accordance with ISO 12956 and ISO 11058 respectively, shall be 125 micrometer and 190 l/m².sec. Installation shall be in accordance with the manufacturer's guidelines and the contractor's proposal in this regard shall be submitted for the Engineer's approval before installation commences.

1.16 Disposal of Surplus Material

The contractor shall transport and dispose of off Site, at a dump to be provided by the Contractor, all excavated material surplus to that required for the Works. The locations proposed by the Contractor for storing excavated materials temporarily prior to removal from site shall be subjected to the approval of the Engineer.

Unless otherwise approved, temporary dumps of surplus material prior to removal from Site shall be graded to slight cross falls and safe, even side slopes. The maximum height of such dumps shall be 2 m.

All excavated material that becomes surplus to the requirement of the Works shall be removed from the Site and disposed of to the Engineer's satisfaction, and at any location or locations agreed to by the Engineer for such disposal.

1.17 Construction Methods

Excavation of trench for conduits and structures shall be carried out using only suitable excavation equipment of such types and in such numbers as is appropriate to a contract of the scale and complexity of this Contract, all subject to the approval of the Engineer. Use of vibratory or pneumatic equipment for excavation is not permitted. The heavy earthmoving equipment shall not be brought within a distance of 1.5 meter from the face of the existing structures and no equipment shall be allowed over the roof of the existing Structures. Full details of the Contractor's proposed method of working and earth moving plant shall be provided in accordance with the instructions for bidding.

1.18 Excavation and Disposal

Material excavated for the construction of Structures, conduit and pipe line may be placed alongside for use in back fill and fill for the embankments. Excess material over and above that required shall be re used in other areas or disposed of in spoil embankments on or off site as directed by the Engineer.

The Contractor shall prepare in advance a plan of earthworks operation for each particular part of the Works to be constructed at any one time, detailing the location and program of excavation and of placing the spoil in embankment etc. The Contractor shall submit his proposed plan at least 28 days before his intended date to commence earthworks on each particular part of the system for Engineer's approval.

Where a method of work is envisaged which will involve the longitudinal movement of excavated material along the pipe line, conduit or road alignments, movement shall be controlled with the use of mass haul diagrams. In such cases copies of these diagrams shall be included in the Contractor’s plan of earthworks operation to be submitted to the Engineer in accordance with the above requirements.

1.19 Embankments

Embankments and ramps shall unless otherwise specified be formed from the material excavated from the site of the Permanent Works, if available. Where material for embankments is required additional to that available from such excavation, or where so specified, it shall be obtained from borrow areas under the terms of Clause 1.14.

The Engineer will maintain a random pattern of compaction testing as per AASHTO T-180 (Modified) for moisture density relationship test and AASHTO T191 (Sand cone method) to ensure that the Contractor is maintaining a working cycle which achieves the required compaction.

Embankments which carry unsurfaced roads shall be aligned and graded on the top surface by use of a motorized grader so as to permit the safe and easy passage of a light vehicle at a speed of 40km per hour and shall be maintained in this condition to the end of the Period of Contract.

The final finish of all unsurfaced roads shall be completed by use of a motorized grader.

1.20 Rock

Before commencement of excavation in rock the Contractor shall demonstrate to the satisfaction of the Engineer his inability to excavate without resort to heavy percussion tools complete with rock bits, or hydraulic wedges.

Where reasonable progress can be made with the aid of ripping tools (200 HP Dozer) the material will not be considered to be rock. The decision of the Engineer about the material to be excavated being rock or not shall be final & binding.

Use of jack hammers, and vibratory tools in proximity of existing structures may be allowed with due care proposed by the contractor.

Prior to the commencement of the excavation of any material which the Contractor considers may be rock, the Contractor shall advise the Engineer of the presence of such material and the said material shall not be classified as rock unless the Engineer has agreed to such classification before excavation commences. The Engineer's agreement shall be subject to reservations on the extent of the rock so classified and the extent of the rock excavation shall be determined after examination of the excavated faces. Excavations where rock has been encountered and classified as such shall not be backfilled before examination of the excavated faces by the Engineer to enable the extent of the rock excavation to be determined.

1.21 Rubble and Loose Rock

Where stone pitching rip-rap or scour protection and rock filled vehicle barriers on existing embankment and structures are to be removed, the stones shall be stockpiled outside the work area for later use in the same works. Additional quantities of stone and granular filter layer shall be provided by the contractor to complete the work as shown on Drawings.

Where backfill or fill is shown as "rubble" or "loose rock", for example for soak ways from septic tanks, the material shall consist of durable gravel, broken stone or crushed concrete with a particle size not exceeding 100 mm. The grading of the material shall be such that there is no migration of fines into the fill and not more than 10% of material shall pass a BS sieve with 5 mm apertures.

The method of placing shall be to the approval of the Engineer and shall ensure that fines separating out during transportation are discarded or selectively placed.

There shall be no compaction or working of the material except that necessary to give a stable fill.

Before covering rubble or loose rock with other fill the surface shall be blinded with a layer of selected fill that closes the surface voids only. The initial layer of covering fill shall not be watered.

1.22 Rough Grading and Excavation by Blasting for Pipelines

The Contractor will perform rough-grading by earth-moving equipment, to match the preceding and succeeding Natural Ground Level of proposed alignment of pressurized water transmission pipe line. Earth moving equipment “Front-Blade Dozers -350 HP” will be used to remove hills and other elevated undulations.

If the Earth moving equipment “Dozers-350 HP” could not provide sufficient progress to remove hills and other elevated undulations, the contractor can use controlled blasting, with the Engineer’s approval.

In view of the existing structures and in proximity to inhabited areas and adjacent structures where blasting is prohibited, the excavation in rock shall be carried out by jack hammer fitted to an excavator.

Blasting where required shall be of such controlled methods so as to minimize vibration and prevent any damage to adjacent line or structures and shall be permitted by the Engineer only after the safety measures is guaranteed by the Contractor.

The contractor will monitor the vibrations to ensure compliance with this requirement and equipment approved by the Engineer shall be used for measurements. In the event of the use of explosives being permitted by the Engineer the Contractor shall comply with the recommendations of manufacturer, rules and regulation of concerned department or the relevant authority or agency. and give at least 48 hours’ notice of blasting to all relevant authorities and the Engineer.

The handling of explosives shall be entrusted only to experienced and responsible men who are specifically qualified and licensed, to the satisfaction of the Engineer, and in conformity with the statutory regulations. All drilling and blasting shall be done in such a manner as to bring the excavation as close as possible to the required cross sections, and to disturb as little as possible the material to be left in place. Blasting by means of drill holes or any other method shall be performed at the entire risk and responsibility of the Contractor who shall have no claim to payment for extra work occasioned by breakage outside the approved cross-sections or dimensions. The greatest care shall be taken by the Contractor during all blasting operations to ensure that no injury be done to persons or damage to property or to the finished work. Shots shall be properly loaded and capped, and only a moderate charge shall be used in each hole. A record of all explosives used, showing locations and amounts, shall be kept by the Contractor for checking by the Engineer.

The contractor shall be solely responsible for obtaining a license to obtain, store & use explosives

If necessary, blasting shall be restricted to time prescribed by the Engineer and if traffic on the road has to be interrupted, the Contractor shall obtain approval of his schedule for such interruption from the relevant authorities and shall satisfy the Engineer that he has obtained it. No extra payment shall be admissible for such arrangements as described here above.

However, for construction of the structures, excavation by blasting with explosives is not allowed within 50 m of any existing structure following approval of the Engineer.

1.23 Storage of Explosives

The acquisition and storage of explosives and detonators and all blasting work undertaken shall be in accordance with statutory regulations. The Contractor shall obtain any permits required and shall comply with the provisions of such permits.

Where explosives are used the Contractor shall provide suitable buildings or warehouses in approved positions for the storage of explosives, which shall be stored in the manner and quantity approved by the Engineer or as per relative laws of government. Such storage places shall be accessible only to authorized personnel. They shall be properly marked; all doors or accesses thereto shall be constructed of materials as directed by the Engineer and provided with secure locks and all necessary means for preventing access by unauthorized persons.

The Contractor shall be responsible for the prevention of any unauthorized issue or improper use of any explosives.

1.24 Measurement and Payments

All excavation in Common Material or Rock, rough grading and backfilling, to be paid for shall be the number of cubic meters of materials measured in its original position computed by average end-area method and excavated to the satisfaction of the Engineer. The pay line for structural excavation and backfilling shall be as shown on drawings.

Measurement for excavation shall not include material removed below the formation level and beyond specified pay-line, as described above or shown on drawings, as a result of anticipated swell, additional materials resulting from sliding, slips, caves-ins, silting or filling, whether due to the action of the elements or the carelessness of the Contractor.

The Excavation and backfilling rate includes:

(a) Excavation and backfilling - mechanical or other means.

(b) Loading, transporting, unloading and compacting the excavated material in fill areas including site levelling, road embankments and channel bunds or disposal off site as directed by the Engineer.

(c) Keeping all excavations free from water by dewatering or establishing the well points for lowering the ground water level below the required excavation level if required.

(d) Levelling or grading and ramming of bottoms, trimming sides and taking all necessary temporary anti-erosion measures and preparing rock surfaces as required.

(e) Multiple handling of excavated material and all transport and handling charges at loading and unloading ends.

(f) Planking and strutting and/or any other means to support the side of the excavation.

(g) Additional excavation, backfilling and ramming for planking and strutting and for working space for the construction and striking of formwork etc.

(h) Additional excavation, backfilling and ramming, should the Contractor opt to batter the face of the excavation in lieu of planking and strutting.

(i) Clearing any falls of earth into excavation.

(j) Compliance with the Engineer's instructions issued from time to time to ensure the safety of excavation

(k) Making records of ground levels and topography and the position and extent in the excavation of services, stratum and obstructions encountered and for all double handling as deemed necessary.

Excavation in rock to be paid for shall be the number of cubic meters of materials measured from the level at which rock is encountered, computed by average end- area method and excavated including breaking, drilling, blasting where ordered by the Engineer, removal and disposal of surplus material to the satisfaction of the Engineer. For unsound material as the volume of material directed for removal by the Engineer.

Fill: as the net volume above the prepared ground surface after topsoil stripping or site clearance or above granular fill around pipes as directed by the Engineer, of the permanent earthwork to the dimensions shown on the Drawings or ordered by the Engineer, from approved of source of material. The rate for filling shall include for preparation and restoration of borrow pits, excavation from borrow pits, re-excavation from stock pile, haulage, selection, handling placing and compaction of selected fill material to the percentage of Maximum Dry Density specified, carrying out compaction test.

Backfilling in trenches or where required with selected excavated earth material from any site locations to be paid for shall be the number of cubic meters of materials measured as the net volume between the relevant lines and levels indicated on the drawings or otherwise ordered by the Engineer or between these lines and levels and the surface ordered by the Engineer. Any allowance for settlement of backfill material will not be measured. The pay line for backfilling shall be as shown on drawings.

The rate for backfilling shall include for selection, multiple handling, breaking clods placing, watering and control of moisture content, spreading and compacting in layers to the percentage of Maximum Dry Density specified, carrying out compaction test.

Disposal of surplus excavated material shall be the sole responsibility of the Contractor and shall be deemed to be included within the rates. No additional payment shall be made for disposal of surplus excavated material after meeting the requirements of fill and backfill. The rate of B.O.Q for other items shall include the cost of haulage and disposal of surplus material within 5.00 Km as directed by the Engineer.

No separate measurements for payment will be made inter alia for site clearance, removal of bush, trees, debris, solid waste etc. unless otherwise specified in the contract. Item rate of Excavation includes making records of ground levels and topography, supporting excavations, making good slips, falls and excess excavation, making benching for excavations in greater depth, working space beyond pay-line, trimming surface of excavations for structure and embankments (other than pavements), making allowance for settlements, special compaction trials, control of moisture contents, preparation and restoration of borrow pits, scarification, location and shaping of disposal heaps and embankments, trenches for pipes and cable within a structure, supplying samples and testing for the Engineer evaluation, interruptions and delays whilst carrying out tests.

The quantities determined shall be paid for at the contract unit price respectively for each of the particular pay item shown in the Bill of Quantities, which price and payment shall be the full compensation for all the costs involved in the proper completion of the work prescribed in that particular item.

1.25 References

Following publications have been referred:

1.AASHTO T-180	Standard Method of Test for Moisture-Density Relations of Soils
AASHTO T-191	Standard Method of Test for Density of Soil In-Place by the Sand-Cone Method
AASHTO T-193	Standard Method of Test for Determining California Bearing Ratio
BS 1377-3	Standard Methods of test for soils for Civil Engineering Purposes

CHAPTER 2 - CONCRETE & REINFORCEMENT

Foreword

Design of all reinforced concrete structures are to be carried out in accordance with ACI 315 and ACI 318. While that of water retaining structures is additionally designed in accordance with ACI 350. Construction of reinforced and water retaining structures is therefore to be carried out in accordance with the relevant provisions of ACI Codes. The specific requirements made in this Chapter take precedence over those specified above.

2.01 Cement

2.01.1 General

Unless otherwise specified the cement used in all Structure Works shall be Ordinary Portland Cement (OPC) complying with ASTM C 150 (Type I) or BS EN 197-1 CEM-I or equivalent and where, Sulphate Resisting Cement (SRC) complying with ASTM C 150 (Type V) or approved equivalent, shall be used where specified and as directed by the Engineer as per approved mix design. The Contractor shall supply the manufacturer's test certificate for each consignment of cement received at the Site as provided for in Section 15 of ASTM C 150 or Clause 11.1 of BS EN 197-1 CEM-I . The Contractor shall maintain a record available for inspection by the Engineer of the locations of concrete for each consignment. The Engineer reserves the right to request additional independent laboratory tests or field trials to verify the performance of the product. Such tests shall be witnessed by the Engineer or his representative, and the Contractor shall provide all necessary assistance and access to facilitate this verification.

Where specified and as directed by the Engineer, sulphate resisting cement (SRC) complying with ASTM C 150 (Type V) or approved equivalent, shall be used in place of OPC.

The Contractor shall ascertain whether the alkali content of proposed cement is greater than 0.6% calculated as Na_2O + 0.658 K_2O. Should the alkali content be found to exceed this threshold, or in the absence of verified data, the Contractor shall, at his own expense, perform additional testing in accordance with BS EN 196-2 or approved equivalent: Part 2 as directed by the Engineer to confirm the material's suitability.

The Contractor shall supply samples of cement for confirmatory testing when requested by the Engineer's Representative, both from any store on Site and the place of manufacture.

“Only one brand of each type of cement shall be used for concrete in any individual member of the structure. Cement shall be used in the sequence of receipt of shipment, unless otherwise directed. There shall be sufficient cement at site to ensure that each section of work is completed without interruption. “

The necessary apparatus shall be maintained on Site to conduct preliminary and works tests as required by the Engineer to determine fineness, compressive strength (mortar cube), initial and final setting time and soundness of the cement, as described in BS EN 196 series: Part 3 or Equivalent ASTM Standards.

Cement and other cementitious material shall be transported to the site in containers approved by the Engineer. It shall be fully protected from the weather during transportation and site storage.

2.01.2 Other Cementitious Materials

Ground Granulated Blast - Furnace Slag (GGBS) shall be used where specified as a cementitious material in concrete with Ordinary Portland Cement (OPC) complying with ASTM C989 or approved equivalent and shall be from an approved source.

Cement shall be certified by the manufacturer as complying with the requirements of the appropriate Standard. Before ordering cement, the Contractor shall submit details of the proposed supplier and information on the proposed methods of transport, storage and certification for approval and show that the quantity and quality required can be attained and maintained throughout the construction period. Cement may be rejected if it fails to meet any of the requirements of these specifications. Cement remaining in silos of the batching plant at site, for a period greater than three months after completion of the tests, shall be tested again and to be rejected if it fails to conform to any of the requirements of these specifications. Cement that is found to be adversely affected by moisture, as determined by the Engineer, shall be rejected. The sampling and testing of Portland cement and ground grinded blast furnace slag shall be in accordance with relevant BS or ASTM standard specifications. The contractor shall carry out all tests - under the supervision of the Engineer- on Portland cement, GGBS and other types of cement, at his own cost, if required by the Engineer.

Cement shall be stored in dry, weather tight and properly ventilated structures. All storage facilities shall be subject to approval and shall be such as to permit easy access for inspection and identification of each consignment. The sacks should be stacked closely on a damp proof floor or on timber planks, raised by a minimum of 300 mm, from the ground and protected by a waterproof structure.

The temperature of the cement shall not exceed the specified limit at the time of incorporation into a concrete mix.

Ordinary Portland cement shall comply with the tricalcium aluminate (C3A) contents between 8%-13% and sulphate resisting cement ≤ 3.5%

Accurate records of delivery of cement and its use in the works shall be kept by the Contractor. Copies of these records shall be supplied to the Engineer in such a form as he may require.

2.02 Aggregates

Aggregates for concrete shall comply with ASTM C-33 at the time of use.

Fine aggregate shall consist of natural sand. The Contractor shall obtain aggregates from deposits of natural sand and gravel or shall procure crushed aggregate from approved quarries, which produce aggregates meeting with the Specifications contained herein. The Engineer will permit the addition of suitable crushed rock fine aggregate, as necessary, to the sand where in his opinion it is impracticable to obtain the specified grading of the combined aggregate, otherwise than by such addition. The maximum quantities of clay, silt and Fine dust shall, in any event, not exceed 3 % by weight when using the test in accordance with ASTM C-117. Fineness modulus shall range between 2.3 and 3.10. The sand equivalent value, as determined by ASTM Designation D 2419, "Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate", shall not be less than 75.

Sand for mortar shall comply with ASTM C270 or BS EN 13139 or approved equivalent. The grading of fine aggregate shall conform to the following requirements:

Table 2-1: Grading requirement of Fine Aggregate.

U.S. Standard Sieve Mesh	Percent Passing
0.375" (9.50 mm)	100
No.4 (4.75 mm)	95-100
No.8 (2.37 mm)	80-100
No.16 (1.18 mm)	50-85
No.30 (0.60 mm)	25-60
No.50 (0.30 mm)	5-30
No.100 (0.15 mm)	0-10
No.200 (75 µm)	0-3

The grading of the coarse aggregate, within the separated size groups, shall conform to the following requirements:

Table 2-2: Grading requirement of the Coarse Aggregate.

US Standard Sieve Size (Nominal Size)	Percent Passing by Weight Finer than Each Laboratory Sieve (Single Size Aggregate)			
	10 mm	20 mm	25 mm	40 mm
2.00" (50.00 mm)	-	-	-	100
1.50" (37.50 mm)	-	-	100	90-100
1.00" (25.00 mm)	-	100	90-100	20-55
0.75" (19.00 mm)	-	90-100	20-55	0-15
0.50" (12.50 mm)	100	20-55	0-10	-
0.375" (9.50 mm)	85-100	0-15	0-5	0-5
No. 4 (4.75 mm)	10-30	0-5	-	-
No. 8 (2.37 mm)	0-10	-	-	-
No. 16 (1.18 mm)	0-5	-	-	-

The shape of the aggregates shall generally be rounded, or irregular or angular as defined in BS EN 933: Part 1 or Equivalent ASTM Standards. The flakiness index, as determined in accordance with BS EN 933: Part 1, shall not exceed 35 and the 10% fine value as determined by BS EN 1097 series: Part 3, shall be greater than 50 k N.

The aggregates shall be such that concrete when made and tested in accordance with ASTM C- 426 or BS ISO 1920-8:2009 shall not show a drying shrinkage greater than 0.065%.

The water absorption of aggregates to be used for Class "A" concrete for water retaining structure shall not exceed 3 % when measured in accordance with BS EN 1097: Part 2.

The soundness of the aggregate, as determined in accordance with ASTM C 88 using magnesium sulphate with 5 cycles, shall not be average loss of greater than 15% for fine aggregate and 18% for coarse aggregate.

Immediately after commencement of the Works, the Contractor shall supply samples of proposed aggregates for preliminary tests of compliance with the Specification to the satisfaction of the Engineer and to give approval to the source of aggregates proposed by the Contractor. Alternatively, and subject to the approval of the circumstances by the Engineer, the

Contractor shall submit a Certificate from an independent laboratory acceptable to the Engineer.

Where 40 mm nominal maximum size coarse aggregate is specified it shall consist of a mix of 40 mm single sized aggregate, 20 mm single sized aggregate and 10 mm single sized aggregate.

The different sizes of aggregates shall be used in concrete mixer or batching plant as per compressive strength requirement of approved mix design of concrete.

During the performance of the Contract, the Contractor shall supply samples of aggregates when required by the Engineer for testing (The samples shall be taken in accordance with ASTM C-33). Testing of all specified requirements will be performed weekly for each source at each grading approved by the Engineer, unless otherwise instructed by the Engineer.

Any rejected aggregate shall be removed from Site within 3 days.

If the Engineer shall so require to determine the potential reactivity of the aggregate and the cement aggregate combinations, the Contractor shall carry out tests in accordance with ASTM C 1260 and ASTM C 1293 with ASTM C 1567.

Should the results of the tests prove unsatisfactory the Contractor shall make provision for the employment of a low alkali content cement to the approval of the Engineer.

Aggregate shall be stored, at site, in such a manner as to prevent its deterioration or the inclusion of foreign matter. Aggregate, which has deteriorated or which has been contaminated, shall not be used for concrete. All methods employed by the Contractor for loading, unloading, handling and stock-piling aggregates shall be subject to the approval of the Engineer.

2.03 Water

The water used as mixing in hydraulic cement concrete and for curing shall generally be of potable drinking water quality standards and shall be from a source approved by the Engineer. The water shall conform to the requirements of ASTM C1602, as to its suitability, for construction and at the time of use shall be free from polluting matter in any quantity which:

(a) Affects the initial setting time of the cement by more than 30 minutes or reduces the compressive strength of test cylinders by more than 20% when tested in accordance with ASTM C39.

(b) Prevents the achievement of the specified test cylindrical strengths at 28 days for the appropriate class of concrete.

(c) Produces discoloration or efflorescence on the surface of the hardened concrete.

The water shall be free from hydrocarbons and from suspended organic matter. Inorganic matter in solution shall not exceed 500 mg/l by weight and in suspension shall not exceed 50 mg/l by weight.

The water which the Contractor proposes shall be tested to the approval / satisfaction of the Engineer before use in the permanent works.

Regular tests of the water shall be made during construction of the Works. The water shall be sampled at the point of discharge into the mix and the frequency of sampling shall be as approved by the Engineer. The Contractor shall supply two copies of each test result to Engineer's Representative.

2.04 Admixtures

Concrete shall be made from cement, aggregates and water as specified. No other ingredient shall be mixed with the concrete or mortar without the Engineer's approval.

If the Contractor proposes to use chemical admixture to add in hydraulic cement concrete for the purpose of water reducing or retarding, then the manufacturer's literature must be supplied in compliance with the performance requirements of ASTM C-494 or any equivalent standards and giving detail of typical dosage, effects of incorrect dosage, the amount of air entrainment associated with its use, and the amount of chloride ion content by weight of admixture. The Engineer's approval to the use of admixtures shall be subject to the following conditions:

(a) Under no circumstances calcium chloride or chloride based admixtures be used in any concrete mix, grout or mortar.

(b) No reduction of target mean strength compared with additive-free concrete of the same class. No change in specified cement or effective water cement ratio.

(c) No corrosive effect on reinforcement steel.

(d) Dosage of admixture shall be strictly in accordance with the manufacturer's instruction in respect of the specific conditions obtaining. Dosage to be ensured by approved dispenser, to within 3% of the required amount.

The admixture which the Contractor proposes shall be tested to the approval / satisfaction of the Engineer before use in the concrete works.

"Air entraining admixture conforming to ASTM C-260 shall be used subject to approval of the Engineer."

The air content of air entrainment admixture shall be 4% for concrete with a maximum aggregate size of 40mm and 5% of concrete with maximum aggregate size of 20mm, an allowable tolerance of + 1.5%.

The method of determining the air content shall be in accordance with ASTM C-231 and the Contractor shall supply the necessary apparatus so that the Engineer may check the air content. If the average air content is greater or less than that specified or the range is greater than 2%, before any further concrete is used in the Works the Contractor shall take such steps as may be agreed with the Engineer to adjust the air content of the concrete or improve its uniformity.

2.05 Chemicals in Concrete Materials

The total sulphate content, whether as gypsum or more soluble salts, of concrete ingredients when measured as sulphur trioxide shall together not exceed 4.0% of the weight of cement in the concrete as per clause 6.2.5.3 of BS EN 1992-1-1 or approved equivalent structural use of concrete.

The chloride content of concrete ingredients when measured as CI shall together not exceed 0.3 % of the weight of cement in concrete using OPC cement and 0.06% of the weight of cement in concrete using SRC.

The sulphate and chloride contents shall be established using the following tests:

Table 2-3: Tests for establishing sulphate and chloride content.

Ingredients	Sulphate	Chloride
Aggregate	ASTM C1580 /BS 1377	ASTM C-1524 / BS 812
Cement	ASTM C-114 / BS 4550: Clause 12	ASTM C-114/ BS 4550
Water	ASTM D-516 /BS 1377	ASTM D-512 /BS EN 1744-1

The contribution of any admixture must also be included. Testing will be weekly, or as directed by the Engineer. When the acid soluble alkali content of the cement is greater than 0.6% (calculated as Na2O + 0.658 K2O) the Contractor must demonstrate that no adverse alkali-silica reaction is likely. Any concrete containing less than 3.0 kg/m3 may be considered not at risk. In the event of higher alkali contents a sample of aggregate from each source must be tested in accordance with ASTM C 1260 and/or ASTM C1293/1293M or approved equivalent. Any aggregate source showing an expansion greater than 0.05% at 3 months shall not be approved.

2.06 Reinforcement

Reinforcement shall be Type 2 deformed bars, either hot rolled high yield steel to ASTM A-615 (Grade 60) or cold worked steel bar conforming to the requirements of BS4449 (Grade 460)

The Contractor shall supply the Engineer's Representative with certificates of the manufacturer issued in accordance with relevant international standards, for all the required tests including the re-bend test in respect of each consignment delivered to Site.

Steel fabric reinforcement shall comply with BS 4483 or ASTM A1064.

The reinforcement shall be clean and free from damage, oil or grease, loose mill scale and loose rust and structural defects prior to placement in permanent works. Bars which have become bent shall not be straightened or reheated for incorporation in the Works without the approval of the Engineer.

“Steel reinforcement bars shall be kept in bundles firmly secured and tagged. The method of storage shall be approved by the Engineer.”

Steel reinforcement shall be stored clear of the ground and supported to prevent distortion. Canvas or similar covers shall also be provided for the reinforcing bars to prevent the deposit and accumulation of deleterious material on the bars and salt laden dews, and deterioration until incorporation into the permanent works. Similar provision shall be made to cover the bars in the reinforcement bending area.

Bars of different diameters and grades of Steel reinforcements shall be kept separately at yard. Stored material shall be inspected once per week and removed from site if deteriorated. The Contractor shall provide all measuring and testing facilities to ascertain quality, weight and quantity of steel, at his own expense, if so directed by the Engineer, testing shall be carried out in the presence of Engineer’s Representative at a laboratory approved by the Engineer.

2.07 Reinforcement Details

The Contractor shall ascertain for himself from the information given on the Drawings and in the Specification the precise requirements of steel reinforcement to be obtained for the Permanent Works. The Contractor shall prepare bar bending schedules as per ACI- detailing manual or BS 8666 and submit them to the Engineer at least 28 days prior to fixing the respective reinforcement.

All concrete other than that described on the Drawings or in the Bill of Quantities as mass, blinding or screed, shall be assumed to be reinforced.

2.08 Water stops

Where specified on the Drawings, the Contractor shall supply and fix water stops to all expansion, contraction and construction joints where shown on the Drawings and as directed by the Engineer. These shall be installed in accordance with the manufacturer’s recommendations and shall be continuous.

The number of joints made, on Site shall be kept to a minimum. Any jointing of PVC water stops on Site shall be by the process of heat fusion using an appropriate jig and heating blade all in accordance with the manufacturer's recommendations.

The width of the water stop which is to be embedded in concrete member shall be 250 mm as shown on the Drawings.

The edge bulb section of internal water stops shall be circular or semi-circular. The center bulb should be hollow or as directed by the Engineer.

The water stop shall be carefully maintained in the position shown on the Drawings and properly protected from damage and the harmful effects of light and heat during all stages of construction. The stop-boards on each side of the water stop shall be accurately wrought to match the profile of the water stop. The concrete shall be carefully compacted under and around the water stop so as to leave no cavities.

The Contractor shall supply the manufacturer's test certificates for each consignment of water stop delivered to Site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure.

The PVC water stops shall be high grade virgin polyvinyl chloride containing no filler, reclaimed or scrap material. It shall comply with the requirements of BS 2571 for type A3 of class 1 but shall have improved tensile qualities.

The compound shall contain such additive resins, plasticizers, stabilizers or other materials, needed to ensure following physical characteristics as per US Corps of Engineers (CRD-C-572-74) when tested by the methods, as specified below:

Table 2-4: Test Requirements for PVC Water stops.

Property	Test Method	Required Limits
Water absorption	ASTM D 570	0.15% max
Tear Resistance	ASTM D 624	200 lb/in (35 kN/m) min.
Ultimate Elongation	ASTM D 638	300% min.
Tensile Strength	ASTM D 638	2000 psi (13.78 Mpa) min.
Low Temperature Brittleness	ASTM D 746	No Failure @ -37° C (-35° F)

Specific Gravity	ASTM D 792	1.45 max.
Hardness, Shore A	ASTM D 2240	79 ±3

The expansion joints shall be PVC water stops of the type having center bulb or rear guard as per drawings.

2.09 Joint Filler

The Contractor shall supply and fix pre-moulded joint fillers in all expansion joints and where shown on the Drawings. Unless otherwise specified the joint filler shall be of resin or bitumen bonded cork. Material shall be obtained from manufacturers approved by the Engineer and shall be stored and fixed in accordance with the manufacturer's instructions. The joint filler of the material and thickness specified shall be cut to shape and fixed to fill the whole space between the concrete faces to the joint not otherwise filled by water stop and joint sealer. Abutting pieces shall be placed in close contact and the joints covered on each side to prevent the passage of cement grout.

The Contractor shall supply the manufacturer's test certificate for each consignment of each type of joint filler delivered to Site and shall supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure.

The filler shall comply with the following American Society for Testing and Materials Specification:

a) Resin Bonded Cork ASTM D 1752 Type II

b) Bitumen Bonded Cork ASTM D 1751

2.10 Joint Sealer

The Contractor shall construct recesses at all joints, and on both faces of the concrete work, except on the underside of ground slabs. The recesses shall be accurately formed to the lines and dimensions shown on the Drawings or as agreed with the Engineer.

The Contractor shall prepare the surfaces of the recess and shall supply a joint sealer and fill or caulk the recess completely with it. Joint sealer shall conform to appropriate BS standard or similar approved.

Joint sealing shall not be commenced without the approval of the Engineer. In conduit joints the sealer shall be poured after the construction of the roof.

All joint sealers shall be from an approved manufacturer. The Contractor shall supply the manufacturer’s test certificates for each consignment of each type of joint sealant delivered to the Site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate test procedure.

Sealants shall be installed in strict accordance with the manufacturer’s instructions. Compressible de-bonding strip shall be used in conjunction with the sealers as indicated on the Drawings. The de-bonding strip shall be compatible with the joint sealer and shall be resistant to attack from the primer used to bond the sealer to the concrete.

Polysulphide sealer shall be used except for buried structures and other structures not subject to direct or reflected sunlight nor to large temperature variations, in which case a bituminous based compound shall be used.

Polysulphide and polyurethane sealers shall not abut bituminous sealers. Surfaces to receive polysulphide and polyurethane sealers shall be kept free from bituminous paints. All sealers shall be appropriate for the prevailing climatic conditions.

2.10.1 Bituminous Sealer

Bituminous sealer or Bitumen rubber mastic sealant shall be obtained from manufacturers approved by the Engineer and shall be appropriate for the prevailing climatic conditions and compatible with drinking water.

The hot poured rubber/bitumen compound for sealing horizontal joints shall comply with BS 2499 for Type AI. For sloping, vertical and soffit joints a bituminous putty shall be supplied which shall not slump in a vertical joint 25 mm wide and 25 mm deep at a temperature of 80°C.

Sealant application should start form the bottom of the joint/groove and continue to the top. Immediately level the joint with the spatula or putty knife to smoothen and compress the sealant to effect total contact with joint surface as per manufacturer’s recommendation.

2.10.2 Polysulphide Sealer

Polysulphide sealer shall comply with BS EN ISO 11600:2003+A1:2011. It shall be obtained from manufacturers approved by the Engineer and shall be appropriate for the prevailing climatic conditions.

In conjunction with this type of sealer an approved bond breaker such as a self-adhesive polythene strip shall be positioned against the exposed edge of the joint filler prior to application of the joint sealer. The bond breaker shall be resistant to attack from any primer used to bond the polysulphide sealer to the concrete.

Polysulphide sealer shall be used except for buried structures and other structures not subject to direct or reflected sunlight nor to large temperature variations, in which case a bituminous based compound shall be used.

The Contractor shall supply the manufacturer's test certificates for each consignment of each type of joint sealer delivered to Site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory test to be carried out in accordance with the appropriate test procedure. Bituminous and polysulphide sealers shall not about one another (move up).

2.11 Bituminous Paint

Bituminous paint shall comply with BS 3416, Type 11 for materials in contact with raw or treated water and Type I for all other cases.

Prior to application of the bituminous paint the concrete faces must be clean and dry. A minimum of two coats of bituminous paint shall be applied and each coating shall be a dry film mass of 35 ±5 g/m= after 48 hours drying.

2.12 Bond Breaking Compound

Bond breaking compound shall consist of 66% of 200 pen bitumen blend hot with 14 light creosote oil and, when cold brought to the consistency of paint by the addition of 20 % solvent naphtha or other approved compound meeting the following requirements:

(a) It shall not retard or in any other way affect the setting of concrete.

(b) The average bond stress on bars coated with the compound with half their length cast into concrete specimens and subjected to pull out tests at 7 days shall not exceed 0.13 N/mm' and the total movement of the dowel bar relative to the concrete specimens shall be not less than 0.15 mm at that stress. The concrete specimens shall be 150 mm x 150 mm in section and 450 mm long and made with the same mix proportion as used in the Works.

2.13 Slip Membrane for Sliding Joints

Slip membrane material used for sliding joints shall consist of two thicknesses of low friction plastic material which shall be non-toxic and suitable for use with potable water, compatible with any other materials used in conjunction with them, non-extruding and durable. The coefficient of friction between the two strips shall not exceed 0.20 when subjected to a load of 220 kN/m2. The maximum bearing pressure for the material shall not be less than 250 k N/ m2.

The lower layer shall be self-adhesive and the concrete surface to which this is fixed shall be smooth, clean and free from dust and be finished with a steel or wood float to provide a smooth true surface.

2.14 Classes of Concrete

The class of concrete is defined by the characteristic cylinder crushing strength and the nominal maximum aggregate size, with additional suffix defining any additional requirements. The requirements for each class of concrete are given in Table 2-7. The main classes of concrete used will be as follows:

Table 2-5: Main classes of concrete.

Location	Class
Washout & Valve Chamber	A
Washout & Valve Chamber	A (1)
Building Works	B
Building Works	B (1)
Concrete surround, Thrust Block & Mass Concrete	C
Blinding Concrete	D

Table 2-6: The requirements for each class of concrete.

Concrete class	Strength (MPa)	Maximum Aggregate Size (mm)	Cement type	Workability*
Class "A"	30	20	OPC	Medium / High
Class "A (1)"	30	20	SRC	Medium / High
Class "B"	25	20	OPC	Medium
Class "B (1)"	25	20	SRC	Medium
Class "C"	20	40	OPC	Medium
Class "D"	15	20	OPC / SRC	-

Note: - *High workability: slump 65 to 135 mm

Medium workability: slump 50 to 100 mm

Quoted slump values are a guide only and may be varied subject to the approval of the Engineer.

The concrete class is defined as the 28-day cylinder crushing strength (psi) below which no more than 5% of results are expected to fall.

Except where otherwise specified herein, the mix design, concrete ingredients, manufacture, testing and workmanship shall conform to the requirements of relevant sections of ACI & ASTM or Sections 6 and 7 of BS EN 1992-3 & BS EN 1992-1-1 or approved equivalent.

Adjustments to the concrete mix proportions shall be made during the contract if in the opinion of the Engineer, such adjustments are necessary. The Contractor shall neither alter the mix proportions nor the source of supply of any of the ingredients without prior approval of the Engineer.

2.15 Lean Concrete

An additional class of concrete specified as `Lean Concrete' shall consist of ordinary Portland cement and combined coarse and fine aggregate mixed in the proportion by dry weight of one part of cement to 9 parts of aggregate. The amount of free water in the mix shall be about 6% of the total dry weight of materials, the actual quantity being decided on Site after the trial mixes have been made so as to permit optimum compaction.

Concrete cylinders shall be made at such intervals and times as the Engineer may direct The cylinders shall be made, cured and tested in accordance with the methods described in ASTM C31 and ASTM C39 except that the cylinders shall be compacted by means of a tamping rod, electric or pneumatic hammer provided with a square or rectangular foot having an area of between 100 and 150 cm^2, using sufficient pressure directly on to each of the three layers of material filled into the mould to result in the material being compacted to refusal.

The 7-day or 28-day compressive strengths of the concrete cylinders shall not be less than 7.0 N/ mm^2 or 10.0 N/mm^2 respectively. If the strengths fall below these specified values the Engineer may require the use of different materials, mix proportions, Constructional Plant or methods notwithstanding any approval which may have previously been given.

The average density of material placed in the Permanent Works obtained from groups of three determinations carried out in accordance with ASTM C29 shall be not less than 95% of the theoretical density of material as compacted to zero air content calculated from the specific gravities determined in accordance with ASTM-C127 and the nominal proportions of the constituents, including the water. If more than one average density in any consecutive five such averages fails to meet this requirement, the Engineer may require the removal of the concrete represented by the low densities and its replacement with further material to the requirements of this Clause.

Unless otherwise approved the grading of the aggregates shall be within the following limits:

Sieve Size	Percentage by Percentage by
40 mm	100
20 mm	45 to 80
5 mm	25 to 45
600 micron	10 to 25
150 micron	0 to 8

2.16 Concrete Mix Design

The Contractor shall determine to the approval of the Engineer the actual proportions of ingredients for each class of concrete to be used to the Permanent Works.

"The concrete shall comply with the strength requirements as specified in the drawings for each member/element of the structure as given in Table 2-7."

Table 2-7: Requirements of Classes of Concrete

Class	Minimum Cement content (kg/m3)	Maximum W/C ratio	Working Strength (Minimum 28 days Cylindrical Strength) Kg/cm^2 (Psi)
Class "A"	400	0.40	350 (5000)
Class "A(1)"	400	0.40	350 (5000)
Class "B"	360	0.45	281 (4000)
Class "B (1)"	360	0.45	281 (4000)
Class "C"	300	0.45	211 (3000)

Class “D”	240	-	105 (1500)

All concrete of Class A & Class C will have a min 30% ordinary Portland cement replacement with ground grinded blast furnace slag (GGBS) and for all concrete structure greater than thickness of 600mm, maximum aggregate size of 40mm may be allowed subject to the approval of the Engineer.

Water/cement (W/C) ratio is the ratio of weight of free water to cement in the mix based on aggregates being in a saturated surface dry condition.

Unless otherwise specified or agreed by the Engineer for concrete Class C and above the proportions of coarse and fine aggregates shall be selected to achieve one of the grading curves defined in Table 2-8, within an allowable tolerance of generally 5%. A change from a maximum positive tolerance to a maximum negative tolerance in consecutive sieve sizes should be avoided.

The Contractor shall submit details of the source of all material and the proposed quantities of each ingredient per cubic meter of fully compacted concrete. The Contractor shall then make trial mixes for each class of concrete using the same type of Constructional Plant and the same materials as are proposed for the Permanent Works. The Contractor shall give 24 hours’ notice of such trials to enable the Engineer’s Representative to attend. For each trial mix, three separate batches of concrete shall be made by the Contractor and will be tested at 28 days all in accordance with ASTM C 39. Such trial mixes shall not be the first batch through the plant in any one sequence of concrete production.

The Contractor shall not commence concreting in the Permanent Works until details of trial mixes and test results for each class of concrete have been submitted to, and approved by, the Engineer.

A trial mix design will be approved by the Engineer with respect to strength if the average compressive strength of the nine cylinders so tested is 20% higher than the specified twenty days strength as given in Table 2-7 and no individual test cylinder shall be below the specified strength.

For concrete Class “C” and above, the Contractor shall cast sample wall panels in two phases. In the first, three different mixes from adjacent aggregate grading curve zones shall be cast into wall panels. When the Contractor has demonstrated that the mix from the middle of the three grading zones is the most practical mix he shall proceed with phase two on the basis of this preferred mix. In the second phase two batches, mixed 48 hours apart, utilizing the preferred mix, shall be cast in two equal lifts to form a wall panel having one horizontal construction joint formed to the manner proposed by the Contractor for the Works. The top surface of the second lift shall have a Type U3 finish. The panels shall not be touched up after stripping.

The panels shall be 300mm thick and 1.5 m long by 1.5m high. The Contractor shall not commence concreting to the Permanent Works until the test panels have been approved by the Engineer.

The Contractor shall not alter the approved mix proportions nor the approved source of supply of any of the ingredients without having previously obtained the approval of the Engineer.

During production the Engineer may require trial mixes to be made before a substantial change is made to the materials or in the proportions of the materials to be used.

Table 2-8: Combined Aggregate Grading

40 mm maximum aggregate size grading curves

Sieve size (mm)	1	2	3	4
50	100	100	100	100
37.5	95	97	99	100
20	50	59	67	75
10	36	44	52	60
5	24	32	40	47
2.36	18	25	31	38
1.18	12	18	24	30
0.60	7	12	17	23
0.30	3	7	11	15
0.15	0	0	2	5

20 mm maximum aggregate size grading curves

Sieve size (mm)	1	2	3	4
37.5	100	100	100	100
20	95	97	99	100
10	45	55	65	75
5	30	35	42	48
2.36	23	28	35	42
1.18	16	21	28	34
0.60	9	14	21	27
0.30	2	3	5	12
0.15	0	0	0	1.5

10 mm maximum aggregate size grading curves

Sieve size (mm)	1	2	3	4
10	95	97	99	100
5	30	45	60	75
2.36	20	33	46	60
1.18	16	26	37	46
0.60	12	19	28	34
0.30	4	8	14	20

0.15	0	1	3	6

2.17 Concrete Exposed to Sulphate Attack

Prior to commence any concreting on site the Contractor shall conduct tests to the satisfaction of the Engineer to determine the concentration of sulphate in the soil and groundwater in order to determine the concrete exposure class.

The Contractor shall ensure that all concrete susceptible to sulphate attack shall be designed to satisfy the additional requirements for the particular exposure class. This shall be taken to include all concrete from below finished ground level up to 1.0m above finished ground level.

SRC cement shall be used for following concentration of sulphates in soil and ground water if approved by the Engineer.

(a) In soil	0.2% or more
(b) In groundwater	0.3 g/l or more 1.0 g/l or more.
(c) In 2:1 water Soil extract	g/l or more.

2.18 Storage of Materials

The Contractor's arrangements for storing and handling the materials for concrete shall be to the approval / satisfaction of the Engineer. Such arrangements shall be directed towards preventing the deterioration or adulteration of the various materials or segregation of the ingredients thereof.

2.19 Control and Mixing of Ingredients

The Contractor shall measure the moisture content in the aggregates and so determine the amount of water to be added to each batch of fresh concrete. Such determinations shall be to the approval of the Engineer and the results and calculations shall be available for inspection by him. The frequency of such determinations shall be as directed by the Engineer and shall depend on the quality of control of storage and handling, weather conditions and variability of aggregate supplied.

The Contractor shall proportion the ingredients of each batch of concrete by weight. Weighing and water-dispensing equipment of automatic batching plant shall be checked and calibrated at the start of preliminary concrete tests and at weekly intervals, and the accuracy shall be maintained within the tolerances described in BS 1305 or BS 3963. The measuring equipment should give an accuracy of ±3% for each ingredient. Scales shall be checked over their complete range by a specialist at intervals not exceeding 6 months. In the event of non-compliance on calibration, all concrete produced since the last compliant calibration will be at risk of rejection Batching equipment shall be maintained in fully operational condition enabling consistent measuring of concrete constituents within tolerance as specified.

The water shall be added to the aggregates and cement in a mechanical batch mixer; it shall not exceed the maximum ratio with regard to cement given in Table 2-7 hereof, and shall otherwise be the minimum amount necessary for consistent or complete compaction. The device for measuring the water shall show accurately the weight required with a given moisture content of the aggregate and shall be so designed that the water supply will be automatically stopped when the correct quantity has been discharged into the mix. The concrete ingredients shall then be thoroughly mixed.

“Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue to flow for a period which may extend to the end of the first 25% of the specified mixing time.”

The minimum mixing time shall be:

(a) For mixes of 1.5 m^3 Capacity or less 1.5 minutes.

(b) For mixes of larger capacity than 1.5 m^3 the time shall be increased by 15 seconds for each additional 0.75 m^3 capacity. For intermediate sizes the time shall be assessed by proportion.

In special circumstances, for quantities not exceeding one cubic meter and at the sole discretion of the Engineer, the proportioning of materials by volume may be approved. In such circumstances the cement content of the concrete shall be increased by 10% over the amount in the approved mix. The boxes used for proportioning shall be deep and narrow to the approval of the Engineer, and shall be separately constructed for each class of concrete to be proportioned by volume.

Ready-mixed concrete plants shall be subject to approval, and shall hold current accreditation to an approved quality scheme. Standard ready-mix supplier’s mixes shall be used, and satisfactory production test results shall be submitted which demonstrate compliance with requirements of this Specification continuously before use in permanent works.

2.20 Concrete Sampling and Testing

The temperature of concrete, concrete constituents, reinforcement, formwork and the atmosphere shall be monitored continuously for every concrete pour. All sampling and testing of fresh and of hardened concrete shall be carried out in accordance with the relevant provision of ASTM or equivalent international standard unless such provision is at variance with the specification.

Table 2-9 gives the program for sampling and testing of concrete for each class of concrete from each batching center in each active day.

The Contractor shall establish a plan for sampling and testing to the approval of the Engineer. Samples shall be taken at the place of deposition from each class of concrete at random. The frequency of sampling shall in general be in accordance with Table 2-9, but the actual rate of sampling may vary with the approval of the Engineer and shall be increased when ordered by the Engineer in appropriate frequency. From each such sample three test cylinders shall be prepared; each cylinder shall be marked indelibly for identification when it is in the mould. After retention at the site for 24 hours the cylinder shall be delivered to the testing laboratory for curing and testing.

Table 2-9: Program for Works Sampling and Testing.

Grade	Class C And above	Class D
Workability (slump test)	1	0
Workability (compacting factor test)	2	0
Compressive strength	2	3

Where:

0 - No testing required
1 - Every batch at point of deposit
2 - One sample from every 10 batches, one sample per 20m^3 of concrete or one sample from each day's concrete, whichever involves the maximum number of samples.
3 - One sample from every 50 batches, one sample per 50m^3 of concrete or one sample from every three day is concrete; whichever involves the maximum number of samples.

2.21 Compliance with Specified Concrete Requirements

Of the three cylinders made from each sample of fresh concrete in accordance with the Specification, one will be crushed at 7 days and the other two at 28 days. The average of the two 28 days strength will be taken as the test result. Compliance with the specified strength requirements shall always be judged on the 28 days test results.

Concrete shall be considered to have failed to comply with the Specification if:

(a) The minimum average 28 days test result of all samples tested at any time shall be the specified twenty eight (28) days strength.

(b) No individual samples tested after 28 days shall show a test result lower than eighty five (85) percent of the required twenty eight (28) days.

Concrete represented by any single test cylinders that fails to comply with the requirement under (b) above will be rejected unless the Contractor at his expense, provides evidence that the strength and quality of the concrete placed in the work are acceptable. If such evidence consists of tests made on cores taken from the work, the cores shall be obtained and tested in accordance with the specifications of ASTM C42.

Should the test results fail to comply with the requirements under (a) above and should any individual test show less than 95 percent of the specified 28 days strength, concrete of that particular pour shall be rejected and removed as directed by the Engineer and reconstruction of representative structure at Contractor's risk and cost. Furthermore, contractor shall redesign the concrete mix for approval of the Engineer.

In case, seven (7) days strength shows less than seventy (70) percent of the twenty eight (28) days strength (in case of type-1 cement), Engineer may stop further work on that particular portion of concrete, unless twenty eight (28) days strength gives satisfactory results.

If a mix fails to achieve the requirements for fresh concrete the batch shall be rejected and no further concrete of that class shall be placed in the Permanent Works until the cause of failure has been rectified.

2.22 Transporting, Placing and Compacting Concrete

The concrete shall be handled so that at the point of deposition it is of the specified quality and approved consistency, nothing having been added to it or lost from it since leaving the mixer. Any free water shall have been removed from the section to be concreted before concrete is deposited.

The Contractor shall submit drawings showing proposed limits and sequence of individual pours, location of construction joints and the height of lifts and proposals to minimize thermal and shrinkage strains in the concrete. The contractor shall also obtain the approval of the Engineer to the arrangements he proposes to use for concreting before commencing concrete work.

At least 24 hour notification shall be given by the Contractor to the Engineer of the intention to place concrete.

The Contractor shall regard the compaction of the concrete as work of fundamental importance and shall produce a watertight concrete of maximum density compatible with the approved mix. Compaction shall be assisted by the use of mechanical vibrators of the immersion type, but shall not involve the vibration of reinforcement or shutters except that vibration of shutters may be allowed in precast concrete, with the approval of the Engineer. Vibrators shall be inserted at least to the full depth of the newly deposited concrete, kept in position for about a quarter of a minute and then slowly withdrawn to prevent the formation of voids. The procedure shall be continuous with points of insertion 150 to 225 mm apart. The number and type of vibrators available for use during each period of concreting shall be to the approval of the Engineer, which will not be given if sufficient stand-by vibrators in good working order are not readily available. If concreting is in the dark, ample lighting shall be provided at the mixing stations and at every place where concrete is being deposited.

Concrete without a retarder/plasticizer which is not deposited in the Works within 30 minutes after the start of mixing shall not be used unless the Engineer approves otherwise.

Concrete may be pumped provided the mix design and the nature of pumping comply with the recommendations given in the `Guide to Concrete Pumping' as per BS 8476:2007 and are not in conflict with any specified requirements.

The first batch of concrete to be made every time work is commenced shall contain 10% more cement than the normal amount.

Concrete shall be placed continuously up to positions of joints prepared prior to commencement of concreting. No concrete shall be dropped or chuted into the shuttering in such a manner as to cause segregation of the ingredients. In no case the concrete shall be allowed to fall freely from a height of 1.2 m or more. The deposited layers of concrete shall not exceed 600 mm in thickness and each layer shall be properly merged into the preceding layer before final set takes place. Shallow beams may be concreted to full height in one operation as directed by the Engineer. Care shall be taken to ensure that reinforcement projecting from concrete recently placed is not shaken or disturbed.

Concrete placing shall not be interrupted except where joints occur, and shall continue after normal hours if necessary to achieve this.

Where steps, splays and kickers occur these shall be cast in one with the slab and additional care shall be taken in the vibration and finishing techniques and procedures to ensure that thorough compaction is achieved and the unset concrete is not subjected to tension and no cracks are formed. The techniques and procedures to be adopted shall be discussed with the Engineer's Representative and his approval received before any such concreting is commenced.

2.23 Concreting in Unfavorable Conditions

The Contractor shall not place concrete in the Permanent Works:

(a) During heavy rains or dust storms.

(b) When the air temperature is more than 32°C.

(c) If the temperature of the concrete on discharge from the mixer is less than 4°C or more than 32°C.

(d) When the air temperature exceeds 25°C, without taking precautions and demonstrating to the approval of the Engineer that the maximum internal temperature of the concrete within 24 hours after casting in place is unlikely to be more than 30°C in excess of the ambient temperature.

(e) If the temperature of the shutters or reinforcement exceeds 30°C.

To keep within these limits the Contractor may, among other means, spray aggregates with water, and use chilled mixing water, or add crushed ice direct to the mixer provided that no ice is present in the mix when discharged from the mixer.

When concreting in hot weather all material used shall be kept in the shade. Water tanks, mixers and chutes should be shaded, but where this is not possible they shall be painted white and kept white.

2.24 Temperature Control in Concrete Sections

Where the minimum dimension of the concrete element exceeds 600 mm, the Contractor shall adopt special precautions, subject to approval of the Engineer, to avoid thermal cracking due to temperature differential.

Temperature differential is defined as the difference in temperature between the form or face of concrete pour and the Centre of the pour, or at a distance of 1.5 m, whichever is shortest. Peak temperature is defined as the maximum temperature at any point in a pour.

Concrete shall not be placed until the Contractor’s Pour Sequence Proposals, (and the outcome of trials where performed), demonstrate that the differential temperature limits will not exceed 20 ° C.

The differential temperature limits may be revised upwards or downwards on the basis of the Contractor’s Pour Sequence Proposals.

For pours having a minimum dimension exceeding 600mm, the Contractor’s Pour Sequence Proposals shall also include the following:

(a) system for monitoring concrete temperatures

(b) formwork type and removal time

(c) time intervals between pours

(d) measurements of concrete heat of hydration

(e) proposed additional precautions including but not limited to, thermal insulation, concrete cooling, or cooling pipes.

(f) calculations of temperature and strain development at internal and surfaces, taking account of ambient conditions and physical restraints, as well as the items listed above

(g) reference should also be made to concreting temperatures and concrete cooling techniques, as defined elsewhere in this Specification

For pours having a minimum dimension exceeding 600 mm, the Contractor shall also undertake a trial pour under conditions representative of those anticipated during the works. Thermocouples shall be used to monitor the ambient, core and surface temperature values in the trial pour and in the works. Cores shall be removed from trial pours and from any parts of the works which fail to comply with the limits on total sulphate or peak temperature. The cores shall be subject to sulphate testing to BS 1881- 124, petrographic examination, and expansion testing, the cores shall be nominal 75 mm diameter and 150 mm long. If the expansion exceeds 500 micro strain during the period of the test, the concrete shall be assessed to be potentially at risk of developing delayed ettringite formation.

2.25 Concreting Records

A written record of the concrete works shall be made each day by the Contractor and kept available for inspection by the Engineer's Representative. The diary shall contain notes and records of:

(a) The names of the Contractor's engineers who are responsible for the different phases of the concrete work, and also the names of their assistants.

(b) The temperatures of air, water, cement, aggregates and concrete, together with the air humidity and type of weather.

(c) Deliveries to the Site of concrete materials (quantity, brand of cement, etc.).

(d) Inspections carried out, tests performed, etc., and their results.

(e) Times of commencement and completion of different parts of the concrete works, and times of erection and striking of forms.

(f) Quantity of cement, fine and coarse aggregate and admixture used for each section of work, and the number and kind of test samples taken on these ingredients and water.

2.26 Formwork

The terms formwork and shuttering shall be interpreted as meaning one and the same thing, namely Temporary Works set up to obtain the required profiles and surface textures of the concrete. The Contractor shall obtain approval of the methods and materials proposed. Details of formwork for special finishes shall be approved before materials are ordered. Shuttering shall be such that it remains rigid during the placing and setting of the concrete and prevents the loss of any concrete ingredients. Formwork panels shall have true edges for accurate alignment and shall be fixed with either vertical or horizontal joints. Where chamfers are required the fillets shall be cut to provide an even line. Joints shall not permit leakage of grout, nor steps and ridges in exposed surfaces.

All shuttering shall be of steel unless permitted by the Engineer for curved surfaces and formwork will be designed by the contractor and submitted with design calculation to the Engineer for approval prior to installation.

The shuttering shall be fixed in correct alignment and to the true shape and dimensions of the Permanent Works and shall be designed so that it can easily be removed for curing of concrete to commence as soon as practicable. Where necessary, shuttering should be so arranged that the soffit form, properly supported on props only, can be retained in position for such periods as may be required to allow the concrete to mature as specified. A method of support which would involve holes or tie wires extending the whole width from face to face of work to be concreted will not be permitted, unless authorized by the Engineer in writing. No plugs, bolts, wire ties, holdfasts or any other appliance whatsoever for the purpose of supporting the shuttering or reinforcement shall be fixed permanently into the structure so that they have less cover than that specified for the reinforcement or in any way impair the strength or appearance of the work, nor shall they be placed in such a manner that damage to the work would result in the removal of the same at the time of striking the shuttering.

Bolts and Tie rods, used for internal ties, shall be so arranged, that when the forms are removed; metal will not be less than 2" (50 mm) away from any concrete surface. Whenever form work ties are used, their arrangement and spacing shall be in a regular pattern, in accordance with the dimensions of the formwork panels and as instructed by the Engineer and Tie cavities shall be roughened and filled with approved non-shrink mortar or epoxy mortar.

Before the concrete is placed the retaining surfaces shall be cleaned of sawdust and shavings, dirt, other debris and standing water.

The inside of shuttering shall be coated with an release agent of non-staining mineral oil, nepthalene form oil or with other approved material. That will effectively prevent sticking and will not stain the concrete surface. The Contractor shall submit to the Engineer for approval a sample not less 2 liters of the form oil proposed for use at least 30 days before its use is required. At the time the concrete is placed in the forms the surface of the forms shall be free from incrustation of mortar, grout, or other foreign material. The release agent must be compatible with any applied finish.

Temporary openings for cleaning and inspection before concreting shall be provided at the base of column and wall shuttering and where necessary. Shuttering for walls or other thin sections may have openings where approved by the Engineer for the placing and compacting of the concrete.

Not less than 24 working hour notice shall be given for the inspection and approval of the formwork and reinforcement, prior to which concrete shall not be placed.

No concreting shall be started before the shuttering has been inspected by the Engineer's Representative. Unless otherwise approved, top shuttering shall be provided to concrete faces where the slope exceeds one vertical to three horizontals. Exposed arises shall be formed with a chamfer measuring 20 mm x 20 mm.

Form work shall be provided for concrete surfaces at slopes steeper that 30^{o} to the horizontal. Surfaces at slopes less than 15^{o} may be formed by screeding surfaces at slopes between 15^{o} and 30^{o} shall generally be retained which form work unless the contractor can demonstrate to the satisfaction of the Engineer that such slopes can be screeded with the use of special screed boards to hold the concrete in place during vibration.

2.27 Surface Finishes

The faces of all concrete shall be left sound, solid, and free from voids and to the class of finish specified.

No treatment to the finished concrete other than that specified in the class of finish shall be carried out unless approval to do so has been given by the Engineer.

Bolt bobbin holes shall be filled with cement and suitable fine aggregate mortar to match the color of the concrete. The mortar shall be well worked in and thoroughly cured.

Classes for formed surfaces:

Class FI - This finish requires no special treatment and is for surfaces which will remain hidden in the permanent Works.

Class F2 - This finish is for all exposed surfaces unless otherwise shown on the Drawings. The formwork shall be faced with marine plywood or steel in large sheets rigidly supported so as to prevent distortion under load. The sheets shall be arranged to coincide with architectural features, or changes in direction of the surface. All joints between panels shall be straight and either vertical or horizontal unless otherwise directed and the joints between panels to slab soffits shall be parallel to the supports. Suitable joints shall be provided between sheets to minimize joint marks and to maintain accurate alignment in the plane of the sheets. Facing sheets shall be free from blemishes which would affect the concrete surface.

Class F3 - This finish is identical to Class F2 finish except that the permitted deviations for irregularities are more stringent as given in Table 2-10.

Where a surface is partly below and partly above the final ground level the finish for exposed surfaces shall extend for 500 mm below the final ground level.

Classes for unformed surfaces:

Type UI - This finish is for surface, where a superior finish is not required. It is also the first stage for finishes U2 and U3. The finishing operations shall consist of grading, tamping and screeding the concrete to produce a uniform, plain or ridged surface.

Type U2 - This is a smooth matt finish such as may be achieved by a wood trowel, as required, inter alia, to receive mastic paving, or block or tile paving, bedded in mastic. Smoothing shall be done only after the concrete has hardened sufficiently, and may be by hand or machine. Care shall be taken that the concrete is worked no more than is necessary to produce a uniform surface free from marks.

Type U3 - This is a smooth power float finish for surfaces of concrete paving, tops of walls, copings and other members exposed to weathering or water, surfaces to receive thin flexible sheet, tile paving, bedded in adhesive, and seating's for bearing plates and the like where the metal is in direct contact with the concrete. Troweling shall not commence until the moisture film has disappeared and the concrete hardened sufficiently to prevent excess laitance from being worked to the surface. The surfaces shall be troweled by hand or machine under firm pressure and left free from trowel marks.

2.28 Permitted Deviations in Finished Work

The irregularities in formed and unformed surfaces for the various classes of finish shall be within the target limits shown in Table 2-10. If irregularities exceed the target the Contractor shall take the necessary steps to bring subsequent work within the target. If, however, the irregularities exceed the maximum allowable shown in the table it shall be sufficient cause for the structure, member or section of a member of the structure to be removed and properly reconstructed.

In Table 2-10, the type of irregularity is defined as follows:

1 Departure from alignment, and grade and dimension shown on the Drawings.

2 The cross-sectional dimensions of structural members less than 600mm, such as walls, columns, beams, etc., where, for structural reasons, it is desirable to keep the tolerances within closer limits than those for alignment and grade.

3 Gradual irregularities measured from a 3 m long template placed against the concrete.

4 Abrupt irregularities such as those resulting from defective or displaced facing or movement of supports.

Table 2-10: Permitted Deviations for Irregularities of Concrete Surfaces.

Formed finish

Type of Irregularity	Target (mm)			Maximum allowed		
	F1	F2		F1	F2	F3

1	+20	+5		+ 40	+10	+2
2	+7	+5		+ 15	+10	+2
3	7	5		15	10	+2
4	7	3		10	5	+2

Unformed finish

Type of Irregularity	Target (mm)			Maximum allowed		
	U1	U2		U1	U2	U3
1	+20	+10		+ 35	+20	+6
2	+7	+5		+15	+10	+6
3	10	5		20	10	6

2.29 Fixing Reinforcement

Steel reinforcement shall be cut from straight bars free from kinks and bends or other damage, and cold bent by experienced competent workmen. Bars shall be bent in a bending machine approved by the Engineer. Cutting, bending and marking shall be to the tolerances and format given in BS 8666:2020 or equivalent unless otherwise specified or ordered by the Engineer.

The distance between any two parallel bars shall not be less than 5 mm more than the nominal maximum size of aggregate in the concrete, except at approved laps. The length of lap shall be as shown on the Drawings or ordered by the Engineer.

The Contractor shall place and fix steel reinforcement accurately in the positions shown on the Drawings and shall ensure that it remains rigidly in that position during the placing of concrete. Tack welding with BS EN ISO 17660-1:2006 shall not normally be permitted, however, in particular cases it may be allowed with the prior approval of the Engineer. Supports, spacers, including PVC spacers, and ties shall be subject to the approval of the Engineer. Tying wire shall be galvanized mild steel of diameter approximately 1.5 mm. Tying wire shall have the same minimum concrete cover as detailed for reinforcement. Concrete spacers shall be made of the same quality concrete as that for the work in which they will be embedded with any tying wires galvanized and located to give a minimum cover specified for the reinforcement. Metallic spacers, fixing clips and tying wire shall be compatible with the material of the reinforcement, and the specified cover shall be maintained.

Spacers should be of such materials and designs as will be durable, not lead to corrosion of the reinforcement and not cause spalling of the concrete. Concrete spacers shall be provided in accordance with BS 7973

Reinforcement projecting from previously cast concrete shall not be bent so as to require rebinding without the prior approval of the Engineer.

The main wires of adjacent sheets of steel fabric reinforcement shall be lapped at least 300 mm and the transverse wires at least 150 mm.

The Contractor shall not place concrete around reinforcement until the reinforcement has been inspected by the Engineer's Representative.

2.30 Cover to Reinforcement

Except where otherwise shown on the Drawings the nominal concrete cover to the nearest reinforcement (exclusive of concrete blinding and rendering) as well as for surface exposed to water in a water retaining structure shall be 50 mm and concrete cast against permanently exposed to earth shall be 75mm. However, for internal faces in buildings the minimum cover shall be 20 mm exclusive of plaster or decorative finishes. This requirement does not apply to concrete faces in box-outs left for the installation of fixtures.

The actual concrete cover shall not differ from the nominal cover by more than +5 mm for bars up to and including 12 mm size and ±10 mm for bars greater than 12 mm size.

2.31 Construction Joints

Where not shown on the Drawings, the details and positions of construction joints shall be submitted to the Engineer for approval before any concreting takes place. They shall be located so that, when considered with the sequence of concreting, the effects of shrinkage and temperature are minimized.

Construction joints shall be watertight. They shall be formed in straight lines with rigid shuttering perpendicular to the principal line of stress and as far as practicable at points of least shear. They shall be the plain butt type unless otherwise specified or approved.

As soon as the exposed concrete has sufficiently hardened the surface of the joint shall be brushed with a stiff brush to expose the larger aggregate without it being disturbed. Roughening of the surface by chipping or hacking will not generally be approved. Before placing fresh concrete against a construction joint all loose material shall be removed and the surface sluiced with water until it is perfectly clean, thereafter all ponded water should be removed.

A period of at least 3 days and not more than 14 days, except under special circumstances and with the approval of the Engineer, shall elapse between the castings of successive lifts of concrete.

In the case of water retaining structures, a maximum period of 7 days will be permitted to elapse between casting of the base or footing to a wall panel and the casting of the stem of the wall on such base or footing.

In case any joints have been shown on the Drawings, the Contractor will not be permitted to alter these joints or their positions or to increase or decrease their number.

2.32 Dowel Bar

Where dowel bars are to be provided through movement joints they shall be mild steel plain round bars with sawn cut ends and complying with ASTM A615/BS 4449.

In expansion joints the part of the bar to be free to move shall be coated with bond breaking compound as specified, encased in a rigid PVC or metal sleeve and fitted with a compressible cap of joint filler or other materials approved by the Engineer. The diameter of the sleeve should be the minimum necessary to allow free movement of the bar after concreting.

In full contraction joints the part of the bar to be free shall be coated with bond breaking compound as specified.

In joints between roofs and walls of reservoirs vertical dowel bars shall be provided with a rigid PVC or metal sleeve so packed with compressible material so as to allow a free movement of 5 mm in any direction in the horizontal plane.

2.33 Reinforcement at Partial Contraction Joints

Only 50% of the longitudinal reinforcement will be continuous at partial contraction joints in the walls of the conduit unless shown otherwise on drawings.

2.34 Pipes through Concrete Sections

All pipes passing through concrete to water retaining structures or where a thrust load has to be transmitted to the concrete shall be fixed in position before and rigidly held in position during concreting. Boxing out in either of the above circumstances will not be permitted, unless approved by the Engineer.

2.35 Protection and Curing of Concrete

The Contractor shall take measures to the approval of the Engineer for the protection of concrete from the harmful effects of wind, sun, high and low temperatures, rapid temperature changes, premature loading, deflection, impact and aggressive groundwater. Such measures shall continue from the time of the concrete is placed for a minimum of 7 days.

Concrete shall also be cured as follows. Unless otherwise approved by the Engineer, exposed concrete surfaces shall be kept continuously moist after casting for not less than 14 days after placing. Such surfaces, immediately upon exposure, shall be covered with polythene sheeting, thick hessian or other material as may be approved by the Engineer, which shall be in continuous contact with the concrete and which shall be kept wet to the satisfaction of the Engineer.

Concrete containing blast-furnace slag, pulverized fuel ash, or micro-silica requires particular attention to curing.

For horizontal members such as slabs, exposed to wind and /or sun, special measures to prevent occurrence of shrinkage cracks shall be taken immediately after placing of concrete and until it is hard enough to commence curing as specified above. The following measures shall be taken to prevent the loss of moisture in the surface of the concrete:

(a) Erection of wind barriers and sun shades of suitable construction to provide adequate protection.

(b) Application of water as a fog spray to keep the concrete surface moist without in any way damaging the fresh concrete or surface finish.

Concreting shall not take place until all Hessian cloth, polythene and a supply of fresh drinking water is on the site and ready for use, and the relevant Method Statements and Inspection and Test Plans have been submitted and approved by the Engineer.

2.36 Removal of Shuttering

Shuttering shall be removed in accordance with principles agreed by the Engineer and with the permission of the Engineer's Representative. Unless the soffit shuttering to beams and slabs has been designed so that it can be struck without disturbing the props, it shall be retained in position for the minimum period given in Table 2-11 for the retention of the props. Great care shall be exercised during the removal to avoid shocks to, or reversal of stress in, the concrete.

Earlier removal of formwork may be permitted by the Engineer by determination of the early strength of the concrete in accordance with BS EN 13670 or approved equivalent. However, the approximate elapsed time before removal of formwork shall be as stated below:

Table 2-11: Minimum Period before Striking Formwork.

Type of formwork	Minimum period before Striking surface
Vertical formwork to columns, walls and large beams	36 hours
Formwork of beams & slab	14 days
Mass concrete	24 hours

At least 24-hour notification shall be given by the Contractor to the Engineer of the intention to remove false work or formwork.

"The Contractor shall remain fully responsible for the safety of the structure from which the formwork has been removed."

2.37 Cement Mortar

Unless otherwise specified the dry ingredients of cement mortar shall consist of one part of ordinary Portland cement to three parts of sand. The sand shall comply with BS EN 13139 or approved equivalent with a grading complying with Table 2-1 thereof. The cement and sand shall be thoroughly mixed with just sufficient water to make it workable. With the approval of the Engineer a non-shrink admixture may be used subject to the provision of Clause 2.04.

Cement mortar which has begun to set shall not be used or reworked for use in the Works.

2.38 Precast Concrete

Unless otherwise specified or described all precast concrete work shall be of Class A

Each mould for concrete work which is specified or approved by the Engineer to be precast shall have a different embossed or recessed identification mark in a position to the approval of the Engineer. Each precast unit shall be indelibly marked with the date of casting and after the mould is removed shall not be disturbed until the cylinders representing them reach the appropriate 28- day characteristic strength. Each precast unit shall, where required, be provided with lifting eyes and holes located to avoid excess stress during handling to the approval of the Engineer.

The contractor shall submit detailed methodology for precast concrete slab including details of proposals for casting, storage, transportation, delivery, erection and protection. Precast concrete products shall comply with BS EN 13369 or a specific product standard.

The Contractor shall cast samples of each typical type of pre-cast unit for approval, and approved units shall be retained on site as the control standard for subsequent panel production. Pre-cast concrete units shall be cast on manufactured beds. The beds shall not be liable to settlement and shall have smooth, hard and level surfaces.

Precast units must be of a sufficient age and handled with sufficient care to avoid permanent damage.

2.39 Building Ground Slabs

The position of all joints shall be indicated on the Contractor's Drawings. The joint types shall be indicated on the assumption that the slabs will be cast in chequered board fashion as defined in Cement and Concrete society TR34 or approved equivalent 'Concrete Ground Floors.

Control joints may be substituted for transverse construction joints to permit the use of long strip casting in accordance with Cement and Concrete society TR34 or approved equivalent provided that:

(a) The Contractor can demonstrate previous experience using this technique in ambient conditions similar to those prevailing on Site.

(b) The joints layout is approved by the Engineer.

(c) The joint is as detailed by the Contractor and approved by the Engineer and the crack inducer is in one piece between the side forms.

(d) The groove is straight and sawn before random cracking occurs.

Fabric reinforcement may be located in the top face of a ground slab either by the use of chairs or, provided the concrete remains workable for an adequate period, by placing and compacting the concrete to the design level of the fabric, placing the fabric on the compacted concrete and placing and compacting the top layer of concrete to such a manner as to ensure the mixing of the layers.

The top layer of concrete not exceeding 50 mm deep shall be compacted using a double beam vibrating screed compactor.

Where the surface of a slab is to be sealed at a later date any curing membrane used shall be compatible with the use of the specified sealant.

2.40 Screeds

(a) Concrete Mix

Screeds placed on concrete made with ordinary Portland cement shall themselves be made with ordinary Portland cement. The Engineer may at his discretion direct that the maximum aggregate size be reduced from 20 mm to 10 mm and that the maximum water cement ratio be reduced to not lower than 0.48 at no additional cost.

(b) Mixing

Mixing shall be done in pan or paddle type mixers of a capacity matched to the rate of placing.

(c) Surface Preparation

Where the screed concrete is placed more than 1 hour and less than 12 hours after the base concrete, the base concrete shall be brushed with brooms or wire brushes to remove laitance and expose clean aggregate.

Where the screed is placed more than 12 hours after the base concrete, the base concrete shall be well roughened to give a fresh face over the whole surface. Loose particles and dust shall be cleaned away and the surface then soaked with water. Immediately before placing the screed concrete the water shall be mopped from the surface and a stiff cement/water grout shall be brushed in.

Where the screed concrete is placed less than one hour after the base concrete and provided that no curing compound has been used the screed shall be placed directly on the concrete.

(d) Screed Bay

Screed bays shall whenever possible be rectangular and shall not exceed 15 m^2, the length of a bay shall not exceed 11/2 times its width. Screed bay shall not span joints in base concrete. Alternate bays shall be cast initially and no screed concrete shall be placed against other screed concrete placed less than 48 hours previously.

(e) Screed Battens

Screed battens shall have a thickness the full depth of the adjoining screed and shall be fixed firmly to the base concrete so that they do not move under the action of the screening battens. Fixing shall be such that screening battens can be removed without disturbing the screed concrete. Battens shall not be removed until adjoining screed concrete has been placed for at least 12 hours.

(f) Placing and Finishing

The screed concrete shall be placed as soon as possible after mixing. It shall be worked into place with a screening board with the screed alongside the battens troweled into the corners. A preliminary pass with a vibrating screed board shall be made if conditions permit. The surface shall be worked with a power float if conditions permit. Unless otherwise shown the finish of screeds shall be Type U3.

2.41 Protective Coatings to Concrete

Where ordered by the Engineer or shown on the drawings, water proof coatings shall be applied to concrete structures in order to protect the concrete against the aggressive effects of saline ground water. Generally, protective coatings will be applied to surfaces of structures which are close to or in contact with ground water.

Before applying any coating, the surface of the concrete shall be cleaned of all dirt, dust and loose material and where necessary any surface shall be made good so that the surface is smooth and free from air or water holes. No coating shall be applied until the Engineer has approved the preparatory work.

The coating shall be applied using bituminous coatings or similar approved coatings.

2.42 Provision of Hydrophilic Water stop

The joint between existing and new concrete or around pipes shall be provided with hydrophilic water proofing compound strip of size 20 mm x 25 mm at the locations shown in drawings and as directed by the Engineer. These stripes comprise of rubber based bentonite compounds and other equivalent Hydrophilic Water proofing compound strips which are old tested products will also be acceptable.

The hydrophilic water stop strip shall be fixed by experienced personnel as per manufacturer’s recommendations using recommended adhesives to provide excellent adhesion to the concrete. No nails or steel fixtures are to be used and these should be minimum cover of 100 mm concrete over the hydrophilic water stop.

The Contractor is required to submit for approval necessary test report about the suitability and compatibility of the material for use in the project under Karachi climatic conditions. The Engineer may arrange third-party testing if deemed necessary. The Contractor shall also provide manufacture’s guarantee for performance and durability of the product for at least 20 years.

2.43 Water Tightness of the Structures

The Contractor is responsible to construct the water retaining structures water tight and take necessary precautions at every stage of construction so as to ensure that no leakage or seepage and decay in concrete occurs when filled with water.

2.44 Geotextile Filtration & Erosion Control

The Jet filter with one way check valve (Flap Valve) prevents retaining walls failure or movement by relieving hydrostatic water pressure and allowing drainage and also backflow preventer.

The Jet filter assembly includes:

A housing containing a flat flange and a perforated conical shell, the shell adapted to extend into the hole with its apex extending toward the landward side, the flange having a frontward side adapted to fit flush against the earth retaining structure, the flange having a landward side connected to the shell, the flange having an opening that defines an open base for the shell.

Jet filter of 6” dia closed end one way check valve, complete assembly shall be stainless steel conforming to ASTM 316 and position behind the wall to sieve fines and sand with deflection cap & woven geotextile such as Mirafi® FW300 which is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids or perforated stainless steel filter mesh screen as directed by the Engineer.

Mirafi ® FW300 geotextile shall be composed of high-tenacity monofilament polypropylene yarns as per ASTM A-240 Type 316 standards for complete assembly, which are woven into a stable network such that the yarns retain their relative position.

The contractor shall submit product data of jet filter in accordance with 6” diameter weep holes and as specified in drawing for approval of the Engineer.

Filter Jet assembly shall be inserted into the weep holes on retaining walls of intake structure and common inlet chamber as per manufacturer’ recommendation and as directed by the Engineer.

2.45 Measurement and Payments

2.45.1 Concrete Work

The quantity of concrete to be paid for shall be the number of cubic meters of concrete of the various classes complete in place and accepted. In measuring the volume of concrete to be paid for, the dimension to be applied shall be those shown on the Drawings. Deductions from the theoretical volume of concrete shall be made for the volumes of draining holes, weep holes, pipes and conduits, recess or fixtures etc., in case where their cross sectional areas exceed 500 square centimeters.

The measurement shall not include any concrete used in the construction of false work.

The unit rate for items of each class of concrete are deemed to be include , inter alia, for supplying and testing of concrete ingredients; storage of materials; determination of mix proportion; making and testing of trial mixes; supplying samples of water, cement, aggregate and concrete for testing by the Engineer; cylinder moulds; slumps cones; control mixing of concrete; transporting, placing and compacting concrete; recesses; formation of construction joints and movement joints (whether shown on the Drawings or not) water stops in frame for transporting and fixing precast work; precautions for concrete in unfavorable weather ;

preparation of surfaces; curing; ascertaining requirements for reinforcement, bending, cutting and fixing reinforcement or working space for erection and handling of back and soffit shuttering.

No deductions will be made, from the above computed concrete volumes, for the reinforcement steel, water stops and joint materials.

For all concrete structures or portions, thereof, no separate measurement or payment shall be made for false work, centering, formwork or any other temporary work to complete the concrete structure or portion thereof, payment for all such temporary works shall be deemed to be included in the contract price paid under various items of concrete work.

2.45.2 Reinforcement Work

The quantity of reinforcement to be paid for shall be the calculated theoretical number of metric tons of reinforcement steel bars as determined from the approved bar bending schedule and incorporated in the permanent work and accepted. Bar bending schedules and reinforcement drawings will be prepared for all permanent work for Engineers approval. The mass of reinforcement shall be calculated using the appropriate mass per meter run value from the following table 2-12

Table 2-12: Unit Weights for determining the weight of concrete reinforcement.

Bar Designation	Unit Weight Kg/m (lb/ft.)	Bar Size (mm)	Unit Weight kg/m
# 3	0.560 (0.376)	10	0.616
# 4	0.994 (0.668)	12	0.888
# 5	1.553 (1.043)	16	1.579
# 6	2.236 (1.502)	20	2.467
# 8	3.975 (2.670)	25	3.854

Chairs, spacers to provide cover to reinforcement and separation between bars, binding wire and other items required for supporting and securing the reinforcement in its correct position shall not be measured.

Steel wire fabric reinforcement shall be measured by area for each mass of fabric with no allowance for laps.

If bars are substituted upon the Contractor's request and as a result more steel is used than specified, only the amount specified shall be measured for payment. When laps are made for splices, other than those shown on the Drawings or required by the Engineer and for convenience of the Contractor, the extra steel shall not be measured nor paid for. When continuous bars are shown on the Drawings, without the splices being shown the necessary steel in the splices will be paid for on the basis of the individual bars not being shorter than twelve (12) meters.

The unit rate for all items of reinforcement shall be deemed to be include for supplying reinforcement bars, all sorts of transportation, wastages, all operation including cleaning ,cutting ,bending ,placing and fixing in position ,preparing bar bending schedules ,carrying out sampling and testing and all other operations ,procedures and requirements necessary to complete the work in accordance with these specifications.

2.45.3 Water Stops

Measurement, for PVC water stops, shall be made in the specified units of length of the water stops, of specified type and size, acceptably placed, on the basis of the dimensions, in accordance with the Drawings or directions of the Engineer.

No allowance will be made, in the above computed lengths, for the laps and splices.

The unit rates for all items of water stops, shall be deemed to include; Providing all materials including splicing, jointing, fixing and all operations related with transportation, storage of materials, all sorts of wastages, including installing, and securing water stops; in construction joints, control (CC.JT) and expansion joints; and protection of the water stops, carrying out all sampling and testing .

All other operations, procedures and requirements necessary to complete the work in accordance with these specifications.

2.45.4 Joint Sealant

Measurement, for Joint Sealant shall be made in the specified units of length of the joints of specified size and acceptably placed in accordance with the Drawings and as directed by the Engineer.

The unit rates for all items of joint sealant shall be deemed to include; Providing all materials including substrate preparation , cleaning & drying , inserting a suitable back rod to the required depth, application of primer , filling of sealant in joints by sealant gun and make sure it comes into full contact with the sides of the Control Joints and expansion joints ,and avoid any air entrapment. and all operations related with transportation, storage of materials, all sorts of wastages, and protection of the joint sealant, carrying out all sampling and testing .

All other operations, procedures and requirements necessary to complete the work in accordance with these specifications

2.45.5 Joint Filler

The quantity to be paid for shall be in the units of square meters of expansion joint's specified size with preformed joint filler by fixing cork sheet and placed in accordance with the drawings.

The unit rates for all items of joint Filler shall be deemed to include; Providing all materials including substrate preparation, cleaning & drying , fixing cork sheet in expansion joints and all operations related with transportation, storage of materials, all sorts of wastages, and protection of the joint filler ,carrying out all sampling and testing .

All other operations, procedures and requirements necessary to complete the work in accordance with these specifications.

2.45.6 Bitumen Coating

The quantity of bitumen coating on concrete surfaces exposed to earth shall be in square meter following application of minimum two coats as per drawings and as directed by the Engineer.

Payment for protective coating of min two coats shall be based on the Contract Unit Price per structure coated as indicated in the priced bill of quantities. The Contract Unit Price shall be payment in full for performing the work and for furnishing all labor, supervision, materials, equipment and all the testing necessary to complete the work.

The quantity to be paid for shall be in square meters of either expansion joint with preformed joint filler.

2.45.7 Flap Valves

Numbers supplied by approved manufacturer according to drawings and specification shall measure flap valves along with filter in retaining walls of intake structures. Installation shall be included in the rate for fixing of one way valve at the locations specified in the drawings including supervision, materials; SS bolts etc. and all testing necessary to complete the work.

2.46 References

Reference standards are given in the text and shall be the latest. The standards and subjects are listed below for convenience:

1	ACI 315	Guide to Presenting Reinforcing Steel Design Details
2	ACI 318	Building Code Requirements for Structural Concrete

3	ACI 350	Code Requirements for Environmental Engineering Concrete Structures
4	ASTM C 150 (Type I)	Standard Specification for Portland Cement
5	BS EN 197-1 CEM-I	Composition, specifications and conformity criteria for common cements
6	ASTM C 150 (Type V)	Standard Specification for Portland Cement
7	BS 4027	British Standard for Sulfate-Resisting Portland Cement (Withdrawn)
8	BS EN 196	Methods of testing cement
9	ASTM C989 (ASTM C1709 – 18)	Standard Specification for Slag Cement for use in Concrete and Mortars
10	BS 6699	Specification for ground granulated blast furnace slag for use with Portland cement (Withdrawn)
11	ASTM C-33	Standard Specification for Concrete Aggregates
12	ASTM C117 95	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
13	ASTM D 2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
14	ASTM C270	Standard Specification for Mortar for Unit Masonry
15	BS EN 13139	European Standard on aggregates for mortar
16	BS 812-1	Testing Aggregates Part 1: Methods for Determination of Particle Size and Shape
17	BS 812-3	Testing Aggregates Part 3: Methods for Determination of Mechanical Properties
18	ASTM C88 / C88M – 18	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
19	ASTM C227-10 :	Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method) (Withdrawn 2018)

20	ASTM C289-07	Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method) (Withdrawn 2016)
21	ASTM C1602 / C1602M – 18	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
22	ASTM C494 / C494M – 19	Standard Specification for Chemical Admixtures for Concrete
23	ASTM C1580	Standard Test Method for Water-Soluble Sulfate in Soil
24	BS 1377	Methods of test for soils for civil engineering purposes - Classification tests
25	ASTM C-114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
26	BS 4550	Clause 12 : Methods of testing cement - Chemical tests
27	ASTM D-516	Standard Test Method for Sulfate Ion in Water
28	BS 1377	Soils for Civil Engineering Purposes. PART 1: General Requirements and sample Preparations
29	ASTM C-1524	Standard Test Method for Water-Extractable Chloride in Aggregate (Soxhlet Method)
30	ASTM C-114(2018)	Standard Test Methods for Chemical Analysis of Hydraulic Cement
31	BS 4550-2	Methods of Testing Cement Part 2: Chemical Tests
32	ASTM D-512	Standard Test Methods for Chloride Ion In Water
33	BS EN 1744-1	Tests for chemical properties of aggregates - Chemical analysis
34	ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
35	BS 4449	Steel for the reinforcement of concrete. Weld able reinforcing steel. Bar, coil and recoiled product
36	BS 4483	Standard for Steel Reinforcement For Concrete

37	BS 2571	Specification for general-purpose flexible PVC compounds for molding and extrusion
38	CRD-C572-74	Corps Of Engineers Specifications For Polyvinylchloride Water stops
39	ASTM D 1752 Type II	Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
40	ASTM D 1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non extruding and Resilient Bituminous Types)
41	BS 4254	Specification for two-part polysulphide-based sealants
42	EN ISO 11600:2003	Building construction - Jointing products – Classification and requirements for sealants (ISO 11600:2002)
43	BS 3416	Specification for Bitumen-based coatings for cold application, suitable for use in contact with potable water
44	BS EN 1992-3	Design of concrete structures - Liquid retaining and containing structures
45	BS EN 1992-1-1	Design of concrete structures - General rules and rules for buildings
46	BS 1305:1974	Specification for batch type concrete mixers
47	ASTM C42 / C42M – 20	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
48	BS 1881- 124	Testing Concrete - Methods for analysis of hardened concrete
49	BS 8666:2020	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete. Specification
50	BS 7973	Spacers and chairs for steel reinforcement and their specification Fixing and application of spacers and chairs and tying of reinforcement

51	ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

CHAPTER 3 – MISCELLANEOUS

3.01 Gabion Mattress

This work shall consist of wire-mesh gabions mattress, furnished and placed in accordance with these specifications at the locations and in conformity with the lines and grades shown on the Drawings. The work in general covers gabions mattress used for river and stream stabilization work, such as bank revetments scour protection and retaining structures.

Gabions shall be enclosed by galvanized steel wire mesh, which shall be supplied folded flat to facilitate transport and handling. Gabions shall be furnished in accordance with the various lengths, widths and heights required by the Drawings, or as directed by the Engineer.

a. Stones

Stones used for gabion mattress shall be clean, natural, hard and durable that will not deteriorate when submerged in water or exposed to severe weather. Filled gabions shall have a minimum density of 2650 kg/m3. Stones shall be well graded within the limits of 250 mm to 125 mm nominal size. Stone shall be rounded rather than angular. Void spaces shall be evenly distributed and shall not exceed a maximum of thirty (30) percent.

b. Wire Fabric

Gabions shall be in the form of rectangular baskets of the required dimensions and shall be manufactured from wire as specified below.

The fabric shall be triple-twisted hexagonal woven steel wire mesh complying with BS 1052. The wire shall be PVC coated or galvanized to BS EN ISO 1461:2022 or approved equivalent coated after weaving. The minimum wire thickness shall be 2.0 mm and the mesh size shall be 60 mm x 80 mm.

Wire mesh shall withstand 220 hours of exposure before failure by rusting of any part when subjected to a salt spray test in accordance with ASTM B 117. The tensile strength of the wire shall be in the range of four thousand (4,000) to six thousand (6000) kg. / sq. cm. and shall have an elasticity to permit elongation of the mesh equivalent to a minimum of ten (10) % without reducing the gauge or tensile strength of the wire.

Four cross-connecting wires shall be provided in each cell having a height of one half the width or less, and eight (8) cross-connecting wires shall be provided in each cell having a height greater than one half the width.

c. Method of Construction.

When the gabion length exceeds its width, it shall have securely tied diaphragms connected at all edges to form individual cells of equal length and width. Diaphragms shall be of the same material and manufacture as specified above for the gabions.

Installation shall be performed in a workmanlike manner as approved by the Engineer. Beds for gabions shall be suitably level. Gabions forming elements of structures shall be securely connected along the complete length of top contact edges by means of the above specified tying and connecting wire.

Before the rock fill is placed the gabions shall be stretched in such manner as will permit proper shape, alignment and compaction of fill.

Rock fill for exposed faces of gabions walls shall be carefully selected for uniformity or size, and the pieces shall be hand placed to provide a neat appearance as approved by the Engineer.

The vertical joints of gabion baskets shall be staggered as in running bond brickwork.

3.02 Stone Pitching and Cladding

Stone pitching shall be hard durable rock from an approved source. It shall be sound, clean and free from impurities such as earth or decomposed rock.

Where dry pitching is specified the stones may be of random situ and shall be roughly hammer dressed so that they fit closely together. Individual stones shall weigh not less than 20 kg and shall be not less than 200 mm in length or width. The pitching shall be laid to a true and even surface on a bed of gravels, 150 mm thick unless otherwise specified.

Where mortared pitching is specified, the work shall be carried out as described for dry pitching except that the stones shall be bedded and jointed in 1:4 cement mortar in such a way that no voids remain in the completed pitching.

3.03 Gravel Bedding or Backing for Mattresses or Pitching

Gravel bedding or backing for mattresses or pitching shall consist of approved clean, hard natural gravel or broken stone well graded from 50 mm to 10 mm and shall be laid to the thickness specified or ordered by the Engineer to give an even surface parallel to the exposed face of the mattresses or pitching.

3.04 Manholes and Chambers

Manholes and chambers shall be rectangular.

Chambers shall be cast in-situ Class ‘A’ concrete with steel reinforcement as shown on Drawings. All chambers shall be watertight.

All chambers shall project a minimum of 300 mm above ground level or as shown in drawings, except under roads and verges where the chambers shall be constructed so that the tap of the cover is level with finished road level.

3.05 Cover Slabs and Covers

Cover slabs shall be either precast or cast in situ in Class ‘A’ concrete. Unless otherwise shown, all cover slabs shall be reinforced as shown on Drawings.

The chamber covers shall be of precast concrete and obtained from an approved manufacturer and shall be to the internal minimum clear opening as specified in the Bill of Quantities and the drawings. All chamber covers in road and footpaths shall be to an approved heavy-duty pattern unless otherwise specified. The frame and lid shall have key holes formed with sealed pockets underneath to prevent ingress of sand, grit and surface water and shall be of an approved non-rocking pattern. The covers and frames shall have accurate seating faces to prevent rocking and the ingress of sand or water, and shall be tight fitting to resist overflow conditions or unauthorised removal. The seating faces shall be coated with graphite grease before installation of the cover. A supply of keys for use with every type of manhole cover and surface box shall be handed over by the Contractor at the completion of the Contract on the basis of one set of keys for each 50 covers or part thereof. Manhole and chamber cover frames shall be set to the required level and, where for pre-cast concrete manholes, on at least two and not more than four courses of Class B engineering, bricks, C 20 P in-situ concrete or special purpose concrete brickwork or pre-cast concrete cover frame seating rings. The frames shall be set to level and bedded in cement mortar and haunched over the base and sides of the frame with Grade C 30 P concrete. It shall be the Contractor's responsibility to establish the finished road levels from the appropriate authority and fix the covers accordingly. Surface boxes and chamber covers shall be set in cement mortar to the correct camber and fall.

3.06 Step-irons

Step-Irons shall be fabricated from 20 mm diameter hot dip galvanized reinforcing bars. They shall be provided in all manholes and chambers over 900 mm deep from the top of the cover slab to the base of the chamber. Step-irons shall be spaced at 300 mm centers vertically according to BS 4211.

3.07 Inspection Chambers

Stub pipes entering an inspection chamber shall be surrounded with a layer of cement mortar immediately before concreting. Benching will be formed of concrete, rendered with three coats of cement mortar; the render to be extended to the fillets between the pipe ends and the chamber sides. The profile of the benching shall be brought up vertically to the level of the crown of the highest pipe entering the chamber; the top of the benching shall slope at 1 in 6 towards the channel and be connected to the vertical section by a curve of radius not exceeding 50 mm. All pipe ends shall be taken a clear 75 mm into the chamber, including those entering at an angle.

3.08 Washout Sumps

Stub pipes entering a washout sump shall be surrounded with a layer of cement mortar immediately before concreting.

3.09 Concrete Classes

Unless noted otherwise on the Drawings the classes of concrete to be employed in the construction of manholes, chambers and anchor blocks shall be as follows:

Class A	Structural Concrete
Class B	Structural Concrete
Class C	Mass Concrete
Class D	Blinding

3.10 Fixing and Building-in

The dimensions of holes and openings left in concrete for the subsequent fixing and concreting-in of steelwork, pipes, etc., shall be the minimum practicable. Holes shall be tapered where possible (with maximum area of cross section farthest from the fixing surface) to suit the proposed method of fixing and concreting, all as approval by the Engineer. No hole or opening shall be formed nearer than 75 mm to an edge of concrete.

Drilling of holes shall be undertaken using a diamond tipped or other sharp drill.

All holes and openings shall be thoroughly cleaned before use by hacking, wire brushing, water or air under pressure, or other approved means to remove all laitance and expose the aggregate.

All fixing bolts shall be fixed using epoxy resin which shall be made using approved type resin/hardener cartridges, used in strict accordance with the manufacturer's recommendations.

The size or number of resin cartridges shall be determined based on the sizes of the hole and bolt or bar and the length of bond required for maximum strength. After installation and mixing the bolt or bar shall be supported in the precise position required until the resin has set.

Steelwork and other items to be concreted in position shall be firmly secured against movement during concreting, the supports not being removed without the Engineer's approval. Fixing bolts positioned by template shall be similarly screwed in perfect alignment and level until the concrete or grout is set hard.

Frames and flanges to be fixed against the face of concrete shall be supported against the face and separated therefrom by 10 mm packing of a waterproof and durable material to the approval of the Engineer and sufficiently flexible to take up any shrinkage of the filler during final tightening. Immediately before fixing the frame or flange the face shall be carefully cleaned and roughened over the area of contact. Securing nuts shall be lightly tightened to hold the item in position without distortion and the space between the frame or flange and the concrete shall be filled with cement mortar or hard setting butyl mastic. After the filling has hardened the securing nuts shall be finally tightened in a sequence to ensure equal load carrying and freedom from distortion.

Except where otherwise specified, when a metal surface is to be fixed permanently to a metal or other surface, the metal surfaces shall be painted on Site with two coats of epoxy paint immediately prior to fixing abiding all DFT requirements.

All steel fixings nut bolts and washers shall be galvanized in accordance with BS EN ISO 1461:2022 or approved equivalent unless otherwise stated.

Where the type of fixing is not specified, the Contractor shall obtain the Engineer's approval to the type and position of fixing before proceeding. Proprietary fixings supplied by reputable manufacturers will generally be allowed, subject to their use and loading conforming to the manufacturer's instruction.

3.11 Hand Railing

Hand railing shall be constructed from galvanized Grade 43 mild steel. The posts and hand railing shall be 40 mm Nominal Bore (N.B.), 3.5 kg per meter run. The maximum distance between posts shall be 1.00 meter for a 1.00 meter-high standard post. The post connections shall be 60 mm diameter balls with grub screw fixings. The posts shall be fixed to steel using a bolted cleat as shown on the Drawings. The posts shall be fixed to concrete using a base plate bolted to the primary concrete using approved bolts.

Removable sections of the handrail shall have half-lap joints secured with a countersunk pin.

Chains across openings shall be fabricated from 10 mm diameter grade 316 stainless steel links, 3 links per 100 mm stainless steel manufactured from Grade 316 S31 steel complying with BS EN 10088 grade 1.44011 / X5CrNiMo17-12-2 or approved equivalent. The hooks and retaining eyes shall be securely fixed to the standards.

After manufacture hand railing components shall be galvanized in accordance with relevant BS standards.

3.12 Open Type Metal Flooring and Stair treads

Open type flooring complete with cut-outs and in sizes suitable for removal by hands shall be of mild steel and of sufficient thickness to carry a loading of 2.5kN/m^2.

The open steel flooring shall be supported by rolled steel members built into the concrete piers.

The open steel flooring shall be secured to frames by means of stitching bolts as recommended by the manufacturer the top of the open steel flooring shall be flush with the top of piers. The open steel flooring and cross supporting members shall be removable and of a convenient size for handling.

Galvanized open steel flooring shall be 'Safe tread', as supplied by M/s Allan Kennedy Company Limited, Stockton-On-Tees, UK, or other similar approved type.

Any supporting structures to flooring shall be designed and supplied by the Contractor.

3.13 Metal Plate Decking

Metal plate decking complete with cut-outs and to sizes suitable for removal by hand shall be of galvanized mild steel and of sufficient thickness to carry a loading of 3 kN/m^2 but not less than 5 mm thick. This shall be measured excluding the pattern, which shall be raised self-draining non-slip pattern, and with the finishes as specified.

The metal plate decking shall be set in mild steel rebated surround frames built into the floor. The metal plate decking shall be supported where necessary by rolled steel joists of size not less than 76.2 mm x 76.2 mm.

The metal plate decking shall be secured to the surround frames and supporting joints by means of countersunk stainless steel pins or set-screws and the top of the metal plate decking shall be flush with the adjacent floor. Suitable separators between the dissimilar metals shall be used. The metal plate decking and supporting joists shall all be removable and of a convenient size for handling. Lifting holes shall be provided in each plate and the Contractor shall supply two sets of lifting keys.

3.14 Ladders and Step Irons

Ladders shall be fabricated of mild steel and galvanized as specified. The stringers shall be flat section 65mm by 10 mm spaced 400 mm apart. Top stays welded to stringers shall be flanged and drilled for wall fixing. The bottom of the stringers shall be flanged and drilled for floor fixing. Fixing bolts and nuts shall be specified herein.

Rungs shall be 20 mm diameter sold at 250 mm centers shouldered at each end and securely riveted into countersunk holes. Rungs shall not be less than 240 mm from the walls.

Ladders shall have intermediate stays at not less than 1.7 m unless otherwise approved.

Step irons shall be formed from 20 mm dia. mild steel solid bar, bent to shape and galvanized as specified. The steps shall be 300 mm wide and project 200 mm from the wall face. They shall be built into the wall a minimum depth of 100 mm and shall have their ends bent through 90 degrees to run parallel to the wall face by 150 mm to form an anchorage. Unless otherwise directed by the Engineer step irons shall be spaced at 300 mm intervals vertically and in-line.

3.15 Fencing

This work shall consist of constructing post and barbed wire fence or chain link fence in accordance with the details and at the locations shown on the Drawings or as directed by the Engineer.

Barbed wire shall conform to the requirements of ASTM A 121, Class I. The barbed wire shall consist of two (2) strands of twelve and half (12.5) gauge wire, twisted with two (2) points, fourteen (14) gauge barbs spaced 10 cm apart.

Concrete posts shall be made from Class C concrete in accordance with specification clause 2.16. The posts shall be cast to the length shown on the detailed drawings and shall have a smooth surface finish.

The posts shall be erected to the height and location shown on the Drawings or as directed by the Engineer.

Steel reinforcement for the concrete posts shall be deformed steel bars conforming to the provisions of clause 2.06.

Nuts, bolts, washers and other associated hardware shall be galvanized after fabrication as specified in ASTM 153.

Fences shall be constructed with plastic coated chain link mesh on concrete posts set in concrete with cranked top to take barbed wire all generally to BS 1722: Part 1.

The post type shall be GLC 180C but with top cranked through 45 degrees to take three strands galvanized barbed wire to BS 4102. The post size shall be as shown on Drawings.

The fencing shall be heavy duty plastic coated chain link mesh. The erection shall be in accordance with BS 1722, Section 3.

The double opening gates shall be manufactured to match the fencing as shown on the Drawings and shall be provided with all hinges, bolts, fastenings and padlock with two keys.

Gates and frames shall be galvanized in accordance with BS EN ISO 1461:2022 or approved equivalent.

3.16 Cleaning of the Conduit

On completion, all water retaining structures shall be carefully cleaned by sweeping and brushing with stiff brooms, first with the minimum use of water and subsequently with water hosing, to the approval of the Engineer. The water shall be run off, bailed or pumped out after cleaning and any sediment removed to the satisfaction of the Engineer.

3.17 Testing of the Conduit

The conduit shall be tested for water tightness after completion of 1 km maximum as directed and approved by the Engineer, in accordance with the following method.

The testing shall not be undertaken until the structure to be tested has been completed structurally (including roof, floor, wall, finishes & joints treatment / sealants etc. complete) and has been passed by the Engineer in writing as satisfactory in all respects other than water tightness, especially in regard to the final completion of the Work; the filling shall not take place earlier than 28 days after the casting of the final sections of the structure which will be stressed by the filling of the structure.

The conduit shall be filled with clean water to a level within 100mm of the roof slab. The rate of filling shall be reasonably constant and shall not exceed 2.5m of depth in 24 hours. A higher rate may be used with the agreement of the Engineer. After filling, the structure shall be allowed to stand full (being topped up as necessary) for at least 72 hours, for absorption of water by the concrete to take place, at the end of which period the level shall be accurately noted. The structure shall then be accepted as watertight if:

1 No leaks or damp patches on the backs of walls are discovered during the period of the test (if the backs of walls are wetted by rainfall or any other cause the test must be delayed until they are dry for at least 72 hours). In the case of individual parts of a structure being tested independently, the division walls also must be watertight.

2 The floor under-drainage system of the structure (if any) remains dry, or the flow in it before the test is not increased as a result of filling the structure with water.

3 There is no discernible change in the level of the water in the structure during the period of the test. For the purposes of this clause, the limit of discernibility will be taken as 3 mm.

The roof of the conduit shall be tested for water tightness by lagooning the roof slabs to a minimum depth of 50mm for a period of 72 hours. The roof slab shall be regarded a satisfactory if no leaks or damp patches appear on the soffit.

Should the part of the structure under test fail the above test in any respect, the Contractor shall immediately take such steps as may be necessary to ascertain the nature and positions of any defects or leakages, shall empty the structure, and remedy the defects in a manner approved by the Engineer, employing men who are specialists in this class of work. A damp patch appearing on the outside of the wall must be rectified from the water face, a repair to the outer face only will not be approved; this applies to bobbin holes also.

When the remedial work has been completed in a manner approved by the Engineer, the testing and if necessary rectification shall be repeated until a satisfactory test is achieved.

If necessary, in extreme cases of lack of water tightness, the Engineer may reject the structure, any member or section of a member of the structure.

3.18 Measurement and Payment

1 General: Stone pitching shall be measured by superficial area in cu.m and shall include bedding.

Pipe line protection works complete in all respects shall be measured by volume in cubic meter of the protection blanket including excavation, gravel filter blanket, gabion mattress including stones filling, fixing galvanized wire, diaphragm in gabion mattress, stone pitching, backfill where required, removal of existing protection, extension and reinstatement complete as shown on the drawing and as directed by the Engineer.

Other protection works complete in all respect as per drawings shall be measured by volume in cubic meters as defined above at given locations directed by the Engineer and the rate shall include all incidental works as well.

2 The rate for galvanized mild steel covers or Pre-cast RCC covers and for galvanized mild steel ladders inclusive of installation, all fixings fastenings, anchor bolts, locking bolts, padlocks, and the likes shall be measured by numbers according to drawings and specifications. The rate shall include all incidental works as well.

3 Open type metal flooring and metal plate decking by chequered plate shall include all supporting structure, framing, edging and toe plates, fixing, clips, etc. No deduction shall be made for openings in the decking plates unless specifically measured otherwise.

4 Hand railing shall be measured by length in meters as double rail or otherwise including all fittings and foot or wall fixings, chain or removable sections, and any required protection such as galvanizing or painting.

5 The Excavation, concrete, reinforcing steel, ladders, fixtures and fittings and manhole cover and protective coating, backfilling etc. of Chambers and other structures shown on the detail drawings shall be measured as per BOQ item in Bill of Quantities.

3.

References

1.	BS EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
2.	BS 4483	Steel Fabric for the Reinforcement of Concrete
3.	BS 4449	Steel for the reinforcement of concrete. Weld able Reinforcing steel. Bar, coil and recoiled product
4.	BS EN 10088-3	*Stainless steels. Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resistant steels for general purposes.*

5.	BS 4102	: Steel wire for general fencing purposes.
6.	BS 1722-3:1986	: Specification for strained wire fences

CHAPTER 4- PRESSURE PIPELINES

4.01 Application

This chapter shall apply to the pressurized conveyance system comprising of mild steel (MS) transmission mains, washout pipelines and appurtenances. Transmission Mains will be constructed in MS pipeline to convey the water. Where necessary transmission mains will be provided with air valves, washouts and other appurtenances which will be connected in steel pipeline.

4.02 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.

'**Flexible pipes'** shall mean pipes having a specific stiffness of:

$E' = (EI)/D^3$

of less than 11 kN/m per unit length of pipe.

Where E = Young's modulus of pipe wall material

I = moment of inertia of pipe wall per unit length

D = pipe diameter

'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.

‘Flexible joints’ shall mean joints made with factory made jointing materials, loose collars, rubber joint rings and the like which permit angular deflections between adjacent pipes.

- **‘Differential settlement joint’** - is a flexible and expandable ductile-iron sliding fitting, manufactured in a factor (ISO 16134), that has been developed to protect pipelines against the risk of displacement and damage caused by rare but serious ground movements: landslides, subsidence of loose or unstable ground or stresses caused by earthquakes, seismic earth movements, tsunamis, tidal waves etc.

‘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 is 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.

‘Raw water’ is water from a lake before it has received any treatment other than that inherent in pumping and conveyance.

‘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

4.03 General

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

The manufacturer shall have a facility licensed by the American Petroleum Institute (API)or an equivalent internationally recognized licensing institute approved by the Engineer. and is intended to supply line pipe bearing the API Monogram. Also, the pipe manufacturer shall possess and maintain valid certifications for ISO 9001 (Quality Management), ISO 14001 (Environmental Management), and ISO 45001 (Occupational Health and Safety Management), or equivalent internationally recognized standards approved by the Engineer. 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 Specification**, ISO 3183, EN 10217-1, or the specific design requirements of AWWA C200**,.

No pipes; fittings; valve; appurtenances; gaskets or accessories 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 odour or toxicity or otherwise be harmful to health or adversely affect the water conveyed (BS 6920). All such materials shall be certified as suitable for contact with potable water and shall comply, as a minimum, with the relevant Pakistan Standards for Drinking Water Quality and/or the World Health Organization (WHO) guidelines for drinking-water quality.

Certification by WRAS (Water Regulations Approval Scheme), NSF/ANSI 61, or any other internationally recognized body satisfactory to the Engineer shall be regarded as evidence of the material's suitability for use in contact with potable water.

4.04 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 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 or his authorized representative shall witness all tests, including Factory Acceptance Tests (FAT), to verify compliance with the Specifications , and to witness works tests, all at the Contractor's cost for providing access and necessary facilities.

4.05 Material and Equipment Procurement Plan

The Contractor shall submit a detailed procurement plan for the steel pipeline 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 the procurement process and conformity checks on approved suppliers 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 an audit on purchase order to reaffirm specifications, third party inspection protocols and certifications, to be witnessed and approved by the Engineer.

The contractor shall maintain quality control checks at the 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 contractor shall confirm the pipe delivery notification of being free from defects due to transport and handling and the contractor shall resolve noncompliance directly with the manufacturer.

4.06 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 specification along with resources to be deployed for the construction of MS Pipeline . This plan shall include a detailed Quality Inspection Plan (QIP) and activity-specific Method Statements for both factory and site works, which must be submitted for the Engineer's review and written approval prior to the commencement of any related works. This system should be managed by an experienced and qualified staff and should include but not limited to the following activities.

(a) Quality Control surveillance and monitoring (including defined Hold, Witness, and Review points for the Engineer)

(b) Health Safety & Environmental management

(c) NCR Procedures

(d) Safety Check List

(e) On Site Inspecting & testing programme in compliance with the necessary specifications

(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 ultrasonic examination of welding joints of MS Pipe Line with the witness and 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) Fusion Bonded Epoxy

(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. The Engineer shall maintain the right to audit these internal measures and conduct independent inspections at any stage of the project.

All procedures for testing and inspection shall be subject to the approval of the Engineer prior to commencement of work. The Engineer's approval shall not relieve the Contractor of their sole responsibility for the quality and safety of the Permanent Works.

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.

4.07 Pipeline Materials

Unless otherwise specified or shown on the drawings, **pipelines shall be manufactured from steel of grade X 42.**

4.07.1 Steel Pipe and Fittings

(i) Pipes

Steel pipes for the pipeline shall be of spiral welded construction complying with API 5L, specification for Line Pipe product specification level PSL2 as follows:

Nominal Diameter (mm)	Outer Diameter (mm)	Thickness (mm)
DN2400	2438	20.6
DN1800	1828	12.7
DN1600	1626	16.0
DN1400	1422	14.0
DN1200	1219	12.0
DN1000	1016	10.0
DN800	813	8.0

The manufacturing process shall be proposed by the Contractor and approved by the Engineer.

Steel pipes for the washouts shall be Grade X-42 with a yield stress of 290 MN/m^2 and of **welded** construction complying with API 5L specification or any other approved standard specification 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 12 m each. 'Nominal length' shall be as defined in API 5L specification or any other approved standard 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 or any other approved standard specification. for line pipe PSL2 including ladle and check analyses of the steel. These tests shall include, but not limited to, Ladle and Check chemical analyses, Tensile and Charpy V-Notch impact tests, 100% Non-Destructive Examination,Destructive Flattening/crushing tests. Additionally, every pipe length must pass a Hydrostatic Test at 90% of the Specified Minimum Yield Strength to verify pressure containment. The Contractor shall provide as well a test certificate to confirm that the pipe is suitable for use under the operating conditions specified herein, with design temperatures between –10°C and 80°C.

During manufacture and before despatch from the place of manufacture the Contractor shall allow for inspection of all Pipeline Materials by an inspector appointed by the Engineer. The inspection will include attendance at all pressure and material tests, execution of dimensional checks and inspection of the workmanship and standard of manufacture with scrutiny of evidence of the materials used in the fabrication of the Pipeline Materials.

(ii) Truly Circular Pipes

Pipes intended for fabrication at Site by welding and for cutting into closing lengths shall be referred to as 'truly 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 'truly 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 pipeline 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 Contractor 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 bevel ended, in accordance with the requirements of clause 15.12.5.2 of API 5L Specification unless otherwise specified in the drawings.

4.08 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 16 flanges shall comply with EN 1092.

Flanges connecting to valves and Fittings shall be compatible with the flanges attached to them (similar pressure rating).

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 two full threads shall show through the nut when in the fully tightened condition (ASME B31.1 and B31.3). Measures to prevent galvanic corrosion (between different types of metals) shall be taken between flange to flange connections (pipes, valves, fittings, etc…). Electrical insulated washer (PTFE/teflon or phenolic resin ASTM D1710, ASTM D3308, ASTM 3307) together with electrical insulating teflon tape, for bolt threads, shall be added to the flange to flange connections to prevent galvanic corrosion (ASTM D1000). The Contractor shall provide Material Test Certificates (MTC) and Certificates of Compliance for all jointing components, including bolts, nuts, gaskets, and insulating sets, to verify conformity with the specified standards prior to installation.

After cleaning the flanges, the gasket (EPDM) 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 a torque wrench (shall be set to meet manufacturing specification for torque) with spanners and shall be approved by the Engineer.

Graphite grease shall be applied to the threads of bolts before joints are made. Grease source is subject to formal approval by the Consultant, and the Contractor shall submit **certified laboratory test reports** to verify its chemical composition and performance properties. All flanged joints which are buried or in chambers shall be protected with grease tape wrapping and petrolatum mastic, 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. All welded flanges, whether factory or field-attached, shall be subject to 100% Visual Inspection and Non-Destructive Testing (NDT) in accordance with API 1104 or other approved standard. The Contractor shall submit detailed NDT procedures for the Engineer's approval prior to commencement. All results must be documented in a specific Flange Weld Inspection Report and cross-referenced with the joint's unique identification number.

4.09 Flange Gaskets

Gaskets for flanges shall be made of EPDM (BS 6920, WRAS) 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. The Contractor shall submit the proposed gasket manufacturer's profile and technical data sheets for Engineer's source approval prior to procurement. For Quality Assurance, each batch of gaskets delivered to the Site shall be accompanied by a manufacturer's Material Test Certificate and a Certificate of Analysis verifying compliance with EN 1514 and WRAS standards. The Engineer reserves the right to request independent laboratory testing of randomly sampled gaskets to verify shore hardness, tensile strength, and compression set properties at the Contractor's expense.

4.10 Slip on Type Flexible Couplings and Dismantling Joints

Slip on type joints and Dismantling Joints for use with plain ended pipes shall be of the type indicated in AWWA C219. Joints shall be standard, harnessed or tied as indicated on the Drawings or described in the Bill of Quantities.

The Contractor shall submit the manufacturer's profile, technical catalogs, and a comprehensive Inspection and Test Plan (ITP) for the Engineer's source approval prior to procurement. If buried or located in chambers, all joints and couplings shall be protected with a petrolatum-based mastic and tape system (complying with AWWA C217) or an equivalent approved wrapping system. They shall be supplied complete with the following:

(a) For a coupling

(i) Sleeve (without center register but with locating studs);

(ii) End flanges;

(iii) joint rings;

(iv) bolts and nuts;

(v) brackets welded to sleeves (where specified).

(b) For a tied coupling

(i) sleeves;

(ii) end flanges;

(iii) joint rings;

(iv) bolts and nuts;

(v) special tie bolts and nuts.

(c) For a harnessed coupling

(i) sleeves;

(ii) end flanges;

(iii) joint rings;

(iv) bolts and nuts;

(v) harness lugs or flanges;

(vi) harness bolts.

(d) For a dismantling joint

(i) end flanges/sleeve;

(ii) joint ring;

(iii) gasket;

(iv) flange bolts and nuts;

(v) studs and nuts.

(e) For a tied flange adaptor

(i) end flanges/sleeve;

(ii) joint ring;

(iii) gasket;

(iv) flange bolts and nuts;

(v) studs and nuts;

(vi) tying lugs or flanges;

(vii) Special tie bolts and nuts.

All steel components of couplings shall be designed to limit the stresses at the specified test pressure to not more than 65% of their minimum field stress subject to satisfying the minimum requirements for flanges and gaskets as specified.

The main body of these components shall be coated internally and externally with fusion bonded epoxy (FBE) with minimum thickness of 250 microns and shall have UV stabiliser additives which shall be approved by the Engineer.

Joint rings shall be provided to withstand the specified pipeline test pressure without leakage and without extrusion of the joint ring from the coupling.

4.11 Welding and jointing

All welding of joints, fittings, and related facilities shall be butt-welded in accordance with API 1104 or other approved specification. Prior to commencement, the Contractor shall submit for approval:

- Site Installation Quality Inspection Plan (QIP): Defining the sequence of operations, Contractor Review Points, and Engineer Surveillance/Hold Points.
- Welding Procedure Specifications (WPS): The type of welding electrodes to be used on Site and the site Welding Procedure Specification (WPS) shall be submitted by the Contractor for review and approval by the Engineer prior to commencement of welding works. This shall include details of the plant, number of runs, and current strength.
- In-Situ Methodology: Proposals for field fit-up, environmental protection, and jointing.

Welding shall be performed by welders qualified for all positions per API 1104 Clause 6. The Contractor shall provide evidence of qualifying tests and each welder shall mark his work with a unique ID using indelible crayons (steel stamping is prohibited). Approval may be revoked for inconsistent workmanship. All NDT procedures and final interpretations shall be managed by a certified Level III operator (ISO 9712/ASNT). Visual inspectors shall hold AWS CWI or CSWIP 3.1 qualifications.

Parts shall be cleaned of scale, rust, and paint. No welding shall proceed until the setup is approved by the Engineer.

Large diameter butt welds shall include a root pass, hot pass, filler, and capping runs, with a back-weld pass from the inside after necessary cleaning/gouging of the root per API 1104 Clause 5.3. Weld metal must be free from cracks, gas holes, and slag. Slag must be removed after each run. Fillet weld throat thickness shall be not less than 0.7 times wall thickness; butt welds shall be not less than full wall thickness.

Final joints shall undergo visual and NDT as per **API 1104 Clauses 6.4–6.6**. No weld shall be painted or buried prior to Engineer approval. Defects shall be cut out and re-welded at the Contractor’s expense.

4.13 Weld 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 and clause 11 of API 1104 specification or other approved specification. The Contractor shall give adequate advance advice of welding operations and provide test equipment for the welds. Welds shall first be visually inspected for weld capping, followed by magnetic particle inspection.

Non-destructive testing (NDT) of all pipeline welds—including standard mainline production welds, tie-in welds, repair welds, joints enclosed in casings or concrete weighting, welds between pipes of differing wall thicknesses, and welds joining special fittings (such as bends, tees, reducers, and valves)—shall be executed in a strict chronological sequence. Testing shall begin with a 100% Visual Testing (VT) examination of all finalized weld caps and adjacent heat-affected zones (HAZ) to evaluate geometric conformances and surface profile irregularities in accordance with Section 9 of API 1104. This shall be supplemented by Magnetic Particle Inspection (MPI) or Dye Penetrant Testing (DPT) specifically on the finalized weld capping to ensure full detection of fine, open-to-the-surface cracks before internal scanning is permitted. Following documented surface examination clearance, advanced Volumetric Ultrasonic Examination (UT) shall be carried out in the presence of the Engineer to evaluate internal weld integrity, deploying Phased Array Ultrasonic Testing (PAUT) and/or Time of Flight Diffraction (TOFD) for lower thickness welds and a combined hybrid PAUT and TOFD technique for higher thickness welds.

All testing operations shall be conducted by certified, qualified personnel using calibrated equipment in strict compliance with Section 11 of API 1104. The quality of all examined production welds must satisfy the applicable acceptance standards specified in Section 9 of API 1104. No reduction in NDT frequency, random sampling regimes, or progressive performance-based testing reductions shall be permitted under any circumstances. Any weld found defective shall be repaired and re-tested using 100% volumetric and surface NDT in accordance with the approved repair procedure until full compliance is achieved.

All tie-in welds, repair welds, welds to be enclosed in casings or concrete weighting, welds between pipes of different thickness etc. shall be subject to 100% ultrasonic examination by the Contractor’s qualified NDT personnel. Magnetic Particle testing shall also be done to confirm weld integrity as prescribed by the Engineer. Welds for joining special parts and fittings such as bends, tees, reducers, valves shall be subject to 100% Ultrasonic examination by the Contractor’s qualified NDT personnel.

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The acceptance or rejection of any weld shall be mentioned in the ultrasonic inspection report including digital scan data (A-scans, B-scans, and C-scans) or as applicable. The format of the report has to be approved by the Engineer in advance.

Each joint to be inspected 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 cases of doubtful ultrasonic indications, the Engineer may request supplementary Magnetic Particle test (MT) or Liquid Penetrant test (PT) inspection for verification at the Contractor’s expense.

100 % 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 ll visual inspection shall be performed in accordance with **ISO 17637**, with acceptance criteria as per **API 1104 Section 9,** 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.

4.14 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. Same has to be approved by the Engineer prior to commencement of work.

4.15 Internal Pipe Protection

All internal protection works shall comply with AWWA C210 with NSF/ANSI 61, and AWWA C213. The Contractor shall submit an affidavit confirming that all materials and workmanship furnished comply with these standards. All lining materials must be certified for potable water use according to NSF/ANSI/CAN 61 and BS 6920, holding valid certification from an internationally recognized organization (WRAS, NSF, or DVGW).

4.15.1 Surface preparation and factory application

Internal surfaces shall be blast-cleaned in accordance with ISO 8501-1. The resulting anchor profile depth shall be between 50–100 microns to ensure optimum adhesion. Internal protection shall be factory-applied Fusion Bonded Epoxy (FBE), and the minimum Dry Film Thickness (DFT) shall be 400-500 microns for all pipes and fittings. Any alternative thickness proposed by the manufacturer is subject to the Engineer’s formal written approval, provided it never falls below the minimum requirements of the applicable AWWA standards.

4.15.2 Performance Testing and Quality Assurance

Internal lining performance shall be verified through pull-off adhesion testing in accordance with ASTM D4541 or ISO 4624, yielding minimum results of 12 MPa for FBE and 10 MPa for solvent-free liquid epoxy.

All such testing is designated as a mandatory Witness Point, requiring the Contractor to provide at least 48 hours' advance notice to the Engineer; results shall only be deemed valid for acceptance if conducted in the presence of the Engineer or an authorized representative.

Furthermore, 100% of the internal lining must successfully undergo high-voltage holiday detection testing both at the factory and following field-joint completion to ensure electrical continuity. Prior to the commencement of mainline production, a 5-meter trial section shall be lined, cured, and tested using approved equipment and techniques to serve as an on-site quality benchmark for the duration of the project.

4.15.2 Handling, Storage and Transportation

Pipes shall be braced, supported, and handled using wide, non-abrasive slings to prevent distortion or damage to the lining. Securely fastened plastic end caps shall be maintained on all completed pipe sections until the time of installation to protect the epoxy from contamination and UV degradation. Any lining section found unsatisfactory upon inspection shall be removed and re-lined at the Contractor's expense.

4.15.2 Field Joints and Roll-out Sections

To facilitate field welding, a bare metal band (holdback) of sufficient width, typically 150 mm ±20 mm or as specifically recommended by the manufacturer and approved by the Engineer, shall be maintained at all pipe ends. Following the completion of welding and the full backfilling of the trench, the internal field joints shall be lined with a solvent-free liquid epoxy within a maximum period of 10 days. The thickness of this field-applied lining shall be consistent with the factory-applied coating, maintaining a minimum Dry Film Thickness (DFT) of 400-500 microns in strict compliance with AWWA C210 with ANSI/NSF 61. To ensure operational feasibility, the Contractor shall provide specially designed roll-out pipe sections to allow access for lining equipment; these sections must be lined, cured, and protected to the same rigorous standards as the mainline pipe sections.

4.15.3 Curing and Repair

Curing of the epoxy lining shall be strictly verified via Shore D Hardness testing in accordance with ASTM D2240, ensuring the material has achieved its full mechanical strength, within 48–72 hours for factory applications and 24-72 hours for field applications, prior to the imposition of any mechanical stress.

All Dry Film Thickness (DFT) measurements shall be conducted exclusively using non-destructive digital gauges, and the use of needle indenters or any other destructive testing methods is strictly prohibited. Any identified damage to the lining shall be repaired in rigorous accordance with the manufacturer's approved instructions using compatible materials, ensuring that seamless continuity of protection is maintained across all pipe sections, branches, tees, and fittings.

If defects in a single pipe length exceed 1% of the total internal surface area, the Engineer may reject the pipe or require a full re-lining.

4.15.4 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 AWWA C210 with NSF/ANSI 61 and AWWA C213 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"

(c) Holiday Detection

(d) Dry Film Thickness Measurement

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 witnessed and 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.

The surface of the epoxy lining of the joints and repairs has to have the same appearance and shall be as smooth and even as the lining of the pipes.

4.17 External Pipe Protection

The external protection against corrosion will be applied on line pipes, fittings, including bends and valves. The 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 coated with application of electrostatic process “EKB” by the valve manufacturer. The external coating of all valves shall have an approved UV stabiliser additive to protect against chalking.

4.17.1 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 investigations in case of doubt and conduct additional testing, batch sampling and manufacturing inspection in order to satisfy and comply with the applicator at the 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 the joint.

The Contractor shall provide details of facilities available at the 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 the contractor shall be its own laboratory and test facilities fully equipped with calibrated equipment, 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 and coated pipes are properly stored at the factory in strict accordance with the Manufacturer's recommendations; specifically, coated pipes shall never be placed directly on bare ground or abrasive surfaces, but must be supported on sandbags or timber skids. Stacking arrangements must be designed to prevent point-loading, ovality, or coating distortion, and raw materials such as FBE powder must be maintained in a temperature and humidity-controlled environment. Furthermore, due to high local UV exposure, any pipes stored outdoors for over 30 days shall be protected with opaque covers. The Engineer reserves the absolute right to reject any pipe section where the coating has been compromised by improper storage or handling arrangements detected.

4.17.1.1 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

4.17.1.2 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

4.17.1.3 Abrasive Blasting

Blasting and other dust producing areas shall be separate from coating application areas. After cleaning and prior to abrasive blasting the pipe lengths shall be uniformly heated to at least 50°C to remove all moisture, and preclude any condensation of moisture on the pipe after blast cleaning.

The surfaces of the pipes shall be blasted until a finish of Grade 2.5 to DIN EN ISO 8501-1 is attained. The surface profile shall be between 50 and 100 microns, measured in accordance with DIN EN ISO 8503-2.

The elapsed time between the start of blasting and the heating of pipes shall be indicated in the application procedure submitted by the Pipe Coating Contractor and shall be reflected on his plant scheme. The maximum time limit between blasting and coating for humidity below 50% shall be 4 hours.

4.17.1.4 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 thickness of 400-500 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 at 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

For the external 3LPE coating system, 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 adhesion strength shall be ≥ 12 MPa when tested using the pull-off adhesion test (ASTM D4541 or ISO 4624). 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

To ensure protection from welding heat, the total cut-back from the pipe end shall be 150 mm +/-20 mm. Within this zone, the FBE primer shall protrude past the polyethylene layer by at least 10 mm to facilitate a stepped seal with the field-applied heat shrink sleeve. All coating edges shall be beveled at an angle between 30° and 45°.

4.17.1.5 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.

4.17.1.6 Coating Procedure Qualification Testing (PQT)

Prior to commencing or at the start of full production one pipe joint of each diameter coated with FBE only and one pipe joint 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. The 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.

4.17.1.7 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 Tests
Bare steel pipes		
On Arrival ● Pipe Damage	Minor damage/grinding <3 per pipe	Each pipe
After Cleaning Chloride Oil Salt	2 .1g/cm^2 No contamination3 .1g/cm^2	Each pipe
After Abrasive Blasting ● Cleanliness ● Profile ● Contamination	SA 2.5 according to ISO 8501 50 - 100 .1mg No contamination	Each pipe Each pipe Each pipe
Pipes with FBE only		
FBE Layer ● Visual Inspection ● Holidays ● Thickness ● Adhesion	No surface defects No holidays Min/max	Each pipe Each pipe 10 per pipe 2 per pipe
Pipes with full coating system		
Coating Thickness ● minimum		16 per pipe
Holidays	No holidays.	Each pipe
Visual Inspection		
Coating Bare steel at pipe ends Protruding FBE PE cut backs	No surface defects 150 +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
Adhesion ● 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 disbondment		2 per pipe
Other Tests as per DIN 30670		1 per pipe

4.17.1.8 Production Testing

Production testing shall be performed at the frequency shown below:

Property	Acceptable Values	Minimum Frequency
Bare steel pipes		
On Arrival		
Pipe Damage	Minor damage/ grinding <3 per pipe	Each Pipe
After Cleaning		
Chloride Oil Salt	2 .ig/cm^2 No contamination 3 .1g/cm^2	1 per 100 pipe 1 per 100 pipe 1 per 100 pipe
After Abrasive Blasting		
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		
FBE Layer		
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		
Coating Thickness of		
Final Coating (minimum)		Each pipe
Holidays	No holidays	Each pipe
Visual Inspection		
Coating Bare steel at pipe ends Protruding FBE PE cut backs	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
Adhesion Peel Test	>100 N/cm at 20°C ±5°C	1 pipe per 100
Cathodic Disbondment at Room Temperature		First pipe, lastpipe and at intervals of every 350 pipes

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, submitted for the written approval of the Engineer. The contractor shall submit manufacturer'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 a 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 a quality assurance system as is 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. Indentation Hardness
vi. Air Entrapment Test.
vii. Degree of Cure
viii. Dry Adhesion Test (For Epoxy)
ix. Cathodic Disbandment test
x. Elongation at break

4.17.1.9 Coating Thickness

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

PIPE DIAMETER	PIPE BODY	OVER THE MANUFACTURING WELD

<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.

4.17.1.10 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 an audible signaling device. The test shall be carried out in accordance with NACE SP0490-2007 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 defects.

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.

4.17.1.11 Adhesion (Peel) Test

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

4.17.1.12 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.

4.17.1.13 Cathodic Disbondment Test

Cathodic Disbondment testing shall be conducted:

As a pre-qualification test - 48 hour duration at 65 +/- 2°C As a pre-qualification test - 28 days duration at 23 +/- 2°C

As a production test - 48 hours duration, at the frequency of one test per 350 coated pipes at 65 +/- 2°C. The test requirements shall be in accordance with ASTM G 8.

4.17.1.14 Coating Repairs

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

4.17.1.15 Preservation, Marking and Shipping

a) 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.

b) 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.

c) 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.

Upon arrival at the project site or designated yard, a mandatory Post-Shipping Inspection shall be conducted as a formal Hold Point, where the Engineer and Contractor shall jointly inspect 100% of the delivery for transit-related damage, damage to beveled ends, and the integrity of protective end caps. This inspection must be documented via a Joint Inspection Report, and the Consultant reserves the right to perform field holiday detection to verify coating continuity. Any pipe found with damage exceeding allowable limits or arriving without secure end caps shall be subject to quarantine, rejection, and return to the factory at the Contractor’s sole expense

4.17.1.16 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.

4.17.1.17 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 the 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.

4.17.1.18 Release Documentation

The 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

4.17.2 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.

Prior to the commencement of any field coating activities, the Contractor shall submit a comprehensive Method Statement for the formal review and written approval of the Engineer.

4.17.2.1 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.

4.17.2.2 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 100 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

Once installed the sleeve system shall have an average min. thickness of 3.25 mm. The PE backing shall be of high density with a density >0.95gm/cc and Hardness > 55 Shore D.

To prevent damage to the adjacent 3LPE line coating, the pre-heat of the weld area prior to epoxy application shall not exceed 80°C. After application of epoxy to the 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.

4.17.2.3 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.

4.17.2.4 Coating Performance Requirements

(a) The contractor shall ensure that all material proposed for field joint coating has been tested and meets 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. To verify this track record, the Contractor shall submit a formal Performance Provenance Portfolio for the Engineer’s approval, including Reference list, Client Completion Certificates, Performance affidavits, manufacturer’s warranty history..

(c) The 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. The Engineer, or their authorized representative, shall be formally notified at least fourteen days in advance to witness these tests at an independent ISO-certified laboratory. No material shall be delivered to the site or approved for installation until this witnessed test report has been formally accepted by the Supervising Consultant.

(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
Epoxy		
Dry Film Thickness on steel		≥100 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 10 kV
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 sleeves.
Holidays Detection		Pass at 5kV/mm + 5kV

4.17.2.5 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.

4.17.2.6 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.

4.17.2.7 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, Grade Sa 2.5 in accordance with ISO 8501-1 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 be checked 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 a 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 continuing 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.

4.18 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 the 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 being 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.

4.18.1 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.

4.18.2 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.

4.18.3 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 screwdriver, 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.

4.18.4 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.

4.19 Repair Procedure

Damaged PE line coating or shrink sleeves shall be repaired with repair materials that meet the following criteria:

(a) Small Damages Extending up to 1.0 cm^2

Small damages to 3 LPE line coating or sleeve shall be repaired using PE melt sticks; with epoxy primer if bare metal is visible.

(a) Damages Extending up to 300 mm or 100 cm^2

Polyethylene repair patches precoated with hot melt adhesive, shall be used in conjunction with a hot melt filler adhesive and epoxy primer (if bare steel visible) as per manufacturer's recommendations. Repair patches when installed should overlap the damaged area by minimum 50 mm all round.

(a) Damages Extending Over 300 mm or 100 cm^2 Full encirclement heat shrink sleeves with epoxy primer shall be used.

Following repair, the repaired section shall be tested for any Holidays at minimum 5kV/mm + 5kV.

4.20 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 16 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 - Ductile Iron to BS EN 545 and BS EN 598 and coated with Non –Toxic fusion bonded epoxy with an approved UV stabiliser additive.
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.

4.21 Gate Valves (High Pressure Type)

In general, valves up to and including DN 300 shall be gate valves and valves larger than DN 300 shall be butterfly valves except where otherwise specified on drawings or in bills of quantities.

Resilient Seated Gate Valves with smooth straight-through bore for use with water pipelines shall be made of ductile iron EN-GJS-400-18 according to EN 1563 (GGG 400 – DIN 1693) and EN 558-1 GR 14-short, (DIN 3202 F 4), smooth straight-through bore, wedge gate encapsulated with vulcanized EPDM, inside and outside epoxy powder coated according to DIN 30677-T2 in accordance with DIN 3476 and all quality and test requirements of RAL quality mark 662, suitable for under-ground installation, suitable for nominal working pressure of 16 bars or higher pressure class as specified, according to Drawings, Specifications and Bill of Quantities.

Resilient Seated Gate Valves shall be provided with suitable non-rising stainless steel spindles (St 1.4021 / X20Cr13). The wedge shall be made of ductile iron EN-GJS-400-18 according to EN 1563 (GGG 400 – DIN 1693), inside and outside fully rubberised with vulcanised elastomer, suitable for potable water, with drain hole. The wedge guide shall be of wear resistant plastic with high gliding features; optimally placed design guarantees lowest wear and tear and lowest closing torques; the wedge nut shall be of dezincification resistant brass CuZn36Pb3As, generous over sizing of the required thread length in the wedge nut shall guarantee highest possible breaking torques; O ring bush of Ms 58; O rings of elastomer, suitable for potable water, embedded in non-corrosive material (according to DIN 3547-T1) and replaceable under pressure (according to ISO 7259); Back seal of elastomer, suitable for potable water; Allen screws St 8.8 DIN 912 (body) shall be absolutely corrosion protected by being sunk into the body and sealed, and by passing through bonnet gasket. Extension spindles shall be galvanised steel and the associated guide brackets shall be of approved type (PE) and shape, manufactured from fabricated steel (galvanized after manufacture).

All universal joints shall be supplied and installed in accordance with the details stated on the Drawings and in the Bill of Quantities. Sluice valves shall be flanged to DIN 28605, drilled to EN 1092-2 PN16 and DIN 2501 – PN 1616-39 Minimum life cycle shall be 250 cycles according to DIN 1074. Hand wheels shall be suitable for particular valves, epoxy powder coated and have closing and opening indicators.

Selection of the valve manufacturer is subject to formal approval by the Engineer, contingent upon a comprehensive review of technical documentation and a mandatory joint factory audit by the Client and SC to verify production standards and material provenance. Prior to dispatch, 100% of the valves must undergo Factory Acceptance Testing (FAT) in accordance with an approved Quality Inspection Plan; all shipments must be accompanied by certified FAT reports, and no valve shall be accepted at the site without documented proof of successful witnessed testing and quality assurance compliance. Incorporate & recommend spare parts for all types of valves.

4.22 Check Valves (High Pressure Type)

Check valves of PN16 shall be piston type horizontal flow valves complying with BS 1868 and main body shall be ductile iron (BS EN 545). 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.

Selection of the valve manufacturer is subject to formal approval by the Engineer, contingent upon a comprehensive review of technical documentation and a mandatory joint factory audit by the Client and SC to verify production standards and material provenance. Prior to dispatch, 100% of the valves must undergo Factory Acceptance Testing (FAT) in accordance with an approved Quality Inspection Plan; all shipments must be accompanied by certified FAT reports, and no valve shall be accepted at the site without documented proof of successful witnessed testing and quality assurance compliance. Incorporate & recommend spare parts for all types of valves

4.23 Butterfly Valves (High Pressure Type)

Butterfly valves shall be according to DIN and EN 593, double eccentric type with face to face dimensions to EN 558-1 GR 14-short (DIN 3202-F4), flange dimensions and drilling to EN 1092-2 PN 16 (DIN 28605 / DIN 2501) and shall be suitable for a nominal working pressure of 16 bar or higher pressure class (e.g. PN16) as specified, according to Drawings, Specifications and Bill of Quantities. Body and disk shall be of ductile iron EN-GJS-400-18 acc. to EN 1563 (GGG 400 - DIN 1693) and shall be inside and outside fusion bonded epoxy coated with a minimum coating thickness of 250 microns with an approved UV stabiliser additive.

Buried valves shall be inside and outside fusion bonded epoxy powder coated suitable for potable drinking water complying in general with DIN 30677 Part 2, coating thickness shall be minimum 250 microns, freedom from imperfections shall be tested by high-voltage holiday detection method. Shaft, body seat, bolts and pins shall be made of stainless steel 304 EN 1.4301 or grade 316 EN 1.4401 as specified or approved complying with BS EN 10088.. Endless profile sealing ring and O-rings shall be of EPDM or NBR suitable and approved for potable water. All butterfly valves shall be equipped, if not otherwise requested in the bill of quantity, with gear box and hand wheel. - body test at a minimum pressure of 1.5 times the maximum permissible pressure - seal test at a minimum pressure of 1.1 times the maximum permissible pressure. Valve testing pressure shall be carried out in accordance with BS EN 12266-1 or approved equivalent and comply with leakage rate Class A.

All butterfly valves shall have an integrated bypass valve and system allowing for ease of operation due to high pressure differences.

Selection of the valve manufacturer is subject to formal approval by the Engineer, contingent upon a comprehensive review of technical documentation and a mandatory joint factory audit by the Client and SC to verify production standards and material provenance. Prior to dispatch, 100% of the valves must undergo Factory Acceptance Testing (FAT) in accordance with an approved Quality Inspection Plan; all shipments must be accompanied by certified FAT reports, and no valve shall be accepted at the site without documented proof of successful witnessed testing and quality assurance compliance. Incorporate & recommend spare parts for all types of valves

4.24 Ball 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 ductile 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 16

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 the 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.

Selection of the valve manufacturer is subject to formal approval by the Engineer, contingent upon a comprehensive review of technical documentation and a mandatory joint factory audit by the Client and SC to verify production standards and material provenance. Prior to dispatch, 100% of the valves must undergo Factory Acceptance Testing (FAT) in accordance with an approved Quality Inspection Plan; all shipments must be accompanied by certified FAT reports, and no valve shall be accepted at the site without documented proof of successful witnessed testing and quality assurance compliance. Incorporate & recommend spare parts for all types of valves

4.25 Automatic Air Valves

Automatic air relief valves shall be designed to meet the following conditions and comply 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.

The main body of the valve shall be made of ductile iron and shall withstand the relevant pressures within the systems.

Selection of the valve manufacturer is subject to formal approval by the Engineer, contingent upon a comprehensive review of technical documentation and a mandatory joint factory audit by the Client and SC to verify production standards and material provenance. Prior to dispatch, 100% of the valves must undergo Factory Acceptance Testing (FAT) in accordance with an approved Quality Inspection Plan; all shipments must be accompanied by certified FAT reports, and no valve shall be accepted at the site without documented proof of successful witnessed testing and quality assurance compliance. Incorporate & recommend spare parts for all types of valves

4.25.1 Triple 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 at all pressures above atmospheric pressure except when air accumulates in the valve chamber.

The nominal pressure rating shall be PN16

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.

4.25.2 Air Inlet Check Valves

Air inlet check valves shall be purposed designed for rapid admission of air into pipeline under vacumm conditions and shall comply with BS EN 1074-1 and BS EN 1074-4 or approved equivalent. The valve should be suitable for use in potable water and shall be rated for PN-16. The valve should be of the conical body and disc type with a sliding rod passing through a bronze bearing, flange dimensions and drilling to EN 1092-2 PN 16 (ISO 7005/2, BS 4504) and shall be suitable for a nominal working pressure of 16 bar as specified, according to Drawings. The internal flow profile shall be designed to provide high air inlet capacity, low pressure loss and reliable opening at low differential pressure. The disc shall modulate in response to pipeline pressure and shall close positively when normal operating pressure is restored. Flanged connection shall be PN 16 and shall comply with Bs-EN 1092-1 for steel flanges and applicable part of BS EN 1092 where an alternative body material is approved. Flange drilling, face typed gasket seating and bolting shall be compatible with adjoining pipework and the installation details as shown on the drawings. The body, inlet cone, connection cone and disc shall be manufactured from S235JR steel complying with BS EN 10025-2 or approved equivalent. The stem shall be stainless steel grade 304 / EN 1.403 minimum, the washer shall be S235 steel or stainless steel as approved, and the bearing shall be bronze suitable for continuous service in specified water environment. All internal and external ferrous surfaces shall be fusion bonded epoxy powder coated, suitable and approved for contact with potable drinking water.

The installation of an air inlet check Valve must take into account the risk of suction of potentially polluted stagnant water present in the manhole when operating the valve. Thus, a swan's neck installation is most often recommended. In all cases, place an isolating valve upstream of the air inlet check valve.

The coating shall comply with DIN 3476-2 or approved equivalent. The coating shall be continuous fully cured and free from holidays pinholes cracks blisters and other defects. Holiday detection shall be carried out by the high voltage method using a test voltage appropriate to the coating thickness and approved coating procedure.

Seats, sealing rings, O-rings and all other non-metallic wetted components shall be EPDM, NBR or other approved suitable for potable water. Non metallic materials in contact with water for human consumption shall comply with Bs-6920, WRAS, NSF/ANSI 61 or approved equivalent.

Each valve shall be factory pressure tested in accordance with BS EN 12266-1 and BS EN 1074-4, or an approved equivalent. The shell test shall be carried out at not less than 1.5 times the maximum allowable pressure (static pressure), with the provision that a minimum baseline of 10 bars shall be used for the static pressure value if the actual system pressure is less; the test shall yield no visible leakage, sweating, or permanent deformation. The seal test shall be carried out at no less than 1.1 times the maximum allowable pressure—subject to the same 10-bar minimum static pressure baseline—and shall successfully achieve the designated leakage rate.

All air inlet check valve shall include rapid air entry at high flow rates when the pipeline is subjected to vaccum conditions. The contractor shall submit manufacturers technical data, flow capacity curves, pressure loss data, coating certificates, potable water approval certificates, material certificates and factory test certificates prior to delivery.

The installation of air inlet check valve shall take into account the risk of suction of polluted or stagnant water present in the chamber during valve operation.

4.27 Ball Float Valve

Ball float valves shall be designed for fitting in the top of tank or reservoir to automatically control the rate of filling and shut off completely when a predetermined level is reached and the balanced equilibrium design makes sure that operation is smooth and reliable.

The balanced equilibrium float valve shall be designed for water to maximum 80°C and working pressure PN 16.

The main body of the float ball valve shall be ductile iron with epoxy resin coating to min 300 micron inside and outside and float shall be polypropylene (PP).

The materials of sealing rings shall be EPDM rubber and seat rings shall be bronze.

Flanges of the valves shall be in accordance with EN 1092-2 and hydraulic test shall be according to EN 1074-1 and 2 or EN 12266.

The material of the float valve shall be in conformity to Belgaqua and approved according to water regulation advisory scheme up to 60°C.

The main features of ball float valve shall be as follows:

(a) Right angled design.
(b) Long actuating lever for slow closure
(c) Flange outlet for fitting of down pipe
(d) Drop tight shut off
(e) Fully removable bronze cylinder
(f) Easily maintained.
(g) Float in control of valve at all positions of travel
(h) Face and pistons seals easily replaceable.
(i) Float position adjustable in horizontal plane.

4.28 Roll-out Pipe Sections

'Roll-out' pipe sections shall comprise a flanged pipe with a tied dismantling joint to provide flexibility for insertion in the appropriate gap in the pipeline after internal lining and continuity of rigidity during operation of the pipeline. They shall also provide for future removal and replacement of the 'roll-out' section or adjacent valve if necessary and directed by the Engineer, otherwise Roll out Sections may be required for final tie-in at locations of test heads for hydrostatic testing only. This tie-in shall be golden weld joints and subject to 100% Ultrasonic (UT) inspection test.

The steel pipe shall be of the same strength as the section of pipeline of which it becomes a part.

The components of the 'roll-out' sections shall be designed to withstand the specified test pressures without leakage or extrusion of joint rings and in accordance with other relevant clauses of this Specification.

Before placing orders, the Contractor shall submit to the Engineer for approval full details with drawings and calculations for the 'roll-out' pipe sections.

Spare flange gaskets and joint rings shall be provided as detailed in the Bill of Quantities. These shall be individually wrapped and clearly marked with type, size, etc. in an approved manner for long storage.

If the Contractor has reason to disturb the flange gasket or joint rings for removal of the 'roll-out' sections after initial fitting, new gaskets and joint rings shall be fitted on replacement. The new gaskets and joint rings shall be provided at the Contractor's expense and shall not diminish the stock of spares.

4.29 Plunger Valve

Plunger valves shall be according to EN 1074-1 & 5 for water supply services and shall be tested in accordance with BS EN 12266-1. Valves shall be rated PN 16 minimum or higher where specified. Flanges shall comply with BS EN 1092-2 PN 16 for cast iron or ductile iron bodies or BS EN 1092-1 PN 16 for steel bodies. Face to face dimension shall be in accordance with applicable EN 558 series or the manufacturer approved statement subject to written approval by the Engineer

All documentation must be supplied with the equipment including FAT certificate.

4.29.1 Plunger Valve Performance Requirements

1) Performance: Plunger valves shall be capable of controlling flow across the entire flow range specified without exceeding MSHA dictated noise level requirements.

2) Noise: Operating noise levels shall not exceed 95 decibels (dBA) at a distance of three (3) feet from the valve at the normal flow point. Material stresses shall not exceed 1/5 of the ultimate or 1/3 of the yield strength of the material. Flow rate as a function of pressure drop across the valve shall be linear to within 3-percent.

3) Operation Data:

- **R1 to Y Junction**

Interconnection Diameter (mm)	Diameter of Plunger Valve (mm) *	Maximum Flow Rate Conditions			
		Flow (m3/s)	Max. Inlet Pressure (bar)	Min. Outlet Pressure (bar)	Operation
Old Pepri (1200mm)	DN 800	0.736	4.32	0 & 1.5	Continuous
Y-junction (1200mm)	DN 1000	1.05	4.48	0 & 1.5	Continuous
5 1/2-PS (1200mm)	DN 1200	1.63	5.02	0 & 1.5	Continuous

- **R2 - Hasan Square to Gulbai**

Interconnection Diameter (mm)	Diameter of Plunger Valve (mm) *	Maximum Flow Rate Conditions			
		Flow (m3/h)	Max. Inlet Pressure (bar)	Min. Outlet Pressure (bar)	Operation
Gulbai (1800mm)	DN 1400	3.42 m3/h	6.7	0 & 1.5	Continuous

- **R3 to Banaras**

Interconnection Diameter (mm)	Diameter of Plunger Valve (mm) *	Maximum Flow Rate Conditions			
		Flow (m3/s)	Max. Inlet Pressure (bar)	Min. Outlet Pressure (bar)	Operation

Banaras (1800mm)	DN 1600	3.42	3.86	0 & 1.5	Continuous

*The plunger valve supplier must examine and adapt the diameter according to its manufacturing specifications, in order to ensure compliance with specified operating conditions. To be submitted to Approval by the Engineer.

4.29.2 Plunger Valve Operating Requirements

A. Valve Assembly Components: Each plunger valve assembly shall consist of a flanged short conical inlet section having an internal cone to divert the water flow into the annular chamber of the body section.

B. An oval body section with an inner annular chamber shall be formed by the body shell. The plunger shall be designed with a customised control cylinder that is part of the internal slider-crank mechanism and is driven by an outside slider nut operating gear.

C. The plunger shall move in an axial flow direction to reduce or enlarge the annular flow cross section through slots in a digressive manner and the medium will flow through the customized control cylinder from the outer annular chamber to the inner chamber of the plunger.

D. The downstream plunger face shall hold the profile seal ring. The main plunger O-ring seal shall sit against a replaceable stainless plunger seat, located in the downstream end of the plunger valve body, which creates a leak tight seal when the plunger is in the fully closed position. The main O-ring seal, shall be recessed from direct impact of the flow media and shall be outside the zone of cavitation. Plunger seat seals located in the plunger body or in the cavitation zone shall not be allowed. The upstream plunger O-ring seal shall only be energised when the plunger is in the fully closed position, thus to provide an optimum sealing system and minimize wear. The plunger valve input crank shaft shall be o-ring sealed to ensure corrosion protection to the crank arm and prevent stagnant water in the crank bore.

4.29.3 Plunger Valve Design Features

A. Plunger valve shall be either a one-piece body design with separate and replaceable body seat or a two piece body design, and shall feature an interior geometry that provides water flow that is guided around the streamlined internal body structure. The design shall feature a geometrically optimized design, a continuous annular cross-sectional reduction from inlet to throttle cross section, and continuous rise of flow velocity to the exit without producing damaging cavitation.

B. Plunger valve design shall feature a specially customized designed control cylinder with application specific flow control cage to minimize cavitation. Slots shall be fully closed when the valve is placed in the closed position. The seal Oring on the plunger shall also seat against a replaceable stainless steel seat ring in the body when closed.

C. Plunger valve design, when open during operation, shall feature plunger assembly movement towards the upstream direction to release water through the slots.

D. Plunger valve design shall feature advance and retract axial strokes of the plunger, guided in the internal body by an internal slider-crank mechanism. The crank shall have a 90° angle of rotation.

E. Plunger guide rails shall have a bronze welded overlay applied directly on the body. The minimum thickness of the bronze overlay shall not be less than 5/32” (4 mm) in the finished machined condition. There shall be a minimum number of 4 guide rails, symmetrical to the plunger load, to allow uniform wear of the guide rails and improved plunger support and vibration attenuation.

F. Motion of the plunger shall be controlled by means of an irreversible, submersible self-locking slider nut gearbox, with optional electric or hydraulic cylinder actuator attached to the slider nut unit.

G. The design of the annular throat cross section in any position of the plunger shall ensure linear regulation of flow.

H. The profile sealing ring at the downstream side of the valve body shall be exchangeable without the need to dismantle the valve from the pipeline.

I. Valve end connections shall be ANSI standard pattern flanges for the size and pressure rating specified. They shall be flanged to applicable BS EN 1092 standard with flange dimensions, drilling patterns and pressure rating suitable for valve size and specified pressure class.

4.29.4 Materials Requirements

A. Materials of construction for the principal component parts shall be as listed in the table below:

Item	Size	Material	Specification
Valve Body	All	Ductile Iron	EN-GJS-400-18 EN 1563 (GGG 400 - DIN 1693) ASTM A536, GR. 65,45,12
Plunger	All	Stainless Steel	AISI 304, EN 10088-3
Regulating Cylinder	All	Stainless Steel	AISI 304, EN 10088-3
Shaft Bushing		High strength Aluminum/Bronze alloy	EN 1982
Crank shaft	All	Stainless Steel	AISI 420, EN 10088-3

Item	Size	Material	Specification
Crank Mechanism	All	Stainless Steel	AISI 304, EN 10088-3
Seat/Retaining Ring	All	Stainless Steel	AISI 304, EN 10088-3
Plunger Guide Rails	All	Copper alloy	EN 12165, EN 12420
Plunger Sealing Rings	All	EPDM or Technopolymer	WRAS, BS EN 681, BS EN 1514
Profile Sealing Ring	All	EPDM or NBR	WRAS, BS EN 681, BS EN 1514
O-Ring at Actuator	All	EPDM or NBR	WRAS, BS EN 681, BS EN 1514

B. Fasteners: All studs, bolts, washers, and nuts in contact with water shall be Type 304, 316 or superduplex stainless steel.

C. All materials of moving components in contact with each other shall be of dissimilar hardness to prevent galling. The valve shall be moved through an open-close-open cycle three (3) times after final assembly and prior to shipment to ensure this requirement is met.

D. The body shall be fusion bonded epoxy coated with a minimum dry film thickness (DFT) of 400 microns with an approved UV stabiliser additive.

4.29.5 Flanges

A. All flanges shall be made of ductile iron (EN 545) in compliance with ISO 7005-2, EN 1092-2.

B. The flanges shall be raised faced and the pressure rating of the flanges shall be 16 bars as per the related pressure in the pipe sections.

C. Flanges shall be attached at the factory by the manufacturer and shall be coated with fusion bonded epoxy with a DFT of 400 microns with an approved UV stabiliser additive.

4.29.6 Installation

A. Valve installation by the contractor shall be in strict accordance with the manufacturer's printed recommendations.

B. Dismantling joint shall be installed with the plunger valve (just upstream) for easy removal.

C. Provide four (4) bound copies, and one (1) CD of the Operations and Maintenance Manual. The manual shall include installation instructions, maintenance procedures, and operation parameters.

4.29.7 Automation and Control of Plunger Valve

1) **<u>Automatic Control Scenarios:</u>**

The automation system must allow three control modes according to downstream hydraulic conditions:

- Non-pressurized Downstream Network - Flow Control:

-Objective: Maintain constant flow corresponding to design flow.

-Methodology:

- Flow meter sensor (electromagnetic type) installed downstream
- 4-20 mA signal sent to PID controller (PLC)
- Valve actuator proportionally controlled to modulate flow Equipment

-Supervision: Integration of HMI to the PLC for displaying measured flow, setpoint, actuator status, and alarms.

-Equipments:

- Electromagnetic flow meter
- PLC with PID function
- 4-20 mA electric actuator
- HMI
- Control cabinet with analog and digital terminal block

- Pressurized Downstream Network - Pressure Control:

-Objective: Maintain maximum pressure of 1.5 bar.

-Methodology:

- Pressure sensor installed downstream
- PID regulation in PLC
- Valve adjusted to limit pressure below the limit value

-Supervision: Connection to HMI system for pressure monitoring, valve status, and thresholds.

-Equipments:

- Pressure sensor 0-6 bar, 4-20 mA

- Controller PLC

- Electric actuator with analog input

- Alarm for exceeding threshold

- HMI

- Control cabinet

● Hybrid Network - Combined Control

-Objective: Automatically switch between flow and pressure control

-Methodology:

- Pressure sensor detects hydraulic state
- PLC switches between two PID controllers
- Hysteresis and time delay to prevent instability

-Supervision: Display of active mode (flow or pressure), thresholds, setpoints, and alarms.

-Equipments:

- Pressure sensor (status + control)

- Flow meter for PID flow control

- PLC with 2 selectable PID controller

- Actuator 4-20 mA

- HMI

- Control cabinet

2) Recommended Architecture:

Sensors (pressure and flow) → PID Controller with mode logic → 4-20 mA valve actuator → Plunger valve

All elements are interconnected to an HMI remote management system for control, real-time visualization, and data logging.

The system will consist of the following elements:

- Pressure and flow sensors (4-20 mA signal)
- Control PLC with PID switching logic
- Valve electric actuator controlled by 4-20 mA
- Communication interface with local control via HMI

3) **Recommended Actuator:**

- Type: Multi-turn electric control actuator, suitable for linear control of the selected plunger valve.
- Minimum Specifications:
  - Control input: analog 4-20 mA (continuous control)
  - Position feedback: 4-20 mA or Human Machine Interface (HMI)
  - Torque adapted to valve model (according to AVK calculation)
  - Local interface: open/close control, signaling, local/auto switch
  - Communication: Modbus RTU, Profibus, or digital I/O
  - Protection rating: IP68 (wet chamber)
  - Integrated anti-condensation heater
  - Power supply: 230/400 VAC depending on cabinet

The exact choice will be confirmed by the plunger valve supplier after torque calculations and actual hydraulic configuration.

The torque will be adapted according to the manufacturer's calculations.

4.29.8 Workmanship

A. Valve shall be free from manufacturing defects and shall be manufactured in a workman like manner.

B. Specification for Painting and Coating. Grease and scale shall be completely cleaned from the valve prior to painting per Society for Protective Coatings (SSPC) standards.

C. Valves shall be manufactured under the direction of a registered professional engineer.

D. All ductile iron components shall be coated with a Fusion Bonded Epoxy. A certificate of compliance shall be furnished with each valve stating that the materials supplied meet the material specifications set out herein and the manufacturer’s quality assurance program.

4.29.9 Field Test & Performance

A. Furnish all required start-up assistance and inspection of installed valves at the facility.

B. Valves shall be field leak tested to the specified operating pressure in the closed position and shall not leak. Field leakage relevant to the plunger valve shall be corrected by the manufacturer at the manufacturer's expense.

C. Plunger valve shall be subjected to onsite performance testing as part of the commissioning activities in accordance with a written performance test plan. To the extent possible, the valve shall be subjected to variable flow conditions, and the resulting control settings, flow, upstream and downstream pressures, noise levels, and vibration levels shall be documented and compared to the manufacturer's shop test results.

D. Function test through three (3) complete cycles of operation with the valve settings in place, including but not limited to switches, torque switches, and pilot pressure settings.

E. Upon completion of the necessary field testing, the shop test results and field test results comparison shall be discussed and resolved during a meeting or teleconference, as determined by the client.

4.29.10 Warranty

A. The manufacturer shall have ISO 9001, ISO 14001 and ISO 45001 certification.

B. The manufacturers shall warrant its products, including anti-cavitation and venting systems, to be free from defects in materials, workmanship and performance for a period of twenty years after successful testing and acceptance by the client.

C. Upon notice by the client, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no cost to the client.

D. If warranty service is not immediately available from the Vendor, supplier or the manufacturer, the client will perform repairs to re-establish proper operation of the valve. Maintenance or repair work performed by the client during the warranty period shall not be cause for voiding the warranty.

4.30 Electromagnetic Flow Meters

Electromagnetic (EM) flow meter shall be of both mains power and battery power type used for potable water in compliance with BS EN ISO 20456, BS EN ISO 4064-1 and BS EN ISO 4064-2.

All documentation must be supplied with the equipment including FAT certificate.

All EM flow meters shall be suitable for continuous

4.30.1 EM Flow Meter Performance Requirements

A. The table below gives the necessary performance requirements the electromagnetic flow meters to be used:

Parameter	Specification
Nominal Diameter (mm)	> 600
Flow Velocity Range (m/s)	0.02 - 10 (bidirectional)
Accuracy - calibration (%)	± 0.2
Repeatability (%)	± 0.1 of reading
Minimum Conductivity (µS/cm)	≥ 20
Empty-pipe Detection	Automatic zero-flow alarm
Response time (s)	< 1
IP rating for permanent immersion in water up to 1.5 metres	IP 68

B. The specific size of flow meter:

Main Pipe Diameter (in - mm)	Diameter of EM Flow Meter (mm)	Nominal flow (m^3/h)	Min Flow (m^3/h) *(Nominal -20%)*	Max. Flow (m^3/h) *(Nominal +20%)*	Min. Velocity (m/s)	Max. Velocity (m/s)
R1 / Old Pepri interconnection 32" - 800 mm	800	2650	2120	3180	1,2	1,8
R1 / Y junction interconnection 40" - 1000 mm	1000	3780	3024	4536	1,1	1,6
R1 / 5 ½ PS interconnection 48" - 1200 mm	1200	5868	4694,4	7041,6	1,2	1,7
R2 / Gul-Bai interconnection 56" - 1400 mm	1400	12312	12312	14774,4	1,8	2,7
R3 / Banaras interconnection 72" - 1800 mm	1600	12312	9849,6	14774,4	1,4	2

4.30.2 EM Flow Meter Operating Requirements

A. Power supply:

i. Mains power : 100 - 240 VAC ± 10%, 50/60 Hz, max 15 VA
ii. Internal battery backup: 3.6 V lithium D-cell pack (13 Ah), automatic switchover < 100 ms
iii. Optional external battery or super-capacitor module for extended hold-up

B. Fluid Properties
i. Minimum conductivity ≥ 20 µS/cm
ii. Fluid must fully fill the pipe (no air or cavitation
iii. Compatible with potable water liner (EPDM: 0 to 80℃; PTFE: -40 to 150℃)

4.30.3 EM Flow Meter Material Requirements

Component	Material Specification	Standard
Sensor Body / Flowtube	Stainless Steel 316L (X2CrNiMo17-12-2)	BS EN 10088-3:2014 – Technical delivery conditions for semi-finished stainless steels (Grade 1.4404)
Flange Connections	Stainless Steel 316L	BS EN 1092-1 – Flanges and their joints, PN-designated circular flange
Liner (Elastomer)	EPDM, potable-water grade, hardness 65 ± 5 Shore A	BS EN 681-1:2017 – Elastomeric seals for water supply, vulcanized rubber (static seals)
Liner (Polymer)	Virgin PTFE	BS EN 1186-1:2002 – Food-contact plastics; overall migration test methods
Electrodes	Stainless Steel 316L (X2CrNiMo17-12-2)	BS EN 10088-3:2014 – Technical delivery conditions for stainless steels
Grounding Rings	Copper, ≥ 99.9 % purity	BS EN 13602:1997 – Copper and copper alloys; rods and bars specification
O-rings / Seals	EPDM or NBR	BS EN 682:2018 – Elastomeric seals (O-rings) specification

4.30.4 Installation

A. EM flow meter installation by the contractor shall be in strict accordance with the manufacturer's printed recommendations.

B. Provide four (4) bound copies, and one (1) CD of the Operations and Maintenance Manual. The manual shall include installation instructions, maintenance procedures, and operation parameters.

4.30.5 Workmanship

A. EM flow meter shall be free from manufacturing defects and shall be manufactured in a workman like manner.

B. EM flow meter shall be manufactured under the direction of a registered professional engineer.

C. A certificate of compliance shall be furnished with each EM flow meter stating that the materials supplied meet the material specifications set out herein and the manufacturer's quality assurance program.

4.30.6 Field Test & Performance

A. Furnish all required start-up assistance and inspection of installed EM flow metres at the facility.

B. EM flow meter shall be field leak tested to the specified operating pressure in the closed system and shall not leak. Field leakage relevant to the flow meter shall be corrected by the manufacturer at the manufacturer's expense.

C. EM flow meters shall be subjected to onsite performance testing as part of the commissioning activities in accordance with a written performance test plan. To the extent possible, the flow meter shall be subjected to variable flow conditions and compared to the manufacturer's shop test results.

D. Upon completion of the necessary field testing, the shop test results and field test results comparison shall be discussed and resolved during a meeting or teleconference, as determined by the client.

4.30.7 Warranty

A. The manufacturer shall have ISO 9001, ISO 14001 and ISO 45001 certification.

B. Vendor shall supply the manufacturer's warranty

C. The manufacturer shall warrant its products, including anti-cavitation and venting systems incorporated in the work, to be free from defects in materials, workmanship and performance for a period of 18 months after successful testing and acceptance by the client.

D. Upon notice by the client, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no cost to the client.

E. If warranty service is not immediately available from the Vendor, supplier or the manufacturer, the client will perform repairs to re-establish proper operation of the valve. Maintenance or repair work performed by the client during the warranty period shall not be cause for voiding the warranty.

4.31 Strainers

T-Strainers shall be installed upstream of pressure regulating valves, plunger valves, and check valves as protection from particulate matter and to protect downstream equipment. The strainer shall conform to EN 1563, EN1092, EN 12266, BS 6920, NSF/ANSI61 and ISO 9001. Strainer body and cover shall be ductile iron complying with EN 1563 or approved equivalent. Flanges shall comply with EN 1092-2 for ductile iron bodies or EN 1092-1 for steel bodies with the pressure rating specified in the drawings & BoQ. Strainers shall be pressure tested in accordance with EN 12266-1. All components shall comply with BS 6920, NSF/ANSI 61 or approved. The manufacturer shall be certified to ISO 9001, ISO 14001 & ISO 45001 and all material, pressure test & FAT certificates shall be submitted with the equipment.

The manufacturer shall comply with ISO 9001, ISO 14001 and ISO 45001 and all documentation must be supplied with the equipment including FAT certificate.

4.31.1 Strainer Performance Requirements

A. Pressure rating:

   i. PN16 - Maximum pressure 16 bar

B. Temperature rating: 0 ℃ to 50 ℃ under continuous operation (up to 80 ℃ intermittent)

C. Mesh retention: 2000 μm standard

D. Hydraulic performance: manufacturer to publish Cv table

4.31.2 Design & Construction

A. Body geometry: compact H-pattern with a flat, removable, vertical stainless steel mesh screen located in-line with the flow for low pressure drop and easy access. Also included a drain plug at the bottom of the housing.

B. Maintenance: removable top cover only, without disturbing connected piping.

C. Installation orientation: vertical with cover up is recommended for optimum drainage.

D. End connections: flanges as per EN 1092-2 (PN16) matching system rating.

4.31.3 Materials

Component	Material	Notes
Body & Cover	Ductile iron (EN 1563, Grade EN-GJS-400-15)	Fusion-bonded epoxy coating, NSF 61 approved

Component	Material	Notes
Strainer Element	316 stainless steel mesh	Standard 10 mesh (2000 μm); optional 16 mesh or finer
Cover Seal	EPDM or NBR	Potable-water grade per NSF/ANSI 61/BS6920
Drain/Blow-off Plug	316 stainless steel, threaded for valve	Grooved plugs not permitted
Fasteners	316 stainless steel bolts and nuts	Minimum property class 70
Optional Accessories	Differential pressure gauge or switch	Mounted on body taps

4.31.4 Installation

A. Strainer installation by the contractor shall be in strict accordance with the manufacturer's printed recommendations.

B. Provide four (4) bound copies, and one (1) CD of the Operations and Maintenance Manual. The manual shall include installation instructions, maintenance procedures, and operation parameters.

4.31.5 Workmanship

A. Strainer shall be free from manufacturing defects and shall be manufactured in a workman like manner.

B. Strainer shall be manufactured under the direction of a registered professional engineer.

C. A certificate of compliance shall be furnished with each strainer stating that the materials supplied meet the material specifications set out herein and the manufacturer’s quality assurance program.

4.31.6 Field Test & Performance

A. Furnish all required start-up assistance and inspection of installed strainer at the facility.

B. Strainer shall be field leak tested to the specified operating pressure in the closed system and shall not leak. Field leakage relevant to the strainer shall be corrected by the manufacturer at the manufacturer's expense.

C. Strainers shall be subjected to onsite performance testing as part of the commissioning activities in accordance with a written performance test plan. To the extent possible, the strainer shall be subjected to variable conditions and compared to the manufacturer's shop test results.

D. Upon completion of the necessary field testing, the shop test results and field test results comparison shall be discussed and resolved during a meeting or teleconference, as determined by the client.

4.31.7 Warranty

A. The manufacturer shall have ISO 9001, ISO 14001 and ISO 45001 certification.

B. Vendor shall supply the manufacturer's warranty

C. The manufacturer shall warrant its products to be free from defects in materials, workmanship and performance for a period of 12 months after successful testing and acceptance by the client.

D. Upon notice by the client, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no cost to the client.

E. If warranty service is not immediately available from the Vendor, supplier or the manufacturer, the client will perform repairs to re-establish proper operation of the valve. Maintenance or repair work performed by the client during the warranty period shall not be cause for voiding the warranty.

4.32 Marking and Protection of Pipes 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 fusion bonded epoxy from chalking, 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.

4.33 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. Pipes with FBEcoating shall be stored in areas protected from direct sunlight to prevent ultraviolet (UV) degradation of the coating.

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. 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.

4.34 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.

4.35 Inspection of Pipes and Fittings

Transportation of pipes to Site over extremely rough terrain may give rise to a high proportion arriving damaged. A mandatory Post-Delivery Site Inspection shall be conducted as a formal Hold Point, and a Joint Inspection by the Contractor and the Engineer. Before incorporating into the pipeline each pipe shall be brushed out and carefully examined for soundness. 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 of 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.

4.36 Survey of the Pipeline Route

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.

The Engineer will review all the identified crossings as well as the design prepared by the Contractor for these crossings with accurate position and elevation.

At all times the route surveying shall be 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.

The Contractor shall define and demarcate a minimum permanent servitude width of 15 meters (centered on the pipeline) to ensure long-term access for maintenance. During the construction phase, a temporary working strip of 30 meters shall be established to accommodate trenching, soil spoil heaps, and heavy plant movement. These widths may be revised based on the specific construction methodology furnished by the Contractor, subject to site parameters and the formal agreement and approval of the Engineer

The Contractor shall perform a formal Cadastral Survey of the route with a registered land surveyor or geomatic engineer, in the presence of the Engineer, identifying all property boundaries, land parcels, and existing encumbrances. For all sections of the pipeline located outside of designated road reserves or existing utility corridors (Power/Gas), the Contractor shall prepare and submit the necessary survey diagrams and legal descriptions to the Surveyor General’s Office (or relevant Land Management Authority) for formal registration of the servitude in favor of the Client.

4.37 Earthwork

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

4.37.1 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 providing a lateral distance of 500mm on each side of the pipe barrel, inclusive of any allowances required for temporary supports, all in accordance with drawings.

Trenches shall be shored according to OSHA regulations or ISO 45001 requirements.

4.37.2 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 safety of the Works.

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

(a) First Stage – Pipe bedding and surroundings

Pipe bedding and surrounding shall be constructed using imported selected granular material strictly classified as Class A-3 in accordance with the AASHTO soil classification system, subject to the approval of the Engineer.

The use of screened native excavated material in lieu of imported sand shall only be permitted if strictly compliant with the AASHTO Class A-3 classification and upon written approval of the Engineer, supported by compliant third-party laboratory test reports.

The bedding material shall be placed to a minimum thickness of 200 mm beneath the pipe, shaped and trimmed to provide uniform and continuous support along the full length of the pipe. Surround material shall be placed carefully around the pipe and up to a minimum of 300 mm above the crown, ensuring full contact without displacement or damage to the pipe, leaving the joints exposed until inspection, testing and approval by the Engineer.

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

Placement shall be carried out in layers not exceeding 150 mm loose thickness, including watering, levelling, and compaction. 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.

In areas with a high groundwater table or saturated soils, the Contractor shall provide a stabilized formation. This shall include a minimum 300 mm drainage layer of 10-20 mm crushed stone, entirely encapsulated in a non-woven geotextile filter fabric to prevent the migration of bedding fines.

The Contractor shall submit a Dewatering and Stability Plan for approval, demonstrating how they will maintain a dry trench and prevent pipe flotation (buoyancy) during installation and until the backfill has reached a sufficient height to counteract uplift forces. Any damage or displacement of the pipeline due to groundwater ingress or buoyancy shall be rectified at the Contractor's sole expense

The trench bottom shall be prepared to ensure a minimum Safe Bearing Capacity sufficient to support the pipeline without settlement. In soft, unstable, or rock-laden ground, the Contractor shall over-excavate and provide a stabilized foundation layer (such as crushed rock or a sand cushion) as required to achieve a firm formation.

The Contractor is solely responsible for maintaining trench stability and preventing pipe flotation during all stages of construction. Any dewatering or specialized bedding required to achieve this shall be considered part of the Contractor's installation methodology

At all road crossings and utility intersections, the bedding and backfill shall strictly adhere to the standards and standard drawings of the relevant Statutory Authority. The most stringent requirement between this specification and the Authority's standards shall prevail.

The backfilling of the trench shall be carried out in two stages. Backfilling shall be partial; all welds, fittings, and valves shall remain entirely exposed and visible to allow for inspection during hydrostatic testing.

(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% Modified Proctor as specified for the appropriate levels.

The remainder of the trench shall then be filled with common material using suitable excavated material classified as Class A-4 or better, in accordance with the AASHTO classification system, and subject to the approval of the Engineer. Excavated material that does not comply with the minimum Class A-4 requirement shall not be used for backfilling.

Where suitable excavated material is unavailable or insufficient, selected imported material classified as AASHTO Class A-2-4 or A-4, or better, shall be provided and used, subject to the Engineer’s approval.

Backfilling shall be carried out around and over the works in layers not exceeding 150 mm loose thickness, including trimming, watering, levelling, and compaction.

Compaction shall be carried out using suitable equipment and methods to achieve not less than 95% of the Modified Proctor maximum dry density, as determined in accordance with BS 1377. Mechanical compaction shall be carried out in a manner that does not cause damage to adjacent structures or services.

Before backfilling trenches the Contractor shall obtain approval from the Engineer of the methods he proposes to use and he shall demonstrate by means of tests that the specified compaction can be achieved. The method of compaction shall at all times be to the approval of the Engineer's.

This work shall be commenced and completed without delay.

A berm shall be placed above the pipeline, where allowable, with minimum height of 0.5 meters above the natural ground level. Berms shall be installed in such a way that it does not prevent storm water draining to the natural watercourses.

4.38 Underground Warning Tape

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. The warning tape shall be installed at 300mm 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 resistant 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 for identification purposes. It shall be printed in English language with the words "Caution: Buried Waterline Below" for water pipeline.

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

4.39 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 crew 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 300 m beyond the end of a tested, completed and backfilled length of pipeline unless otherwise approved by the Engineer. Within this limit, backfilling shall be partial, leaving all joints, fittings, and valves exposed for inspection during testing. The exposed joints between test sections shall be disregarded in the above definition. Prior to the commencement of pipe laying, the Contractor shall submit a comprehensive Rigging Plan to the Engineer for approval.

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 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 overnight, 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.

4.40 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 1200mm 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.

4.41 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.

4.48 Puddle and Thrust Flanges

Where a water barrier is required in the wall of a structure, a structure is required to take the thrust resulting from a pipe passing through it, a puddle or thrust flange, or anchor ring shall be fitted as specified or indicated on the Drawings.

4.49 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 is surrounded by concrete.

4.50 Pipework Built into Concrete

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

4.51 Anchor Blocks

Anchor blocks or thrust blocks shall be provided at horizontal bends, vertical bends, tapers, blank flanges, Tees and valves 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 Contractor shall prepare the detailed designs of concrete anchor blocks using accurate pressure and site condition (geotechnical, spacing, interface with other utilities, etc…).

The Anchor / Thrust blocks design shall also follow the design-and-build model. The Contractor shall present the designs to the Engineer for approval, the Contractor shall start construction of the anchor blocks once approval is given.

The maximum operating pressure for each pipeline shall dictate the design of the respective anchor and thrust blocks. In general, the design pressure shall follow the updated hydraulic model or AWWA M11. The Contractor shall formally validate all design pressures with the Engineer before commencing any design work. A baseline pressure of 10 bars shall be adopted as the default design pressure unless site-specific hydraulic analysis indicates alternative requirements approved by the Engineer. In instances where the maximum operating pressure remains unclear, a minimum of 10 bars shall be utilized, subject to final confirmation by the Engineer.

The concrete Class C to be used in the anchor blocks and thrust blocks on pipelines.

4.52 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.

Final disposal of discharge water shall be achieved either via gravity to the nearest stream or field, utilizing energy dissipators to prevent erosion, or by vacuum trucks where gravity discharge is unfeasible. The Contractor shall ensure all disposal methods prevent flooding of adjacent properties and comply with environmental regulations, as detailed in an approved Discharge Management Plan.

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.

4.53 Flexible joints at Chambers and structures

Pipe lines entering and leaving chambers and structures shall include two flexible joints with Differential settlement 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.

4.54 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. Proposals shall show a traffic plan for both vehicles and pedestrian traffic wich employs proper HSE practices.

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

The Contractor shall minimize traffic disruption and must obtain written permission from all relevant Road Authorities before commencing work. Detailed proposals, including construction methodology (open-cut excavation or thrust boring), trench protection, bedding, backfill specifications, and reinstatement procedures, must be approved by both the Road Authority and the Engineer.

4.55 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.

4.56 Hydrostatic Testing

4.56.1 General

Hydrostatic testing shall be performed on the basis of VdTUEV Leaflet 1051 or another approved standard .

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

(c) 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.

The Contractor shall be solely responsible for the identification, procurement, and transportation of a sufficient volume of water required for all hydrostatic and water-tightness testing, including the payment of all associated costs, fees, and permits required by the relevant authorities.

4.57.2 Hydrostatic Test Sections and Test Pressures

The test pressure at the lowest point of a test section shall correspond to 1.5 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 1 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

4.58 Test Crew 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.

4.59 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.

4.60 Pipe Cleaning and inspection of FBE 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 FBE 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 at all times. A calibrated portable gas detector suitable for confined space entry shall be mandatory and used to monitor hazardous gases before and during entry. Spare breathing apparatus units shall be kept readily available on site, and all work shall be conducted in strict compliance with applicable safety precautions and confined space entry procedures.

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 FBE lining shall take place. Inspection is visual and is done by inspectors walking through the entire length of the pipeline.

4.61 Quality of Filling Water

Water shall be fresh, clear and clean and shall be comparable to drinking water quality according to WHO guidelines.

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”.

4.62 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.

Following the successful completion of the hydrostatic test, the test heads shall be removed, and the pipe ends shall be re-bevelled using a mechanical bevelling tool to the original specification profile to ensure a proper fit-up for the final tie-in welds.

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 FBE 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.

4.63 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.

4.64 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 FBE 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.

4.65 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 FBE lining. During this period all parameters shall be recorded continuously. 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 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 be 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 150 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.

4.66 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

4.67 De-watering after Hydro test

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 water is left in the pipeline, the quantity shall be as per Contractor's detailed program, which shall be approved by 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.

4.68 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, following The methodology is based on the principles of BS EN 1992-3, or another approved standard.

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.

4.69 Pipeline Disinfection

4.69.1 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.

4.69.2 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.

Disinfection shall be scheduled to occur immediately prior to the final commissioning of the pipeline. If the period between disinfection and actual commissioning exceeds 7 days or if the pipeline is subjected to any contamination or repair work in the interim, the Contractor shall be required to redo the entire disinfection process at their own expense to ensure water quality standards are met at the time of handover.

4.69.3 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.

4.69 Design & Build - Cathodic Protection System

All cathodic protection works for all pipeline sections shall be carried out by the Contractor on a full design-and-build basis. This includes the detailed engineering design, selection and procurement of all materials and equipment, installation, commissioning, performance testing and monitoring provisions, and provision of complete operation, maintenance and warranty documentation. The Contractor shall submit design calculations, shop drawings and manufacturer data sheets for approval by the Engineer prior to fabrication or installation, ensure compliance with relevant standards (e.g. EN ISO 12696, SP0490-2007) and project requirements, and deliver certified as-built records and performance certificates at handover. This aspect of the project will be based on a lump sum cost.

The sections below give the specifications that the contractor must comply with when performing **the design-and-build** for the cathodic protection system for the transmission mains.

4.69.1 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.

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 Fusion - Bonded Epoxy (FBE) 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 Reservoir Stations, between the pipe line sections and neighboring structures, and for existing pipelines where connections are made 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.

4.69.2 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

	--	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.

4.69.3 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:

(a) Cathodic Protection of Pipeline

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 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.

4.69.4 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.

4.69.5 Survey

a. General

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.

Any soil resistivity data provided to the contractor is indicative only. The contractor to do the soil resistivity test and verify the data at their end and collecting other soil conditions like data of similar pipelines and underground cables, transmission line/railway line interferences, etc. for proper design and execution of the work and submitting the survey report for review, approval and records.

b. <u>Soil Resistivity Measurements</u>

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.

c. 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.

d. Neighboring 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.

4.69.7 Equipment

a. CP transformer / Rectifiers

All CPS transformer / rectifier shall be designed for outdoor installation with sun shades.

Outdoor mounted rectifier units must be equipped with a self-standing steel enclosure with a degree of protection minimum IP55. For outdoor rectifier units the respective foundations shall be provided.

The rectifier units will be fed from the 400 V or 230 V level with a frequency of 60 Hz. If at minor station areas no 400 V or 230 V level exists, the rectifier units might be supplied from the 24 VDC level. The size of the rectifiers is subject of a respective calculation during detail design. The rated output current shall not be less than three (3) times the calculated current requirements.

Rectifier units for connection with the low voltage AC level shall mainly consist of the following parts:

(i) Main switch (miniature circuit breaker),
(ii) Leakage current switch,
(iii) Isolation transformer,
(iv) Control transformer, variable adjustable,
(v) Full wave silicon diode bridge,
(vi) Overvoltage protection cascades,
(vii) Terminal strip for all cables.

Outdoor rectifiers must be provided a welded steel waterproof tank which shall be oil-filled, that all components of the transformer, rectifier and regulation equipment are below oil level. Cooling shall be done by natural air cooling with oil/air heat exchanger.

Units connected with 24 VDC shall be equivalent equipped, but without facilities for transformation from AC to DC. The adjustment of output voltage must be possible without larger losses of energy.

For measuring of the ON/OFF potentials the rectifier units shall be equipped with a cyclic timer, suitable for remote GPS synchronization. The frequency of switching ON/OFF shall be variable and has to correspond with the units of foreign lines along the pipeline route or connected station areas respectively. If parts of the cathodic protection system are supplied via existing CP systems, the switching frequency must also correspond with the existing units.

Each unit shall be provided with the following measuring instruments:

(i) Supply voltage,

(ii) Output voltage,

(iii) Total output current,

(iv) Partial current of downstream side (for pipeline only),

(v) Protection potential (measured against a reference electrode).

For a continuous remote monitoring of total current and protection potential and the signalization of low potential, each unit shall be equipped with the respective monitoring devices. If a common device is monitoring more than one transformer / rectifier station, it must be ensured that remote monitoring station is still active if one monitored station is tripped or in maintenance. The alarm for low potential warning shall be provided with a time delay, adjustable between 30 sec. and 60 min. Low potentials with duration up to the adjusted time shall not be forwarded. The signal transmission shall be via potential free contracts or Ethernet.

Barbed wire fencing along with appropriate support and lockable gate to be provided around the anode bed and the TRU (if located outdoor) of ICCP system.

Required No of Transformer Rectifier Unit (TRU). In case CP Stations are required at location in between of these two points, Contractor has to make suitable arrangement for alternate power supply source (like solar power etc) for such CP stations. Solar powered electric supply or any other alternate source shall be provided with battery bank suitable for min. 100 hours' backup at 100% load and other necessary accessories required to complete the system.

b. **Solar System**

System size shall be designed and calculated after survey and design. System sizing shall be 20% derating of PV array to account for dust, debris, temperature and other factors. 40% battery derating to account for maximum depth of the discharge, temperature, aging and other factors. All cables, connectors and electrical equipment shall be derated for temperature and 20% spare capacity

4 Days autonomy of the system and suitable for non-hazardous location complete solar power system shall self-contained with controller and battery capable of beneath PV Array.

c. **Charge Controller**

System size shall be decided by the design to meet the CP requirement. Designed and manufactured for industrial 'off-grid' battery charging applications with an operational life expectancy of >25 years without maintenance. No active power conversion such as PWM (Pulse Width Modulation) or MPPT (Maximum Power Point Tracking) shall be used as they reduce operational life to <10 years. It shall be suitable for non-hazardous location with an independent enclosure suitable for IP 66. Painted Steel, lockable enclosure with detachable gland plate on the bottom edge for cable entry.

Alarms and monitoring facilities shall be provided minimum with battery voltage below minimum value, battery voltage above maximum value and array failure and controller failure.

Adjustable time delays shall be provided to prevent alarm activation to account for the transient condition.

Communication shall be Minimum RS 232 supplied complete with all required cables, conduits, conduit adaptors, crimp connectors, cable ties and cable labeling.

Battery Isolation to be included. Circuit breakers for input/output DC cables and all incoming/outgoing cables via appropriate glands. All connections within the enclosure are via clearly labeled DIN rail mounted terminals.

d. 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.

e. Battery Bank and Enclosure

Industrial heavy-duty type sealed lead acid maintenance-free, VRLA valve regulated gas recombination type in accordance with BS 6290 Part IV or IEC 60896-22. Battery shall be designed specifically for long life in industrial off-grid solar applications.

Suitable for non-hazardous location and high-cycle (not deep cycle) type with minimum manufacturer cycle life of 2500 cycles at 50% depth of discharge (DOD). Battery bank shall be supplied complete with insulated interconnects.

Independent enclosure in acid-resistant, polypropylene including ventilation and stainless-steel locking facilities. Specifically designed to house above batteries. IP23 ventilation (minimum) and suitable for IP65 enclosure. Supplied complete with all required cables, conduits, conduit adaptors, crimp connectors, cable ties and cable labeling.

f. PV Array for Solar System

PV Modules shall be nominal 12V/24V, Module designed specifically for industrial 'off-grid' battery charging application. Manufactured in accordance with IEC61215-1.

Array Junction Box shall be minimum suitable for IP 65, fitted with compression glands suitable for 4 mm single color cable. PV should not supply with pre-installed cable and connectors to avoid any splice in current caring cable.

Aluminum Frame to include mounting holes, corner drain holes and fixing holes for bird spike PV modules should be of high strength design tested to 5400pa.

Modules to be supplied with factory test I-V performance data Conformance to a) IEC 61215 and IEC 61730, b) TUV to Class II equipment Schutzklasses II, c) European Specs ESTI503 Electromagnetic compatibility to Directive 89/336/EEC d) Manufactured to ISO-9001-2015 & 14001 standards & e) Electrical Performance: 90% of rated output of current for minimum of 10 years and 80% of rates out of current for minimum of 20 years.

g. Anodes and Anode Ground Beds

Types of Anodes

The anode type and the number, dimensions and weights of anodes per ground bed must be selected by the Contractor in accordance with the calculations of the detail design.

In principle the following types shall be used:

(a) Impressed current systems

(i) Silicon-iron-chromium (Fe-Si-Cr) anodes, to be used for horizontal or vertical shallow anode ground beds and for single anodes,

(ii) Mixed metal oxide coated titanium anodes, to be used for deep well anode ground beds,

(iii) Cable-anodes, consisting of copper conductor, conductible polymer, coke breeze backfill and fabric jacket, to be used for single anodes.

(b) Sacrificial systems

magnesium (Mg) sacrificial anodes, imbedded in a backfill from a mixture of calcium sulphate, granular bentonite and sodium sulphate, pre-packaged in a cotton bag. The required number and size of anodes must be determined by the allowable current density, the life time and the circuit resistance of the respective CP segment or station.

Each anode shall have a factory assembled single core HMWPE insulated copper cable of at least 6 mm^2. The cable connections to cable-anodes will be performed on site.

High silicon cast iron type anodes shall be center-connected hollow type or end connected solid type. Composition shall conform to requirements of ASTM A518-86 Grade III.

Mixed metal oxide coated titanium anodes shall be of pure titanium having substrate composition of titanium of ASTM B 338, Grade II, over laid with mixed oxide of noble metals (MMO coated) and shall be dimensionally stable. The anodes shall be center connected sealed tubular type.

The design life of anode under burial condition, at the design operating current in minimum be the design life of the CP system specified.

h. Horizontal Anode Ground beds

The minimum anode bed distance for horizontal ground beds from the pipeline shall be 100 m and at least 100 m from all other metal structured work buried within the area. The anodes shall be laid in a depth of approximately 1.5 m, imbedded in a continuous coke-bed of minimum 40 x 40 cm (W x D). The anodes are to be installed with a space of 6 m. The ends of the coke-bed shall exceed the final anodes by 3 m.

For connection of the anodes a loop cable shall be provided. Each anode will be terminated on this loop cable via splicing kid. The loop cable shall be connected with an above ground anode junction box, located at one end of the ground bed. At the other side of the ground bed a concrete marker is to be installed. All anode cables and the loop cable must be accessible over the coke-bed. Before backfilling, the anode ground bed shall be approved by Engineer.

i. Deep well Anode Ground beds

The deep well anode ground beds shall be placed within the right of way or within stations respectively.

The upper anode of the ground bed must be laid in a depth of 30 m, at least. The anodes are to be installed with a space of 3 m in a continuous coke-bed. The ends of the coke-bed shall exceed the final anodes by 1.5 m. The diameter of the borehole shall be according to the requirements, but in minimum 20 cm.

Each anode is to be provided with a separate feeder cable, connected with an above ground anode junction box. The borehole shall be equipped with a vent pipe about the whole depth. The inactive part of the ground bed is to be closed with gravel.

Before bringing down, the anode string shall be approved by Engineer.

j. Single Anodes, Cable-Anodes

Single anodes and cable-anodes for hot-spot purposes shall be laid near the piping which is to protect and in a depth of center line of the respective piping. The Sacrificial anodes for hot-spot shall be supplied as pre-packaged container anodes. The current output of single anodes and cable-anodes must be adjustable.

k. Sacrificial Anodes

Sacrificial anodes shall be laid in 1 to 2 m distance of piping and in a depth below base line of the respective pipe.

The zinc anode shall conform to the requirements of ASTM-B 418 standard and magnesium anode shall conform to the requirements of ASTM-B 843 standard

4.69.8 Test and Bonding Stations

a. Test Posts

Test posts shall consist of the following main parts:

(i) terminal box (head),

(ii) conduit,

(iii) Marker plate.

The head of the test post shall be of the concrete type or big fink type, provided in orange color. The cap of the head must be lockable. The terminal plate is to be equipped with pillar type terminals (banana jacks) according to the requirements, but at least five (5) terminals must be installed. Each terminal is to be used for one (1) conductor only.

The conduit shall be a hot dip galvanized steel pipe with a size of 3”. The head shall be fixed by clamping the terminal box compression nut on the pipe. For fixing of cables a suitable pull relief device must be provided.

For a clear identification of conductors regarding their measuring purpose a common termination system for all test stations shall be applied, that means terminals of the same purpose must be identically placed at each test post. In addition, all cables shall be correctly identified and labelled using heat shrinkable sleeves in different colors. The Contractor shall prepare the respective termination system and the cable marker color code for Engineer’s approval.

For the test posts suitable foundations have to be provided. The size of the foundations shall be according to the soil requirements, but in minimum 40 x 40 x 50 cm (L x W x D).

The height of the test posts including head shall be 1.2 m above finished ground level. The length of the buried part and as well the total length of the post depends on the required foundation size.

Each test post is to be equipped with a marker plate of stainless steel, fixed on the conduit. The plate shall be inscribed (engraved) with number and type of test station. The numbering system for the test stations shall be prepared by Contractor and approved by Engineer.

b. Potential Test Station

The potential test station shall consist of the following main parts:

(i) test post,

(ii) one (1) pipeline connection,

(iii) measuring cable.

Potential test stations located in the middle of two rectifier stations shall be additionally equipped with one (1) reference electrode and one (1) test coupon.

c. Current Test Station

The current test station shall consist of the following main parts:

(i) test post,

(ii) two (2) pipeline connections,

(iii) measuring cables.

The distance between the pipeline connections shall be of 100 m. The resistance of the pipe between the two pipeline connections shall be recorded in the measuring protocol and mentioned on a label fixed to the terminal plate inside the head of test post.

d. Foreign Line Test Station

The foreign line test station shall consist of the following main parts:

(i) test post,

(ii) one (1) pipeline connection on the own pipeline,

(iii) pipeline connection(s) on the foreign pipeline, according to the requirements of foreign line owner/operator,

(iv) resistor(s),

(v) one (1) reference electrode, located at the own pipeline,

(vi) measuring cables.

This type of test station will be used for crossings and as well for parallel laying with foreign pipelines.

e. Steel Case Test Station

The steel case test station shall consist of the following main parts:

(i) test post,

(ii) two (2) pipeline connections (one at each end),

(iii) two (2) connections with the steel case (one at each end of steel case),

(iv) one (1) to three (3) zinc electrodes between pipe and steel case (depends on length of steel case),

(v) Measuring cables.

f. Isolation Coupling Test Station

The isolation coupling test station shall consist of the following main parts:

(i) test post,

(ii) two (2) upstream pipeline connections,

(iii) two (2) downstream pipeline connections,

(iv) one (1) surge arrestor,

(v) Measuring cables.

To avoid to high potential differences in case of overvoltage, the surge arrestor has to be installed on shortest way above the isolation coupling.

g. Bonding Station

Bonding stations shall be used for the following purposes:

(i) negative connections for incorporation of a new cathodic protection system in an existing cathodic protection system,

(ii) negative connections (loops) between the non-grounded sides of isolation couplings for incoming and outgoing pipelines of stations.

The bonding stations shall mainly consist of a junction box and a support, mounted on structures or on a separate foundation.

The junction boxes shall be of stainless steel or aluminum cast wit sufficiently size. The boxes have to be equipped with all necessary devices according to the purpose.

Supports shall be of hot dip galvanized steel. For foundations please refer to item “Test Posts”.

4.69.9 Polarization Cells

On high voltage influenced sections of pipeline, caused by high voltage overhead lines or by electrified railways, polarization cells shall be installed.

The polarization cells shall have the following main data:

(i) DC voltage blocking level – 3/ + 1 V,

(ii) AC rms steady-state current rating 40 A,

(iii) AC rms fault current 9 kA for 0.5 sec.,

(iv) lightning surge current rating (8/20) 100 kA.

A polarization cell with liquid filling will not be accepted. For necessity and placement of polarization cells a high voltage influence calculation shall be carried out.

Polarization cells shall be installed inside the fenced area of line valve stations or major stations, preferably. If polarization cells must be placed at other locations, the respective earthing system according to specification “Earthing and lightning protection” has to be installed. The connection with the earthing system shall be carried out with copper cable with a minimum size of 50 mm^2, the connection with the pipe with copper cable of 25 mm^2 minimum size.

4.69.10 Reference Electrode

The permanent reference electrodes shall be of the Cu/CuSO4 type. Each reference electrode shall consist of a terracotta vessel with inbuilt soft solid copper wire and copper sulphate gel or solution filling. The reference electrodes are to be provided with minimum 10 m copper cable 2 x 2.5 mm^2 or 1x6 mm^2. The cable connection point at the electrode must be fully insulated and sealed with epoxy resin. Each electrode shall be supplied with a backfill of a mixture from gypsum, bentonite and sodium sulphate, pre-packaged in a cotton bag.

The Cu/CuSO4 electrodes should be used in soils with a chloride content <1000 ppm, only. However, for soils with a chloride content >1000 ppm the Ag/AgCl electrode is recommended.

The reference electrodes will be installed at the depth of pipe centre line, adjacent to the pipe and have to be imbedded in the same soil type as the pipe.

4.69.11 Pipeline and Steel Case Connections

The connection of measuring, drain or other cables on the pipeline shall be carried out by mans of pin brazing. Thermic welding shall not be used. The pin brazing is to be carried out by properly trained personnel only. The Engineer shall be notified of the names of the persons authorized by the Contractor to perform this work, other persons will not be admitted.

Before pin brazing any pipe coating shall be removed at the soldering point. The work piece surface has to be cleaned down to the bare metal over a sufficiently large area, using a scraper or brush.

Each conductor of a measuring cable shall be connected with a separate pin with a distance of 100 mm between the pins. Single core cables with a size of 25 mm^2 or larger shall be connected via two (2) pins in a distance of 40 mm, using a twin hole cable lug.

The insulation material for the connection shall be factory assembled and from equal type as the pipeline insulation. After insulation the connections shall be checked with a high voltage test by means of a holiday detector.

The kind of connection with foreign lines shall be agreed with the respective pipeline owner/operator.

4.69.12 Polarization Coupons

To monitor the adequacy of the CP system to polarize / protect coating holidays steel coupons of pipeline material shall be provided along the pipeline at CP station drainage points, predicted cathodic protection mid points along the pipeline, at locations where the pipeline is bonded, interference prone areas, at locations such that minimum one coupon is installed for every 10 km approximate. The coupons shall be constructed from the pipeline material of minimum thickness 10 mm, shall have uncoated surface of 100 mm x 100mm exposed to soil. Two cables one for connection to pipeline for protection and other for potential measurement shall be provided for each coupon. The polarization Coupons shall be made from the material of the pipeline.

4.69.13 Surge Diverter

Explosion proof spark gap surge diverter shall be provided across each insulating joint to protect it from high voltage surges. Coming across it due to lightning strikes, electrical faults, etc. on the above ground portion of the pipeline. The surge diverter shall be of spark gap type. The device shall have weatherproof enclosure suitable for outdoor mounting.

4.69.14 Anode Junction Box

Each ground bed shall be provided with one or more anode junction boxes depending on the size of anode ground beds, all tail cable from individual anodes shall be terminated onto the respective anode junction boxes, which shall be further connected to the main anode junction box (where applicable) which in turn shall be connected to the cable coming from CP power source.

Junction boxes shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters and shall be weatherproof with degree of protection IP – 55. It shall be epoxy painted on the inside and outside surface.

Junction boxes shall have anode bus of copper with nickel/ silver plated or tinned.

Provision shall be made for measurement and control of individual outgoing circuit /anode current by providing suitable shunt and resistors of grid coil type and each outgoing citcuit shall be labeled.

Disconnecting links shall be provided for each outgoing / anode circuit. 30% spare outgoing circuits shall be provided in each anode junction box.

A nameplate of anodized aluminum with black background and white letters shall be fixed to the inner side of the junction box shall be provided with the information such as Ground bed current rating, Ground bed resistance, Connection scheme, Distance from pipeline and CP station in meters.

4.69.15 Cathode Junction Box

A cathode junction box shall be provided near the pipelines - wherever output of the CP power supply unit is connected to multiple pipelines-at the location of connection of the negative drainage cable to the pipelines.

The negative of the CP power source shall be connected to the incoming circuit of the cathode junction box. The junction box shall have separate out-going circuit one for each pipeline to collect the negative drainage currents from each of the parallel pipelines.

The incoming circuit shall have a current measurement shunt. Each outgoing circuits shall have isolation link, variable resistance of grid coil type and a current measurement shunt. One number spare outgoing circuit shall be provided.

Junction boxes shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters and shall be weatherproof with degree of protection IP – 55. It shall be epoxy painted on inside and outside surface. Identification labelling shall be provided for each terminal and shall clearly indicate the size and identification of the pipeline to which it is connected.

A nameplate of anodized aluminum with black back ground and white letters shall be fixed to the inner side of the junction box shall be provided with the information such as chainage in KM, Connection scheme, Direction of flow in pipeline, Distance from pipeline and CP station in meters.

4.69.16 Cables and Cable Laying

All cables shall be one to five core cables with stranded copper conductors and HMWPE insulation. The nominal voltage of the cables shall be 0.6 kV. For feeder cables of transformer/rectifiers cables with solid copper conductor may be used.

The minimum size of copper conductor cable shall be used. The Engineer shall review the cable sizes in accordance with the detailed design of Cathodic protection system:

(i) drain (negative) pipe connections 1 x 25 mm^2

(ii) spark gaps/polarization cells 1 x 25 mm^2

(iii) grounding connections/loop cables 1 x 50 mm^2

(iv) anode ground bed (positive) connections 5 x 6 mm^2

(v) cables for negative bonding 1 x 25 mm^2

(vi) measuring connections foreign line test stations 2 x 6 mm^2

(vii) cables for reference electrodes 2 x 2,5 mm^2 or 1 x 6 mm^2

(viii) cables for reference electrodes and test coupons 2 x 2.5 mm^2

(ix) cables for other measuring connections 2 x 2.5 mm^2

(x) feeder cables of transformer/rectifiers as required.

The cables outside of buildings and shafts shall be buried directly in ground. If cable routes are running outside of the right of way or outside of fenced stations, the cables shall be covered with concrete plates (W x H: 30 x 3 cm). The concrete plates shall be placed 10 cm above the cable layer. Inside of buildings, shafts, etc. the cables will be laid in pipes or on cable racks.

4.69.17 Cable Laying

Cables shall be laid in accordance with layout drawings. No straight through joint shall be permitted. Cable route shall be carefully measured and cables cut to required length. Minimum one meter cable slack shall be provided near anodes, anode junction box, pipeline and test stations to account for any settling.

All cables inside station / plant area shall be laid at a depth of 1. 0 meter. Cables outside station / plant area shall be laid at a depth of minimum 1.5 meters.

Cables shall be laid in sand under brick cover and back filled with normal soil. For cables laid outside the station /plant area, polyethylene warning mats shall be placed at a depth of 0.9 meter from the finished grade, to mark the route.

In case of above ground cables, all unarmored CP cables shall be laid in GI conduits for protecting against the mechanical damage.

All underground unarmored cables including anode tail cables shall run through PE sleeves. Permanent reference cell cables routed along the pipeline shall be carried at the top of the carrier pipe by securely strapping it at intervals.

PVC pipes of proper class & size shall be provided for all underground cables for road crossings.

The cables for reference cells and pipeline potential measurement shall be routed in a separate trench other than the trench provided for the rest of the CP system cables, AC cables for TRU units etc.

The armor of the cables from CP station to test station (potential measurement, reference cell & drainage cables etc.), CP station to ground bed (anode cable) and test station to pipeline shall be earthed only at CP station end and test station end respectively of the cables. The cable armor shall be insulated to avoid armor carrying CP current.

4.69.18 Cable to Pipe Connections

Connections of all cables other than cathode drainage cables to the pipeline or to charged pipelines shall be made by low temperature thermit welding as per the established procedure and anode cap shall be filled up with Epoxy hardener. The strength of the joint shall be tested by striking with hammer. The resistance of the cable to pipe at the pin brazing connection point shall not exceed 0.1 ohm.

The cathode drainage cable shall be connected to a bolt welded to a metal plate, which is weld connected to the pipeline. The material of the plate shall be same as that of the material of the pipeline.

Pipe coating shall be repaired after connection of cable to pipeline. The coating repair material shall be compatible with the original coating and shall prevent ingress of water along the cable surface and at the interface of coating repair with the original pipe coating.

4.69.19 Cable Termination

The cables shall be taken through double compression glands inside all equipment/ panels.

Termination of cables shall be done with crimped heavy duty copper lugs supplied along with the equipment with proper crimping tools.

Control cables of single strand shall be directly terminated on to the terminals. An aluminum tag/ PVC ferrule for identification of the cable shall be attached to each cable at both ends. Power cables shall be identified with red, black and blue PVC adhesive tapes/ sleeves.

4.69.20 Cable Identification

All cables will be identified and labelled at terminal blocks of test station and transformer rectifier.

b) To this purpose, colored heat shrinkable sleeves will be supplied for use as per following color code key:

Structure to protect	:	Black
Structure to T/R U connection	:	Red
AJB to T/R U	:	Red
Casting Pipe	:	Blue
Plant side shorting connection	:	Green/Brown
Monitoring connection	:	Black: White

Reference cell

Half cell	:	Yellow
Structure	:	Yellow/Green
Anode to JB	:	Black

4.69.21 Thermit Welding

Thermite welding shall be used for cable attachment to steel or iron with metallurgically limited usage. This process enables copper to be welded to steel or iron without the use of welding equipment. The temperature of the reaction is such that the surface layer of base metal undergoes a metallurgical change by both heat treatment and partial alloying with the copper content of the thermit charge. Because of the intense reaction, extreme care shall be taken in preparation and firing together with the correct choice of attached cable size, change and mould.

4.69.22 Temporary Cathodic Protection

The temporary cathodic protection shall be performed with sacrificial anodes of suitable size, terminated on the test points. In time with the installation of temporary cathodic protection all foreign line test points on the respective pipeline section shall be provided to allow a connection to the foreign lines via resistor in order to avoid influence.

For temporary Cathodic protection of Pipelines the sacrificial anodes shall be installed every 1-2 km typically and connected via the test posts. Before commissioning of the final ICCP system, all sacrificial anodes shall be disconnected, from the pipeline (at the test posts).

The protection potential to be reached shall be -0.85 V measured against a Cu/CuSO4 reference electrode.

Prior to commissioning of the permanent cathodic protection all temporary anodes must be disconnected.

The temporary CP is not necessary, if the pipes will be without permanent CP less than one (1) month. The Contractor shall work out a respective detail procedure to ensure, that no segment of pipeline/station will be in the ground without any CP (temporary or permanent) for more as the mentioned time.

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.

4.69.23 Inspections and Tests

All components of the cathodic protection systems shall be tested in manufacturers workshop. All tests required by the codes and standards as well as all manufacturer tests have to be performed. The rectifiers and other pre-assembled equipment shall be completely tested in manufacturers workshop, for devices such as anodes, surge arrestors, cables, heads of test posts, etc. a type test shall be performed.

The test program for the test of transformer/rectifiers and other pre-assembled equipment has to be submitted prior to start of the tests. Detailed test protocols of all tests performed have to be submitted prior to shipment.

All tests required as per specification. Contractor shall be responsible for making all arrangements (including supply of materials) for all tests, performance of tests in presence of Engineer's representative.

Maintaining records of all the works and inspections as per advice of the Engineer and all other materials necessary but not mentioned herein specifically to complete the Cathodic Protection system in all respects to the best engineering practices shall be included by the contractor.

The contractor is responsible for carrying out all tests and checks envisaged in compliance with specifications & to request the Engineer to be present when required so as to meet the provisions of the contract. All expenditure in respect of testing of materials shall be borne by the contractor unless otherwise specified.

Such inspection by the Engineer however in no way relieves the contractor of his responsibilities & obligations.

All inspection & tests shall be according to the method indicated in the specifications/ codes/ and contractor's approved drawings.

The entire erection of the CP system shall be finally inspected by the Engineer to check its conformity with all the drawings & specifications furnished. The contractor shall rectify all the defects and finally hand over the system to the entire satisfaction of the Engineer

Contractor shall mobilize at site adequate testing equipment/apparatus including skilled, unskilled, managerial manpower required at site for all testing. All instruments and consumable required during erection/pre commissioning, performance testing & monitoring shall be arranged by the Contractor.

The entire erection of the CP system shall be finally inspected by the Engineer to check its conformity with all the drawings & specifications furnished. The contractor shall rectify all the defects and finally hand over the system to the entire satisfaction of the Engineer.

4.69.24 Pre-Commissioning Cathodic Protection of Pipeline

The contractor shall furnish the detailed field testing and commissioning procedure for Engineer's approval. Field tests as per approved procedures shall be carried out on the equipment/ systems being put into service.

The contractor shall perform pre-commissioning operations after installation of the system including pre-commissioning checks, calibration and setting of all instruments, control and protective devices. All site tests, reliability and performance tests shall be carried out including supply of all materials and consumables. Before the electrical facilities are placed in operation, contractor shall perform suitable tests to establish to the satisfaction of the Engineer that all equipment, devices wiring and connections have been correctly installed and are in good working conditions.

In this connection the impressed protection current shall be adjusted. The pre- commissioning may be carried out in steps from isolation coupling to isolation coupling.

Field testing and pre- commissioning shall generally include but not be limited to the following:

(i) Visual inspection, comparison with drawings and specifications

(ii) Detailed physical inspection and if necessary, by taking stage wise inspection of component parts.

(iii) Simultaneous tests and trial runs of entire equipment to determine its operational fitness

(iv) insulation resistance of cables (can be done earlier),

(v) effectiveness of protection against touching of live parts (before switching on),

(vi) resistance to earth of all anode ground beds,

(vii) test of isolation couplings,

(viii) natural pipe-to-soil potentials within line valve stations, at isolation couplings and at foreign line crossings/parallelism and natural casing-to-soil potential at all steel cases (ground beds and sacrificial anodes must be disconnected 48 hours prior start of the measurements),

(ix) ON/OFF potentials at all rectifier stations,

(x) ON/OFF potentials in the middle of two rectifier stations and at both ends of the pipeline or the pipeline segment,

(xi) current distribution along the current test stations,

(xii) resistances between pipeline and steel cases.

The Contractor shall work out a detailed description and procedure for pre-commissioning and shall submit to the Engineer. All pre-commissioning results have to be recorded on standard forms and shall be submitted for approval.

Generally, the following tests shall be carried out and recorded on the proforma approved by the Engineer including checking, inspection and testing.

4.69.25 Commissioning Cathodic Protection of Pipeline

Not earlier than 2 to 3 months after pre-commissioning the commissioning of the whole cathodic protection system of pipeline, connected with an additional adjustment shall be carried out.

During commissioning the following measurements/checks shall be carried out (minimum requirements):

(i) current, voltage and potential of rectifiers,

(ii) adjustment of potential monitoring devices,

(iii) calibration of all current test stations

(iv) resistances of isolation couplings,

(v) ON/OFF potential at all test stations,

(vi) high voltage influence at all test stations,

(vii) resistances between pipeline and steel cases,

(viii) current distribution along the current test stations,

(ix) interference between pipeline and foreign lines (if necessary connection between the lines via resistor),

(x) polarization potential at test coupons,

(xi) surge arrestors and polarization cells.

The Contractor shall work out a detailed description and procedure for commissioning and shall submit to the Engineer. The installed cathodic protection system shall be commissioned as per procedure approved by the Engineer Measurements and checks in connection with foreign pipelines shall be carried out in the presence of personnel of the respective pipeline owner/operator. All results shall be recorded on standard forms and shall be submitted for approval. After commissioning a respective report shall be prepared, which shall include all commissioning results. The report shall also include a discussion of the results giving conclusion.

The report shall contain as a minimum the following information:

(i) measuring values of pre-commissioning,

(ii) measuring values of commissioning,

(iii) ON/OFF potentials and currents at all test stations in both tabular and graphical formats,

(iv) calculation of protection current average and of pipeline coating resistance average,

(v) information about critical points at the cathodic protection system. The Contractor shall brief the operation personnel in operation and maintenance during installation, pre-commissioning and commissioning phase and during a training on site.

4.69.26 Functional Guarantee.

The vendor shall give functional guarantee as elaborated below.

(a) The contractor shall guarantee that the performance/ function of the CP system installed shall be strictly in accordance with and conforming to the codes specified and as per approved design. The functional guarantees for Cathodic Protection system after allowing for applicable tolerances as per codes shall be demonstrated by the contractor to the Engineer.

(b) If the contractor fails to prove the functional guarantee of the CP system, the contractor shall investigate the causes and rectify/ replace the detects within a reasonable period to prove the guarantees.

(c) Functional guarantees shall be in respect of the entire cathodic protection system including material supplied and utilized in the CP system.

(d) On successful completion of initial operation, the systems and equipment shall be subjected to functional guarantee test and parameters shall be verified during the test

(e) After successful conductance of the guarantee tests, the monitoring services of the system shall be carried out by the vendor and the system parameters shall be maintained.

4.69.27 Documentation

The following minimum design documentation [not essentially limited to these only] shall be furnished by the successful contractor for review and approval of the Engineer

(i) Corrosion survey report with interpretation.

(ii) Basic design package and system optimization studies.

(iii) Material and equipment specifications, data sheets.

(iv) Quality plans for all equipment/ items.

(v) Field Quality Plan covering site storage, handling, installation and commissioning checks.

(vi) Detail engineering and final design report.

(vii) Key diagrams of each discrete systems and complete CP system.

(viii) Anode installation drawings representing all variations in type, environment, depth, placement, supports etc. including anode.

(ix) Cable layout schedules and terminals.

(x) Foundation, weather protection cover details and support details for T/R sets, anodes, Test Station, distribution boxes and cables of all description.

(xi) Installation details of T/R sets, test stations distribution boxes etc.

(xii) Design package on T/R sets essentially incorporating circuit diagrams, fabrications and installation details, parts list, description on operation and maintenance.

(xiii) Design package on anodes essential incorporating composition, fabrication and installation details.

(xiv) Connection schemes for all applicable type of test stations and their schedules. 15. Fabrication and installation details of test stations.

(xv) Fabrication and installation details of anode and cathode junction boxes, schedules and connection schemes.

(xvi) Interconnection, sectionalization, isolation schemes for all structures to be protected and those to be isolated but to be checked out for interaction.

(xvii) Power supply arrangement for each T/R set.

(xviii) Safety earthing details.

(xix) Procedures for testing during installation, commissioning and monitoring of (after installation) complete CP system & each equipment.

(xx) Design and drawings that may be required for mitigation purposes.

(xxi) Complete CP system layout drawings for each CP station.

(xxii) Cable to pipe joint arrangement using thermite welding.

(xxiii) Material test certificate for the materials purchased by the contractor along with copy of manuals.

(xxiv) Inspection and test certificates for items fabricated and erected.

(xxv) Performance Test Report.

(xxvi) Final check list and completion report.

(xxvii) Composite Operation and Maintenance Manual.

(xxviii) Monitoring formats.

(xxix) Monitoring schedules.

(xxx) List of E&C Spares.

4.69.28 Spare Parts and Special Tools

The Contractor shall deliver all spare parts, which are necessary for commissioning and for operation during warranty period.

Spare parts shall be available until ten years after commissioning. All necessary special tools for operation and maintenance of the cathodic protection systems shall be supplied, at least consisting of:

(i) one (1) set of all special tools required for operation and maintenance; if more than one maintenance center exists, for each center one (1) set of special tools shall be provided,

(ii) one (1) set fuses (12 fuses of each used size),

(iii) key set for cabinet doors and locks,

(iv) three (3) complete sets measuring instruments and portable reference electrodes (gel filled) to allow the operation personnel all measurements on the cathodic protection systems.

4.70 Measurement and Payment

4.70.1 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, 400-500

microns fusion bonded-epoxy 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 FBE lining as per AWWA C213.
(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

4.70.2 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.

4.71 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

CHAPTER 5 - ROADS

5.01 General

Roads shall be surfaced Roads comprising earthwork shaped to the formation profile, a granular sub-base and aggregate base course, asphaltic aggregate base course and a dense bitumen macadam wearing course as specified, or shown on Drawings.

They shall be constructed to the levels, grades and dimensions shown on the drawings and as directed by the Engineer.

All roadway construction, especially during the reinstatement of existing infrastructure, shall strictly adhere to the standard specifications and requirements of the relevant Road Authority. The Contractor shall be responsible for obtaining all necessary permits and shall ensure that all traffic management, diversions, and permanent reinstatements are approved by both the Engineer and the Road Authority. In the event of a conflict between these Specifications and those of the Road Authority, the more stringent requirement shall apply.

5.02 Clearing and Grubbing

This work shall consist of removal to the specified depth, grubbing and disposal of all surface objects, as and where directed in writing by the Engineer, stumps, roots, bushes and trees with less than 150 mm girth, vegetation, logs, rubbish and other objectionable material, except such objects as are designated to remain or are to be removed in accordance with other section of specification.

5.02.1 Construction Requirement

In roadway cut areas, all surface objects or any object to the depth of 30 cm below subgrade level such as stumps, roots, vegetation, bushes, logs, rubbish shall be cleared and/or grubbed as directed by the Engineer. In roadway fill areas where clearing and grubbing is required, same shall be carried out to the depth of 30 cm below natural surface level as described above. Operation of clearing and grubbing shall in no way be deemed to effect any level or volume change of the area. After clearing and grubbing, the natural ground shall be compacted to 95% of AASHTO T-180. However, Engineer may direct in writing to the Contractor for stripping (if so required) and for compaction of Natural Ground, if the original compaction is less than the required for respective zone. Payment of these items will be made separately under the relative items used for such purpose. Before bottom layer of embankment is placed, contractor will grub up and remove without extra payment, any vegetation that may, in the meantime have grown on surface previously cleared and grubbed. All trees having girth less than 150 mm measured at (600) mm above ground and falling within the construction limits shall be felled & removed by the contractor under this item. The excavation and removal of trees, roots and stumps including backfilling and compacting of holes and restoring the natural ground to the original condition shall be responsibility of the contractor for which no extra payment shall be made to him. The trees, stumps & roots remain the property of the Employer, which shall be delivered at designated place as directed by the Engineer.

5.02.2 Protection and Restoration

The Contractor shall prevent damage to all pipes, conduits, wires, cables or structure above or below ground. No land monuments, property markers, or official datum points shall be damaged or removed until the Employer/Engineer has witnessed or otherwise referenced their locations and approved their removal. The Contractor shall so control his operations as to prevent damage to shrubs, which are to be preserved. Protection may include fences and boards latched to shrubs, to prevent damage from machine operations. Any damage as a result of contractor’s operation shall immediately be rectified by him at his own expense.

5.03 Removal of Tress

This work shall consist of the removal of trees and stumps along with their roots to a depth, to ensure complete removal of roots and stumps and their disposal as provided in Special Provision or as directed in writing by the Engineer.

5.03.1 Construction Requirement

Such individual trees as the Engineer may designate and mark in white paint shall be left standing uninjured. All other trees to be removed shall be counted and an inventory prepared showing girth of the tree stem at 600 mm from ground. When necessary to prevent injury to other trees or structures or to minimize danger to traffic, trees shall be cut in sections from top downwards. Whole or loose earth resulting from the removal of trees shall be filled and recompacted to a degree of compaction of adjoining area. Any extra material required for such purpose shall not be measured for payment.

5.03.2 General Requirements

Contractor shall prevent damage to all under-ground utilities, such as pipes cables or conduits etc. For this purpose, if so required, removal of trees shall be carried out manually. Any under-ground or over-ground property damaged by the contractor shall be immediately repaired by the contractor at his own expense.

5.04 Stripping

This work shall consist of removing unsuitable topsoil, transporting and depositing in stockpiles or spreading where indicated on the Drawings or as directed by the Engineer. Engineer shall give instruction in writing, stating area and depth to be stripped.

The topsoil so removed shall be deemed to become the property of the Employer and shall be set aside for re-use for any purpose such as soiling of slopes of cuttings and embankments and preparation for beds or disposal as directed by the Engineer. Topsoil is defined as the surface layer of soil, which by its humus content supports vegetation. This layer of soil is unsuitable, due to weathering and vegetable content, as a formation to roads and concrete structures or as a backfill or bedding material. The presence, extent and depth of topsoil in excess that stated above that needs removal shall be agreed with the Engineer. The Contractor shall make his own arrangement for temporary storage sites for heaps of topsoil either inside or outside of the site of works to suit his convenience. The cost of all operations needed in excavation, loading, carting, depositing and stacking together with arranging for the storage sites, hire or purchase of land thereof and all necessary access roads for this purpose is to be included in the rate for stripping topsoil and shall be applicable whatever the nature of underlying sub-soil.

5.04.1 Construction Requirement.

The areas from which stripping of topsoil is required shall be as directed by the Engineer. The Contractor shall remove topsoil from these areas to depth as directed by Engineer. Stripping of topsoil in any case shall be not less than 10 cm. in depth. The removed topsoil shall be transported, deposited in stock piles at locations designated by the Engineer and/or spread where indicated on the drawings or as directed by the Engineer.

Engineer shall, however identify the soil as unsuitable through laboratory tests The top soil shall be placed separately from other excavated materials and be completely removed to the required depth from the area prior to the beginning of regular excavation or embankment work in that area. No payment will be made for topsoil removed from places other than that directed by the Engineer. Engineer shall, however identify the soil as unsuitable through laboratory tests, before such a decision at his own expense. or as ordered by the Engineer.

5.05 Natural Ground Preparation

The natural ground or surface ready for construction purposes after clearing & grubbing or stripping, levelling and dressing will be considered as natural Ground for the purpose of this item. The natural ground is required to be compacted up to 95% of AASHTO T-180. The formation level of the earth work shall be formed to level, camber or cross fall to proposed levels and grades of the pavement.

5.05.1 Construction Requirements

Up to a depth of twenty (20) cm below the natural ground, all sods and vegetable matters shall be removed and clear surface shall be broken up by ploughing and scarifying to compact to the degree as defined below.

Table 5-1 Compaction Requirement for Natural Ground

For height of Embankment below sub, grade level.	Percent of Maximum Dry Density as determined by AASHTO T-180.
0 to 30 cm	95
30 to 75 cm	93
Below the foundation of structures	95

Unsuitable material arising from roadway excavation is such material which is declared in writing by the Engineer following sampling and testing for classification of soil as per AASHTO M-145.

The material shall be declared unsuitable if it falls under A-6 or A-7 of AASHTO soil classification.

Unsuitable or surplus material arising from roadway excavation shall require being disposed as per contract.

Unsuitable material shall be removed up to the depth of 200mm falling under road construction and be replaced with suitable borrowed earth work.

5.06 Formation of Embankment

This work shall consist of formation of embankment, including preparation of area for placing and compaction of embankment material in layers and in holes, pits and other depressions within the roadway area in accordance with the specifications and in conformity with the lines, grades, thickness and typical cross-section shown on the plans or established by the Engineer.

5.06.1 Material Requirements

Material for embankment shall consist of suitable material excavated from borrows, roadway excavation or structural excavation and shall include all lead and lift. Borrow material will be used only when material obtained from roadway or structural excavation is not suitable or is deficient for embankment formation and shall include all lead and lift.

The material under this item shall conform to the following specification.

(a) Contractor shall use AASHTO Class A-1, A-2, A-3, A-4 soil as specified in AASHTO M-145 or other material approved by the Engineer.

(b) CBR of the material shall not be less than ten (10) percent, determined in accordance with AASHTO T-193. CBR value shall be obtained at a density corresponding to the degree of compaction required for the corresponding layer.

(c) Swell value of the material for embankment formation shall not exceed five tenth (0.5) percent. However, while establishing the swell value, surcharge weights representing the overburden will be used. In case sandy material is used for embankment formation, it shall be properly confined at no extra payment with a material and to the extent as approved by the Engineer and sandy material shall not be used on slopes of embankment.

5.06.2 Construction Requirements

Material for embankment, obtained and approved as provided above, shall be placed in horizontal layers of uniform thickness and in conformity with the lines, grades, sections and dimensions shown on the Drawings or as required by the Engineer. The layers of loose material other than rock shall be not more than 20 cm. thick, unless otherwise allowed by the Engineer after a trial section is prepared and approved. The material placed in layers and that scarified to the designated depth for formation of embankment shall be compacted to the density specified below:

Table 5-2 Compaction Requirement for Embankment

Depth in centimeters below sub grade level.	Percent of Maximum Dry Density as determined by AASHTO T-180.
0 to 30 cm	95
30 to 75 cm	93

5.07 Protection of Natural Ground and Subgrade

The Natural Ground and Sub grade, after approval by the Engineer, shall be protected and kept well drained. Storage or stockpiling of materials, or passage of Construction Plant on the formation level shall not be permitted.

Traffic will not be permitted to pass over the completed/prepared Natural Ground / Earthwork.

Prior to placement of the sub base, the Natural Ground and Sub grade shall be cleaned of all foreign substances. Ruts, soft spots, areas of inadequate compaction or any deviation of the surface from the specified requirements shall be made good to the approval of the Engineer.

5.08 Subgrade

The subgrade preparation shall be that part of the work on which, the subbase is placed, act as the base of the pavement structure. It shall extend to the full width of the road bed including the shoulders as indicated on the Drawings.

5.08.1 Construction Requirements

All materials down to a depth of 30 cm below the subgrade level in earth cut or embankment shall be compacted to at least 95 percent of the maximum dry density as determined according to AASHTO T-180 Method 'D'.

5.08.2 Subgrade Preparation in Earth Cut

In case bottom of subgrade level is within thirty (30) cm of the natural ground, the surface shall be scarified, broken up, adjusted to moisture content and compacted to minimum density of ninety five (95) percent of the maximum dry density as determined by AASHTO T-180 Method D. Subsequent layer of approved material shall be incorporated to ensure that the depth of subgrade layer is thirty (30) cm. In case, the bottom of subgrade is below the natural ground by more than thirty (30) cm, the material above the top of subgrade shall be removed and subsequent layer of thirty (30) cm shall be scarified, broken up, adjusted to moisture content and compacted to the same degree of compaction as described above. In case, unsuitable material is encountered at the sub grade level within a depth of thirty (30) cm, the same shall be removed in total and replaced by the approved material. The contractor shall be paid for removal of unsuitable material and for replacement of approved material, the payment will be made under pay Item of formation of embankment from borrow area.

5.09 Granular Sub-Base

Granular Sub base shall consist of furnishing, spreading in one layers and compacting granular sub base according to the specifications and drawings and/or as directed by the Engineer.

5.09.1 Material Requirements

Granular sub-base material shall consist of natural, processed or blended aggregates such as gravel, sand or stone fragment and shall be clean and free from dirt, organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable sub-base.

The material shall comply with the following grading requirement:

Table 5-3: Grading Requirements for Sub-Base Material.

Grading Requirements for Sub-base Material		
Sieve Designation		**Mass Percent Passing Grading**
mm	**Inch**	
60	$2^1/2$	-100 55-85 40-70 30-60 20-50 10-30 5-15
50	2	
25	1	
9.5	3/8	
4.75	No. 4	
2.0	No. 10	
0.425	No. 40	
0.075	No. 200	

Sources of the material shall be determined by the Contractor and approved by the Engineer. Preliminary approval of a source shall not infer that all material derived there from will be acceptable.

The Material shall have a CBR value of at least 30%, determined according to AASHTO T-193. The CBR value shall be obtained at a density corresponding to ninety eight (98) percent of the maximum dry density determined according to AASHTO T180 Method D.

The coarse aggregate material retained on sieve No. 4 shall have a percentage of wear by the Los Angeles Abrasion (AASHTO T-96) of not more than fifty (50) percent.

5.09.2 Construction Requirements

Approved sub base material shall be stockpiled in the manner and at the locations approved by the Engineer. Prior to stockpiling, storage sites shall be cleaned and levelled by the Contractor at his own expense.

The relative compaction of each layer of the compacted sub-base should not be less than 98% of the maximum dry density determined according to AASHTO T-180 Method D. The field density shall be determined according to AASHTO T-191 or other approved method.

Granular sub-base shall be spread on approved compacted Natural Ground/Sub grade as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials. The sub-base material shall be levelled, rolled and compacted to the specified thickness.

The sub base shall be thoroughly compacted by vibrating and/or rolling and sprinkling with water.

All equipment tools and machines employed for the Works shall be subject to the approval of the Engineer and shall be maintained in a satisfactory condition at all times.

Tolerance in surface levels shall be +05 mm to -05 mm. The surface regularity shall be tested at points decided by the Engineer with a straight edge 3 m long placed parallel with or at right angles to the center line of the road. The maximum allowable deviation of the surface below the straight edge shall be 10 mm.

Where any tolerances are exceeded the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the pavement course or formation as follows:

If the sub-base level is too high, it shall be re-trimmed and recompacted as specified. If the formation surface is too low the deficiency shall be corrected by the addition of suitable material of the same classification or other approved material laid and compacted to Specification.

The sub base shall be scarified to a depth as per the specification requirements 75 mm, reshaped, with material added or removed as necessary and recompacted all to Specification. The area treated shall be not less than 10 m long and 1.5 m wide or such area to be determined by the Engineer.

5.10 Aggregate Base Course

Aggregate Base Course shall consist of furnishing, spreading and compacting one layers of aggregate base on a prepared sub base, in accordance with the specifications and the drawings and/or as directed by the Engineer

5.10.1 Material Requirement

Material for aggregate base course shall consist of crushed hard durable gravel, rock or stone fragments. It shall be clean and free from organic matters, lumps of clay and other deleterious substances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm, stable base for both flexible and rigid pavements.

The material shall comply with any one of the following grading requirement:

Table 5-4: Grading Requirements for Aggregate Base Material.

Grading Requirements for Aggregate Base Material			
Sieve Designation		**Mass Percent Passing Grading**	
Mm	**Inch**	**A**	**B**
50.0	2	100	100
25.0	1	70-85	75-95
9.5	3/8	30-65	40-75
4.75	No. 4	25-55	30-60
2.00	No. 10	15-40	20-50
0.425	No. 40	8-20	12-25
0.075	No. 200	2-8	5-10

Crushed Aggregate (material retained on sieve NO. 4) shall consist of material of which at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.

If filler, in addition to that naturally present in the aggregate base material is necessary for meeting the grading requirement or for satisfactory bonding of the material, it shall be uniformly blended with the base course material at the crushing plant or in a pug mill unless otherwise approved. The material for such purpose shall be obtained from sources approved by the Engineer. The material shall be free from organic matter, dirt, shale, clay and clay lump or other deleterious matter and shall conform to following requirement.

Table 5-5: AASHTO sieve requirement.

AASHTO Sieve	Percent Passing
3/8 Inch	100
4	85-100
100	10-30
Plasticity Index (AASHTO T-90)	6 maximum
Sand Equivalent (AASHTO T-176)	30 minimum

When tested in accordance with the Method of Test of Soundness of Aggregates by use of Sodium Sulphate, AASHTO Test Method T-104, and the weighted average loss in five cycles shall not exceed 12% by weight. The aggregates shall have a Los Angeles Abrasion loss of not more than 40 %.

The California Bearing Ratio (CBR) value of this material compacted and tested at the approved density and moisture content shall be not less than 80%.

However, the combined aggregates prepared by mixing the coarse material and filler shall satisfy the requirements of grading curve as mentioned above.

Sources of the material shall be determined by the Contractor and approved by the Engineer. Preliminary approval of a source shall not infer that all material derived there from will be acceptable.

5.10.2 Construction Requirement

Approved aggregate base course material shall be stockpiled in the manner and at the locations approved by the Engineer. Prior to stockpiling, storage sites shall be cleaned and levelled by the Contractor at his own expense.

The relative compaction of each layer of the compacted Aggregate Base course shall not be less than Hundred (100) percent of the maximum dry density determined according to AASHTO

T-180 Method D. The field density shall be determined according to AASHTO T-191 or other approved method.

Aggregate base course shall be spread on approved granular sub-base as a uniform mixture. The granular sub-base course shall not have loose material or moisture in excess to optimum moisture content. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials. The aggregate base course material shall be levelled, rolled and compacted to the specified thickness.

The aggregate base course shall be thoroughly compacted by vibrating and/or rolling and sprinkling with water.

All equipment tools and machines employed for the Works shall be subject to the approval of the Engineer and shall be maintained in a satisfactory condition at all times.

Tolerance in surface levels shall be +05 mm to -05 mm. The surface regularity shall be tested at points decided by the Engineer with a straight edge 3 m long placed parallel with or at right angles to the center line of the road. The maximum allowable deviation of the surface below the straight edge shall be 10 mm.

Where any tolerances are exceeded the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the pavement course or formation as follows:

If the aggregate base course level is too high, it shall be retrimmed and recompacted as specified. If the formation surface is too low the deficiency shall be corrected by the addition of suitable material of the same classification or other approved material laid and compacted as per requirement of specification.

The aggregate base course shall be scarified to a depth of 75 mm, reshaped, with material added or removed as necessary and recompacted all the requirement of the specification.

5.11 Asphalt Cement

Asphalt Cement shall be oil asphalt, or a mixture of refined liquid asphalt and refined solid asphalt, prepared from crude asphaltic petroleum. It shall be free from admixture with any residues obtained by the artificial distillation of coal, coal tar, or paraffin and

shall be homogeneous and free from water. No emulsification shall occur when a thirty (30) gram sample is boiled for two (2) hours with two hundred and fifty (250) cubic centimeters of distilled water in a five hundred (500) cubic centimeters Erlenmeyer flask equipped with a reflux condenser.

Asphalt Cement shall be classified by penetration and when tested in accordance with the standard methods of tests of the AASHTO, the grades of asphalt shall conform to the requirements set forth in Table 5-6.The grade of asphalt to be used shall be in accordance with these specifications or as directed by the Engineer.

5.12 Environmental Factors

In extremely hot climates, asphalt mixes should be designed to resist rutting and maintain stiffness at high temperatures.

Because asphalt mixtures are influenced by temperature, it is recommended that different asphalt grades be used where different temperature conditions prevail. Table below gives recommended asphalt grades for various temperature conditions.

Table 5-6: Selecting Asphalt Grade.

Temperature Condition	Asphalt Grade ±
Cold, mean annual air temperature ≤ 7 degree C (45 degree F)	AC-10 AR-4000 80 / 100 pen
Warm, mean annual air temperature between 7 deg. C (45 deg. F) and 24 deg. C (75 deg. F)	AC-20 AR- 8000 60 / 70 pen.
Hot, mean annual air temperature ≥ 24 deg. C (75 deg. F)	AC-40 AR-8000 40 / 50 pen.

Both medium setting (MS) and slow setting (SS) emulsified asphalts are used in emulsified asphalt base mixes. They can be either of two types: cationic (ASTM D2397 or AASHTO M-208) or anionic (ASTM D-977 or AASHTO M-140). Selecting one of the two shall depends on the type of aggregate used for better affinity.

The grade or emulsified asphalt is selected primarily on the basis of its ability to satisfactorily coat the aggregate. This is determined by coating and stability test (ASTM D-244, AASHTO T-

59). Other factors important in the selection are the water availability at the job site, anticipated weather at the time of construction, the mixing process to be used, and the curing rate.

5.13 Prime Coat

The surface of the road base shall be primed with bitumen and the asphaltic aggregate base course laid as soon as practicable after completion of the road base.

Immediately before spraying the primer all dust, dirt, sand and other loose material shall be removed. If required by the Engineer the road base shall be lightly sprayed with water but not saturated to assist penetration of the primer. The primer shall be applied uniformly by pressure distribution. The rate of application shall be such that the primer penetrates the surface of the road base to a minimum depth of 4 mm and dries to a matt finish within 24 to 48 hours.

The primer shall be a low viscosity medium curing cut back bitumen to BS-EN 12591 type MC 30 to MC 70 and the rate of application shall be between 0.5 l/m^2 and 1.4 l/m^2. The temperature of application shall be 30°C to 60°C for grade MC 30 and 80°C for grade MC 70.

5.14 Asphaltic Aggregate Base Course.

This work shall consist of furnishing of plant, labor, equipment and material and performing all operations in connection with the construction of an asphaltic plant-mix base course on a previously constructed and accepted base course, subject to terms and conditions of the Contract, and in strict accordance with the Specification, the Drawings and the directions of the Engineer.

5.14.1 Material Requirements

a. Mineral aggregate

Mineral aggregate for bituminous base course shall consist of coarse aggregate, fine aggregate and filler material, if required, all conforming with the following requirements:

Coarse aggregate which is the material retained on AASHTO No. 4 sieve shall consist of crushed rock, crushed gravel or crushed boulder. It shall be clean, hard, tough, sound, durable, free from decomposed stones, organic matter, shale, clay lump or other deleterious substances. Rock or boulders from which coarse aggregate is obtained, shall be of uniform quality throughout the quarry.

The crushing shall be so regulated that at least ninety five (95) percent by weight of material retained on AASHTO No. 4 sieve shall consist of pieces with at least two (2) mechanically fractured faces, and when tested for stability of bituminous mix shall show satisfactory stability.

Fine aggregate which is material passing No. 4 sieve, shall consist of 100% crushed material from rock or boulder. No natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, hydrated lime, hydraulic cement or other suitable mineral matter. However, in case the coarse aggregates are of quarzitic nature, then hydrated lime or a better material shall be allowed. At the time of use, it shall be sufficiently dry to flow freely. Filler material shall conform to following gradation:

Table 5-7: Gradation of Filler Material

US Standard Sieve	**Percent Passing by Weight**
No.30	100
No.50	95-100
No.200	70-100

The coarse and fine aggregates shall meet the applicable requirements:

(a) The percentage of wear by the Los Angeles Abrasion test (AASHTO T 96) shall not be more than forty (40%).

(b) The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T- 104) shall be less than twelve (12) percent.

(c) The Sand Equivalent (AASHTO T - 176) determined after all processing except for addition of asphalt cement shall not be less than forty five (45).

(d) Fine aggregates shall have a liquid limit not more than twenty five (25) and a Plasticity Index of not more than six (6) as determined by AASHTO T 89 and T-90.

(e) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimensions = 2.5:1).

(f) Stripping test shall be performed on coarse aggregates as described under AASHTO T-182 and only that material shall be allowed which qualifies the test.

(g) The coarse aggregates shall be checked if desired by the Engineer for cationic and anionic behavior so that their affinity with the bitumen to be used is verified.

(h) Petrographic examination of the coarse aggregate shall be conducted if so directed by the Engineer.

b. Asphaltic Material

Asphaltic Materials shall meet the relevant requirements of these Specifications. Asphalt binder to be mixed with the aggregate to produce asphaltic base shall be asphalt cement having penetration grade 40-50, 60-70 or 80-100 as specified by the Engineer. Generally, it will meet the requirements of AASHTO M - 20.

c. Asphalt Concrete Base Course Mixture

The composition of the asphaltic concrete paving mixtures for base course shall conform to Class A and/or Class B shown in the following table:

Table 5-8 Combined Aggregate Grading Requirements

Mix Designation	Class A	Class B
Compacted Thickness	50-80 mm	35-60 mm
Asphalt Content weight percent of total mix	3.5 (Min.)	3.5 (Min.)

Table 5-9: Combined Aggregate Grading Requirements.

Sieve Designation		Percent Passing by Weight	
mm	**Inch**	**Class A**	**Class B**
25	1	100	-
19	3/4	90-100	100
12.5	1/2	-	75-90
9.5	3/8	56-70	60-80
4.75	No. 4	35-50	40-60
2.38	No. 8	23-35	20-40
1.18	No. 16	5-12	5-15
0.075	No. 200	2-8	3-8

The asphalt concrete base course mixture shall meet the following Marshal Test Criteria:

Table 5-10: Marshal Test Criteria.

Compaction, number of blows each end of specimen	75
Stability	1000 Kg (Min)
Flow 0.25 mm (0.01 inch)	8-14
Percent air voids in mix	4-7
Loss of Stability	25% (Max.)
Percentage Voids in Mineral Aggregates (VMA)	As per Table 5.3 of MS-2

Mixes composed of larger size aggregates with maximum size up to 38 mm (1.5 inches) will be prepared according to modified Marshall Method as per MS-2 Asphalt institute, sixth edition, 1993 or the latest edition. The procedure is basically the same as the original method except for following differences that are due to the larger specimen size that is used:

(a) The hammer weighs 10.2 kg (22.5 lb.) and has a 149.4 mm (5.88 inches) flat tamping face. Only mechanically-operated device is used for the same 457 mm (18 inches) drop height.

(b) The specimen has a 152.4 mm (6 inches) diameter by 95.2 mm (3.75 inches) height.

(c) The batch weights are typically of 4 Kg.

(d) The equipment for compacting and testing (molds and breaking heads) are proportionately larger to accommodate the larger specimens.

(e) The mix is placed in the mold in two approximately equal increments, with spading performed after each increment to avoid honey-combing.

(f) The number of blows needed for the larger specimen is 1.5 times (75 or 112 blows) of that required for the smaller specimen (50 or 75 blows) to obtain equivalent compaction.

(g) The design criteria shall be modified as well, the minimum stability shall be 2.25 times and the range of flow values shall be 1.5 times normal-sized specimens.

(h) Similar to the normal procedure, following values shall be used to convert the measured stability values to an equivalent value for a specimen with a 95.2 mm (3.75 inches) thickness, if the actual thickness varies:

Table 5-11: Conversion of the Measured Stability Values

Approximate Height	**Specimen Volume (Cubic cm)**	**Correlation Ratio**

mm (inches)		
88.9 ($3^{1/2}$)	1608 to 1626	1.12
90.5 (3 9 /16)	1637 to 1665	1.09
92.1 (3 5 /8)	1666 to 1694	1.06
93.7 (3 11/16)	1695 to 1723	1.03
95.2 (3 3 /4)	1724 to 1752	1.00
96.8 (3 $^{13/16}$)	1753 to 1781	0.97
98.4 (3 7 /8)	1782 to 1810	0.95
100.0 (3 $^{15/16}$)	1811 to 1839	0.92
101.6 (4)	1840 to 1968	0.90

d. Job-Mix Formula

At least one (1) week prior to production, a Job-Mix Formula (JMF) for the asphaltic base course to be used for the project, shall be established jointly by the Engineer and the Contractor in the project laboratory. Job mix formula shall combine the mineral aggregates and asphalts in such proportion conforming to specification requirements.

The JMF shall be established by MARSHALL Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), sixth edition 1993, or the latest Edition.

The JMF, with the allowable tolerances shall be within the range as specified in Asphalt Concrete Base Course Mixture. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregate.

The ratio of wt. of filler (passing sieve No. 200) to that of asphalt shall range between 1—1.5 for hot climate areas with maximum ambient temperature more than 40oC.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto. Moreover, upon receiving the job-mix, approved by the Engineer, the Contractor shall adjust his plant to proportion the individual aggregates, mineral filler and asphalt to produce a final mix that, when compared to job mix formula shall be within the following limits, however, due to this variation in percentage of materials no individual sieve component shall fall outside the envelope given in Table 5-7 for applicable class of combined gradation.

Table 5-12 Maximum Allowable Variation of Materials

Retained No. 4 and larger	+ 7.0%
Passing No. 4 to No. 100 sieve	+ 4.0%
Passing No. 200	+ 1.0%

Table 5-13 Asphalt Content

Weight percent of total mix	+ 0.3%

In addition to meeting the requirements specified in the proceeding items, the mixture as established by the JMF shall also satisfy the following physical property.

Loss of Marshall Stability by immersion of specimen in water at sixty (60) degree centigrade for 24 hours as compared with stability measured after immersion in water at 60 degrees centigrade for 20 minutes shall not exceeds twenty five (25) percent. If the mixture fails to meet this criterion, JMF shall be modified or an anti-stripping agent shall be used.

Should a change of sources of materials be made, a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, a new Job Mix Formula will be required.

5.14.2 Construction Requirements

a. Bituminous Mixing Plant

Plants used for the preparation of bituminous mixtures shall be "Batching Plants" conforming to AASHTO M 156, and of adequate capacity, coordinated and operated to produce a mixture within the limits of these specifications. Plant shall have minimum three cold bins and at least 3.5 decks of hot sieves.

b. Preparation of Aggregates

Before being fed to the dryer, aggregates for the asphaltic base courses shall be separated into three or more sizes and stored separately in cold bins. One bin shall contain aggregate of such size that eighty (80) percent will pass sieve No. 4, and the other two bins shall contain aggregate of such sizes that eighty (80) percent will be retained on sieve No. 4. Should fine material, be incorporated in the mix, separate bin shall be provided in addition to the three bins mentioned above. If filler is used as a separate component it will also be stored and measured separately and accurately before being fed into the mixer through filler screw mechanism.

Asphalt cement shall be heated within a temperature range of hundred and thirty five to hundred and sixty three (135-163) degrees centigrade at the time of mixing. Asphalt cement heated above maximum shown shall be considered overheated and shall be rejected and removed from job site.

Dried aggregate weighed and drawn to pug mill shall be combined with proportionate quantity of asphalt cement according to the job mix formula. Temperature of asphalt, except for temporary fluctuations, shall not be lower than fifteen (15) degrees centigrade below the temperature of the aggregate, at the time; the two materials enter into the pug mill.

For placing the materials in bins or in moving them from bins to the dryer, any method which causes segregation or uncontrolled combination of materials of different grading shall be discontinued and the segregated or degraded materials shall be prescreened for reuse.

Each aggregate ingredient shall be heated and dried at temperature not to exceed hundred and sixty three (163) degrees centigrade. If aggregate contain sufficient moisture to cause foaming in the mixture or their temperature is in excess of hundred and sixty three (163) degrees centigrade, they shall be removed from the bins and returned to their respective stock piles. In no case, shall the temperature of asphaltic mix exceed 163 degrees centigrade when discharged from the pug mill.

Immediately after heating, the aggregates shall be screened to required sizes and stored in separate hot bins for batching and mixing with bituminous material.

Asphalt plant shall have minimum three and half (3 $^{1}/2$) sieve decks to effectively control the gradation of hot bins.

c. Hauling Equipment

Dump truck used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with an approved material to prevent adhering of material to the beds. Each truck shall have a cover of canvas or of other suitable material of sufficient size as to protect the mixture from the weather. The mixture will be delivered on the road at a temperature not less than hundred and thirty (130) degree C. Drivers of dump trucks will ensure that while reversing the vehicles, paver is not pushed back producing a hump.

d. Bituminous Pavers

Bituminous pavers shall be self-contained, power-propelled units, provided with an automatically controlled activated screed or strike-off assembly, heated if necessary, capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thickness shown on the plans. Pavers used for shoulders and similar construction shall be capable of spreading and finishing course of bituminous plant mix material in widths shown on the plans.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The paver shall be equipped with automatic feed controls, properly adjusted to maintain a uniform depth of material ahead of the screed.

The screed or strike-off assembly shall be capable of producing a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture. When laying the mixtures, the paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture. The paver shall be operated at speeds which will give the best result for the type of power being used.

The mixed material shall be delivered to paver in time to permit completion of spreading, finishing and compaction of mixture during day light hours.

The paver shall be equipped with automatic screed controls with sensors for either or both sides of the paver, capable of sensing grade from an outside reference line, sensing the transverse slope of the screed and providing the automatic signals which operate the screed to maintain the desired grade and transverse slope. The sensor shall be so constructed that it will operate from a reference line or a ski-like arrangement.

The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent variation.

Manual operation will only be permitted in the construction of irregularly shaped and minor areas.

Whenever a breakdown or malfunction of the automatic controls occurs, the equipment may be operated manually or by other methods in order to allow the contractor to use the asphalt already produced at the plant or in transit, provided this method of operation will produce results otherwise meeting the specifications.

Reference lines will be required for both outer edges of the traveled way for each main line roadway for vertical control. Horizontal control utilizing the reference line will be permitted. The grade and slope for intermediate lanes shall be controlled automatically from reference lines or by means of a ski and a slope control device or a dual ski arrangement. When the finish of the grade prepared for paving is superior to the established tolerance and, when in the opinion of the Engineer, further improvement to the line, grade, cross sections and smoothness can best be achieved without the use of the reference line, a ski-like arrangement may be substituted subject to the approval of the Engineer. The use of the reference lines shall be reinstated immediately whenever the Contractor fails to maintain a superior pavement. The Contractor shall furnish and install all pins, brackets, tensioning devices, wire and accessories necessary for satisfactory operation of the automatic control equipment.

e. Rollers

Rollers shall be steel wheel, pneumatic tyre and vibratory, or a combination thereof. The roller(s) shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Vibratory rollers shall be acceptable for bituminous mixture compaction. The use of equipment, which results in excessive crushing of the aggregate, will not be permitted.

f. Preparation of Base

Before spreading materials, the surface of base on which the mix is to be placed shall be conditioned by application of a prime or tack coat as specified.

After a prime coat is applied, it shall be left undisturbed not less than twenty four (24) hours. The Contractor shall maintain the primed surface until the mix material has been placed. This maintenance shall include the spreading of sand or other approved material, if necessary to prevent adherence of the prime coat to the tyres of vehicles using the primed surface, and patching any breaks in the primed surface with additional bituminous material. Any area of primed surface that has become damaged shall be repaired before the mix is placed, to the satisfaction of Engineer. It shall be ensured that primed surface is not in tacky condition, when premix is laid.

When the surface of the existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by leveling course as directed. The leveling course mixture shall conform to the requirements of Item 5.14.1

A thin coating of bituminous material shall be sprayed on contact surface of curbing, gutters, manholes, and other structures, prior to the bituminous mixture being placed against them.

g. Spreading and Finishing

The mixture shall be laid upon an approved surface, spread and struck off to the section and elevation established. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.

The longitudinal joint in one layer shall offset to that in the layer immediately below, by approximately 15.0 cm; however, the joint in the top layer shall be at the centerline of the pavement if the roadway comprises two lanes of width, or at lane lines if the roadway is more than 2 lanes in width.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be spread, raked and luted by hand tools. For such areas the mixture shall be dumped, spread and screeded to give the required compacted thickness, ensuring even distribution of coarse and fine material.

When production of the mixture can be maintained and wherever practical, pavers shall be used in echelon to place the wearing course in adjacent lanes and compacted to form a surface without lateral joint.

All mixtures shall be spread at a temperature of not less than hundred and thirty (130) degree C and all initial rolling or tamping shall be performed when the temperature of the mixture is such that the sum of the air temperature plus the temperature of the mixture is between 165 degrees C and 190 degrees C, subject to "Weather Limitations". The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

h. Compaction

After spreading and strike off and as soon as the mix condition permits the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted. Rolling shall not be prolonged when cracks appear on the surface.

Initial or breakdown rolling shall be done by means of either a tandem steel roller or three wheeled steel roller. Rolling shall begin as soon as the mixture will bear the roller without undue displacement.

The number and weight of rollers shall be sufficient to obtain the required compaction while the mixture is still in workable condition. The sequence of rolling and the selection of roller types shall provide the specified pavement density. Initial rolling with a tandem steel roller or a three-wheeled steel roller shall follow the paver as closely as possible.

Unless otherwise directed, rolling shall begin at the lower side and proceed longitudinally, parallel to the road centerline, each trip overlapping one-half of the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On super elevated curves the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the centerline. Intermediate rolling with a pneumatic tyred roller shall be done behind the initial rolling. Final rolling shall eliminate marks from previous rolling. In no case shall the temperature be less than hundred and twenty (120) degree C. for initial break down rolling while all other compaction operations shall be completed before the temperature drops down to hundred and ten (110) degree C.

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until all roller marks are eliminated and a minimum density of Ninety seven (97) percent of a laboratory compacted specimen made from asphaltic material obtained for daily Marshall density is achieved.

Any displacement resulting while reversing the direction of a roller, or from other causes, shall be corrected at once by the use of rakes and addition of fresh mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture.

To prevent adhesion of the mixture to the rollers, wheels of rollers shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers. On depressed areas, tempers be used or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective in finish or density shall be removed and replaced with fresh hot mixture, which shall be compacted to conform with the surrounding area. Any area showing an excess or deficiency of bituminous material shall be removed and replaced.

Sequence of laying and compaction of premix shall be so managed, that a long time does not elapse between successive dump trucks, which may cool down the uncompacted premix, between paver and compacted asphalt below 120o C.

i. Frequency of Testing for Cores

One core shall be taken for each 100 linear meter of each lane of Asphaltic Base, or fraction thereof, in special cases. If the core so taken is failed against the specified 97% density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) meters on either side with respect to the failing core and shall be tested against field density. If all the three cores give an average of 97% compaction, and the individual compaction of the core is not less than ninety five (95) percent, then the compaction is acceptable. If average of the cores further fails against compaction, then retake the cores at a distance of fifteen (15) meters on either side and compaction shall be checked for all the five cores in the same fashion. If average of five cores is 97%, the area will be accepted. In case average is ninety six 96% or more, then Engineer may withhold the payment in full or partly and observe behavior during maintenance period, for the release of payment or otherwise. In case of failure of the average of these five cores giving average compaction of less than 96%, the failed area shall be removed and subsequently be replaced by specified mix in an approved manner at the expense of contractor.

j. Surface Tolerances

After completion of final rolling, the finished surface shall be tested for smoothness with three (3) meters straightedge by Engineer at selected locations. The variation of surface from testing edge of straight edge between any two (2) contacts with the surface shall at no point exceed six (6) millimeters when placed either parallel or perpendicular to centerline of roadway.

Any irregularities that exceed the specified tolerances or that retain water on the surface shall be corrected by removing the defective area and replacing with new asphaltic base course without additional cost to the Employer.

k. Base Thickness Tolerances

For determination of thickness, one (1) core for each hundred (100) linear meter of each lane shall be taken. Unless otherwise permitted, cores extracted for thickness measurement shall not be used for density determination and density cores shall not be used for thickness measurements.

When layer thickness of asphaltic base course is deficient by more than five (5) mm from that specified in the Drawings, the deficiency shall be removed with satisfactory base course material and/or made up by additional asphalt concrete wearing course thickness without extra cost to the Employer. If such remedial action is authorized, revised thickness determinations shall be made by measurements of new cores taken after placing of "Asphaltic Wearing Course" material or as directed by the Engineer. If base course deficiencies are corrected in this manner, full payment for the "Asphaltic Base Course" will be made to the Contractor, but no additional payment will be made for the increase in thickness of the "Asphaltic Wearing Course".

l. Acceptance Sampling and Testing

Acceptance of samples and testing of materials and construction requirements, shall be governed by the relevant, "Table for Sampling and Testing Frequency" or as approved by the Engineer.

m. Weather Limitations

Hot asphaltic mixtures shall be placed only when the rising air temperature is four (4) degrees centigrade or above and no asphalt shall be laid under foggy or rainy weather or over moist surface.

n. Trial Section

Contractor shall prepare a trial section before the start of work to the satisfaction of the Engineer.

5.15 Asphaltic Concrete Wearing Course

This work shall consist of furnishing and mixing aggregates and asphalt binder at a central mixing plant, transporting, spreading and compacting the mixture on a prepared base in accordance with these specifications and to the lines, grades and typical pavement sections shown on the Drawings or as directed by the Engineer.

5.15.1 Material Requirements.

a. Aggregates.

Coarse and fine aggregates shall be clean, hard, tough, sound particles free from decomposed material, vegetable matter and other deleterious substances, and be of uniform quality, geology and petrology. Water borne material such as river bed gravel, if used, shall also conform to the above criteria.

Coarse aggregate, which is material retained on the No. 4 sieve, shall consist of crushed rock, crushed gravel or a mixture of natural and crushed gravel. The aggregate shall contain no more than 8% by weight of flats/or elongated particles (ratio maximum to minimum 5:1) and shall contain 100% angular material, such that all faces of each piece are fractured faces in cuboid shape.

Fine aggregate, which is material passing the No. 4 sieve shall consist of 100% crushed material from rock or boulder. No natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing the No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock crust, hydrated lime, hydraulic cement or other suitable mineral matter and shall conform to the following gradation:

Table 5-14: Gradation of Filler Material

US Standard Sieve	Percent Passing by Weight
No. 30	100
No. 50	95-100
No. 200	70-100

The Coarse and fine aggregates shall meet the following requirements:

(a) The percentage of wear by the Los Angles Abrasion test (AASHTO T 96) shall not be more than 40%.

(b) The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T 140) shall be less than 12%.

(c) The Sand Equivalent (AASHTO T-176) determined after all processing except for addition of asphalt cement should not be less than 45.

(d) All aggregates shall have a liquid limit of not more than 25% and a Plasticity Index of not more than 4 as determined by AASHTO T-89 and T-90.

(e) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimensions = 2.5:1).

b. Asphaltic Material

Asphaltic binder to be mixed with the aggregate to produce asphaltic base shall be as asphalt cement penetration grade 40-50, or 60-70 or 80-100, as specified by the Engineer. Generally, it will meet the requirement of AASHTO M-20.

c. Asphalt Concrete Wearing Course Mixture.

The composition of the asphaltic concrete paving mixture for wearing course shall conform to class shown in table 4-15, the compacted thickness of wearing course shall be 50 mm as per drawing.

Table 5-15: Combined Aggregate Grading Requirements

Sieve mm	**Designation Inch**	**Percent Passing by Weight**
25	1	100
19	3/4	90-100
9.5	3/8	56-80
4.75	No. 4	35-65
2.38	No. 8	23-49
0.30	No. 50	5-19

0.075	No. 200	2-8

The asphalt concrete wearing course mixture shall meet the following Marshal Test Criteria:

Table 5-16: Asphalt Concrete Wearing Marshal Test Criteria

Asphalt Content Weight Percent of total mix.	**3.5 (min)**
Compaction, number of blows each end of Specimen	75
Stability (Minimum)	1000KG
Flow, 0.25 mm (0.01)	8-14
Percent air voids in mix	4-7
Percent voids in mineral aggregate	according to article 5.3, MS-2, (Asphalt Institute USA) 6 t h edition 1993
Loss of stability	20% Max
Filler/Bitumen ratio	1-1.5 (applicable to hot climate > 40 oC.)

Table 5-17 Maximum Allowable Variation of Materials

Retained on No. 4	+ 7.0%
Passing No. 4 to No. 100 sieves	+ 4.0%
Passing No. 200	+ 1.0%

Table 4-18 Asphalt Content.

Weight percent of total mix	+ 0.3%

Should a change of sources of materials be made a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other conditions made it necessary, a new Job Mix Formula will be required.

d. Job-Mix Formula

At least one week prior to production, a Job-Mix Formula (JMF) for the asphaltic concrete course mixture or mixtures to be used for the project, shall be established jointly by the Engineer and the Contractor.

The JMF shall be established by Marshal Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), May 1992 Edition.

The JMF, with the allowable tolerances, shall be within the master range specified in Table 214-2. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregates.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto with the tolerances as per combined aggregate gradation table 5-17 of these specifications.

5.15.2 Construction Requirements

Construction requirements for this item shall conform with the same construction requirements specified for Asphaltic Concrete Base Course Plant Mix under clause 5.14.2, except as modified in the following sub-items.

a. Preparation of Base Course Surface.

Before spreading materials, the surface of the previously constructed and accepted base course on which the mix is to be placed shall be conditioned by application of a tack/or prime coat, as directed by the Engineer.

b. Pavement Thickness and Tolerances

The asphalt concrete binder course shall be compacted to the desired level and cross slope as shown on the drawings or as directed by the Engineer.

The tolerances in compacted thickness of the binder course shall be + 10 percent from the desired thickness shown on the drawings. For determination of the thickness, one (1) core per hundred meters of each lane will be taken. If the thickness so determined is deficient by more than + 10 percent, the Engineer shall decide whether to accept the deficit thickness or to direct reconstruction.

The surface of the binder course shall be tested by the Engineer using at 3-meter straight edge at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts, longitudinal or transverse with the surface shall at no point + 5.0 millimeters. The cross fall (camber) shall be within + 0.2 percent of that specified, and the level at any point shall be within drawings. All humps or depressions exceeding the specified tolerance shall be corrected by removing the defective works and replacing it with new material, by overlaying, or by other means satisfactory to the Engineer.

5.16 Pre-Cast Concrete Kerb Stone and Paver Block

Pre-cast concrete kerb stone and paver blocks shall be of minimum concrete strength of 3000 psi and 6000 psi respectively, shape and size as specified in drawing.

5.17 Lane Marking

This work shall consist of furnishing reflective chlorinated rubber based paint material on the pavement surface all in accordance with these Specifications.

The paint shall be applied in conformance to the size, shape and location of the markings as shown in the Drawings.

A standard and acceptable quality of Chlorinated Rubber based paint shall be used. The paint shall be ready for application and shall be of a smooth quality. The paint shall be homogeneous, well dispersed to a smooth consistency and shall not cake, liver, thicken, curdle, gel, settle badly or show any objectionable properties after period of storage not to exceed six (6) months.

5.17.1 Composition White Traffic Paint

i. Pigment	Titanium Dioxide Rutile and extenders	100%
ii. Vehicle	Modified Chlorinated Rubber	
	Plasticized and Resin Blend	52±4%
	Solvents	45±4%
	Additives i.e. Flow leveling, adhesion improving agents, anti-oxidants	
	Siccative's etc.	1- 3%
iii.Paint Composition:	Pigments	55±4% by Weight
	Vehicle, Solvent and Additives	45±5% by Weight

Yellow Traffic Paint

I.Pigment:	Chrome Yellow and Extenders	100% by Weight
II. Vehicle :	Same as for white traffic paint	
III.Paint Composition:	Pigments	55±4% by Weight
	Vehicle, Solvent and Additives	45±5% by Weight

The volatile material shall be of such character that has a minimum solvent action of asphalt, and such that the resins and non-volatile components will be entirely dissolved in the volatile material, and will not precipitate from the solution on standing. The non-volatile material shall be of such quality that it will not darken or become yellow when a thin section is exposed to the sunlight.

Other pavement marking paint may be submitted by the Contractor as an alternative to the above, for the approval of the Engineer.

Traffic markings shall be applied with approved equipment capable of applying the paint at the specified width and at the specified rate of application. In no case shall the Contractor proceed with the work until the equipment, method of application and rate of application as established by a test section have been approved by the Engineer

The painting of lane markers and traffic strips shall include the cleaning of the pavement surfaces, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic on the pavements, the protection of all parts of the road, structures or appurtenances against disfigurement by spatters, splashes or smirches of paint or of paint materials, and the supplying of all tools, labor and traffic paint necessary for the entire work.

The paint shall not be applied during rain, wet weather, when the air is misty, or when, in the opinion of the Engineer, conditions are otherwise unfavorable for the work. Paint shall not be applied upon damp pavement surfaces, or upon pavements which have absorbed heat sufficient to cause the paint to blister and produce a porous paint film.

The application of paint shall preferably be carried out by a purpose-made machine but where brushes are used only round or oval brushes not exceeding 10 cm. in width will be permitted. The paint, when applied, shall be so applied as to produce a uniform, even coating in close contact with the surface being painted.

Traffic paint shall be applied to the pavement at a rate of one (1) liter to two and half (2.5) square meters or less. Contractor shall provide adequate arrangements that applied paint is not disfigured by moving traffic, till its complete drying and sticking to road surface.

5.18 Reflectorized Pavement Studs

Reflectorized Studs shall be "cat-eyes" either the 'Flush Surface' type of Raised Profile' type having the following characteristics.

5.18.1 Flush Surface Type

The 'Flush Surface' reflector shall be the short base type having a maximum base area of 18 cm x 14 cm or as shown on the Drawings.

The base shall be formed in cast-iron with adequate webbing to ensure a firm key to the road when installed.

The pad shall be highly resilient and durable rubber reinforced with canvas and shall have an anticipated life of at least five (5) years. The pad shall be so designed as to produce a self-whipping action of the reflector when depressed.

The reflectors shall be made of impact and abrasion resisting glass and shall be hermetically sealed into a copper socket.

5.18.2 'Raised Profile' Type

The 'Raised Profile' reflectors shall consist of an acrylic plastic shell filled with an adherent epoxy compound moulded from methyl methacrylate into the shape of a shallow frustum of a pyramid having base dimension of approximately 10 cm x 10 cm and thickness not more than two (2) cm or as shown on the drawings.

The shell shall contain one or two prismatic reflector each inclined at an angle of thirty (30) degree to the horizontal and having an area not less than twenty (20) square cm or as indicated on the plans.

The reflectors shall attain the following standards for their photometric and physical qualities:

5.18.3 Photometric Requirements

The reflectors shall have the following minimum Specific Intensity values (S.I) expressed as candle power per foot candle of illumination at the reflector on a plane perpendicular to the incident light.

Table 5-19: Specific Intensity values for reflectors.

	COLOUR		
	Crystal	**Yellow**	**Red**
Divergence Angle	0.20	0.20	0.20
(in Degree)	S.I.	S.I.	S.I.
Incidence Angle			
0	3.00	1.80	0.75
20	1.20	0.72	0.30

The reflector for testing shall be located with the center of the reflecting face at a distance of one and half (1.5) m from a uniformly bright light source having an effective diameter of half (0.5) centimeter.

The width of the photocell shall be 1.27 cm and shall be shielded from stray light. The distance from the centers of the light source and photocell shall be 0.53 cm.

Failure of more than four (4) % of the reflecting faces shall be cause for rejection of the lot.

5.18.4 Strength Requirement

The reflectors shall support a vertical load of 1000 kg when tested in the following manner.

A reflector shall be cantered horizontally over the open end of a vertically positioned hollow metal cylinder seventy five (75) mm internal diameter, twenty five (25) mm high and wall thickness of six (6) mm. The load shall be applied to the top of the reflector through a six (6) mm diameter by six (6) mm high metal plug centered on top of the reflector.

Failure shall constitute ether breakage or significant deformation of the marker at any load less than one thousand (1000) kg.

5.18.5 Epoxy Adhesive

When 'Raised Profile' type reflectors are used, a two-component epoxy adhesive conforming to Type-I (Rapid Setting) or Type-II (Standard Setting) as per AASHTO M 237 shall be applied to the stud for bonding to the pavement surface. Adhesive primarily composed of asphaltic material shall not be used for bonding of studs to the pavement.

5.19 Traffic Road Signs

This work shall comprise furnishing and installing traffic signs, permanent safety devices and post assemblies in accordance with these specifications and to the details shown on the Drawings. All sign faces and lettering shall be in accordance with NHA sign standards or as shown on plans. Prior to manufacture and fabrication of the signs the contractor shall submit to the Engineer for approval detailed drawings showing letter sizes, traffic symbols and sign layout. The permanent safety devices shall consist of road posts and hazard markers and will be provided as per specifications, drawings or as directed by the Engineer

5.19.1 Material Requirements

Sign Panels Sign panels for regulatory, warning and informatory signs shall be manufactured from aluminum alloy conforming to ASTM B 209, alloy 6061-T6 or 5052-H38 plates of three (3) mm thickness as shown on the drawings. The planks shall be free from laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. The thickness shall be uniform and the plank commercially flat. Perform shearing, cutting and punching before preparing the planks for application of reflective material. The planks shall be cleaned, degreased, and chromate or otherwise properly prepared according to methods recommended by the sheeting manufacture

a. Reflective sheeting

Reflecting Sheeting used on road sign shall be made of flexible white or colored, wide angle retroreflective sheeting (herein after called sheeting), and related processing materials designed to enhance nighttime visibility. The sheeting shall consist of prismatic optical elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface. Sheeting shall comply with ASTM D-4956-09 and shall be of one of the six (6) types as specified:

b. Color Requirements.

Daytime color and nighttime color shall be specified and conform to the requirements of NHA standards. The Contractor shall submit shop drawings of traffic Sign boards as directed by the Engineer.

c. Performance Requirements and Obligation.

The sign manufacturer shall submit a certificate from the sheeting manufacturer stating that the sheeting used for finished retroreflective signs meets all requirements and Tested in accordance with ASTM D-4956

The reflective material shall be weather-resistant and following cleaning, shall show no definite fading, darkening, cracking, blistering or peeling and shall have not less than seventy five (75) % of the specified wet or dry minimum brightness values when exposed to normal weathering for seven (7) years.

d. Metal Posts and Plates

Wide flange of 10 x 10 centimeters metal posts shall be fabricated from structural steel conforming to the Specifications of ASTM A-283 Grade-D. In lieu of wide flange steel posts the Contractor may use tubular steel posts of minimum internal and external diameters of sixty three (63) mm and seventy five (75) mm respectively conforming to the specifications of ASTM A-501. All posts shall be thoroughly cleaned, free from grease, scale and rust, and shall be given one coat of rust inhibitive priming paint and two coats of grey paint. Length of the posts shall be such that their top flushes with the top of the sign penal, whereas bottom of sign panel is at least hundred and eighty (180) centimeters above shoulder level.

Plates shall be non-porous, smooth, flat, rigid, weather proof and shall not rust or deteriorate otherwise. It shall be so cut that there are no sharp edges and that the corners are rounded off to a radius of thirty seven and half (37.5) mm. Any trade mark or other printing shall be carefully removed with liquid thinner.

The reflective sheeting for the background should cover the whole area of the sign plate.

Prior to application of the reflective sheeting, the sign plate shall be cleaned and shall be wax-free. They shall be degreased by vapor or by alkaline immersion and etched by scrubbing with abrasive cleaner. The plate shall be rinsed thoroughly and dried with hot air before applying the sheets.

The sheeting after application to the sign base shall not come off the edges, which shall be sealed, nor shall it peel off nor warp. The surface shall be smooth and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weather-proof.

e. Concrete Foundation Blocks

The concrete for the foundation blocks shall be in situ Class C in accordance with specification and shall of the size 450 x 450 x 650 mm.

5.20 Stone Pitching

This work shall consist of furnishing and laying dry and grouted stone pitching works, on grades and on slopes, in accordance with these specifications and to the lines, grades, thickness and cross-sections shown on the Drawings and/or as directed by the Engineer.

The stones shall comprise good, hard and durable broken boulders or pieces of rocks, from a source approved by the Engineer. These shall be sound, dense, resistant to the action of air and water and suitable in all aspects for the purpose intended. Stones to be used for pitching, shall confirm to the following specifications:

Table 5-20: Stone Pitching Specifications

Description	Class A	Class B
Application	Heavy Pitching	Light Pitching
Range of weight of stones	15-25 kg	10-15 kg
At least 50% stones by weight to have weight more than	20 kg	12 kg
Depth of stones	20-25 cm	15-20m

Mortars, where used in the stone pitching, shall conform to the requirements as specified in block masonry work.

The sub-grade or gravel bed, as the case may be, upon shall be firm and compacted to the specified degree, as shown in the Drawings or as which pitching is to be laid, directed and approved by the Engineer.

The stones shall be roughly dressed and shaped, to the satisfaction of the Engineer.

5.20.1 Dry Pitching

The stones shall be securely bedded with breaking bond and closely packed with all interstices filled with selected stone aggregates hammered in, all to secure a stable mass. The stones shall be placed by manual dumping or other methods approved by the Engineer.

The edges of pitched areas shall be protected from undermining by the use of edge stones at least twice the general size and weight set on end. In large or sloping areas of pitching, key stones shall be provided at the rate of one per square meter, at least one and a half times the general size and weight, set on end.

5.20.2 Grouted Pitching

The materials and their mix proportions, by volume, for mortars, where used in the stone pitching, shall be as shown in the Drawings and/or specified in the Bill of Quantities.

Preparation and use of mortars, where used in the stone pitching, shall be in accordance with the requirements as specified in masonry work.

The surfaces of the rock shall be cleaned of adhering dirt and clay and shall be moistened, before being laid.

Stones shall be carefully arranged by hand to inter lock and so as to yield true and even surface with minimum voids and conforming to the contour required.

The exposed surface of the stones shall project not less than four (4) centimeters and not more than eight (8) centimeters of the grout surface.

The grouted stone pitching shall be cured by an approved method for a minimum period of 10 days and after expiration of the curing period, the exposed surfaces shall be cleared of all curing mediums.

Any mortar, which falls from the joints or removed due to raking of joints shall not be reused and must be cleaned and removed from work-site at the end of the day.

5.21 Measurement and Payments

5.21.1 Clearing and Grubbing

Clearing and grubbing will be measured for payment only on areas so designated in writing by the Engineer or shown on the drawings. The quantity to be paid for shall be the number of square meters satisfactorily cleared and grubbed. Any tree having girth of less than 150 mm (measured 600 mm above ground level) shall be measured to be under this item. Engineer shall ensure that a minimum of 500 SM area is designated for clearing and grubbing in any stretch of roadway for the sake of ease to construction activities. Clearing and grubbing carried out by the Contractor in roadway cut areas and borrow pits shall not be measured for payment.

The quantities determined as provided above will be paid for at the contract unit price for the pay item mentioned and shown in the Bill of Quantities, which price and payment shall be full compensation for clearing and grubbing and restoration of area, to its original condition.

5.21.2 Removal of Trees

Engineer and Contractor shall jointly measure the girth and number of trees to be removed under this item. Any tree having a girth of less than 150 mm measured six hundred (600) mm above ground level shall Not be measured under this item, as the same shall be removed under item "Clearing and Grubbing".

The quantities determined as provided above shall be paid for at the contract unit price for the pay item mentioned in the Bill of Quantities which price shall be deemed to include all cost of labour equipment and incidental related to the item.

5.21.3 Stripping

Measurement shall be made by multiplying the length, breadth and depth of layer approved by the Engineer in cubic meter of material removed and disposed as directed by the Engineer. However, space thus created shall be filled by the material as directed by the Engineer and paid separately under relative item.

The payment under this item shall be made for at the contract unit price per cubic meter of stripping measured as above, for removal of material to a depth approved by the Engineer including its disposal at designated place and in the manner as directed by the Engineer.

5.21.4 Natural ground Preparation

The measurement shall be made by multiplying the length and breadth of the area approved in writing by the Engineer to be paid under this item. The measurement of the item shall be in Square meter. Any subsidence of levels of Natural Ground due to compaction under this item shall not be measured for payment, the contractor is expected to take care of such factors while bidding.

The payment under this item shall be made for at the contract unit price for Square meter of compaction of (natural) ground measured as above and shall be deemed to include cost of scarification, watering, mixing, leveling, rolling, labor, equipment, tools, and incidentals necessary to complete this item.

5.21.5 Formation of Embankment

The quantities to be paid for shall be the number of cubic meters calculated on theoretical designed lines and grades and the ground levels, compacted in place, accepted by the Engineer.

The quantity to be paid for shall be the number of cubic meters placed in embankment, measured as provided above for material from borrow excavation and such a payment will be deemed to include cost of excavation, borrow material, payment of royalty, levies and taxes of

Local, Provincial Government, cost of hauling including lead and left up to 5km from project area, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item.

The quantity to be paid for shall be the number of cubic meters placed in embankment and measured as provided above for material from roadway or structural excavation and such payment will be deemed to include cost of excavation, hauling, dumping, spreading, watering, rolling, labor, equipment, tools and incidental necessary to complete this item.

5.21.6 Subgrade

The quantity to be paid for shall be the number of square meters of subgrade prepared as herein before prescribed and accepted. Subgrade in rock cuts and on embankment not consisting of the existing road surface in fill area shall not be measured for direct payment. Subgrade preparation on "Existing Surface" shall only be measured and payment shall be made subgrade preparation in earth cut when ordered by the Engineer.

The quantities, determined as provided above, shall be paid for at the contract unit price respectively, for each of the particular pay items that is shown in the Bill of Quantities which prices and payment shall be full compensation for furnishing of material, water, equipment, tools, labor, and all other items necessary for completion of work.

5.21.7 Sub Base, Base Course, Bituminous Coat and Surface Treatment

Measurement, for sub base, base courses, bituminous coat and surface treatment will be made in the specified units, of theoretical volume of compacted sub base, base courses, bituminous coat and surface treatment, acceptably placed, on the basis of the dimensions, for the neat pavement finish lines, in accordance with the Drawings or directions of the Engineer.

Payment for sub base, base courses, bituminous coat and surface treatment will be made for the respective quantities of these items, measured at unit rates, tendered in the priced Bill of Quantities.

The unit rates tendered for sub base, base courses, bituminous coat and surface treatment shall be deemed to be inclusive of, but not limited to the following:

(a) Providing all materials

(b) All operations related with transportation, involved in the process

(c) All operations related with storage of materials

(d) All sorts of wastages

(e) All operations including placing, mixing, spreading, watering, rolling and compaction, of the materials; and maintenance, protection and repairs, of the courses

(f) Carrying out all sampling and testing

(g) All other operations, procedures and requirements necessary to complete the work in accordance with these specifications.

No measurement and payment shall be made for providing and maintaining access track throughout the length of the project.

No separate payment shall be made inter alia for complying with the provisions of Chapter 5 of the Specification; selection of materials; preparation and restoration of borrow pits; placing and compaction; control of moisture content; bulking; shrinkage; site trials; testing; forming to tolerances; bedding and haunching of kerbs; bedding and surrounds of drains and pipes, surveys of routes.

5.21.8 Stone Pitching

Except where otherwise laid down in the Bill of Quantities, measurement, for stone pitching will be made in the specified units of area, of stone pitching, of specified type and thickness, acceptably placed, on the basis of the dimensions, for the neat pitching finish lines, in accordance with the Drawings or directions of the Engineer.

Payment, for stone pitching, of specified type and thickness, will be made for the quantity of stone pitching, measured in accordance with the unit rates, tendered in the priced Bill of Quantities.

The unit rates tendered, for stone pitching, shall be deemed to be inclusive of, but not limited to the following:

(i) Providing all materials for stone pitching layer and the aggregate/gravel base (if any)

(ii) All operations related with transportation, involved in the process

(iii) All operations related with storage of materials

(iv) All sorts of wastages

(v) All operations including mortar preparation, grouting and curing (in case of grouted pitching only); cutting, dressing and laying, of stones; laying and compaction of aggregate/gravel base (if any) and protection, maintenance and repairs, of the work

(vi) Carrying out all sampling and testing

(vii) All other operations, procedures and requirements necessary to complete the work in accordance with these specifications.

Except where otherwise specified in the Bill of Quantities, preparation and compaction of the sub-grade shall be measured and paid separately.

5.22 Measurement and Payments

Where payment for the construction of the road network is to be based on the pavement area of the asphalt concrete road and the rate shall include items of works including sub-grade, sub-base, aggregate base coarse, prime coat, wearing coarse, kerb stone, paver etc. with compaction, concrete and filter material etc as detailed in the Specifications and drawings complete in all respects and as directed by the Engineer.

The cumulative percentage set against a stage of construction in the Appendix to Preamble is the percentage of the sum entered for the item or sub-item which may be paid to the Contractor upon certification by the Engineer that the relevant stage of construction and the preceding stages have been constructed in accordance with the Contract.

The unit rates tendered for asphalt concrete road works shall be deemed to be inclusive of, but not limited to the following:

(i) Providing all materials

(ii) All operations related with transportation, involved in the process

(iii) All operations related with storage of materials

(iv) All sorts of wastages

(v) All operations including placing, mixing, spreading, watering, rolling and compaction, of the materials; and maintenance, protection and repairs, of the courses

(vi) Carrying out all sampling and testing

(vii) All other operations, procedures and requirements necessary to complete the work in accordance with these specifications.

No measurement and payment shall be made for providing and maintaining access track throughout the length of the project.

No separate payment shall be made inter alia for complying with the provisions of Chapter 5 of the Specification; selection of materials; preparation and restoration of borrow pits; placing and compaction; control of moisture content; bulking; shrinkage; site trials; testing; forming to tolerances; bedding and haunching of kerbs; bedding and surrounds of drains and pipes, surveys of routes.

5.23 References

Following publications have been referred:

1. BS EN-1340 (BS 340) : Concrete Kerbs requirements and tests method.

2. BS-1377 : Methods of test for soils for Civil Engineering purposes. General requirements and sample preparation.

3. BS EN 13924 : Bitumen for building and civil engineering. Specification for bitumen for roads and other paved area.

4. BS EN 13108 : Coated macadam (asphalt concrete) Specification for

roads and other paved areas. Specifications for transport, laying and compaction.

5. AASHTO T-191 : Determination of the dry density of soil.

6. ASTM D-421 : Soil gradation analysis by mechanically vibrated sieves.

7. AASHTO T-96 : Los Angeles Abrasion test.

8. AASHTO T-104 : Sodium Sulphate Soundness test.

9. AASHTO T-176 : Determination of sand equivalent.

10. AASHTO T-89 and T-90 : Determination of Plasticity Index.

11. AASHTO T-193 : Determination of California Bearing Ratio.

12. AASHTO T-180 : Determination of maximum dry density by Method D.

13. AASHTO T-191 : Modified proctor test.

14. AASHTO T-182 : Stripping test on crush aggregates

15. AASHTO M-20 : Asphalt cement penetration test.

16. Asphalt Institute Manual Series No. 2 (MS-2), sixth edition 1993 or the latest Edition: Marshall method of mix design.

17. AASHTO T-89 : Plasticity Index.

18. AASHTO M-145 : Classification of Soil.

The Contractor shall provide the Engineer with records of grout pressures and quantities pumped during the filling operation.

CHAPTER 6 - Micro-Tunneling / Pipe Jacking Specific Codes & Specifications

All pipe jacking works for all pipeline sections shall be carried out by the Contractor on a full design-and-build basis. This includes the detailed engineering design, selection and procurement of all materials and equipment, installation, commissioning, performance testing and monitoring provisions, and provision of complete operation, maintenance and warranty documentation. The Contractor shall submit design calculations, shop drawings and manufacturer data sheets for approval by the Engineer prior to fabrication or installation, ensure compliance with relevant standards and project requirements, and deliver certified as-built records and performance certificates at handover. This aspect of the project will be based on a lump sum cost.

The sections below give the specifications that the contractor must comply with when performing the design-and-build for the pipe jacking for the transmission mains.

6.01 Trench less Crossings

Where open trench excavation for crossing of railways or roads any other utility services is not allowed, crossings shall be constructed by the use of trenchless methods.

6.02 General

Construction by the pipe jacking technique is preferred but suitable alternative methods will be considered by Engineer.

The work shall only be carried out by a specialist Sub-Contractor with proven experience in the particular methods of construction proposed.

The Contractor shall carry out the works to the approval of the Engineer and strictly in accordance with the requirements of the railway authority or Highway authority or the concerned department of utility agency.

The Contractor shall design the Permanent and Temporary Works to withstand all anticipated dead loads and traffic loading without damage to the pipeline and to prevent any adverse effects on the construction by way of settlement or otherwise.

The Contractor shall be solely responsible for obtaining all necessary permits, NOCs, and clearances from Railway, Highway, or Utility Authorities. This includes the payment of all associated fees, deposits, and the preparation of all technical documentation required by said Authorities.

6.03 Method Statement

The Contractor shall submit to the Engineer for approval a fully detailed Method Statement which shall include inter alia all design calculations, details of manufacture and suppliers of materials, details of vertical and horizontal loadings and pressures, means of maintaining control of line and level, type and method of pipe jointing and type and methods of grouting.

6.04 Sleeves

The diameter of the sleeves for jacking shall be larger than the outer diameter of pipe and shall be the smallest possible size to accommodate the pipe line and joints and allow free passage for in situ annulus grouting.

The sleeve pipes shall be approved by the Engineer and shall be steel.

The sleeve's material shall be fully compliant with a 50 years lifetime design hypothesis in the ground conditions where it will be left . In particular all effects of corrosion by the watertable (outside) and the water (inside) shall be prevented by a rigorous installation of the sleeve joints after welding of steel pipe joints.

The contractor shall propose a detailed method statement for the installation of the sleeve in the entry pits.

6.05 Shafts

The access and exit shaft shall be under the full responsibility of the contractor.

The client shall determine whether the shaft shall be useful for the operation of the network.

The contractor shall then anticipate and integrate the given information for the needs of water network operation and maintenance. (safe access for the operators, light and ventilation as needed).

The contractor shall integrate, in its execution drawings, all necessary place and reinforcement for the hydraulic equipment to be installed after jacking works.

In particular, the concrete slab shall be strong and waterproof enough for longtime service, if requested by the client.

The second phase of civil work shall be anticipated (concrete walls, precast walls or roof slabs, opening for lifting down all necessary equipment

If the client validate that both shafts (entry and exit) shall only be temporary works and have no use for the network operation, then the contractor shall proceed with a fully dismantlable construction system or , in the worst case, explain all the mitigation measure will be undertaken to cancel as much as possible any tracks of construction after the crossing is carried out. (Cutting of the steel sheets head, filling of the shaft with relevant soil compaction and stabilization.

6.06 Pipe Jacking

Excavation for pipe jacking shall be undertaken from within a shield equipped with steering jacks for adjustment of alignment. Face boards shall be available for boarding up the exposed excavation.

All geotechnical investigations, laboratory testing of soil and groundwater, and additional underground surveys required to validate the design and safety of the crossing shall be performed by the Contractor at their own expense.

The contractor shall carry out a detailed site investigation to determine soil characteristics in the vicinity of the excavation. The contractor shall propose strengthening or stabilization methods. Of the soils and the existing infrastructure within an area of minimum 20 meters around the pipe installation.

The contractor shall provide any additional underground survey and Risk's Analysis for the client's approval before starting any works on site.

When requested by the client, the contractor shall carry out any additional calculation note, or justification report, to justify the proposed methodology.

No excavation shall be carried out (nor pits, nor tunnel exaction) before the execution drawing has been duly approved by the engineer.

The contractor shall not be allowed to claim any additional time of money in the case of delay due to engineer or client visa's duties. It is the entire responsibility of the contractor to provide, on time, any relevant precision, clear and strong demonstration of its ability to face the risks of the project.

The Contractor shall provide continuous, experienced supervision of operations in order to maintain the line and level of the sleeve to a tolerance of + 75 mm of the true line and level shown on the Drawings. Adjustment of line and/or level should be gradual and the pipe manufacture's permitted draw or angular deflection shall not be exceeded at any individual joint.

The contractor shall provide a calculation note detailing the estimate jacking force for the project.

The contractor shall provide a detailed operational planning with the following items:

- Cadence of the excavation (average and peak) per team (shift)
- Number of shifts per 24 hours, and per week.
- Maximum time of
- Daily cadence and estimated time of completion of the work
- Critical path for the project, including time for ordering and delivering key elements (Jacking Pipes, jacking equipment, mobilization of working force)

The contractor shall explain when and how long time will occur periods of non-production once the excavation has started. An estimation of the impact on the friction forces on the Jacked Pipes and the shield shall be provided. A calculation Note justifying the number of additional jacking station shall be provided.

A method statement detailing the installation and dismantling the additional jacking stations shall be provided.

The Shield equipment shall be proposed to approval with relevant justification details. Any risk of destabilization and collapsing of the soil shall be taken into account.

The way of excavating the ground (tools, fluid control, pressure stabilization) shall be treated either by mechanical or hydraulic carriage. Direct excavation on the ground without soil anti decompression system shall not be allowed. No worker shall never be exposed to direct risk of soil collapse in the gallery.

A fully hydraulic method (Slurry Pipe Jacking Machine) is recommended.

Thrust walls for jacking operations shall be constructed normal to the proposed line of thrust and shall be adequate for installation of the sleeve. Intermediate jacking stations may be used where frictional resistance might result in unreasonably high jacking forces subject to the approval of the Engineer and the relevant authorities.

The Contractor shall maintain up-to-date records of thrusting pressures and line and level measurements for inspection by the Engineer as required.

6.07 Pipeline Installation

The pipeline shall be installed and maintained in position within the sleeve to the line, levels and gradient shown on the Drawings and in accordance with the pipelines of the Specification.

Insertion of the pipeline into the sleeve shall be by towing or jacking using suitable supports and spacers to facilitate installation and to prevent damage to the pipes. Joints between individual pipes shall be made before insertion into the sleeve.

Annular void shall be filled with special grout in order to anchor the pipe and ensure a long-term soil condition for the water pipe.

The design of the jacking pipes and determination of acceptable pipe fabrication tolerances shall be the responsibility of the Contractor.

The pipes wall thickness shall be determined by the Contractor and is a function of the following:

- Length of drive
- Maximum jacking forces
- Designed
- Jacking forces at maximum angular deflection

- Dead and Live loads and hydrostatic pressure
- Pipe stiffness requirements
- Pipe lining requirements
- Handling and positioning of pipe

Letter of confirmation of guarantee by the pipe supplier shall be provided to protect the client against any loss of guarantee with the installed pipe.

After installation and before grouting, the water pipes shall be tested. The relevant compliance test form shall be provided. In case of failure in this test, the contractor shall propose and undertake a curative method to fully comply with the hydraulic requirements. This includes the possibility of removing, repairing and re-inserting the water pipes.

After fixing all non-compliance, the contractor shall undertake a new series of tests at its own charge.

6.08 Grouting

Grouting of the annulus space between the sleeve and the pipeline and between sleeve and the excavation shall not commence until the pipeline has been hydraulically tested to the full specified test pressure and approved by the Engineer.

Grouting material shall be cement sand grout of 1:2 ratio by weight and an additive of aluminum powder as per manufacturer’s recommendations for expansion of grout and as per the approval of the Engineer.

Mixing shall be carried out in pan or paddle type mixers suitable for the purpose to produce a grout of adequate workability for pumping. Materials shall be batched by the whole bag by weight with particular attention paid to the water content. After mixing the grout shall be transferred to a holding tank before pumping.

Hand mixing of grout will not be allowed without the expressed permission of the Engineer.

Grout shall be pumped continuously in one operation until the annulus space is completely filled.

The amount of grout to be pumped to completely fill the annulus space shall be calculated taking into account an allowance for wastage and the quantity of grout pumped continually monitored to ensure that the annulus is completely filled.

The Contractor shall provide the Engineer with records of grout pressures and quantities pumped during the filling operation.

A ovalization test shall be undertaken for the waterpipe after strengthening of the grout. A certificate of approval shall be given by the pipe manufacturer to confirm the life duration of the pipes and its fittings (joints, special pieces, bolts and nuts)

6.09 Pipelines Under Railway line or Roads

Crossing of railway line or roads shall be permitted subject to approval from the relevant Authority and to the provisions below:

6.09.1 Method

The Contractor shall submit program of the Works to keep disruption to rail and road traffic to a minimum, before any work commences in existing railway line or road shall:

i.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 Regulation.

ii.Submit details of his proposals, and obtain approval from the Engineer.

Crossing shall be as shown on the Drawings. Reinstatement shall use the form of construction and materials as ordered by the relevant Authority, generally in accordance with water retaining structures and as shown on the drawings.

The bedding and jointing shall be as specified by the Engineer and the trench re-filling shall be carried out using granular bedding material and compacted at the sides of the pipes to not less than 95% of the modified proctor maximum dry density as specified in BS 1377, Test 13.

The Contractor's responsibility includes the design, implementation, and maintenance of all Traffic Management Plans, temporary diversions, signage, and safety barriers as required by the Road Authority. Any damage caused to existing road surfaces, railway embankments, or third-party utilities during the works shall be repaired immediately by the Contractor to the satisfaction of the relevant Authority at no additional cost to the Employer.

6.09.2 Reinstatement of Roads

The replacement of the road pavement structure shall be carried out as soon as practicable after backfilling has been completed. Suitable excavated road pavement materials which complies with the requirement of standards may be used at the subbase levels.

The edges of the trench shall be carried out as soon as practicable after backfilling has been completed. The edges of the trench shall be cut to a uniform line consistent with the varying width of the trench and the agreed trimming allowances. Any part of the road pavement which has been damaged beyond the width of the trench shall 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 contractor’s control.

A vertical joint shall be formed between the new work and the existing road surface and shall be painted with hot bitumen, or as approved by the Engineer, and the 2 layer wearing course steeped 75mm.

The finished level of the completed reinstatement shall conform to the adjoining carriageway surface.

Reinstatement of the road pavement shall match as nearly as nearly as practicable the color of other characteristics of existing surface.

Where the carriageway surface adjoining the trench is of rolled asphalt the Contractor may, with the approval of the relevant authorities and the written approval of the Engineer, lay a temporary wearing course of class 20 concrete 100mm thick. At a later date, to be decided by the Engineer, the temporary wearing course may be removed and replaced with 2 layers of rolled asphalt each 50mm thick.

6.10 Measurement and Payment

Pipe jacking shall be measured per meter length of pipeline comprising the pipe line jacked as a complete item including inserting MS sleeve, laying carrier MS pipe, grouting of the annulus space between the sleeve and the pipe and between sleeve and the excavation and hydrostatic testing etc. complete at the unit rate per meter of jacked pipe line entered in the priced B.O.Q.

The carrier pipe shall be paid separately at the unit rate per meter length of pipe line entered in the priced BOQ.

The above payment is full compensation for all works specified in this section for pipe jacking, BOQ and executed at site along with all safety arrangements for the satisfactory completion of works as required under the Contract and approved by the Engineer.

6.11 Reference

1. BS 1377 : Methods of test for soils for civil engineering purposes Classification Tests

CHAPTER 7- SITE REQUIREMENTS

7.01 Meetings and Reports

Approved representatives of the Contractor shall attend meetings at the office of the Engineer's Representative and at the office on Site, when called upon, for the purposes of Contract administration. Such meetings, unless otherwise agreed, shall not be less frequent than twice per month.

The Contractor shall submit to the Engineer each month a report on his progress in the performance of the Contract. The report shall include a copy of the approved work program with the current progress for each activity shown.

The monthly progress reports shall be delivered to the Engineer in the English language, within five working days after the end of each month.

The Contractor shall include with his monthly report details of all plants (including their values) and labour force employed on site together with description of their deployment. The report shall present the situation for all activities required under the Contract: design, drawings, procurement, production, factory testing, delivery, installation, testing and commissioning.

Any delays shall be described in detail by the Contractor and action proposed to deal with the delays.

7.02 Photographs and Videos

The Contractor shall supply digital soft copies and unmounted color positive prints of photographs, not less than 200 mm by 225 mm, of such portions of the Works in progress and completed, as may be directed by the Engineer and specified herein. The soft copies and prints shall not be retouched. The soft copies of each photograph shall be the property of the Employer and shall be delivered to the Engineer with the prints. No prints from these soft copies shall be supplied to anyone without the written permission of the Engineer.

The photographs shall be of two categories:

(a) Progress photographs;

(b) Record photographs.

Both categories of photographs shall be properly referenced to the approval of the Engineer and on the back of each print shall be recorded the date of the photograph, the direction in which the camera was facing, an identifying description of the subject, and the reference.

Photographs taken for record purposes as ordered by the Engineer shall be supplied with two prints, having on the reverse of one print the signatures of the Contractor and the Engineer (or their authorized representatives) for the purpose of attestation.

The Contractor shall supply soft digital copies and two prints of each progress photograph ordered by the Engineer. He shall supply sets of four additional prints of progress photographs selected by the Engineer for incorporation in albums. He shall supply albums, mount the prints, and title the prints and albums all to the approval of the Engineer.

The Contractor shall make available one high definition digital camera with built in GPS, minimum 30 X Optical Zoom with 500 GB memory card (Sony Cyber Shot latest model or equivalent), for the sole use of the Engineer for the purpose of the project, all at his cost. The digital camera shall be the property of the Employer at the completion of the project.

In addition to still photography, the Contractor shall provide professional-grade video documentation to record key construction milestones and specialized installations (such as micro-tunneling or internal pipe inspections…). Videos shall be captured in 4K resolution at 30 fps minimum. The Contractor shall also utilize Drones to provide monthly aerial progress views of the pipeline route and road reinstatement. All video files shall be delivered in MP4 format on a high-capacity external drive and shall remain the property of the Employer.

7.03 Temporary Laboratory

The Contractor shall supply, construct and erect, service and insure until the end of maintenance period (defects liability period) for the sole use of the Engineer’s laboratories with provision of water supply, plumbing, power supply, etc. all as per the direction of the Engineer with car port for ten vehicles, all as specified or as directed by the Engineer.

Laboratory prepared and provided as above and under the terms of the Clauses herein for the Engineer’s Representatives shall be maintained for the duration of the Contract and serviced as specified. On completion of the Contract all fixtures, fittings, furnishings and equipment shall be handed over to the Employer and will continue to remain Employer’s property.

The Contractor shall provide a full complement of qualified and experienced laboratory personnel, including a Laboratory Manager and certified Testing Technicians, to be dedicated solely to the Engineer's requirements. All personnel shall be subject to the Engineer's approval and shall be responsible for performing all sampling, testing, and reporting in accordance with the Project Specifications.

The building area of laboratories shall not be less than 200 sqm and 80 sqm, respectively. These laboratories are for the sole use of the Engineer's Representative and his staff and employees of the Employer.

The design of buildings for the laboratories shall be suitable for the climate with air conditioning, all to the approval of the Engineer.

The laboratory shall be complete with electrical, water and sewage installations and with a complete inventory of furniture and equipment as listed above, or as otherwise agreed with the Engineer.

All weather access roads shall be provided and maintained for the currency of the project, to serve the buildings.

Surface water drainage facilities shall be provided to protect the buildings from surface run-off and to convey it from the compounds.

The Contractor shall prepare detailed shop drawings for Engineer's approval before commencing with establishment of laboratories.

7.04 Location of Laboratories

The locations of laboratories shall be decided by the Engineer in consultation with the Employer.

7.05 Furniture, Equipment, etc.

The Contractor shall supply the furniture, fittings and equipment listed below and install them in the laboratories, as instructed by the Engineer. All furniture, fixtures and equipment shall be supplied new, and a manufacturer's description or sample shall have been approved by the Engineer before any item is ordered. The Contractor shall keep insured all furniture, fittings and equipment supplied to the Engineer to their full local value (including duty) until the end of the Period of Maintenance when the same will be handed over to the Employer in satisfactorily working condition and shall remain Employer's property.

The laboratories shall be provided with working shelves and stools besides storage shelves and a small office with air conditioning, furniture, fixtures, equipment, etc. A curing tank shall be provided outside the building.

And any other new item(s) or change in quantities of above items, deemed necessary to smoothly run laboratories, may be required, to be provided on Engineer's instruction, for which no additional payment shall be made and their cost is deemed to be included in contract price.

The Engineers Site Laboratories shall be provided with calibrated testing equipment with the regular supply of consumables and replacement as needed, for following minimum tests and maintained for the duration of the Contract.

- Aggregate gradation analysis by mechanically vibrated sieves (all sizes) (BS 1377)	2 sets
- Soil gradation analysis by mechanically vibrated sieves (all sizes) (BS 1377)	2 sets
- Soil gradation by Hydrometer (BS 1377)	2 sets

- Atterberg's Limits tests (BS 1377)	2 sets
- Determination of organic content in soil (BS 1377)	2 sets
- Laboratory Oven for moisture content	2 sets
- Concrete cylinder crushing strength testing machine & 20 sets of cube moulds	2 sets
- Speedy moisture tester (20 gms) complete test	4 sets
- Determination of dry density / moisture content relationship of soil.	2 sets
- Aggregate moisture test for determination of water cement ratio (200 mm dia. complete test)	2 sets
- Slump cone with base plate	3 Nos
- Cement briquette moulds	2 sets
- Flakiness index test equipment for aggregate	2 sets
- Field Density measuring equipment (sand cone)	2 sets

The provision of laboratory's equipment shall not be limited to aforementioned tests only but it may be increased or decreased at the direction of Engineer. The said laboratory equipment along with consumables shall be maintained for the duration of Contract and replacement shall be provided as and when required. The laboratory equipment shall be the property of the Employer at the end of the Contract. Some of the specified tests for which the site laboratory is not equipped to perform shall be carried out at an approved outside laboratory all at contractor's cost. The Engineer may increase / decrease the quantities of above tests equipment or may add new equipment, for which no additional payment shall be made and their cost is deemed to be included in contract price.

7.06 Materials and Workmanship

The materials used and workmanship employed in the construction of the laboratories, shall be in accordance with the other requirements of the Specification and shall otherwise be of good quality.

7.07 Deadlines and Penalties

The offices, laboratories and CRE's office shall be prepared, furnished and ready for occupation within two months of the Engineer's notice to commence the work. The Contractor shall provide alternative accommodation to the satisfaction of the Engineer if he fails to complete, or provide as appropriate, the buildings within the above stated time.

7.08 Water, Electricity and Gas

The Contractor shall be responsible for providing continuous supplies of water, electricity and gas to laboratories. In case of electricity power failure, the Contractor shall ensure power supply through suitable Electrical Generators.

7.09 Servicing and Maintenance

The Contractor shall service and maintain with all ancillary works, laboratory, furniture, fixtures and equipment including provision of security guards (24 hours), janitorial services and refuse disposal services along with continuous supply of water and electricity, until the end of Defect Liability Period. The Contractor shall replenish stationery items for laboratories as and when required. At the end of the Defect Liability Period, the furniture, fittings and equipment shall be cleaned, repaired or replaced, as necessary, to bring them into good condition, and they shall remain, fencing, walling, gates, roads and paths the property of the Employer at the conclusion of the Contract.

7.10 Laboratory Staff and Equipment

The contractor shall provide two teams consists of senior laboratory technician and two assistants with adequate labor and transport to carry out the tests required under the Contract or any further tests which may be required by the Engineer. The Material Engineer and Laboratory Technician shall be fully qualified and shall have had a minimum of ten years' experience of this type of work. The qualification and experience of the Material Engineer and Laboratory Technician shall be subject to the approval of the Engineer. The transport for laboratory staff shall be maintained with driver, consumables, POL, spares and insurance and shall be solely at the disposal of the Engineer and his staff.

The laboratory, equipment and staff provided by the Contractor under this contract shall be under the control of the Engineer for quality assurance work on this contract and as well as on other adjacent or nearby contracts as deemed necessary by the Engineer.

The contractor shall not be entitled to separate payment for the provision of the laboratory equipment, services, laboratory staff and their transport but the cost of the same shall be included in the items of provision and maintenance of laboratory and assistance to the Engineer.

The laboratory equipment shall be handed over to the Employer at the end of the Defects Liability Period or earlier if ordered by the Engineer.

7.11 Security to Laboratory

The Contractor shall arrange round the clock security services for Laboratories, for the entire duration of the Contract. The contractor shall not be entitled to separate payment for the provision of security services but the cost of the same shall deemed to be included in the other items of BOQ.

7.12 Measurement and Payment

Where no separate item exists in the Bill of Quantities for any services, works, equipment, materials specified in Chapter 8 of “Site Requirements” then the cost of providing the same shall be deemed to be included in the rates of items in the Bill of Quantities.