

#### **4009 Transportation and Handling**

All pipes and specials fabricated in the yard and/or factories and temporarily stocked in the factory shall be transported carefully to the site of laying after internal cleaning.

Any vehicles 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.

Additional precautions shall be taken to avoid deformation of flexible pipes. To maintain their circular cross-section internal struts shall be fitted in the pipes. Details of the proposed strutting system shall be submitted to the Engineer for approval and if required by the Engineer, the method of strutting shall be demonstrated and tested on site.

The pipes and specials shall be handled in such a manner as not to distort their circularity or cause any damage to their coating. Wide non-abrasive or other approved slings shall be used and all hooks and other metal devices shall be well padded. Hooks engaged on the corner 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 to a minimum.

Pipe handling equipment shall be maintained in good condition 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.

No valves shall be lifted by the spindle.

Fabricated materials such as man-hole covers, appurtenances, bolts, nuts, flanges, saddles, collars, bypass arrangements etc. shall be transported to the site of laying from the fabrication yard according to needs of the laying operations only.

#### **4010 Pipeline Construction**

##### **(1) General**

Laying/Erection of fabricated pipe lengths shall be carried out by the Contractor who shall equip himself, at his cost, with all necessary tools, machinery, labor etc., required for the purpose. The pipeline shall be constructed in lengths with a separate full-time gang working on each length..

Except for routine welding of joints, no other work shall be done in the absence of the Engineer.

The components of the exposed sections of the pipeline such as plates and pedestals, have been so designed that the centers of the plates and pedestals shall coincide at the mean temperature of the locality. For this reason, all works such as fixing flanges, plates etc. in true alignment, and in correct position and tack welding pipes shall be done at the mean temperature. For ascertaining

in the temperature, the Contractor shall provide mercury cups and fix them to the pipe shell from outside and shall also provide thermometers of the required type and range. No extra payment shall be made for this.

## **(2) Laying Program**

The Contractor shall submit a detailed bar chart for manufacturing and laying of the pipeline, which shall be subject to the Engineer's approval. In preparing this bar chart, the Contractor shall plan his activities such that the laying of pipes shall closely follow the manufacturing schedule and no pipes shall remain stacked in factory or at site for a period more than two months.

Together with the schedule, the Contractor shall submit a methodology describing construction method of the pipe laying as well as required construction equipment and other facilities within the construction period by the Contractor.

## **(3) Re-survey of the Pipeline Route**

The Contractor shall undertake detailed survey of the pipeline route and compare to the survey supplied at the time of tender and maintain a joint records. Levels are to be taken at 50 m intervals and at any sharp changes in level. Where practical the change points shall coincide with those original surveys. Not less than one month before commencement of pipe laying, the Contractor shall submit their longitudinal profile with pipe centerline to the Engineer.

The format of the survey shall be identical to the longitudinal sections which formed part of the Contract documents and shall be produced using Auto CAD Release-1.4 software package.

## **4011 External Coating**

### **(1) General**

External coating shall be applied with asphalt vinylon cloth coating and shall conform to ISO5256 and/or JIS G 3491. The coating shall be completed in the manufacturing factory after satisfaction of the inspection and testing by the Engineer.

### **(2) Materials and Dimensions**

The materials for the asphalt vinylon cloth coating shall be the matter of assessing the magnitude of the corrosion, installation and service hazards.

Minimum thickness of the asphalt vinylon cloth coating shall be 3.5 mm for the straight pipe consisting of a primer coating, first layer of asphalt and a wind up of vinylon cloth with covered finishing asphalt, and 5.0 mm for the bend, specials and fittings of pipe consisting of a primer coating, first layer of asphalt, a wind up of vinylon cloth with a second asphalt layer.

## **4012 Buried Pipelines**

### **(1) Trenching**

Trenching includes all excavation which is carried out either by hand or by machine and shall be carried out in accordance with all general requirements of Division 2. In addition to those general requirements, the following requirements shall apply to pipelines:

The trenches shall be dug to grade as shown in the profiles, and minimum earth cover for the weather protection shall be 1.0 m with proper materials as shown on the Drawings.

The width of the trench shall be kept to a minimum consistent with the working space required to avoid damage to pipe coating and having regard to the safety of the trench as shown on the Drawings. The bottom of the trench shall be properly trimmed to permit even bedding of the pipeline.

The 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.

The minimum clearances of side and bottom 0.8m from pipe external and 1.0m width at pipe joints may be requested to allow the joints to be welded and inspected, any proposed increase shall be approved by the Engineer.

The Contractor shall take all other necessary measures to ensure the safety of the working in the trench, public and others.

The maximum length of excavation may be left open in any length is 500 m. The opening of pipes, inspection and testing of joints, coating of joints, placing of backfill and other activities within the pipe trench, to be carried out in a satisfactory manner.

### **(2) Bedding**

The depth and type of bedding shall be as shown on the Drawings or as directed by the Engineer. Specification of laterite material for bedding shall be referred to Sub-Section 2103. In all cases the soluble sulphate and chloride content of the granular material shall not exceed 0.5 % and 0.06 % by weight respectively.

### **(3) Construction of Laterite Bedding on the Pipe Bed and Surrounds**

Laterite bedding on the pipe bed and surround shall be constructed as indicated on the Drawings. The laterite material shall be evenly spread over the full width of the formation and sufficiently compacted as specified in the Sub-Section 2107 to a level slightly higher than level corresponding to the underside of the pipe barrel to allow for settlement of the pipe to the correct level.

Following placement and jointing of the pipe further excavated sand material shall be placed in the trench, special care being taken to fill under the sides of the pipes to ensure full contact with the barrel of the pipe.

Field joints which have not been tested shall be left exposed for a minimum length of 150 mm each side of the joint. The excavated sand material shall then be placed and compacted evenly on both sides of the pipe to a depth of 300 mm above crown of the pipe.

Trench supports, if constructed, shall be withdrawn gradually in accordance with the progress of the fill with the provision that such withdrawal shall not prejudice the safety of the Works.

The Contractor shall ensure that the material to the sides of the pipe is adequately compacted with tamping and drolling equipment in layers of not more than 150 mm in thickness after compaction and that the method of compaction used shall achieve not less than 90 % of the maximum dry density as determined in the Section 2107 of this specification. To prevent excessive line loads on the pipe, sufficient densified backfill shall be placed over the pipe before power-operated hauling or rolling equipment is allowed over the pipe.

After each section of the pipeline has passed the hydrostatic test, the expected joints shall be backfilled and compacted to the above Specification.

#### **(4) Pipe Laying**

Pipes shall be laid in accordance with BS4515 unless otherwise specified herein.

The pipeline shall be constructed in length with a separate full time gang working on each length. The work on lengths may proceed concurrently. The program for pipe-laying shall be submitted to and approved by the Engineer at the commencement of the Contract. Any subsequent changes to the program shall be submitted and approved by the Engineer before work to a different program is started. Excavation for the pipeline in any on length shall not at any time proceed more than 2 km beyond the end of a hydraulically tested, completed and the backfilled length of pipe, unless otherwise approved by the Engineer. The exposed joints between tested sections shall be disregarded in the above definition.

No metal tools, reinforcing bars or heavy objects should be strictly permitted to come into contact with the pipes or fittings. External coated pipe shall be handled at all times with wide non-abrasive canvas, rubber or leather straps or other equipment 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 timber or skids used to support the coated pipe prior to lowering into the trench shall be properly padded with sufficient bags stuffed with sand 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 or fittings placed in the trench. During laying operations, no debris, tools cloth or other material shall be placed in the pipe. Pipes and fitting shall be lowered into the trench with

equipment suitable for the weight or the pipes and fittings, and they shall be carefully cleaned before jointing.

Pipes shall be laid accurately to the lines and levels shown on the Drawings, within a tolerance of  $\pm 10$  mm.

Pipes alignments shall be straight between bends and curves. Length laid to curves shall only be allowed where shown on the Drawings or in accordance with detailed proposals approved by the Engineer.

The contractor may submit to the Engineer for his approval an alternative method of the control of pipe laying to the correct levels and alignments.

The jointing of pipes shall be made in accordance with the requirements of this Specification. The Contractor shall obtain from manufactures all special information regarding the handling of the pipes, joints and other fittings and he will be deemed to have made himself thoroughly conversant with all phases of pipe laying before commencing the works.

#### **(5) Minimum earth cover**

The minimum earth cover above the crown of the pipe to proposed ground level shall be as specified in the drawings but in no case shall be less than 1.00 m unless otherwise directed by the Engineer.

#### **(6) Laying to Curves**

Where pipes are to be laid to curves, the deflection at each joint shall not exceed 0.5 degree. For sharper curves specifically made bends shall be provided.

#### **(7) Lowering and Jointing**

The pipes shall be laid into the trenches such that no part of any shoring in disturbed or damaged and, if necessary, additional temporary struts may be fixed during the lowering operations. Care shall be taken to ensure that the longitudinal joints of two consecutive pipes at each circumferential joint are staggered by 90 degree. While assembling the pipes, the ends shall have to be brought close enough to leave a uniform gap not exceeding 4 mm. There shall be no lateral displacement between the pipe faces to be jointed. If necessary, spiders from inside and tightening rings from outside or other suitable equipment shall be used to bring the two ends in perfect contact and alignment. In no case shall hammering or longitudinal slitting be permitted. Jacking may be permitted for this purpose in particular circumstances and approved by the Engineer.

When the pipe is properly assembled firmly supported on wooden beams and wedges or by other approved means it shall be checked for correct line, level and tack welded. The tack welded circumferential joints shall then be welded fully.

## **4013 Internal Cement Mortar Lining**

### **(1) General**

The Contractor shall submit the proposed mortar lining method for detail before commencement of the works for approval of the Engineer.

### **(2) Materials**

All pipes diameter 700mm or larger and fittings shall be internally lined with cement mortar in accordance with AWWA C602. Cement mortar in lining shall be applied in-situ after pipe laying and before or after sectional hydrostatic testing.

- (i) Cement shall be Portland Cement Type V for sulphate resisting as proposed in accordance with the specification in Sub-Section 3005.
- (ii) Sand used for lining shall be tested with standard sieves as per AWWA C602 and requirements specified in Sub-Section 3005.
- (iii) The proportion of cement and sand in the mortar for the lining shall be in accordance with the Sub-Section 3005 (5) Mortar E and the water cement ratio by mass shall be between 0.3 and 0.45:1.
- (iv) The mortar shall stop 100 mm back from the faces of any joints. The end faces shall be vertical.

### **(3) Surface Preparation**

The interior surface of pipe to be lined shall be cleaned to remove all rust, chemical or other deposits, oil, grease and all accumulations of water, dirt, and debris. The cleaning of the surface shall be carried out by the use of suitable chemical or mechanical means to the approval by the Engineer. The extent of cleaning shall be the satisfaction of the Engineer.

All loose mill scale, dirt, rust, and accumulation of construction debris shall be removed from the interior of the steel pipeline. The pipeline shall be cleaned by use of power-driven cleaner incorporating revolving brushes on rotating arms.

### **(4) Mortar Mixing**

Mortar composing of cement, sand and water shall be well mixed and of proper consistency to obtain a dense, homogeneous lining that will adhere firmly to the pipe surface. The cement mortar mix shall comply with strength and density requirements specified in AWWA C602. No admixtures and pozzolanic materials shall be permitted unless approved by the Engineer.

### **(5) Thickness of lining**

Lining shall be uniform in thickness. The lining thickness shall be in the following table without

negative tolerance and with a positive tolerance of 3 mm unless approved by the Engineer.

Thickness of Cement Mortar Lining in Place

Nominal Diameter(mm)	Thickness(mm)
2,400	13
1,500	10
700	7

#### **(6) Lining Procedure**

The lining shall be placed by spraying method in one course by a machine traveling through the pipe and discharging the mortar at a high velocity over all pipe sections and long radius bends. The discharge shall be from the rear of the machine and the rate of mortar discharge shall be mechanically regulated so as to produce uniform thickness throughout the pipe circumference, regardless of permissible deflection of the pipe roundness. The mortar must be densely packed and shall adhere to the pipe wherever applied.

#### **(7) Surface Finish**

The lining shall be mechanically troweled except for the places where hand troweling is expressly permitted by the Engineer.

The lining machine shall be provided with attachments for mechanically troweling the mortar. Both the application and troweling of the mortar shall take place at the rear of the machine so that the freshly placed and troweled mortar will not be damaged. The trowel attachment shall be such that the pressure applied to the pipe will be uniform and produce a lining of uniform thickness with a smooth and even finished surface free of spiral shoulders. The finished surface of machine-placed and troweled linings in pipe shall be examined according to the following procedure.

Thickness of lining shall be ascertained frequently during placing of mortar and trowelling using an approved non-destructive method.

In the stretch of pipe that has been lined and troweled in each day's run, ten places shall be selected in straight sections of the pipe by the Engineer. In each of the ten places the thickness of the lining shall be measured by non-destructive means as directed by the Engineer.

Defects in lining including but not restricted to sand pockets, voids, over-sanded areas, blasters, cracked and dummy areas, and thin spots shall be removed, and the area shall be repaired to the full required thickness of the mortar lining. Defective areas encompassing the full diameter of the pipe shall be replaced by machine. Defective lining rejected after initial set shall be replaced or repaired by the most practical method as determined by the Engineer.

The Hazen-Williams C factor 130 shall be guaranteed for diameter 500mm or larger in application of AWWA C 602 Section 5. The Contractor shall bear the expense and perform

the repair of defective work in a manner acceptable by the Engineer, if an examination reveals evidence of deficit to reach C=130 because of defective materials or workmanship as defined AWWA C 602 Section.5. Hair cracks or cracks up to 0.25 mm width and not over 300 mm in length in finished linings may be considered acceptable at the discretion of the Engineer but larger cracks shall be repaired or removed and redone all as directed by the Engineer.

#### **(8) Hand Application**

Cement mortar lining of bends, specials, areas closely adjacent to valves and other such places where machine placing may not be practical shall be performed by hand. The Engineer may order the correction for any defect by hand application.

Cement mortar for hand work shall be of the same materials as the mortar for machine placed lining.

The areas to be lined shall be thoroughly cleaned as specified earlier and, if necessary, shall be moistened with water immediately prior to placing the hand-applied mortar.

Steel finishing trowels shall be used for the hand application of cement mortar, except at bends the outer edges of hand troweled areas may be brushed in order to reduce the abutting offset.

All hand finishing work in a section of the pipeline shall be completed within 24 hours after completion of the machine application of mortar lining that section. If necessary, application of mortar lining by machine shall be delayed or stopped to assure compliance with this schedule.

Hand placed mortar shall have a uniform and smooth surface with smooth transitions to adjacent machine placed linings.

#### **(9) Curing**

Curing shall commence immediately after completion of the mortar lining and hand finishing of a section of pipeline. This shall, however, not be later than 8-hours after mixing of mortar. The lining shall be kept continuously in moist condition for a period of 14 days. During the operation of lining, finishing and curing, exterior surface of the pipe exposed to sunlight shall be sprinkled with enough water to keep the pipe cool. So as to avoid such measure, the Contractor may backfill the soil until 600 mm above the crown of the pipe prior to mortar lining. Open ends of pipes shall be suitably closed so as to maintain a moist atmosphere and prevent draught. Curing of mortar lining and simultaneous cooling of the pipeline externally shall be continued even beyond the period of 14 days if so directed by the Engineer.

After 11 days curing, the Contractor may be allowed the coating with seal coat of a polymer of polyvinyl chloride or acryl chloride, painting or sprayed to the surface of mortar lining. The required coating material shall be approximately 100 g/m<sup>2</sup>.



## **(10) Tests**

Test blocks of the same material as used for the lining shall be made in 150 mm circular or cube moulds and subjected to circular or cube crushing tests. Each block shall be removed from its mould as soon as practicable and cured under the conditions of temperature and humidity identical with those in which the lining of the pipe is cured. The number of tests shall be at least 4 samples for each age and each water cement ratio for each days work. The works cube strength of the test cube shall not be less than 300 kgf/cm<sup>2</sup> after 28 days of curing or 170 kgf/cm<sup>2</sup> of 7 days of curing. The density of the test cube shall not be less than 2,300 kg/cm<sup>3</sup>.

## **4014 Backfilling**

On completion of the pipe laying operations in any section, for a length of about 100 m and while further work is still in progress, backfilling of trenches shall be started by the Contractor with a view of restricting the length of open trenches. Pipe laying shall closely follow the progress of trench excavation. Backfilling to a level of 300 mm above the crown of the pipe shall be done in accordance with the requirements of the clause on bedding. Care shall be taken during backfilling, not to injure or disturb the pipes, joints or coating. Backfilling shall be carried out simultaneously on both sides of the pipes so that unequal pressure dose not occur. Walking or working on the completed pipelines shall not be permitted unless the trench has been filled with the instructed bedding and surround material up to height of at least 300 mm over the top of the pipe except as may be necessary of tamping etc., during backfilling work.

The remaining portion of the trench shall be filled in with selected excavated material free from and topsoil, vegetation or boulders and clods of earth larger than 40 mm in size. Filling shall be done in layers not exceeding 150 mm in thickness accompanied by adequate watering, ramming etc., so as to be compacted to 90 % of the maximum dry density as per Sub-Section 2107. The water contents of the soil shall be kept as near the optimum moisture content as possible. The trench shall be backfilled so as to build up to the proposed ground level, keeping due allowance for subsequent settlement likely to take place. The surface of the backfilled excavations shall be left slightly higher than the adjacent ground and be maintained by the Contractor to a smooth even slope as shown on the Drawings.

The Engineer shall, all times, have powers to decide which portion of the excavated materials shall be used for filling and in which portion of the site and in what manner it shall be used.

The Contractor shall take regular measurement for the dry density at various levels in the backfilling as required by the Engineer.

No mechanical plant other than approved compacting equipment shall run over or operate within the trench until backfilling has reached its final level or the approval for the Engineer has been obtained.

Should any subsidence take place either in the filling of the trenches or near about it during the works the Contractor shall make good the same at his own cost.

Surplus excavated material shall be used to fill in any low spots above the pipeline which are identified on the Drawings or are instructed by the Engineer.

#### **4015 Nuts, Bolts and Washers**

Unless otherwise specified, nuts, bolts and washers shall be galvanized and/or zinc electroplated conform to the requirements of ISO7005/BS10. Bolts shall be of sufficient length that at least one thread but not more than three threads shall show through the nut when in the fully tightened condition.

#### **4016 Puddle and Thrust Flanges**

The exterior of built-in pipes shall be cement washed symmetrically about the puddle flange by the Contractor for a length at least equivalent to the thickness of the wall through which it passes.

The puddle flange and weld between the flange and pipe work shall be sufficient to take a total shear force of 600 kN/m of circumference. Puddle flanges on steel pipe work over 1000 mm dia. shall be a minimum thickness of 40 mm and height of 100 mm.

#### **4017 Gaskets**

All gaskets shall be manufactured from SBR rubber in accordance with BS 3063. Gaskets for spigot pipes shall comply with BS 3063. The dimensions of flange gaskets shall comply with BS 4865.

#### **4018 Anchor Blocks**

Anchor Blocks shall, in special, be provided at horizontal bends, vertical bends and/or at intervals on pipelines with gradients in excess of 1 in 6, as requested at the position of imbalance force occurred, and at other locations ordered by the Engineer. The anchorage shall be made from concrete and constructed to the dimensions shown on the drawings or as direction of the Engineer. Where faces of anchor blocks are shown to bear against undisturbed ground, the Contractor shall take all necessary measures to ensure that such bearing is given over the full dimensions shown.

Welded pipelines that shown on the Drawings as having tied couplings or flexible joints shall require anchor blocks only at the positions specifically noted on the Drawings or as direction of the Engineer

#### **4019 Internal Cleaning of Pipeline**

Pipelines shall be cleaned of all dirt, debris, dust or other deposits by repeated housing of copious quantities of water on the pipe surface and simultaneously rubbing the surface with gunny cloth to the satisfaction of the Engineer. Cleaning with metal cleaning solution, acid, wire brushes, scrappers or sand paper shall not permitted.

The section of the pipeline once cleaned shall not be entered into for any purpose later. Sufficient precaution shall be taken to prevent the ingress of any dirt, debris or dust inside the section. Failing this section shall be cleaned again at the discretion of the Engineer.

In case of buried pipelines a section shall be taken up for cleaning after the work of backfilling around and over the pipeline is completed and the spiders have been removed from inside with approval of the Engineer.

During the pipe laying operation in the adjoining section, the Contractor shall take all precautions to prevent ingress of water, debris, dirt etc. in the cleaned section, failing which the section shall be cleaned again at the discretion of the Engineer. When deemed necessary by the Engineer suitable closures shall be provided at the open end of the ends of the cleaned sections.

No separate payment will be made for the work of cleaning and providing closures. The rates quoted for the laying of pipes shall include the cost of cleaning also.

#### **4020 Hydraulic Testing of Pipeline**

Pipelines and fittings shall be subjected to hydraulic pressure tests in the presence of the Engineer, which shall refer to ISO10802 unless otherwise specified.

Testing shall be carried out in two stages:

- (i) Test of sections as construction proceeds before internal cement mortar lining
- (ii) A test of the whole of the pipeline on completion

The Contractor shall equip with all plant, equipment, fittings and water necessary for the hydraulic tests. The Contractor shall submit to the Engineer, well in advance of the time of tests, details of his proposed field testing methods and procedures, including the supply of water.

Test gauges shall be of approved manufacture having dials at least 200 mm diameter, graduated such that the test pressure is at least 75 % of the full scale reading shall be used. Two gauges shall be provided for the sole use of the Engineer and shall remain in the Engineer possession for the duration of the Contract. All gauges shall be dead weight tested and calibrated at the commencement of work and at regular intervals as required by the Engineer.

The Contractor's arrangements for testing shall include a suitable means of quick installation and removal of the Engineer's gauges during testing.

##### **(1) Testing procedure**

The Sectional Hydraulic Test shall be carried out after the pipeline section to be tested has been laid, jointed and backfilled to a depth sufficient. The sections to be tested shall be to the approval of the Engineer and shall be not longer than 500 m or shorter when section includes an air valve chamber.

In addition to the above requirements, the Contractor shall perform a hydraulic test on the first 200 m length of pipeline to be laid under the contract. This test shall be undertaken within one month of the Contractor commencing the laying of pipes. Should the pipeline fail the test or the Contractor fail to undertake the test, all laying and welding work shall come to a halt until that section of pipeline passes a hydraulic test.

Each length of the pipeline to be tested shall be capped or blanked off at each end and securely strutted or restrained to withstand the forces, which will be exerted when the test pressure is applied. Testing against closed valves will not be permitted. Washout valves shall be fitted with blank flanges and these together with in-line valves shall be left open. Air valves already fitted shall be permitted to function during the test.

Proposals for testing where thrusts on structures are involved, even where thrust flanges on the piping are installed, shall be submitted, with the calculations of the forces to be carried, to the Engineer for approval.

The method of filling the pipeline with water shall be approved by the Engineer. The length under test shall be filled making certain that all air is displaced through an air valve installed at the top of the blank flange situated at the high end of the line. The length shall then remain under constant moderate pressure, 10 to 20 m head of water, for a period of several hours until the pressure can be maintained without additional pumping.

The pressure shall then be slowly increased at a maximum rate of 1 bar per minute to the full test pressure and pumping discontinued for 3 hours or until the pressure has dropped by 10 m, whichever occurs earlier. Thereafter pumping shall be resumed and continued until the test pressure has been restored. The quantity of water pumped to restore the pressure shall be the measure of leakage from discontinuation of pumping until its resumption.

The pipe length shall pass the test if the leakage is not more than 0.5 liters per mm diameter per kilometer (1.20 m<sup>3</sup>/2,400 m dia./km) per 24 hours.

Notwithstanding the satisfactory completion of the hydraulic tests, if there is any discernible leakage of water from any pipe or joint the Contractor shall, at his own cost, replace the pipe, repair the pipe or re-make the joint and repeat the hydraulic test.

No pipeline shall be accepted until the leakage on any length is not more than the rate of leakage specified above and all sources of leakage have been rectified.

The Test on completion shall be carried out after all the pipeline sections have been satisfactorily tested and the joints between each section completed to provide a continuous test length between contract interfaces.

Pipeline shall be tested as above except where the Engineer issues such instructions as are necessary for testing parts of the Works that have been designed for stressed limited by considerations other than those applying to the pipeline systems.

**(2) Test Pressures**

Test pressures are to be measured in bars at the center of the blank flange situated at the lowest end of the pipeline under test. Unless otherwise specified or shown on the Drawings pipeline test pressures shall be in accordance with the followings:

Steel pipe and fittings 6 to 22 mm wall thickness (D=400 to 2,400mm) : maximum 15 bar

Test pressures for sections of pipeline containing air valve chambers shall be such that the pressure at the chamber does not exceed valve design pressure as specified by manufacturer.

**4021 Markings of the Facility**

Detailed like valve type, size, cistern number shall be painted on all valve chambers as directed by the Engineer.

**4022 Measurement and Payment**

**(1) Earthworks for steel pipeline**

Measurement for payment of earthworks of pipeline shall be in cubic meters as same as sub-section 2012 and 2110.

Payment of earthworks for pipeline shall cover clearing and grubbing of site, stripping and removal of top soil, excavation, borrow area development, transportation of materials, all kind of fill and backfill with selected materials, necessary protections shown on the Contract Drawings and any other earthworks for pipeline.

**(2) Steel Pipes**

Measurement for payment for steel pipe shall be the length of pipe installed as computed centerline of the alignment of pipeline. The rate shall cover supply and installation of pipes including manufacturing, transportation, jointing, internal and external coatings, and all kind of testing with necessary materials, equipment and facilities.

Payment for steel pipes shall be made respective Pay Item shown in below including bends and fittings of the steel pipeline.

<u>Pipe Diameter</u>	<u>Pay Item</u>
D=2,400 mm	PP-0701
D=1,500 mm	PP-0711
D=700 mm	PP-0727
D=400 mm	PP-0706
D=200 mm	PP-0716, PP-0720, PP-0736
D=100 mm	PP-0732

**(3) Flexible Joints, Pipe Specials, Loose Flanges and any kinds of Valves**

Measurement for payment for flexible joints, pipe specials including man-hole pipe, blow off pipe and T shape joint and all kinds of valves shall be the number of each pipes.

Payment for above shall cover manufacturing, transportation, jointing with welding or flanged, internal and external coatings, and all kind of testing with necessary materials, equipment and facilities.

<u>Flexible Joint</u>	<u>Pay Item</u>
D=2,400 mm	PP-0702
D=1,500 mm	PP-0710
D=700 mm	PP-0726
D=400 mm	PP-0708

  

<u>Pipe Specials</u>	<u>Pay Item</u>
Man-hole Pipe	PP-0703, PP-0714, PP-0730
Blow off Pipe	PP-0705
T-Shape Joint	PP-0709, PP-0725

## **SECTION 4100 APPURTENANT FACILITIES**

### **4101 General**

The Contractor shall provide all materials, equipment and incidentals necessary to furnish, ready, operating manuals and appurtenances as shown on the Drawings and as specified herein.

The materials and equipment shall be the product of an established and reputable manufacture who has previous experience in the manufacture of the similar equipment herein specified.

### **4102 Scope of Works**

This specification cover the general requirement for fabrication, laying, jointing, testing and commissioning of welded or flanged steel of appurtenant facilities and pvc pipeline including associated civil works required for the pipeline systems.

Before installation of any valves and air valve the Contractor shall submit a test certificate from the manufacture, certifying that each valve meets the requirements of this Specification and a record of the specified test, to the Engineer for approval. No, valves and air valve shall be installed prior to approval of the Engineer.

The valves except air valve for manufacturing, installation and testing shall be in accordance with Division 8.

### **4103 Air Valve**

Air valve shall be placed at high points in the pipeline as shown on the Drawings. Air release valve of ND 200mm shall be of high speed air vent type with ND 200mm isolating valve and branch valve ND 50 mm or as direction of the Engineer for irrigation. Flanges shall be to ISO5252 / BS4504. Joint ring shall be full width neoprene rubber to BS4865. Steel bolts and nuts shall be in compliance with Sub-section 4015.

### **4104 Connection Pipes for Blow off**

The connection pipe for blow off shall be conform to ISO2604, BS3601 or/and JIS G 3452 that refer to Section 4000, and the pipe shall be coated with zinc or galvanized at internal and external surfaces.

### **4105 Cathodic Protection Device**

#### **(1) General**

##### **(a) Scope of Works**

The works of cathodic protection shall consist provision, supply, installation testing of the required system and equipment as specified in Bill of Quantities and as shown on the

Drawings.

**(b) Application Scope of Specifications**

The current issue of the specifications for cathodic protection system provided by the National Association of Corrosion Engineers (NACE RP0169-96 "Control of External Corrosion on Underground or Submerged Metallic Piping System") shall be deemed a part of this Chapter.

Unless otherwise specified, all equipment, meters and materials shall be designed in accordance with the specifications of NACE and IEC (International Electro-technical Commission).

**(c) Responsibility of the Contractor**

The Contractor and manufacturer shall perform an on-site survey and take measurements at the Site to satisfy himself that the Cathodic Protection System will perform as required. Modifications shall be made by the Contractor, where necessary, to take account of the conditions of the Site. The Engineer's acceptance or approval of the Contractor's site measurements, method, equipment or personnel shall in no way relieve the Contractor of his sole responsibility for the proper installation, commissioning and testing of the Cathodic Protection System in accordance with this Specifications and the Drawings and to the approval of the Engineer.

**(2) Shop Drawings and Work Program**

The Contractor shall submit for the approval of the Engineer all the shop drawings, detailed working plan, program and schedule, result of shop tests and the manufacturer's information, etc., at least 60 days prior to the commencement of the site work.

**(3) Equipment and Materials**

The major equipment and material to be supplied, installed and made ready for the operation of the system are as follows.

No.	Description
1	Transformer rectifier 50 A, 50V, DC
2	High silicon cast iron anode
3	Test boxes
4	Negative/Positive(Anode)/Junction Boxes
5	Carbonaceous backfill
6	Insulating flanges
7	Thermit welding kit
8	Negative and test terminal
9	Insulation checker
10	Switch Board
11	Guard fence and Concrete Stand for Switch Board, Transformer Rectifier, test and junction boxes



The requirement for the materials, equipment and those shop test shall be as follows :

(a) Transformer Rectifier Unit

1) Transformer-rectifier units to be installed outdoors shall be of oil immerse, self cooled, non-explosion proof and plinth mounted type and shall be protected by sunshade cover. The roof and the sunshade cover shall be 1.2mm minimum thickness of stainless steel.

2) Transformer-rectifier shall meet the following specifications.

Rectification	: Single-phase, full-wave
Rating	: Continuous
Rated input voltage	: 380 V, single phase, 50Hz
Rated output voltage	: 50 V DC
Rated output current	: 50 A DC

Note : 380 V AC power will be supplied on the terminals of the motor control center located in the Pump House building and Contractor shall provide and lay the 9 km length and 70 mm<sup>2</sup> cross-linked polyethylene insulated and steel armoured type (XLPE/PE/AWA/PE) to Transformer-rectifier. Contractor shall consider the voltage drops between the terminals of the motor control center and Transformer-rectifier.

3) The rectifier shall be full wave bridge assemblies of silicon stacks. Stack temperature at full load shall be less than 80% of the maximum allowable operation temperature in the ambient temperature of 50° c.

4) The voltage steps from 4% to full output rating shall be 25 steps by tapping with 5 (five) positions of “coarse” and 5 (five) positions of “fine”.

5) The transformer shall be of the double winding (insulated) type. The transformer shall have an earthed shield placed between primary and secondary windings.

6) Transformer-rectifier units shall include the following accessories at a minimum.

Positive and negative output terminals fitted in a suitable location to facilitate access and cable connection.

Lighting arrester on the AC input side which has 250-600 V and 5 kA withstanding capability for discharge lightning current.

Surge divertor mounted directly across the main DC output side of the DC fuse for protection against induced voltage.

DC voltmeter and DC ammeter with a maximum of 1.5% accuracy at rated output. They shall be suitable for desert area use.

Lifting lugs,

Rating plate indicating manufacturer's name serial number, AC input, DC output and weight of transformer-rectifier unit,

Schematic diagram of electrical connections engraved on brass or equivalent materials.

7) All live terminals shall be covered by transparent plastic cover to protect electrical shock accident or against accidental shorting.

8) Test and Inspection

Following tests shall be conducted in the Manufacturer's shop. The test results shall be recorded and submitted to the Engineer.

- Dielectric strength test,

All circuits and apparatus shall be tested for one minute duration and proved to be safe against the following voltage.

Primary to Ground : 1,500 V  
Primary to Secondary : 1,500 V  
Secondary to Ground : 1,500 V

- Efficiency test,

The efficiency shall not be less than 60% at full rated output (50A, 50V, DC).

(b) Anode ground-bed

1) High silicon cast iron anode shall be used for ground-bed, having standard size of 50 mm. diameter, 1,500 mm. length, and approximately 22.7 kg weight. The anode composition shall be conform to as follows :

Si : 14.25 to 15.25% by weight  
Mn : Max. 0.5%  
Cr4. : 0 to 5.0%  
C : Max. 1.4%  
P : Max. 0.25%  
S : Max. 0.1%  
Fs : Remainder

2) Each anode shall be packaged in steel container of 160.2 mm diameter and 2,000 mm length containing metallurgical grade coke breeze. The 6 stations of 8×2 sides (total 96) anodes for the CP system shall be installed vertically of 6.3 meters depth with 200 mm diameter bore-hole at 10 meters intervals.

- 3) The anode cable conductor shall be 14 mm<sup>2</sup> or over of single core stranded copper with 15 m of the minimum length required.
- 4) The anode lead cable shall be stranded copper conductor, and insulated with cross-linked polyethylene insulated and steel armoured type cable (XLPE/PE/AWA/PE).
- 5) The high silicon cast iron anodes shall be individually tested to meet the following requirements.
  - Workmanship, surface defect and general finish on each anode are to be visually inspected.
  - Cable end to anode head.  
10 amperes DC shall be passed through the lead cable and anode head. The initial voltage drop across the lead cable/anode connection, excluding the voltage drop due to the cable resistance, shall not exceed 15 millivolts.

6) Carbonaceous Backfill

The backfill to be used for installation of the groundbed shall be a fine carbonaceous backfill passed through a No.9 (2 mm.) sieve.

Fixed carbon	: Minimum 85%
Moisture	: Maximum 4.5%
Resistivity	: Less than 50 ohm-cm under well stuffed condition

(c) Cable

- 6) DC cables for cathodic protection except the anode cable, shall be single core, stranded copper conductor, cross-linked polyethylene insulated and steel armoured type cable (XLPE/PE/AWA/PE), with a cross-section area not less than 35 mm<sup>2</sup>.

(d) Junction Box

The boxes shall be case of stainless steel 1.0 mm minimum wall thickness and be fully waterproof and contain a terminal block with threaded lugs for cable termination.

50 mm nominal diameter galvanized conduits shall be provided for cable entry and after the installation/connection of cable to terminal block the cable/conduit at entrance to the box shall be sealed with putty or as approved material.

(e) Test Box

The test boxes shall be fabricated from 0.8 mm stainless steel at minimum and shall have a terminal block inside for cable connections. The entire unit shall be weatherproof.

(f) Insulating Flange Accessories

The insulating flange assemble shall be provided at isolating valve in the Pumping station as shown on the Drawings. The insulating flange accessories consist of insulating gasket, insulated stud bolts with nuts, insulating washers and steel washers, mastic, and shrink tube or polyethylene wrapping tape.

The insulated bolts, used at 50 degrees C maximum, shall be coated with 0.7 mm thick poly-amid resin or equivalent. Coating length shall be more than the total thickness of the flanges, one gasket and two insulating washers.

Insulating washers shall be made of an epoxy glass base fiber reinforced plastic and 20 kg/cm<sup>2</sup> for 4 units of 1,500 mm diameter flange as shown in Bill of Quantities.

Insulating gaskets shall be teflon coated asbestos or rubber type, and suitable for flat face flanges.

(g) Negative and Test Terminals

7) The terminals shall be as shown on the Drawings. The cables shall be thermit welded to a 50 x 32 x 4.5 mm steel plate and the cables shall be single core with cross-linked polyethylene insulated and steel armoured type cable (XLPE/PE/AWA/PE), having the following requirements.

(a) Negative terminal : 35 mm<sup>2</sup>, approx. 20 m length

(b) Test terminal : 8 to 14 mm<sup>2</sup>, approx. 20 m length

(h) Switch Board

Switch Board shall be provided for transformer incoming line.

Molded circuit breakers and lamps indicating the power supply for transformer shall be equipped in and on the board. The roof and the sunshade cover of Switch Board shall be 1.2 mm minimum thickness of stainless steel.

(i) Bond Accessories for Flexible Joints

Flexible joints on surge tanks, blow offs and end point of pipeline shall be provided the bond to keep electric continuity between pipeline and flexible joints.

(j) Guard Fence

Guard fence of 2 m height with a door for boxes (Transformer rectifier, Switch board, Anode junction boxes, Negative junction boxes and Test boxes) shall be constructed as shown on the Drawings.

#### **(4) Construction of Cathodic Protection System**

##### **(a) Scope of Works**

The construction works and supply of cathodic protection system shall consist of the supply, installation and testing of the required materials and equipment as specified and as shown on the Drawings.

##### **(b) Power supply and connection works to the system**

The power supply of AC 380V, single phase, 50 Hz for the cathodic protection system shall be provided from the sub-station and constructed by the Contractor.

##### **(c) Application Scope of Specifications**

The current issue of the specifications for cathodic protection system provided by the National Associated of Corrosion Engineers (NACE) shall be a part of this Chapter.

#### **(5) Equipment and Materials furnished by the Contractor**

The major equipment and material to be furnished, installed and made ready for operation of the system shall be as follows:

<b>No.</b>	<b>Description</b>
1	160.2 mm diameter steel zinc canister with high silicon cast iron anode.
2	Single core 35 mm <sup>2</sup> cross-linked polyethylene insulated and steel armoured type cable (XLPE/PE/AWA/PE).
3	Single core 6 to 10 mm <sup>2</sup> cross-linked polyethylene insulated and steel armoured type cable (XLPE/PE/AWA/PE).
4	Transformer rectifier unit.
5	Concrete stand and stainless steel boxes.
6	Earthing rod and earthing lead wire.
7	Guard fence for switch boards, transformer rectifier, test boxes and junction boxes.
8	All other materials required for the system construction

The requirement for the materials and equipment supplied by the Contractor and those shop test shall be as specified hereunder.

##### **(a) Cable**

- 8) D.C side cables for cathodic protection except anode lead cable shall be 0.6/1 kV single core, stranded copper conductor, cross-linked polyethylene insulation, steel armoured type cable (XLPE/PE/AWA/PE) with a cross sectional area of 35 mm<sup>2</sup>.

AC Supply cables for cathodic protection shall be 4 cores, cross sectional area of 70 mm<sup>2</sup> , steel tape armor cable as specified in Egyptian Code or equivalent approved by the Engineer.

**(b) Guard Fence**

Each switch boards, transformer rectifier, test boxes and junction boxes shall be protected by steel fence of 2 m height with a door as shown on the Drawings.

**(6) Installation**

The installation of equipment and materials shall be carried out as follows in compliance with the Drawings and the methods and manners prescribed in NACE standards.

**(a) Rectifier**

Rectifier, consisting of a control cabinet, a terminal box and an oil tank, shall be installed on concrete foundations with anchor bolts as shown on the Drawings.

The DC cables from the groundbed and from the pipeline shall enter the terminal box through conduit pipes and shall be connected to on the positive terminal and negative terminal respectively.

The casing of the rectifier shall be connected to an earthing rod. Earthing resistance shall be measured after installation and shall meet Egyptian regulation.

**(b) Groundbed**

The location for groundbed installation must be the place shown in the Drawings of approx. 1.7 km distance each other or as the indication of the Engineer.

**1) Boring**

200 mm diameter holes shall be bored vertically at the specified location. Each borehole shall have 6.3 meters depth. Actual soil resistivity shall be measured after completion of boring.

**2) Anode Installation**

High silicon cast iron anode shall be packaged in spiral container of 160.2 mm diameter and 2,000 mm long containing metallurgical grade coke breeze backfill.

The steel container shall be inserted in the bore-hole and the space between the steel container and the soil shall be backfilled with the excavated material.

The anode lead cables shall be connected to the terminal block in the junction box.

**(c) Cable Laying**

The positive main cable shall be laid between the transformer-rectifier and the anode groundbed with anode junction box. The negative main cable shall be laid between the transformer-rectifier and the cable bonding of pipeline with negative junction box. The cables shall be buried at least 600 mm below ground surface. The cable shall be laid on the bottom of the trench and covered with tamped native sand. Concrete tiles with a minimum thickness of 50 mm shall be placed on the sand layer if required and the rest of the trench shall be backfilled with native sand. When cables pass under roads, they shall be protected in 100 mm, rigid galvanized steel conduit.

Where the cable rises from the ground at the concrete stand, it shall be protected by conduit in accordance with Egyptian regulations.

**(d) Junction Box**

Anode and negative junction boxes shall be installed at the cable connection point specified. Junction boxes shall be mounted on concrete stand of height more than 1 m with adequate steps as shown on the Drawings.

**(e) Test Box**

Test boxes shall be installed with approximately 1,700 m interval along the pipeline as shown on the Drawings.

Test box numbers shall be clearly marked on the box with black letters. The test boxes shall be installed on concrete stand of height more than 1 m with adequate steps.

**(7) Field Test**

**(a) Test Procedure**

The field test shall be conducted after the cathodic protection system is energized to determine the specified criteria and operated efficiently. It shall be carried out in accordance with the Manufacturer's cathodic specialist

**(b) Pipe-to-Soil Potential Measurement**

Pipe-to-soil potential measurement shall be made to confirm the protective condition of the pipeline. Pipe-to-soil potential shall be measured with respect to a saturated copper/copper sulphate reference electrode (Cu/CuSO<sub>4</sub>) using an electronic polyrecorder (voltmeter) at all test boxes.

**1) Natural potential measurement**

Before the energization of any impressed current groundbeds, natural pipe-to-soil potential shall be measured at all test boxes.

## 2) Energization potential measurement

The impressed current groundbeds shall be energized to give a pipe-to-soil potential less than minus 0.85 volt (vs. Cu/CuSO<sub>4</sub>) at each test box by adjusting the output voltage of the transformer-rectifier. The measurement method shall be the same as item (a). Energized potentials shall be recorded at all locations where the natural potentials were recorded. If the required potential is not obtained in spite of full capacity operation of the transformer-rectifier, the whole system shall be checked to find faults, for example whether some foreign structures are in contact with the pipelines to be protected and/or each insulating flange is not effective.

## (c) Interference Test

The test of interference possibly caused by cathodic protection system to protect piping is carried out the crossing point of foreign pipeline if necessary.

### 1) Measurement

The pipe-to-soil potential of the new pipeline shall be measured with the reference electrode positioned above the crossing point with the foreign pipeline cathodic protection system switch on.

### 2) Bonding

- In case of foreign pipeline are not protected by cathodic protection system :

When any interference test results show a positive change in potential of foreign pipeline by more than 20 mV, the protected piping shall be bonded with foreign pipelines passing through the variable resistor in resistor bond box in order to reduce the interference.

- In case of foreign pipeline protected by cathodic protection system :

When any interference test results show a potential of pipeline not less than minus 850 mV., with reference to a copper/copper sulphate electrode, the protected pipeline shall be bonded as above mentioned item (a). Bonding are not necessary if the test result show a potential of foreign pipelines less than minus 850 mV.

## (d) Data to be Furnished

The Contractor shall submit, but not limited to, the following data for approval

- 1) Drawings of the protected pipeline route showing the overall layout of the pipeline and the location of significant items of hardware, test stations, electrical bonds, insulating devices and any other information related to the system.
- 2) Site Drawings showing anode installations, fittings and joints, casing, test station, electrically insulating devices, electrical bond and pipe support insulation's or underwater crossings and any details required to understand fully the installation of the system.



- 3) Detailed information and specifications of components of the system such as electrically insulating devices, spacers, test post terminals and others.
- 4) Information of field survey calculations and corrosion test data such as the protective current required, the pipe-to-soil potential along the pipeline, the soil resistivity along the pipeline at 300 meter maximum interval, interference currents, details of calculations, maintenance and operating data etc.,
- 5) Information of site conditions such as
  - existing and future pipelines and/or cathodic protection system
  - possible interference sources
  - special environmental conditions

(e) Other Considerations

During corrosion control surveys, personnel should be alert for electrical or physical observations, which could indicate interference from neighboring source. In area where interference currents are suspected, appropriate tests should be conducted. All affected parties shall be notified before tests are made for the purpose of establishing an interference bond. Any interference currents if found must be corrected by the Contractor at this own expenses.

**4106 Measurement and Payment**

Measurement and payment for the valves, PVC Pipe and Cathodic protection system shall be made under respective Pay Item shown in below. The payment shall be full compensation for supply, installation, testing for every component work, all of the related works, concrete and incidental required in order to complete the respective component works. The following Pay Item No. shall refer to the Bill of Quantities.

**(1) Valves**

<u>Valves</u>	<u>Pay Item</u>
Air Valve	PP-0704
Stop Valve D=400mm with a loose flange	PP-0707
Stop Valve D=200mm	PP-0727, PP-739
Stop Valve D=300mm	PP-0723
Stop Valve D=100mm	PP-0733
<u>Butterfly Valve</u>	<u>Pay Item</u>
Butterfly Valve D=1,500mm	PP-0712
Butterfly Valve D=700mm	PP-0728
<u>Loose Flange</u>	<u>Pay Item</u>
D=1,500mm	PP-0713
D=700mm	PP-0729
D=400mm	PP-0707

<u>Swing type Check Valve</u>	<u>Pay Item</u>
D=1,500mm	PP-0715
D=700mm	PP-0731

<u>Strainer</u>	<u>Pay Item</u>
D=200mm	PP-0718
D=100mm	PP-0734

<u>Float Valve</u>	<u>Pay Item</u>
D=200mm	PP0719
D=100mm	PP0735

## (2) PVC Pipe

Measurement for payment for PVC Pipe shall be the length of pipe installed as computed the alignment of pipeline. The rate shall cover supply and installation of pipes including jointing works with a socket and spigot assembly sealed by an elastometric sealing ring or flange or mechanical coupling or solvent welding.

Payment for PVC Pipe shall be made under respective items shown below.

<u>PVC Pipes</u>	<u>Pay Item</u>
D=300mm	PP0722, PP0737
D=200mm	PP0721, PP0738

## (2) Measurement and Payment for Cathodic Protection Device

<u>Work Description</u>	<u>Pay Item</u>
- Supply and Installation of Insulating Flange Accessories	PP-0741
- Drilling Bore Holes D=200mm, L=6.3m	PP-0742
- Supply and Installation of Transformer Rectifier	PP-0743
- Supply and Installation of High Silicon Anode	PP-0744
- Supply and Installation of Positive(Anode) J B	PP-0745
- Supply and Installation of Negative J B	PP-0746
- Supply and Installation of Test Box	PP-0747
- Supply and Installation of Reference Electrode	PP-0748
- Supply and Installation of Standard Probe	PP-0749
- Supply and Installation of Switch Board	PP-0750
- Supply and Installation of Cables XLPE/P/AWA/PE 1C 35mm <sup>2</sup>	PP-0751
- Supply and Installation of Cables XLPE/PE/AWA/PE 1C 6 to 14mm <sup>2</sup>	PP-0752
- Supply and Installation of Negative and Test Terminal	PP-0753
- Supply and Installation of Bond Accessories	PP-0754
- Supply of Insulation Checker	PP-0755

- Supply and Installation of Cables XLPE/PE/AWA/PE3C 70mm<sup>2</sup> PP-0756
- Supply of Corrosion Test Set PP-0757