



TENDER – CW/xxxx/2010

PROJECT TITLE

VOLUME II

TECHNICAL SPECIFICATIONS STANDARD SPECIFICATIONS

**DUBAI ELECTRICITY & WATER AUTHORITY
P.O. BOX – 564
DUBAI, UNITED ARAB EMIRATES**

TEL: 971-4-324 4444 FAX: 971-4-324 8111 (HEAD OFFICE)
WEB SITE : <http://www.dewa.gov.ae>
E-MAIL: contracts@dewa.gov.ae



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DEWA-PEW
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TECHNICAL SPECIFICATIONS

SECTION 1

GENERAL

1.01 CONTRACT DOCUMENTS

These specifications shall be read in conjunction with the other Tender Documents, including the Tender Form, Form of Agreement, Schedule of Unit Prices (Bill of Quantities) and Appendices, General Conditions of Contract, Special Conditions of Contract, Drawings and Notices and Addenda.

All these documents and drawings are to be regarded as mutually explanatory and complementing each other, and in the event of discrepancy or assumed discrepancy being found, the Contractor shall immediately inform the Engineer of the matter in writing and the Engineer will issue his instructions in the matter in accordance with Clauses of the General requirements for pipe line installations and the Engineer's instructions shall be final and binding.

1.02 CONFIDENTIALITY OF INFORMATION

The Contractor shall treat the details of this contract as private and confidential for his own information only, and shall not publish or disclose the details in any trade or technical paper or elsewhere (except as necessary for the purpose thereof) without the previous consent of the Employer.

1.03 SITE CONDITIONS

Before submitting his tender, the Contractor shall be deemed to have satisfied himself as to the engineering characteristics and qualities of the various soils on site, the suitability of the materials he proposes for use in the works to meet the requirements of the specifications, and the locations of quarries and borrow pits.

The Contractor shall make his own site and soils investigations and he shall not be entitled to additional payments for such investigations. The Contractor must satisfy himself as to the nature of the soil through which excavations and foundations are to be made or which are to be used in the construction. No claim from the Contractor for additional payment will be considered.

1.04 DESCRIPTION OF THE PROJECT

SCOPE

The work comprises of the Supply, installation, testing & commissioning of 100mm to 450mm dia Water Distribution Network of Fibre Cement /Glass Reinforced Epoxy Pipes at Various Locations In Dubai Including Change of House Connections and Associated Works but not limited to all works, as shown in the drawings and as detailed below.

- a. Actual site survey and preparation and submittal of the result of all surveys, survey index drawings, detailed working drawings and as-built drawing etc., including submittal to the Engineer/ Engineer's representative on a monthly basis preliminary "as-built" drawings as actually constructed and certified by the Engineer.
- b. Obtaining all necessary No Objection Certificate from services Authorities, Consultants involved in other Projects within the subject Project areas and from various Departments of Dubai Municipality, RTA, Abu Dhabi Municipality/ADWEA/TRANSCO as applicable, Developers, property owners, including necessary demarcation from Town Planning/Survey Section.
- c. Maintaining a database of all No Objection Certificates.
- d. Bulk excavation in cutting, filling, and site leveling and grading, including preparation of final ground longitudinal and cross section drawings.
- e. Excavation, laying, testing, sterilization, flushing, cleaning, backfilling and commissioning of all works including supply of materials.
- f. Thrust blocks and valve chambers on new and existing pipelines.
- g. Interconnection with new and existing pipelines.
- h. Reinstatement and maintaining of existing surfaces in accordance with the specifications and in conformance with Dubai Municipality /RTA/ Abu Dhabi Municipality requirements.
- i. NDRC work method to install pipe under existing asphalt road/under existing services.
- j. Fixing new valves, air valves and wash outs and other fittings on the Pipelines including the construction of chambers.

- k. Flow meters, Pressure Transmitters, Water Quality Analyzers with other SCADA Installations and interfacing with existing SCADA, if applicable.
- l. Design, supply, and install programming and commissioning of RTU units and fiber optic communications network to enable control/monitor pipeline instrumentation from the Master SCADA system at DEWA Head office and according to contract specification, if applicable.
- m. Preparation and submission of "as constructed drawings" on negative print as well as on formats based on software format which shall be indicated by DEWA during the contract period and as detailed in Clause 4.6.2, Conditions of Contract.
- n. Fixed asset numbering as detailed in clause 16.7, Conditions of Contract.
- o. Installation of flexible Indicator post and Marker posts.
- p. Supply of spares and spare parts to DEWA stores.
- q. Maintenance of work.
- r. Any other work not stated above, and required for the construction, commissioning and successful operation of the pipeline network.

1.05 SITE OF THE WORK

The project is in various locations in the Emirate of Dubai, U.A.E. However, DEWA reserves the rights to add/ delete/ change the locations as per requirement, all as instructed and directed by the Engineer.

1.06 ADJOINING LANDS

The Contractor shall conduct his operations in such a manner as to avoid injury or damage to adjacent property, improvements or facilities. Buildings, trees, ground cover, and shrubbery that are not designated for removal, pole lines, fences, guard rails, guide posts, culvert and property markers, signs, structures, conduits, pipelines and other facilities within or adjacent to the street or right-of-way shall be protected from injury or damage. The Contractor shall provide and install suitable safeguards to protect such objects from injury or damage, which objects if injured or damaged, by reason of the Contractor's operations, shall be replaced or restored by the Contractor at his own expense to a condition as good as when he entered upon the works, or as required by the Specifications. The Contractor shall not disturb any monuments, property corners or survey markers

without permission from the Engineer, and he shall bear the expense of resetting any monuments, property corners or survey markers which may be disturbed.

The Contractor shall be responsible for all damage to streets, utilities, roads, highways, ditches, embankments, bridges, culverts or other public or private property, which may be caused by transporting equipment, materials, or men to or from the work. The Contractor shall make satisfactory and acceptable arrangements with the property owner of the damaged property concerning its repair or replacement.

The convenience of owners of property adjoining the site shall be provided for as far as possible. Convenient access to driveways, and buildings adjoining the work shall be maintained and temporary approaches to intersecting streets and alleys shall be provided and kept in good condition.

1.07 CLEANLINESS OF SITE AND WORKS GENERALLY

Throughout the Contract, the Site and all temporary and permanent works shall be kept in a clean, tidy, and sanitary condition.

1.08 FOULING AND CONTAMINATION

The Contractor shall, at his own expense, take such measures as the Engineer may require, to prevent contamination of the soil and the entry of spillage from concrete mixing operations, oils, or other deleterious materials, into any drainage system, or natural watercourse.

1.09 UTILITY MAINS AND SERVICES, LOCATIONS, ETC.

It shall be the responsibility of the Contractor to obtain all information available from all various Ministries/ Departments/ Municipalities/ Authorities in UAE, regarding the positions of mains and services, and he shall make this information available to the Engineer as soon as he obtains it.

Before opening up the ground for any purpose, the Contractor must notify all concerned parties by issue of a formal "Notice of Intent" and must obtain information by formal notice regarding the location of all underground services.

The complete responsibility for obtaining this information rests with the Contractor or party requiring opening up the ground.

"Notices of Intent" are required to be circulated to all concerned parties and "No Objection Certificates" from all various Ministries/ Departments/ Municipalities/Authorities in UAE.

Drawings and notices shall be sent in duplicate, one of which shall be retained by the addressee and the other returned to the sender duly marked to show underground services. "Notice of Intent" will be given 14 (fourteen) days in advance of the proposed works. In the event that the work is not started within 8 (eight) weeks of the date of the Notice of Intent, it will be deemed to have elapsed. A further Notice of Intent will then be submitted.

All locating work shall be carried out in advance of excavation work. The Contractor shall obtain all information and assistance available from the Service Authorities for locating the mains and services, and shall take the Engineer's approval for any trial excavations, which may be necessary to confirm or establish these locations. The absence of such information shall not relieve the Contractor of his liability for the cost of any repair work necessitated by damage caused by him to such mains and services in the course of his work and for the cost of all losses arising from their disruption.

All costs for executing such boreholes and trial holes shall be deemed to be included in the Contractor's rates for excavation. Only trial holes and boreholes required by the Engineer for particular purposes, and ordered in writing by him, shall be paid for under the appropriate item in the Bills of Quantities.

No public or private facility shall be extinguished or interrupted without the written permission of the Engineer. Such permission will not be given until suitable permanent or temporary alternatives, approved by the Engineer, have been provided by the Contractor, or, in the case of accommodation works, by the owner of the facility or his agents.

The Contractor shall make arrangements with the Service and Public Authorities concerned, for the phasing into his Programme of Works of all work which needs to be done by them or their Contractors, or by the Contractor himself, concurrently with the works.

The Contractor shall take any and all measures reasonably required by any Public or Service Authority for the support and full protection of all mains, pipes, cables and other apparatus during the progress of the works, and shall construct and provide to the satisfaction of the Authority concerned, all works necessary for the prevention of damage or interruption of services. If in the execution of the works, by reason of any subsidence caused by, or any act of neglect or default of the Contractor, any damage to any apparatus or any interruption of, or delay to the provision of any service is caused, the Contractor shall report it to the Engineer immediately and bear and pay the cost reasonably incurred by the Authority concerned in making good such damage and shall make full compensation to the Authority for any loss, sustained by reason of such interruption or delay.

The Contractor shall, at all times during the progress of the works, afford facilities to properly accredited agents of any Public Service Authority for access to all or to any of their apparatus situated in or under the site, as may be necessary for inspection, reporting, maintaining, removing, renewing or altering such apparatus in connection with the construction of the Works or for any other purpose what so ever.

The absence of information shall not relieve the Contractor of his liability for the cost of any repair work necessitated by damage caused by him to such mains and services in the course of his work and for the cost of all losses arising from their disruption.

Any temporary or permanent diversion of mains and services will only be permitted after agreement with the appropriate Service Authority and the Engineer.

Permanent diversions will only be considered where the main or service occupies the line and level of the pipe work or structure to be constructed by the Contractor, or where the position of the main or service completely prevents this construction. Only permanent diversions, which the Engineer considers essential for these reasons, will be measured and paid for under the items in the Bills of Quantities.

Temporary diversion and restoration of mains or services shall be at the Contractor's expense.

1.10 SAFEGUARD OF EXISTING PROPERTY AND UTILITIES

It shall be the Contractor's responsibility to safeguard by means of temporary or permanent supports, or otherwise, all pipes, cables, structures or other things which would be liable to suffer damage if such precautionary measures were not taken.

Temporary safeguards shall be to the approval of the Engineer and of the Authority, Ministry or Owner concerned.

Permanent safeguards shall be to the approval of the Authorities, or Owner concerned and the Engineer.

All temporary and permanent safeguards will be at the Contractor's expense.

Any additional costs, due to difficulty of working or to any other reasons arising from the presence of the aforementioned, shall be borne by the Contractor.

1.11 USE OF PUBLIC HIGHWAY

The Contractor shall ensure that all vehicles, which he intends to use on the public highway, comply with and are used in accordance with all relevant statutory requirements currently in force in U.A.E.

The Contractor shall take every precaution and shall make adequate provisions to prevent excavated material or other debris being deposited on the public highway from his vehicles, and shall promptly comply with any instructions issued by the Engineer or other Authorities to remove any material so deposited, at his own expense.

1.12 COMPLAINTS AND CLAIMS

During the course of the work, complaints and claims may arise from the public or from various Authorities. The Contractor shall satisfy the Engineer that he is dealing with all such matters without delay, until appropriate clearance certificates from any Authority concerned are produced by the Contractor. This Clause shall in no way absolve the Contractor from his obligations under Clause 5.15 of the Conditions of Contract.

1.13 SETTING OUT OF THE WORKS

The Contractor shall prepare detailed setting out drawings based on trial hole information's and data sheets for the Works, as necessary, and submit them to the Engineer, in triplicate, for approval. Any modifications to the setting out drawings or data sheets required by the Engineer shall be made by the Contractor and resubmitted for final approval. Approval by the Engineer shall be signified by the return to the Contractor of one copy duly signed by the Engineer.

Should it be necessary during setting out or during construction for agreed setting out details to be amended, the Contractor shall amend the drawings or data sheets, or make new ones for approval, as required by the Engineer.

Copies of setting out drawings and data sheets shall be preserved for use by the Contractor in preparing final records and drawings, in accordance with the requirements set out elsewhere.

The Contractor to note that it is his responsibility to obtain the NOC and demarcation from the Dubai Municipality/other concerned, before the start of actual commencement of works on site. Any fees associated with the above, shall be included in the contract rates.

The Contractor shall provide on site for the surveying works and sitting out, at least one (1) No. Robotic Total Station, which uses a radio to communicate the Total Station and the prism, to cover both, survey and stake out.

1.14 PROTECTION FROM WATER

Except as elsewhere specified, the Contractor shall keep the whole of the works free from water, and allow in his price for all the measures necessary for the purpose, and shall clear away and make good, at his own cost, all damage caused thereby.

1.15 POLICE AND HEALTH REGULATIONS

The Contractor shall keep in close contact with the police and other officials of the areas concerned regarding their requirements in the control of workmen, passage through adjacent areas, or other matters, and shall provide all assistance or facilities which may be required by such officials in the execution of their duties. The Contractor shall obey Municipal, Police and Health Regulations and all other regulations.

1.16 WATER SUPPLY

The Contractor shall at his expense make adequate arrangements to the satisfaction of the Engineer for the supply of all potable and other water required for any purpose connected with the works, and shall provide, operate, and maintain all the necessary installations.

The Contractor shall pay all charges in respect of the provision of meters and connections, and water rates for water. The Contractor's notice is particularly drawn to the importance of checking the availability of water for use in construction work.

1.17 DISPOSAL OF WASTES

The Contractor shall, at his expense, make adequate arrangements to the satisfaction of the Engineer for the disposal of all debris, rain and subsoil water, sewage, and all other waste materials arising from or connected with the works.

1.18 POWER SUPPLY

The Contractor shall, at his own expense, arrange for the supply (either from DEWA or from his own resources) and distribution of all electricity required for or in connection with the works. The Contractor will not be granted any additional cost or time incase DEWA will not provide power supply for works during construction, testing and commissioning etc., during the contract period.

1.19 OTHER SERVICES

The Contractor shall, at his own expense, make his own arrangements for, and shall provide any services (including telephone and other utilities) which he may require in addition to the foregoing, including 2 projects sign boards etc.

1.20 SAFETY AND MEDICAL FACILITIES

The Contractor shall, at his expense, arrange for medical attention to be available when necessary, and shall provide dressing stations complete with all adequate first-aid equipment on the site. The Contractor shall display in suitable places the names of his employees who are available, from time to time, to render first aid services. The Contractor shall provide for the transport of serious cases to the nearest hospital.

The Contractor shall, at his own expense arrange for special masks to be worn by all his labour and staff, and provide the same for the use of the Engineer's site staff, while working with all types of pipes, i.e., tapping, cutting, etc.

The Contractor shall comply with all requirements of legislation of the UAE and the Emirate of Dubai concerning the working conditions, safety, health or welfare of any employee of the Contractor, the Engineer or the Employer.

The Contractor shall comply with best industry practices for the safety of workmen and the public.

The Contractor shall file with the Engineer, the names, addresses, and telephone numbers of representatives who can be contacted in Dubai at any time, in case of emergency. These representatives shall be fully authorized and equipped to correct unsafe or excessively inconvenient conditions at short notice.

1.21 ACCESS

The Contractor shall, at his own expense, make all arrangements for providing safe and expeditious access from the public highway to the site and, where necessary, shall construct, maintain, safeguard and reinstate, to the satisfaction of the Engineer, all roads and other access works which may be required for that purpose.

The Contractor shall ensure that none of the aforementioned access works (whether of a permanent or temporary nature) shall obstruct or impede any utilities, drainage or irrigation systems, or have other adverse effects on surrounding land or property. Transportation of pipe and other materials to the site for permanent construction shall start only after construction of access roads to the satisfaction of the Engineer.

1.22 ORDER OF CARRYING OUT THE WORKS

The Contractor shall proceed with the construction of the works, in accordance with a sequence approved by the Engineer.

1.23 PROGRAMME OF WORK

In the programme and particulars required under the Conditions of Contract, the Contractor shall:

- A. Provide details of the sequence he proposes for carrying out the works and the time of completion for work areas handed over to him under the provisions of relevant Clause.
- B. State and allow a reasonable margin of time for contingencies.
- C. State his intentions regarding shift work, if required.
- D. The Programme of Work should be submitted to DEWA in a SOFT COPY & HARD copies done in PRIMAVERA software (version 3 or above). The Programme of Work (Approved by DEWA) will be considered as a BASELINE Programme, to compare the actual progress of the project.
- E. The Work Programme shall contain mainly 3 layouts:

- a. First layout to be Work Breakdown Structure Layout (WBS) to show the group of activities with all information's.
- b. Second Layout to be Responsibility Layout will show the Responsible Recourse (contractor-subcontractor-vendors-manager) for each Activity or group of activity this called (Organization Breakdown Structure Layout (OBS)). Third Layout will be Cost Layout, showing the planned value, earned value & actual cost. Planned value will be consider as same as the value mentioned in the BOQ and then actual value will be the payments done to the contractor while earned value will be calculated by Primavera with all Diagrams like Bar Charts and S curves

F. The Programme of Work should be updated to show the progress of the work and shall be submitted to DEWA on weekly basis.

G. DEWA reserve the right to call for any reasonable number of further detailed programmes during the period of the contract so that DEWA may be able adequately to follow the progress of the works both on and off the site.

H. The submission whether approved or not by DEWA of such programmes, particulars or any cash flow estimates shall not relieve the contractor of any of his duties or responsibilities under the contract.

I. If at any time it should appear to DEWA that the actual progress of the works does not conform to the BASELINE Programme of Work, the contractor shall produce at the request of DEWA a revised programme showing the proposed modifications to such programme necessary to ensure completion for DEWA review and approval.

J. Provide monthly a proposed CPM chart, showing his plans for materials supply and implementation, standard listing, period bar chart, a complete resources report and a cash flow curve.

1.24 CONTRACTOR'S PROGRESS REPORTS

The Contractor shall report monthly progress as agreed by the Engineer's representative to the Engineer, on charts submitted in quadruplicate, and showing actual work done superimposed upon copies of the programme. He shall furnish an explanation of any deviation from the programme, and shall state proposals for improving progress, if lacking in any respect.

Along with the monthly progress report, the Contractor shall submit a monthly "As Built" drawing showing overall progress and the pipes laid and commissioned during the month.

1.25 PROGRESS MEETINGS

Progress meetings shall be held on a fortnightly basis in accordance with an agreed schedule. All matters bearing on the progress and performance of the work since the preceding progress meeting shall be discussed and resolved, including any previously unresolved matters, deficiencies in the work or the methods being employed for the work, and problems, difficulties, or delays which may be encountered.

Unless otherwise specified or required by the Employer or Engineer, the meetings shall be attended by the Employer, the Engineer and the Contractor. Subcontractors may attend when involved in the matters to be discussed or resolved but only when requested by the Employer, Engineer, or Contractor.

1.26 ORDERING MATERIALS

All material for incorporation in the permanent and /or temporary works will be supplied by the Contractor, except to the extent specified elsewhere or otherwise instructed by the Engineer. The Contractor shall obtain the Engineer's written approval for the particular supplier from whom he proposes to obtain materials.

Except where otherwise stated or approved by the Engineer, all materials used in the works shall be as specified or described in the Specifications, Drawings and Bills of Quantities and shall comply with the appropriate current standards published by the British Standards Institution, ASTM or other approved standards.

The Contractor shall be responsible for payment of royalties, if any, arising due to the obtaining of materials for use in the works. No separate payment will be made by the Employer as a royalty for materials.

1.27 SAMPLES

In addition to any specific provisions in the Specifications or in the Bills of Quantities for the sampling and testing of materials, the Contractor shall, at his own expense, submit, for retention by the Engineer, samples of all materials which he proposes to employ in the permanent work. No material shall be used in the permanent work unless and until such samples shall have been approved in writing by the Engineer. The Engineer may exercise his powers under the relevant Clause of the Conditions of Contract in respect of any materials which, in his opinion, are inferior to the relevant sample previously approved.

1.28 TESTING MATERIALS

All materials intended for use in the permanent work including necessary soil testing and for the testing of which no specific provision is included elsewhere in the Specifications or in the Bills of Quantities, shall be tested at the Contractor's expense, either at the place of manufacture or fabrication, or on site, or at a laboratory approved by the Engineer. The testing shall determine, to the satisfaction of the Engineer whether the materials comply

with the requirements of the Specifications. If such testing is undertaken at the place of manufacture or fabrication, the Contractor shall submit the supplier's test certificates to the Engineer before the dispatch of the relevant consignment.

Either in addition to, or as an alternative to, testing at the place of manufacture or fabrication, or on the site, or at an approved laboratory, the Engineer may direct that tests be carried out elsewhere by an independent person or laboratory at the Contractor's expense.

1.29 MATERIAL TESTING LABORATORY

The Contractor shall arrange for sampling, hauling and testing for the required laboratory testing of soils and materials, all at his own expense, at an independent laboratory approved by the Engineer and as required by the Engineer.

1.30 INSPECTION OF MANUFACTURING PROCESSES AND FACTORY TESTING OF MATERIALS

The Contractor shall afford the Engineer full access to inspect the manufacture and witness factory testing of all materials to be incorporated into the permanent works.

Reasonable notice shall be given by the Engineer of his intention to visit the factory for such purpose, and the Contractor shall keep the Engineer informed of his manufacturing and testing programme.

Factory tests required on materials shall be as detailed in these Specifications or in the relevant British, American, or other national or international standards, as applicable. Records of all tests carried out shall be kept at the place of manufacture and shall be open to inspection by the Engineer. Copies of tests shall be sent to the Engineer, as required.

1.31 REMOVAL OF CONDEMNED MATERIALS

The Engineer may require the Contractor to remove and dispose of any materials employed in the construction of the permanent works which, in the opinion of the Engineer are unsuitable, or have been incorrectly deposited, or have suffered damage by exposure to the weather, or otherwise are not in accordance with the specified requirements for such materials. The Contractor shall not be entitled to any payment whatsoever in respect of such materials.

1.32 MATERIALS ARISING FROM EXCAVATIONS AND DEMOLITION

The Contractor shall not sell any materials arising from excavation, demolition, and the like, carried out on the site, unless authorized in writing by the Engineer.

The re-use or disposal of any such materials shall have the prior approval of the Engineer.

1.33 PROVISION OF FACILITIES FOR ENGINEER'S INSPECTIONS

The Contractor shall provide the necessary equipment, access including inspection platforms and foot bridges and labour to enable the Engineer and the Engineer's Representative conveniently to carry out such inspections as they may deem necessary, at all times during the currency of the Contract.

1.34 INSPECTIONS BY THE ENGINEER DURING PERIOD OF MAINTENANCE

The Engineer will give the Contractor due notice of his intention to carry out any inspections during the period of maintenance, and the Contractor shall, thereupon, arrange for a responsible representative to be present at the times and dates named by the Engineer. The Contractor's Representative shall render all necessary assistance and take note of all matters and things to which his attention is directed by the Engineer.

1.35 LANGUAGE OF CORRESPONDENCE AND RECORDS

All written communications from the Contractor to the Employer or the Engineer shall be in the English language.

All books, time sheets, records, notes, drawings, documents, etc., shall be in the English language. If the original documents are in another language, a certified translation in English shall be submitted to the Engineer.

1.36 RECORD DRAWINGS

As the work proceeds, the Contractor shall make Record Drawings based on the Contract Drawings, as modified, to portray the works as actually constructed. Drawings shall be supplemented as necessary by schedules, data sheets, etc.

Draft Record Drawings shall be submitted to the Engineer for his approval, and then finalized in accordance with any amendments required by him.

The originals (reproducible transparencies) and three copies of all Record Drawings shall be submitted. Along with drawings on formats based on software format on the latest base maps issued by Dubai Municipality.

1.37 PENULTIMATE ACCOUNT

Not later than sixty days after the issue of the Certificate of Completion for the whole of the works, the Contractor shall submit to the Engineer a penultimate account with detailed final measurements of the whole of the works as constructed, at the date shown on the Certificate of Completion, together with all further sums which the Contractor considers to be due to him under the Contract.

1.38 QUALITY CONTROL, TESTS, METHODS AND DEFINITIONS

1.38.1 Construction Control

The Contractor shall maintain close control of materials and quality of the works, and shall report promptly to the Engineer should any circumstances make him dissatisfied with the progress and/or quality of the work.

1.38.2 Tests During Construction

Unless otherwise stated, the tests referred to are as called for the relevant AASHTO, ASTM, BS and DIN Standard Specifications, and other pertinent international specifications, in accordance with the latest editions current on the effective date of the Contract.

1.39 WATER WASTAGE

The Contractor will be charged by DEWA (PEWC) for all losses of water occurred during the shutdown and execution of work, and that occur as a result of negligence in the execution of the works.

1.40 REFERENCE SPECIFICATIONS

The contractor will make available on site during the duration of the works, a copy of all Standard Specifications referred to in these Specifications, and also any alternative Standard Specifications he may request approval for.

A copy of these Specifications will be submitted to the Engineer upon his request.

1.41 PIPELINE ACROSS PRIVATE PROPERTY.

Contractor shall remove and reinstate at his cost the existing fence wherever the pipes are to be laid across the fenced area.

1.42 DEWA SAFETY AND OCCUPATIONAL HEALTH RULE'S

Contractor shall adhere to the following:

- a) Contractor has to submit a copy of his Safety Policy, prior to starting the work.
- b) Contractor shall strictly adhere to DEWA's Safety Rules, a copy of which be collected prior to the beginning of his work on site.

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- c) Contractor shall produce method of statements outlining how he will approach work activities. The method statements shall include risk assessments.
- d) Contractor shall monitor and provide details and near hit performance during the course of the contract.
- e) Contractor shall ensure that visitors to the site are properly made aware of Safety & Emergency procedures during a check-in procedure.
- f) Contractor shall report on their Health & Safety Performance as part of their project progress reporting.
- g) Contractor shall report to Safety Section of DEWA thru the concerned Dept. all accidents and Near Misses (Near Hits) as per procedure and prescribed form. In continuation of which they shall also fill up the Follow Up Report form including their actions.
- h) Contractor shall report quarterly to Safety Section of DEWA thru the concern department, as per procedure, their Accident Frequency Rates (AFR), Accident Severity Rates (ASR), other parameters in connection with Safety and Occupational Health.
- i) Contractor shall report quarterly to Safety Section of DEWA thru the concern department as per procedure, Risk Assessment Report with their part of action.
- j) Contractor shall provide the all-necessary information and cooperation to the Safety Section of DEWA and DEWA's staff in inspection, investigation and in other safety and occupational health issues.
- k) Contractor shall cooperate with Safety Section of DEWA during cross checking which DEWA reserves the right for.
- l) Contractor shall take the specification thru the concerned department before procuring and after that quality standard clearance of PPE's from Safety Section of DEWA.
- m) Contractor shall take care and take necessary action of all other additional items if found hazardous and risky in nature.
- n) Apart from those mentioned above, Contractor shall adhere to follow the latest advice and suggestions on Health & Safety issues, during the Contract.

1.43 ISO 9001 AND ISO 14001 COMPLIANCE

DEWA is an ISO 9001 and ISO 14001 certified company as well as certified from the British Safety Council as a safety conscious organization. The Contractor and Subcontractors working for the Project shall also be covered under these certifications and therefore, they are obliged to follow strict control, regulations and audits, which are obligatory under these certifications.

Accordingly, all site works on the Project shall be in compliance with ISO 14001. The Contractor shall ensure that his staff and labourers are trained adequately, so that they are familiar and can comply with the general requirements. Control, segregation and disposal of waste shall be according to the requirements of environmental regulations.

SECTION 2

EXCAVATION AND BACKFILLING

2.01 GENERAL EXCAVATION

General excavation means excavation, whether bulk or incidental required for structures and exploratory excavations and shall not include Trench Excavation.

The ground shall be excavated by such methods and to such dimensions and depths shall allow for the proper construction of the Works.

Where nominal "payment" limits of excavation are not shown in the Drawings or otherwise specified they shall be deemed to be the minimum net limits, which would allow the outline of the completed structure to be lowered vertically from ground level into its final position. The Contractor shall make his own allowance for any working space required, any excavation outside the aforesaid limits which has not been ordered by the Engineer, whether it be excavated to suit the Contractor's method of working or unavoidable overbreak or due to his carelessness or error, shall be held to be Excess Excavation and shall not be measured for payment.

Generally Bulk excavation in cut or fill and necessary access road work shall be carried out prior to trench or structure excavation and bulk excavated or filled up level shall form the commencement level of trench excavation . Payment shall be computed only for the approved Bulk excavation in cut and imported fill as per the approved working drawings and not for the quantity of the fill material utilized from the cut quantity or extra available from trench or structure excavation.

2.02 PRE-CONSTRUCTION RECORDS

Before an excavation is started:

- A. Initial ground levels shall be agreed at suitable intervals with the Engineer.
- B. Surface materials and conditions will be recorded in presence of the Engineer and where appropriate the owners or occupiers of the land.
- C. The Contractor shall take photographs to illustrate existing damage or conditions which may prove contentious at the time of reinstatement.

This information shall be neatly presented and submitted to the Engineer. To this shall be added details of any existing natural or piped subsoil drainage or other underground features as work proceeds.

Trial excavations to be carried out along the route of pipeline for location of all existing services and findings to be presented on drawings with location, type and levels. All

services to be included in final drawings. The excavations shall not be backfilled without approval.

2.03 TOPSOIL AND SURFACING MATERIAL

Before commencing excavations or filling to an area, topsoil and other surfacing materials shall be stripped and stored separately from the subsoil. Subsequent spreading of topsoil or removed to spoil shall be as directed on site.

2.04 LAND DRAINS

Where pipelines are to be laid in agricultural land the surface and subsoil drainage shall be maintained whether natural or artificial. Before commencing work the Contractor shall ascertain from the owner or occupier of the land the location of any existing land drains or mole drains.

2.05 EXCAVATED MATERIALS

All excavated material will remain the property of the Employer unless designated as surplus to the Contract requirements in which case it will be removed from site immediately. The Contractor shall dispose of such surplus or unsuitable material and his proposed tips shall be subject to the approval of the Dubai Municipality.

All excavated material shall be deposited so that it will cause as little damage and inconvenience as possible.

Excavated material for use as backfill shall be as approved. Different classes of material shall be handled and deposited separately.

Where (natural) subsoil drainage depends on the relative positions of pervious or impervious strata, special care shall be taken to separate those materials and replace them in their natural positions.

2.06 FORMATION

Damage to the formation shall be prevented by bottoming-up with hand excavation immediately before placing concrete or pipe laying. Any damaged formation shall be excavated and refilled with concrete or selected material as instructed. No permanent works of any kind shall be constructed on an excavated surface until the formation has been approved.

2.07 INSPECTION BY THE ENGINEER

When the specified levels or limits of excavation are reached the Engineer will inspect the ground exposed, and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further. Excavation as ordered to remove

unsuitable material below the specified limits of excavation shall not be held to be Excess Excavation.

Should the material forming the bottom of any excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the Works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. Such further excavation shall be held to be Excess Excavation.

2.08 ROCK AND HARD MATERIALS

For the purpose of this Contract rock and hard material shall mean those natural or artificial materials which are so hard that they require specialized "rock splitting" techniques in order to break them down to such a size that they can be removed by conventional excavating plant. Use of pneumatic tools or rippers will not in itself justify rock or hard material classification. The Contractor shall notify the Engineer as soon as he encounters rock or hard material for which he intends to claim payment to permit an assessment to be made as excavation proceeds. Hard subkha and cemented sand materials shall not qualify for any extra over payment applicable for the above mentioned materials such as Hard/rock category

2.09 USE OF EXPLOSIVES

Explosives shall only be used with approval. Explosives shall be acquired, stored and used in accordance with the laws of the country and any licenses shall be held on site for examination at any time. The storage and use of explosives shall comply with the detailed requirements of the Engineer. Detonators shall be conveyed and stored separately.

The charges shall be limited so that the amplitude of vibration in any direction does not exceed $\pm 0.1\text{mm}$ at 40Hz frequency of vibration or other such amplitude and frequency so that the maximum particle velocity does not exceed 25mm per second. It will be measured at the nearest building, water or service main or where the works are not within 100m of buildings or services it will be measured at this distance. The Contractor is to provide an approved viborgraph such as 'The Cambridge Universal Vibrograph' or 'I.C.C. Combigraph' capable of giving a vibrogram of displacement with an amplitude record all on a time base. Alternatively a Dawes-Elcomatic recorder or equal approved may be supplied, being capable of producing a vibrogram of amplitude and/or a record of particle velocity. Concrete plinths or wall brackets shall be provided to give a firm standing for the vibrograph when recording is taking place. These are to be removed when no longer required.

Notices setting out the procedure shall be posted round the site, together with any other safety requirements. Sufficient watchmen at each end of the excavation or where directed shall be provided, together with fencing and other measures for the protection of persons,

vehicles and property. Adequate screens, shields, matting or other measures to intercept material liable to be blown outside the excavations shall also be provided.

Warning of an impending firing of a charge by a siren shall be given.

Blasting operations shall only be carried out under the supervision of a competent foreman.

The firing of charges must not unreasonably interfere with or be a danger to persons or property. The Engineer reserves the right to withdraw permission for the use of explosives if his Representative is not satisfied with the precautions taken. If there is street lighting or plants etc. in or around the area of blasting, care should be taken to see that the operations are of forces not to damage or affect such plant, street-lighting etc. The Engineer's and DWD's representative must be present during such operations. Proper records of explosives shall be maintained for inspection of Engineer and Police authorities.

2.10 TRENCH EXCAVATION FOR PIPEWORK

Trench excavation means excavation of trenches in which pipes are to be laid and the term pipes shall mean pipes of all kinds and for whatever purpose.

The line and level of trenches shall be as shown in the Drawings or as may be directed by the Engineer. Before commencing Trench Excavation, the route of the trench shall be pegged out accurately and the natural ground levels and lengths shall be measured and agreed with the Engineer.

- A. The Contractor shall include for clearing the route of the pipeline of all surface obstructions, grading the route to provide access for his equipment and personnel, executing all cutting to remove high points of rises in terrain and in all respects prepare the route for pipe laying operations, all in accordance with the requirements of good pipeline construction practice.
- B. Unless otherwise shown on the Drawings or instructed by the Engineer, water pipelines shall be laid in trenches with minimum soil cover as specified in clause 6.04. L..
- C. The bottom of the trenches shall be properly trimmed-off, bottomed and prepared to provide a firm and uniform bearing throughout the entire length of the pipe. Care shall be taken to prevent excavation below the level of the bottom of the pipe, and portions of trenches excavated below the grade shall be filled with suitable material and thoroughly compacted to specific degree in layers of 150 mm by the Contractor at his own expense as directed by the Engineer at the Contractor's own expense.

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- D.** Where rock or hard subkha materials are encountered, the excavation shall be carried below the bottom of the pipe for a depth of 150 mm which shall be back-filled with granular fill or soft sand compacted to the proper grade and density.
- E.** Where pipe trenches are excavated across or along asphalted roads, sidewalks, stairs and pavements, the Contractor shall carefully saw cut the edges of the asphalt, stairs and pavements, remove the hard-core and paving tiles and store them for reuse, or cart away the spoils to tips as directed and shall comply with Dubai Municipality Local Orders and as amended related to this activity.
- F.** The sides of trench excavation shall be vertical unless the Engineer otherwise approved in writing and where this work is in a surface road or adjacent to a road then the conditions of Dubai Municipality Local Orders and as amended relating to such activity shall be strictly adhered to.
- G.** Any widening or deepening of trench excavation necessary to accommodate curves, joints or bends in the pipe or to provide extra working space for the construction thereof shall be held to be Excess Excavation and is deemed to be included in the Contractor's rates.
- H.** Trial holes shall be excavated well ahead of the trench excavation to such depths as necessary to determine the alignment for the trench. Trial holes may also be required by the Contractor to determine the position of underground services, subsoil drains or for any other reason. Trial holes shall be excavated and reinstated at the Contractor's expense and the Contract Rates for pipe installation shall be deemed to include for all trial holes.

All trial holes must be backfilled by same evening, and no trial pit will remain open overnight. Reinstatement of trial holes also must be carried out as per the approved procedure, at no extra cost.

- I.** Hand excavation must be used where existing cables, water mains, sewers, etc., cross or are in the main roads, where traffic is likely to be unreasonably dislocated by use of machine, or for reasons of limited access, or where instructed by the Engineer. In other places, hand or machine excavation may be employed at the discretion of Contractor.
- J.** Excavation by machine must not normally be deeper than 150 mm below the finished grade, unless the Engineer decides otherwise. The Contractor will be held responsible for making good at his own cost all additional damage to road surfaces and private lands caused by the use of mechanical excavators.

2.11 GEOTEXTILE FABRIC & GRANULAR MATERIALS FOR PIPE BED AND SURROUND FOR TRANSMISSION MAIN PIPELINES

2.11.a Granular Material for Pipe Bedding and Surround

Granular material for pipe bedding shall be free-draining, hard, clean, chemically stable gravel or crushed stone to BS 882 and shall be graded in accordance with BS 882: Part 2, as shown in the following table:-

Table 2.11.a; Granular Material for Pipe Bedding

TEST SIEVE (MM)	PERCENTAGE BY WEIGHT PASSING SIEVE
63	—
37.5	—
20	—
14	100
10	85 – 100
5	0 – 25
2.36	0 - 5

NOTE:

1. Total Acid soluble content of the material when tested in accordance with BS1377 shall not exceed 0.3 percent by weight of sulphate expressed as SO_3 (Sulphur Trioxide).
2. The Material shall have a compaction factor value not exceeding 0.15.

2.11.b Pipelines on Granular Beds

Where granular bedding to pipelines are detailed the minimum thickness of bedding materials beneath the pipe shall be 200 mm (minimum 100 mm under sockets)

The time interval between placing bedding material on the trench formation and commencing pipe laying be as short as practicable.

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The bedding material shall be extended to the full width of the trench and shall be carefully compacted in layers not exceeding 200 mm, to achieve positive deflection and to the specified accepted limits.

Recesses shall be formed in the bedding to accommodate pipe joints while ensuring continuous even support along the length. Bedding material shall be prevented from entering pipe joints. After joints has been made bedding material shall carefully placed and hand compacted beneath the joint barrel to close any void left by the recess.

Where the formation of the trench is of silt or soft clay and is below the natural water table a 75 mm blinding layer of sand shall be substituted for the specified bedding materials directly above formation and carefully compacted if directed.

2.11.c Geotextile Filter Fabric

The Geotextile filter fabric shall be laid for pipes above 450mm dia. The granular bedding and surround to all pipes above 450mm dia. shall be enclosed within a geotextile filter fabric

Filter fabric shall consist of thermal bonded/needle punched synthetic polymer fibers. composed of at least 85 percent by mass polyolefins, polyesters, polypropylene, polyethylene or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages.

The geotextile Manufacturer/supplier shall be certified according to ISO 9001 for quality management and ISO 14001 for environmental management system.

The fabric shall be stabilized against ultra violet light, inert to commonly encountered chemicals in the in-situ soil and saline water and it shall conform to the following minimum requirements

Property	Test Method	Min. Requirements
Grab Strength (N)	ASTM D-4632	800
Puncture Strength (N)	ASTM D-4833	355
Burst Strength (kPa)	ASTM D-3786	2000
Trapezoid Tear (N)	ASTM D-4533	220
Permeability (m/sec)	ASTM D-4491	0.0001
Apparent Opening Size (mm)	ASTM D-4751	0.6 (Max)
Ultraviolet Degradation (Percent Retained Strength)	ASTM D-4355	70% @ 150 h

Independent laboratory certificate to comply above data, shall be submitted.

Where filter fabric is used to enclose granular pipe surrounds, the fabric will be placed on the prepared trench formation and carefully supported during pipe laying operations. When the pipe has been laid complete with surround to the correct level, the filter fabric shall be closed over the top of the surround by forming a lap of minimum width 500 mm. All membrane joints shall be overlapped a minimum of 500 mm.

Care shall be taken not to puncture or damage the membrane in any way during installation or during backfilling of the trench. Any fabric damaged or displaced before or during installation or during placement of over laying aggregate material shall be replaced or overlaid to the satisfaction of the Engineer at the Contractor's expense.

During period of shipment and storage, the fabrics shall be maintained wrapped in a heavy duty protective covering and protected from direct sunlight, ultra-violet rays and temperature greater than 70° C.

2.12 WIDTH OF TRENCHES

The width of the trench shall be sufficient to permit the pipe to be laid and jointed properly, and the backfill to be placed and compacted as specified.

Unless otherwise shown on the Drawings or instructed by the Engineer, the minimum width of trenches for the pipes of 150 mm diameter and above shall be equal to the pipe outside diameter plus 600 mm and for all pipes less than 150 mm in diameter, width of trench shall be OD plus 500 mm ..

Trenches shall be of such extra width, when required, as will permit the convenient placing of timber supports, sheeting and bracing and handling of specials. Extra widths and support wherever necessary shall not be paid separately but deemed to be included in rates elsewhere.

2.13 REMOVAL OF PAVEMENTS

The Contractor shall remove pavement and road surfaces as a part of the trench excavation, and the amount removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures.

The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the width of the trench specified by more than 150 mm on each side of the trench. The width and lengths of the area of pavement removed for the installation of valves, meters, fittings, valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 500 mm on each side. Wherever, in the opinion of the Engineer, existing conditions make it necessary

or advisable to remove additional pavement, the Contractor shall remove it as directed by the Engineer but shall receive no extra compensation therefore. The Contractor shall prior to excavation in roads and paved areas mark out the limit of excavation and saw cut the pavement to produce a vertical face through bound materials and suitable for the subsequent tying in of subsequent reinstatement works. The remaining excavation shall be maintained as a vertical face and shall be supported where appropriate or as directed by the Engineer to ensure that no undermining of the remaining road surface takes place. Where in the opinion of the Engineer or Dubai Municipality representatives undermining has taken place then a new edge shall be defined and the surface saw cut and excavated back to this face for reinstatement purposes and shall be done at Contractor's expense. All works shall be in accordance with Dubai Municipality rules and regulations relating to this type of work.

2.14 BARRICADES, GUARDS AND SAFETY PROVISIONS

To protect persons from injury and to avoid property damage, adequate barricades, construction signs, torches, yellow flashing lights, revolving lights and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for traffic to use the road. All materials, stockpiles, equipment and pipes that obstruct to traffic shall be enclosed by fences or barricades and shall be protected by proper lights. The safety rules and regulations of Dubai Municipality, Dubai Traffic Police and shall be complied within full at Contractor's expense.

The Contractor shall comply with regulations relating to the placing of warning signs, lights or flares. In the absence of such regulations, the Contractor is to place warning signs visible during day-light and yellow flashing lights or flares visible during darkness in accordance with the detail approved by Dubai Municipality Roads Department and Dubai Traffic Police relating to the particular location for the road signing.

Where works affect footpaths or access to properties then suitable alternative routes or provisions shall be made and the public protected, guided and informed by approved provisions.

Should the Contractor fail to erect any barrier, safety guards, signs, lights or any other warning signal for protection after being requested to do so by any authorized person or body, the Employer shall erect such signs and barriers, etc., which he considers necessary for the safety of the works and the public, at the Contractor's expense.

2.15 TRENCHES NOT TO BE LEFT OPEN

Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of trench excavations shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and jointed. Pipe laying shall follow closely upon the progress of trench excavation and the Contractor shall not permit unreasonably excessive lengths of trench excavation to remain open while awaiting testing, commissioning, backfilling, etc. of the pipeline. In any case not more than 500m long trenches shall be left open in one section. Greater lengths if

found required shall have the prior approval of the Engineer, and no trench, in any case shall be left open for more than 3 weeks. The Contractor shall be responsible for preventing and taking precautions against floatation of pipes in locations where open trench excavations may become flooded, and these precautions may include the partial filling of the trench leaving pipe joints exposed for water tightness testing of the joints.

If the Engineer considers that the Contractor is not complying with any of the foregoing requirements he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trench excavation. The Contractor will not be permitted to excavate trenches in more than one location in any one road at a given time without the Engineer's written permission.

2.16 MAINTENANCE OF TRAFFIC AND CLOSING OF STREETS

The Contractor shall carry on the work in a manner that will cause the least interruption to traffic and he shall not close, or partly close, any road or street without the written consent of the Dubai Municipality Roads Department, Dubai Traffic Police and the Engineer.

After such consent, the Contractor shall, at his own expense, provide means of access to all buildings, rights of way, etc., warning signs, lights, barricades and diversion notices.

All road crossings in open cut shall be adequately shored and timbered, with arrangements to maintain the flow of traffic as directed by the Engineer and subject to the approval of Dubai Municipality Roads Department, the Services Authorities and the Dubai Traffic Police.

Special attention shall be given to the backfilling of road crossings and the Contractor shall repair and replace road surfacing material by like kind and quality, maintain and make good all such works as directed by the Engineer.

The Contractor, shall, in all respects, comply with the requirements of the Authorities, the Police and the Engineer and in accordance with Dubai Municipality Local Orders and as amended and subject to Dubai Municipality Roads Department NOC. Except as provided above, the Contractor shall at all times maintain free passage over all roads for all traffic.

2.17 PROTECTION OF SERVICES AND/OR STRUCTURES

The Contractor shall be responsible for the care and protection of all existing DEWA/ED, ETC cables, sewer pipes, water pipes, culverts, or other facilities and structures, which may be encountered in or near the area of his work. Temporary support, adequate protection, and maintenance of all underground and surface structures, drains, sewers, and other obstructions encountered in the progress of the work shall be furnished by the Contractor at his expense and under the direction of the Engineer.

Any services or structures that have been disturbed or damaged due to negligence of Contractor shall be promptly restored to their original condition, or better, to the satisfaction of the Engineer and subject to Services Authorities NOC's at contractor's expense.

In the event of any damage to existing structures, facilities and services during the progress of the work and of the failure of the Contractor to exercise proper care, the Contractor will be held liable for the cost of all repairs to said structures, facilities and services.

2.18 SUPPORT TO EXCAVATIONS

The sides and/or the bottom of excavations shall be adequately supported as per provisions of Local Order No: 29 and its amendments.

Supports shall be properly maintained until permanent work is sufficiently advanced to permit their removal and shall be left in if specified or as instructed.

Trench supports shall be so arranged to permit withdrawal during the placing of the pipe bedding so as to prevent voids.

Battered sides to trenches or other excavations will only be permitted if they can be constructed within the limits of the site, without damage or interference to existing services, properties or structures, without undue interference with pedestrians and traffic and to slopes, which are sufficiently flat to ensure stability of the ground.

2.19 CONTROL OF WATER AND FLOATATION

All excavations including trenches, headings and tunnels shall be kept free of water. In addition, precautions shall be taken to prevent floatation of partially built structures, completed structures to be backfilled on commissioning of the works, and pipelines not backfilled.

Dewatering methods, proposed break tanks may include temporary drains, intercepting ditches, cut-off drains, sub-drains, sumps, wells, pumps, well-points or other dewatering equipment and shall include all other things necessary to keep water out of the excavations or to lower groundwater around structures liable to floatation.

All necessary precautions shall be taken to prevent any adjacent ground from being adversely affected by loss of fines through any dewatering process.

The Contractor shall submit methods statements for prior approval of the Engineer. Method Statements shall include proposals for disposal of the water arising from dewatering systems.

Under no circumstances will permission be given for the discharge of groundwater into the existing sewerage system.

If permission is given to use new or existing pipes or culverts which are not part of the live sewerage system, they shall be thoroughly cleaned of all silt and any resulting damage made good after use.

All temporary Works for control of water shall be sited clear of the Works, except where temporary sub-drains under the Works are approved in which case the pipes shall be laid covered with tarred felt cloth or other approve material.

Unless otherwise directed all temporary drains and sub-drains shall be finally sealed with concrete at approved intervals and all temporary ditches, sumps, wells, etc., shall be refilled and reinstated as specified elsewhere.

If lagoons for the storage of groundwater are permitted, they will be suitably protected with fencing and attended by day and night to prevent access by the general public and will not be sited adjacent to buildings. Approved means of preventing the formation of mosquito larvae on the surface of the lagoons will be employed.

All necessary precautions shall be taken to prevent any ground water from entering mains to be used for the conveyance of potable water.

2.20 VENTILATION

Adequate ventilation and efficient apparatus shall be provided to keep excavations, trenches, tunnels and headings free from all gases from whatever source.

2.21 BACKFILLING

Backfilling around structures and in pipe trenches, except where filling is designated on the drawings or specified as "non-structural fill" or "structural fill" to support structures shall be carried out as detailed below.

Backfilling shall normally be carried out using selected excavated materials similar to the in situ materials in which the trench or structure is being constructed. Where the Engineer's Representative designates the excavated material as unsuitable, suitable material shall be imported, at no extra cost.

Material for backfilling may be selected from any part of the site and methods of selection may include sieving to remove large particles or methods of hand or machine sorting.

Where the excavation is near an existing structure liable to subsidence, where part of the works may later be constructed over or near it or in emergencies the Contractor may be instructed to backfill with concrete.

Backfilling shall be carried our as defined below.

A. Cohesive Soils

Cohesive soils shall be placed in layers not greater than 150mm thick (compacted thickness) and compacted such that throughout each layer placed the dry density is not less than 95% of the in situ dry density of the soil prior to excavation when tested in accordance with relevant BS specification.

The placement moisture of the soil shall be within the range 2% below to 1% above the natural in situ moisture content of the soil before excavation.

It is to be noted that the cohesive (subkha) soils or hard materials from excavations shall be broken down to suitable sizes to be used for, backfilling, of the top two layers for stability or as per Engineer's instructions at no extra cost.

B. Granular Soils

Granular soils shall be placed in layers not greater than 150mm thick (compacted thickness) and compacted such that throughout each layer placed the dry density is not less than 95% of that obtained in the vibrating hammer compaction test when the test is carried out on the same soil at the same moisture content in accordance with relevant BS specification.

Unless otherwise directed the moisture content shall be maintained and if necessary adjusted by approved means to fall within the range plus 1.5% to minus 3% of optimum moisture content determined in the vibrating hammer compaction test.

For free draining granular soils that have no clearly defined optimum moisture content, compaction shall be carried out to achieve a relative density of not less than 95%. During compaction the soil shall be made as wet as practicable.

C. Testing of Backfill

The Contractor shall provide at his own cost the services of an approved independent laboratory as is necessary for the carrying out of all the tests for in situ and backfilled soil properties and shall maintain with a copy to the Engineer, a daily log of tests carried out.

All back fills shall be carried out in layers of 150 mm thick. In-situ soil compaction tests shall be carried out for pipe line trenches at the rate of one test per 100mtrs of trench length for each layer of 150mm thick, starting from 450 mm above the crown of the pipe. Deep test shall not be carried out as the test location may not be representative. Also, the Contractor shall continue backfilling the next upper layer only if the test result for the previous layer is available and found to have passed as per the requirements. In addition to the pipeline trench backfilling and testing the chambers pits and pits forming at the sides of the Thrust blocks shall be backfilled in accordance with the relevant specifications and tested for compaction for every

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150 mm thick layers of backfills. The initial layer to be tested shall be the excavated formation level for the Thrust Block or chamber pits, which shall be tested prior to placing the structure. The remaining in-situ soil compaction tests to be carried out as the backfilling progresses layer by layer.

Where a land drain passes through an excavation the backfill shall first be taken up to form a bed for replacement pipes. The severed drains shall then be exposed at each side of the trench excavation. This new drain shall be of similar pipes of the same diameter as those in the existing drain. Before any further backfilling is done the Contractor shall notify the owner or occupier to enable him to see the reinstated land drain. The replacement drain shall be surrounded with pipe bedding material to a minimum thickness of 150mm before further backfilling.

2.22 STRUCTURAL AND NON-STRUCTURAL FILLING

Structural filling is required in paved carriage ways, hard shoulders, footpaths and parking areas and wherever a structure is to be supported on the fill and where settlement is required to be minimized to structurable minimal. Non-structural filling will normally be carried out to embankments and other fill areas. Embankments shall normally be overfilled and subsequently trimmed to the required profiles.

A. Structural Filling

Structural filling shall be carried out using well graded natural sands and gravel having the following minimum requirements:

Liquid limit	not less than 25%
Plasticity index	not less than 6%

The material shall have a smooth grading curve within the sensibly parallel to the grading envelope below:

<u>Sieve Size</u>		<u>% by Mass Passing</u>
75	mm	100
37.5	mm	85 - 100
10	mm	45 - 100
5	mm	25 - 85
600	um	8 - 45
75	um	0 - 10

Above the water table, locally occurring Subkha materials may be used for structural filling, subject to Engineers approval.

The material shall be laid and compacted to layers not greater than 150 mm thick (compacted thickness) to achieve a dry density of not less than 95% of the maximum dry density, determined in the modified vibrating hammer compaction test. The placement moisture content shall be adjusted to fall within the range 1% above to 2% below the optimum percentage determined in the modified vibrating hammer compaction test as per the relevant BS specification.

B. Non-Structural Fills

Cohesive Soils selected as being suitable shall be placed and compacted in layers not greater than 150mm thick compacted to 95% as per the relevant BS specification. The material shall be placed at its natural moisture content unless this is more than 2% below the optimum moisture content determined in the Proctor Compaction Test in which case it shall be raised by approved means to a moisture content in the range of 2% above and below the optimum.

Granular Soils selected as being suitable shall be placed and compacted in layers not greater than 150 mm thick (compacted thickness) to achieve a dry density of not less than 90% of the maximum dry density determined in the vibrating hammer compaction test. The placement moisture content shall be adjusted by approved means to bring the moisture content within the range 3% below to 1.5% above the optimum moisture content determined in the vibrating hammer compaction test.

Disposal on Site of Unsuitable Materials If the Contractor is given permission to dispose of excavated materials which are designated unsuitable for filling or backfill on the site they shall be placed in regular layers without compaction as directed. If the Contractor is not given such permission they shall be classified as surplus excavated material.

2.23 STONE PITCHING

The sides and bed of the watercourse or embankment shall first be trimmed to the required profile.

The pitching shall be hand placed, roughly square on all faces, and the upper (water) face shall be roughly dressed and laid to break joints. Pitching shall be firmly bedded and jointed in 75 mm thick cement mortar.

2.24 REINSTATEMENT OF DAMAGED SURFACES AND PROPERTY.

If any pavement, fences, poles, Irrigation system or other property and surface structures have been damaged, removed, or disturbed by the Contractor, whether deliberately or through failure to carry out the requirements of the contract documents, state laws, municipal ordinances, or the specific directions of the Engineer or through failure to employ usual and reasonable safeguards, such property and surface structures shall be replaced or repaired at the expense of the Contractor. If the Employer specifies that the replacements or

repairs shall be made by the Contractor, he shall replace or repair and restore the structures to a condition equal to that before the work began, and to the approval of the Engineer, and shall furnish all required labour, plant and materials therefore.

2.25 REINSTATEMENT OF UNPAVED LAND

In general the reinstatement of stripped areas of unpaved land shall be restored to a condition not inferior to that which existed before the site was occupied.

The compacted backfill shall be taken up to a level which allows for settlement. In arable, grassed and similar areas the surface to be topsoiled shall then be loosened to a depth of 200mm and topsoil replaced on it to the specified depth without compaction using approved topsoil of comparable quality to make up any deficiency.

Areas where grass is to be sown shall be worked with fine tilth, leveled, graded and rolled with a light roller. The seed shall be sown evenly at the specified rate of application in the proper season and in suitable weather conditions, and the areas again rolled. Restoration and re-seeding of any areas where the new grass is inadequate.

Reinstatement of the grassed area shall be in accordance with the specification and the approval of Dubai Municipality Horticulture Department.

As an alternative to seeding the "dibbing in" at 200mm centres of "Bugunda" or similar tropical grass tufts may be required.

The grass shall be well watered four times a day and the Contractor will be required to keep the grass cut short until the Maintenance Certificate has been issued.

2.26 REINSTATEMENT OF PAVED CARRIAGEWAYS, PARKING AREAS & HARD SHOULDERS

There shall be only "one time" reinstatement for asphalted roads and paved areas and these shall be reinstated strictly in adherence to Local Order No. 29 and its amendments vide Administrative Order No. 22 and is further clarified as follows:

All affected asphalt surfaces shall be reinstated only 'one time' reinstatement by the Contractor as per the cross sections pertaining to the relevant road classification stated in above Administrative Order.

Any settlement in reinstated areas upto a period of one year shall be treated as defective workmanship and will have to be repaired free of cost to the client.

All reinstatement must be carried out by Dubai Municipality approved road contractors only.

The testing of materials and in-situ test shall be those commonly employed on Dubai Municipality Roads Department contracts.

2.27 REINSTATEMENT OF OTHER SURFACED AREAS

Reinstatement of surfaced areas other than roads such as pavements or reservations shall be reinstated with an acceptable wearing surface as per local Order No. 29 and its amendments vide Administrative Order No. 22 and maintained upto a period of one year. Any settlement in the reinstated areas during this period will have to be done at Contractor's expense.

2.28 EXCAVATION AND REINSTATEMENT IN DEVELOPED RESERVATIONS

The Municipality Horticulture Department will remove any trees, bushes and plants from developed reservations that they wish to preserve prior to the commencement of work by the Contractor.

The reinstatement of the developed reservations shall be to backfill and compact the excavations in accordance with Clause 2.20 and to restore the surface in accordance with Clause 2.23 and 2.24.

2.29 CLEANING UP OF PIPELINE ALIGNMENTS

After installation and backfilling of the pipeline and also after restoration of surfaces, the Contractor shall clean the site and the surrounding ground and he shall dispose of all waste material, debris, and rock resulting from his operations. The Contractor shall restore the site and the surrounding ground to the satisfaction of the Engineer.

2.30 NON-DISRUPTIVE PIPELINE CONSTRUCTION BENEATH ROADS

Where instructed to do so, the Contractor will be required to construct pipeline beneath roads, and elsewhere, using non-disruptive methods, such as pipe boring and jacking, which avoid breaking the ground surface. The Contractor shall submit full details of his proposals for such non disruptive methods to the Engineer for approval and subject to Dubai Municipality Roads Department NOC for each such locations.

Work on non-disruptive pipeline construction shall be performed only by contractors, approved subcontractors, who are experienced in the performance of such work under similar conditions, with the approved from Dubai Municipality for the methodology of operation.

SECTION 3

PIPES AND APPURTENANCES

3.1 GENERAL

3.1.1 Scope of Works

The work shall consist of supply and testing of Fibre Cement/GRE pipes and Joints, GRE fittings, Valves, flow meters, Manhole covers with frames, Detectable warning tapes, F.C. Joint Lubricant (Soft Soap), PVC pipes, House connection materials, SCADA items, Control instruments, and all materials related to pipeline works and project etc.

All materials and equipment supplied shall be suitable for use in contact with potable water for cold water and hot water up to 50 degree C and under conditions prevailing in Dubai and at the site of the works.

All the materials are to be approved by the Dubai Electricity and Water Authority-water division before ordering.

Sample for all items shall be submitted to DEWA without any cost charged to DEWA, and will remain DEWA's property. All samples shall conform to the specification. Any deviation in the samples shall be clearly mentioned in the submission. If requested by DEWA, the tenderer shall carry out testing on samples without any extra charges at the evaluation stage and/or after award of the contract. The sample shall have a sticker showing tender number and tenderer name.

The items under 'provisional /optional' or 'provisional/optional quantity' may be ordered either partly or fully or can be deleted from scope of tender.

Any failure in testing in presence of DEWA's representative at the time of delivery, can be considered a cause of rejection for the entire consignment, and DEWA's decision shall be final and binding to the tenderer.

If there is contradiction in different clauses of specification for any item/part, the clause with high in quality or DEWA decision will prevail. If there is any ambiguity/ conflict in interpretation of specification, DEWA decision will be final and binding on the tenderer. In case of difference between this specification and specified international standards, then the most stringent requirements shall prevail and/or DEWA decision shall be binding to tenderer.

All materials shall have five years warranty. The warranty period shall be counted from the date of issuance of the Take Over Certificate of the project even though the delivery and installation is made earlier. The warranty shall be applicable and valid whether the warranty certificate is issued or not by the manufacturer/ supplier/ tenderer to DEWA. The

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F.C.tenderer is responsible of any repair/ replacement of the item during the project defect liability period after which the supplier and manufacturer is responsible for the same.

The following are to be submitted along with the submittal for approval:

Quality system certificate to conform ISO 9000 (or equivalent) series for the manufacturer.

Original detailed catalogues, product technical data and any other required documents.

Details of past supply records for the last four years in U.A.E., Gulf countries, and other countries , separately.

Important:

(i) Where no year is shown following the specification of B.S., I.S.O. etc, the latest edition shall be deemed applicable.

(ii) Non ISO 9000 certified manufacturers with previous successful supply experience for similar items, may be approved at DEWA's sole discretion.

(iii) If the detail in catalogue and technical data is different from DEWA specifications, deviation shall be cleared mentioned and clarify whether actual supply shall be as per DEWA specification or not .

3.1.2 ENVIRONMETAL ASPECTS

DEWA is implementing “ ENVIRONMETEL MANGEMENT SYSTEM –ISO 14001 – 96”. All finished product to be supplied, shall be environmental friendly and shall have no impact on environment. The manufacturer / supplier / Tenderer shall follow Dubai Municipality local order no. 61 of 1991 on the environment protection regulations in the Emirate of Dubai.

3.2 FIBRE CEMENT (F.C.) PRESSURE PIPES FOR POTABLE WATER

3.2.1 General

Fibre cement (FC) pressure pipe shall conform to the requirements of BS-EN 512/1995. F. C. Joints shall be manufactured by the same F. C. pipe manufacturer. No internal or external coating shall be provided. The pipes shall be manufactured by an established F.C. pipe manufacturer having successful experience in the manufacture and supply of large diameters of high pressure F.C. pipes. Evidence of such experience shall be provided with the tender offer. The manufacturer shall be certified to ISO 9001 and 14001. Manufacturer having Kite mark to pipes shall be preferred.

Pipes and Joints shall be made from a close and homogeneous mixture essentially consisting of Chrysotile Asbestos Fibers (no other fibers allowed to use), Sulphate Resisting Cement and Potable Water excluding any materials liable to cause ultimate deterioration in the quality of the pipes.

Full detail of technical collaborator, if any, shall be submitted.

3.2.2 References

The following standards are applicable where referenced in the following specifications:

1	BS - EN	512	1995	Pipes & Joints
2	BS - EN	681 - 1	1996	Elastomeric seals for joints in pipe work and pipelines
3	BS	4027	1996	Cement
4	ISO	2785	1986	Pipe design

3.2.3 Class and Type

Hydraulic test pressure at the factory is the basis of pipe classification. F. C. pipes and joints shall meet the requirements for Class 18, i.e. test pressure in the factory 18 bars. F. C. pipes and joints class-2-4 shall meet the requirement 24 bars of test pressure in the factory. This shall be applied similarly for other class. If class is not mentioned in Bill of Quantity, pipes shall be supplied with class 18. Pipe wall thickness shall meet all design requirements. Pipe ends shall be plain with bevelled edge.

3.2.4 Dimensions

Fibre cement pipe shall be manufactured and supplied in 3-metre nominal lengths for diameters 300 mm and smaller and in 5-metre nominal lengths for above 300mm. Allowance for different lengths will be accepted up to 5% against 10% as mentioned in ISO/BS. For direct supply to DEWA, pipes above 300mm diameter, shall be supplied only in 5 metre lengths. All joints and pipe ends shall have the following principal dimensions:

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CLASS - 18

Nominal Diameter mm	Outside Diameter At The Machined End mm	Calibration Length At The Machined End mm	Length Of F.C. Joint mm
75	93	110	104
80	106	110	104
100	126	125	120
150	178	125	120
200	234	155	150
225	255	155	150
250	288	155	150
300	344	155	150
350	402	210	200
450	508	210	200
500	560	210	200
550	616	240	200
600	668	250	240
700	780	250	240
900	1000	280	270
1200	1320	310	300

CLASS - 24

Nominal Diameter mm	Outside Diameter At The Machined End mm	Calibration Length At The Machined End mm	Width Of F.C. Joint mm
225	270	155	150
300	354	155	150
600	688	250	240
900	1026	280	270
1200	1360	310	300

CLASS 40

Nominal Diameter mm	Class	Outside Diameter At The Machined End mm	Calibration Length At The Machined End mm	Width Of F.C. Joint mm
600	40	734	260	250
900	40	1110	310	300

Tolerance on external diameter of F. C. pipes at the calibrated (machined) end :

Nominal diameter mm	Tolerance mm
Upto 300	± 0.6
Over 300 upto 500	± 0.8
Over 500 upto 700	± 1.0
Over 700 upto 1100	± 1.2
Over 1100 upto 1600	± 1.5

3.2.5 Cement

All cement used in the manufacture of fibre cement pipe and joints shall be a high sulphate resisting cement conforming to BS 4027:1996, type LA with strength class-42.5 N. Copies of cement mill certificates shall be submitted with each consignment of pipe delivered upon request.

3.2.6 Joints

Fibre cement pipe shall be provided with spigot ends to be joined with 'Reka' type couplings using two rubber rings, which compress to form a watertight seal when the joint is assembled. Each pipe shall be supplied with one joint and two rubber rings at no extra cost. Rubber rings shall be of EPDM rubber and conform to the requirements of BS. EN. 681-1:1996. The manufacturer of rubber rings shall have fitness certificate for use in contact with potable water from the Authority of 'Water Regulations Advisory Scheme, U.K.' or equivalent National Authority acceptable to DEWA. The joints shall be capable of withstanding an internal pressure equal to the factory test pressure without any leaks when deflected to the angle specified below:

Nominal Diameter mm	Max Joint Deflection Angle Degrees
80-250	5
300 - 350	4
400 - 600	3
700 - 1200	2
1300 and above	1

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Copies of test reports showing compliance to these requirements shall be submitted to the Engineer for approval if requested. REKA rubber rings for couplings shall be supplied in closed bags / containers shielded from sunlight. Each bag / container shall contain only one size of rubber rings and shall be marked with a clear print indicating the diameter and the number of rings in the bag.

3.2.7 Design Calculations

Pipe design calculation as per ISO 2785 shall be submitted to the Engineer for review, showing maximum safe burial depth for each diameter and class of pipe , if requested.

3.2.8 Curing

Water curing shall be done on all manufactured pipes and joints for a minimum 14 days. No steam curing shall be accepted. Steam curing is a process whereby all manufactured items are transferred into enclosed chamber with steam nozzles spraying steam to accelerate curing. This process does not ensure consistent curing (slow curing) and subsequently quality is affected. Manufacturer is advised to give curing methodology.

3.2.8 Testing

Factory Quality Control :

Fibre cement pipes shall be factory tested in accordance with BS-EN 512-1995 by manufacturer. These tests are to be carried out as their internal routine acceptance test by manufacturer before inspection and testing carried out by client/consultant. Copies of test certificate shall be submitted for each consignment delivered if requested by DEWA / Consultant. The pipes shall pass the result obtained from formulae mentioned in both standard BS 512 and ISO160.

Inspection and testing and of a Consignment of Finished Product at factory:

The inspection and testing of a consignment of finished product is to be carried out in presence of DEWA representative / Consultant. Inspection, sampling, lot size and testing shall be in accordance with BS - EN 512:1995. The size of inspection lot will be at client discretion limited within minimum and maximum lot specified in BS 512, taking into consideration quality of past supplies. Lot size for diameters larger than 1000 mm shall be 200 pipes. The manufacturer shall carry out all tests including destructive tests in presence of DEWA's representative/ consultant before delivery. The tenderer shall give Fourteen days advance notice. The pressure bursting test for pipes diameter above 1000mm shall be carried out hydraulically/mechanically. Testing and related activities shall be carried out at no additional cost. Pipes, which are destroyed in testing, shall be replaced at no additional cost. In addition to above, if requested by DEWA, the tenderer shall carry out tests on pipes/joints delivered to site at tenderer's expense including transportation.

The pipes shall pass the result obtained from formulae mentioned in both standard BS 512 and ISO160.

For outside U.A.E. manufacturer :

In addition to above, 1 % of total numbers of pipes of each size and class after delivery to DEWA stores/sites, the tenderer shall arrange testing at local laboratory / any other arrangement in DUBAI for all tests including destructive tests. The pipes shall pass the result obtained from formulae mentioned in both standard BS 512 and ISO160. Any failure shall lead to for complete rejection of consignment and DEWA decision shall be final and binding to the tenderer. The Contractor/Tenderer shall replace pipes, which are destroyed in testing, at no extra cost. The cost of transport of pipes and joints for testing at local laboratory and delivery once again, shall be born by the tenderer / contractor.

Failure Of Pipes And Joints At The Time Of Testing At Sites In Dubai

During hydro pressure testing at site after delivery to Stores/site and, if pipes/joints failed, shall be replaced at no extra cost including transport expenses. The reason of the failure shall be investigated by DEWA and DEWA decision shall be final and binding to the tenderer.

3.2.9 Markings

Each pipe and joint shall be legibly and indelibly marked with the following:

- i. Manufacturing standard
- ii. Manufacturer's name or trademark.
- iii. Manufacturing date
- iv. Home line positions at pipe ends [pipe only].
- v. Nominal Diameter (ND) in mm
- vi. Pressure rating in Bars (Class)
- viii. DEWA / Contract no.

The date of manufacture and company trade mark / name shall be engraved minimum 2mm deep on the pipe and shall be clearly legible and shall be to the satisfaction of DEWA.

3.2.10 F.C. Pipes -Full Length Calibrated - Class 18

Full length calibrated F.C. pipe shall conform in all respects to F.C. pipe specifications except that pipe shall be machined for full length and shall have the following outside diameter along the entire length of the pipe.

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Nominal Diameter mm	Outside Diameter mm
500	560
550	616
600	668
700	780
900	1000
1200	1320

All pipes shall be pressure tested only, (No destructive tests) in accordance with BS - EN - 512-1995 requirements after normal manufacturing. Each pipe shall be pressure tested for a second time for duration of 5 minutes in presence of **DEWA**'s representative after the entire length has been machined, to insure pipes have not been damaged during the machining works. All pipes above 300 mm dia. shall be of **5 meters** length only. The pipes shall be supplied without joints.

3.2.11 F.C. Special Joints - Class 18

F.C. special joints shall be designed to fit F.C. pressure pipe with the following outside diameters.

CLASS 18

F.C. Special Joint to fit on pipes of Nominal Diameter (mm)	To Fit To Outer Diameter Of F.C. Pipe (mm)	Length Of Joint (mm)
75	97	104
80	109	104
100	130	120
150	183	120
200	240	150
225	258	150
300	350	150
500	565	200
550	618	200
550	620	200
550	622	200
550	624	200
600	672	240
600	674	240
600	676	240
700	784	240
700	786	240
900	1004	270
900	1006	270
900	1008	270
1200	1325	300
1200	1327	300
1200	1329	300

F.C. Special Joints: Class 40:

F.C. Special Joint to fit on pipes of Nominal Diameter mm	Class	To Fit To Outer Diameter Of F.C. Pipe mm	Width Of Joint mm
600	40	734	250
900	40	1110	300

If the outside diameter at calibrated ends (O.D) is mentioned in the item description, then special joints shall be fit to the specified O.D. The F.C. special joints shall be of class 18 and shall conform to BS- EN - 512-1995.

Following shall be marking on special joints **by solid marker (metal marker)**

- 1 The nominal diameter and outer diameter shall be written on each special joint clearly, e.g. 150 / 181 mm for 150mm special joints
- 2 SP. JT.
- 3 Manufacturer name
- 4 Date of manufacturing
- 5 Contract no.
- 6 Two circular black lines to differentiate from normal joints.

3.2.12 F. C. Step Joints - Class 18

F.C. step joints shall be designed to fit F.C. pressure pipe having outside diameters at calibrated ends (O. D.) as specified in the item

The F.C. step joints shall be of class 18 and shall conform to BS- EN - 512-1995. One circular black line shall be on each joint to differentiate from normal joints. The nominal diameter and outer diameter (O. D.) shall be written with metal marker on each side joint clearly, e.g. 75 - 93 mm (on one side) and 80-126mm (on another side) for 80/75mm F. C. step joint. The joint length shall be same as of standard F. C. joint - class 18. If requested by DEWA, shop drawing shall be submitted for approval.

Following shall be marking on step joints **by solid marker (metal marker)**

- 1 The nominal diameter and outer diameter shall be written on each step joint clearly, e.g. 150 / 181 mm on one side of joint and 150/ 178 on another side of joint
- 2 ST. JT.
- 3 Manufacturer name
- 4 Date of manufacturing
- 5 Contract no.
- 6 One circular black lines to differentiate from normal joints.

3.2.13 Samples

The following samples are to be submitted by the F.C. pipe supplier / tenderer, if requested.

1. 225mm F.C. pipe class 18 - one meter long with both ends calibrated and beveled - as per specifications.
2. 225mm F.C. joint class 18 with rubber rings as per specifications- 1 no.

If requested by DEWA, sample of other size shall be submitted.

3.2.14 Pipe Data Sheets

Supplier shall fill the Pipe Data Sheets in section of Schedule of this tender for each pipe size and class in the contract. The data sheets shall be submitted with the tender.

3.2.15 Storing In Stock Piles At Manufacturer Store/ Contractor Store/ Site/ During transport

Care must be taken that the storage surface is leveled and firm and clear of rocks or solid objects that might damage the pipes. The pipes shall be stored in separate stockpiles according to their class and nominal diameter. Any extraneous materials are to be removed from the area.

Stockpile should not exceed a certain height. This height is limited for safety and practical reasons as per the table below.

DN	80-400	450-600	700-1000	1100-1400	>1500
Storing height h	< 2m	< 2.4m	< 3.0m	< 2.8m	< 2.0m

Wooden wedges to avoid off sliding of the whole pipe stack should be placed on both sides of the first layer in the stack. The first layer of pipes shall be placed on white wood bearers.

3.2.16 Transportation of Pipes

Great care is to be taken while loading the pipes on the trucks at the factory. F.C. pipes and joints shall be properly and securely transported from the place of manufacture to stores/sites. Where pipes are transported by truck, the pipes shall be transported on wooden cradles or skids and shall be properly protected from contact with metal surfaces by rubber or wooden spacers or wedges. Ensure that the lower pile is supported by means of timber bearers. Pipe movement should not occur during transport. If required, pipes shall be tightened by means of pliable straps /ropes No stacking shall be allowed for pipe larger than 900 mm in diameter during transport. No nesting (smaller size of pipe inserted in bigger size of pipe) shall be allowed.

Where any part of the transport is done by ocean freight or barge, or other means for pipes imported from outside the U.A.E., then the following packing procedures shall be applicable and followed:

All F.C. pipes and joints shall be transported in full wooden crates. That crates shall be provided with transverse wooden spacer such that the unsupported span of FC pipe does not exceed 2 meter, inside the crates. Crates shall be provided with skids to allow lifting by forklift. Pipes inside the crates shall be provided with rubber or polystyrene end protectors around the spigot surface of the pipe. Crates shall be marked with the manufacturer's name, the contract No. and details of contains. Pipes shall not touch each other inside the crates. No nesting shall be allowed inside the crates. Pipe 600mm in diameter and larger, shall be individually crated. All packing and transportation expenses shall be deemed included in the supply rates and no extra payment shall be made by DEWA. Packing and crating details shall be submitted with the tender. Guideline sketch shall be supplied by DEWA during evaluation of tender, which shall be complied strictly

3.2.17 Unloading

Unloading at stores/sites must be carried out carefully under the control and responsibility of the tenderer. Care should be taken to avoid severe impact with any solid object (i.e. other pipes, ground, etc.). Rate shall include unloading and stacking as directed.

(a) Unloading by hand

Unloading by hand should only be used for smaller diameter pipes not exceeding 35 kg. for one man.

(b) Unloading using skids and ropes

Two wooden skids of suitable size should be placed on the side of the truck at approximately 1/5 of the length of the pipe from each end and set an angle not steeper than 45 degree. One end of each of two ropes should fastened to the truck, on the opposite side of the skids. The other end of ropes should be passed on the outer side of the skids under each end of the pipe to be unloaded. The pipe can then be lowered by rolling carefully all way down the skids, controlled by the ropes. The pipe travel should be under control. In no case, pipes shall be allowed to roll free on the skids. Do not lower more than one pipe at the time

(c) Mechanical unloading

Mechanical unloading is required for pipes heavier than 200 kg. Flexible slings or beams should be used combined with a mobile crane. When unloading with mobile crane, care must be taken that the pipes do not slide off the slings. Therefore it is recommended to use ropes or wide rubber or canvas bands to hold the pipes and not the steel cables. For small diameter pipes one must center the sling in the middle of the pipe and tighten it as much as possible to prevent the pipe from sliding out of the sling. Avoid the use of steel hooks for lifting the pipes at its ends because this can damage the machined ends. If the use of canvas or rubber slings is not possible use hooks with rubber protection.

(d) Unloading couplings

Even very small couplings must be unloaded with great care. They must not be thrown off the truck on the ground. In general, couplings are bundled and can be offloaded like the pipes. With a wooden beam going through the strapped couplings, unloading can be easily performed.

3.2.18 Submission

Following are to be submitted along with tender / for approval of material.

- 1. Sample as described above**
- 2. ISO 9001 and 14001 certificate of manufacturer**
- 3. Kite mark certificate**
- 4. Original catalogue and product technical data**
- 5. Compliance/deviation of specifications paragraph by paragraph. Each page shall be stamped and signed by the manufacturer, supplier and tenderer.**
- 6. Certificate of cement manufacturer showing compliance to the specification**
- 7. Certificate from the Authority of 'Water Regulations Advisory Scheme, U.K.' or equivalent National Authority acceptable to DEWA for rubber used for rubber ring, showing fitness to use with potable water**
- 8. Certified agreement between technical collaborator and manufacturer, if any.**
- 9. Supply record of last four years**
- 10. Copy of all routine test reports**
- 11. Transportation detail – step by step procedure and sketch**

3.2.19 Installation

Installation shall be carried out as per manufacturer recommendation.

All F.C. pipes above 450mm dia. shall be laid with granular surround and geotextile fabric. If the item for installation of F. C. pipes above 450mm dia. in BOQ is not mentioned with granular surround and geotextile, the rate for pipe installation shall be deemed to be included for granular surround and geotextile. For all F. C. pipes of size 450mm and below shall be laid with sand bedding and sand surround. If the soil bearing capacity is less, then necessary solution is to be provided by the tenderer and to be carried out at site after DEWA approval at no extra cost.

One metre sabkha stank shall be provided at every 50 metre along the pipeline route for pipes with granular surround and geotextile. The sabkha stank shall be compacted to 95% compaction. The rate shall be deemed to be included in backfilling of pipes and no extra payments shall be made.

No spacer of wooden / any other material shall be used during installation of pipes for maintaining gap between two pipes, as recommended by the manufacturer. Installation shall be carried out strictly as per manufacturer's recommendation. Please refer their catalogue.

**Earth cover to pipe for pipes 300mm dia. and below – 1m
Earth cover to pipe for pipes above 300mm dia. – 1.5m**

**3.3.A GLASS REINFORCED EPOXY (GRE) FITTINGS SUITABLE
TO F.C. PIPES FOR POTABLE WATER**

All fittings (including bends, tees, reducers and flanges) used with F.C. water pipelines shall be GRE fittings complying with the following specifications.

Please note that specifications mentioned in clause 3.03.B of under section 3 of this volume are also applicable to this clause except dimensions.

The following specifications are referenced as applicable:

<u>Reference</u>	<u>Description</u>
AWWA C 950-88	AWWA Standard for Fiberglass Pressure Pipes
ASTM D3517-91	Standard Specification for "Fiberglass (Glass-Fibber-Reinforced-Resin) Pressure Pipes
BS 5480:1990	Glass Fiber Reinforced Epoxy (GRE) Pipes and Fittings for use for Water Supply or Sewerage. Parts 1 & 2.

3.3.A.1 General

This specification covers the design, manufacture and testing of Glass fiber Reinforced Epoxy pressure fittings for use with Fibre Cement pressure Pipe in nominal sizes 50 mm and larger. GRE fittings and pipe shall be designed and manufactured in accordance with AWWA C950 and the requirements herein. One manufacturer shall produce all components of GRE fittings suitable to F. C. Pipes/Couplers

The manufacturer must demonstrate the experience and capability to produce fittings of the same diameter and pressure range as those required. The manufacturer shall be certified to ISO 9001 and 14001 for quality system management and environment. The manufacturer having kite mark shall be preferred.

A detailed check list (for each clause) shall be submitted by the tenderer along with the tender documents to confirm his compliance to the specifications. Detail of technical Collaborator Company with the manufacturer, if any, shall be furnished along with the tender.

3.3.A.2 Construction

GRE fittings shall have the following principal construction:

- i. Corrosion resistant, resin rich liner having a minimum thickness of 0.5mm. The liner surface in contact with water shall be reinforced with "C" glass veil or mat impregnated with Epoxy Resin. The liner shall be continuous along the circumference of the pipe and shall be of uniform thickness and composition.
- ii. A structural wall consisting of continuous glass filament windings and/or woven rovings and chopped glass reinforcement, and may include fine fillers, all impregnated with Epoxy resin as required.
- iii. A resin-rich exterior surface having a minimum thickness of 0.25 mm.

No dark pigments shall be allowed in the GRE fittings. Flanged joints, where specified, shall be GRE filament wound flanges, manufactured from epoxy resin/polyester resin with glass reinforcements.

All GRE products shall be hot cured. The minimum Glass Transition Temperature shall be 125 degree Centigrade for epoxy resin products. Test results proving Glass Transmission Temperature shall be submitted.

3.03.A.3 Design Requirements

GRE fittings shall be designed for 10 bars maximum sustained working pressure (PN10), 16 bar maximum sustained working pressure (PN16) and 25 bar maximum sustained working pressure (PN25) as per B.O.Q. item to severe internal operating pressure that the system shall be subjected to under all modes of operation, including starts-up, shut downs, etc., throughout the entire life time of the system.

For PN16 or higher, the manufacturer shall submit details and design upon request.

Hydraulic test pressure at the factory shall be 2 x maximum sustained working pressure (PN). This shall be applied similarly for other pressure. If PN is not mentioned in Bill of Quantity, fittings shall be supplied as PN10. The pipe thickness for specified pressure rating shall be based on the Hydrostatic design basis (HDB) obtained using ASTM D-2992 of the pipe with a minimum Safety Factor of 1.8 and minimum temperature 70 degree C. Evidence of long term regression curve in accordance with ASTM D-2992 conducted at a minimum temperature of 70° C certified by an independent third party acceptable to DEWA shall be submitted for approval. The allowable stress used must be derived from the above test at 70° C or higher.

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Fittings wall thickness shall meet all design requirements. Spigot fittings ends shall be plain with bevelled edge and shall have outer dia. same as Fibre Cement Pipe at calibrated ends with tolerance of +0.6 or -0.6.

GRE fittings and flanges shall be designed in accordance with AWWA C950 for service at the following conditions for PN10:

Maximum operating pressures	10.0	Bars
Maximum test pressure at factory	20.0	Bars
Maximum allowable vacuum	-1.0	Bar
Minimum depth of cover	1.0	Metre
Maximum depth of cover	4.0	Metre
Truck loading (Wheel Load)	90.0	KN
Service temperature (Maximum)	50.0	Deg. C.
Design Temp.	70.0 Deg. C in compliance to BS 5480, clause 3.1	

For PN16 and above, manufacturer shall submit design data as above.

Flange / Flange fittings shall be designed for installation above ground (in Chambers) without thrust blocks. Flanged branches on Spigot Tees shall be designed to resist end thrust from closed valves.

The pressure rating for GRE fittings shall be based on the long-term hydrostatic design pressure established in accordance with AWWA C950 and design factor of 2.0.

Laminated or adhesive Joints used in the fabrication of fittings shall be equal or superior in strength to the sections they join. The thickness of laminated joints shall not be less than the wall thickness of the adjoining pipe section. All hand laminations or windings shall utilize only one type of resin throughout.

Design Temperature

The temperature capability of the GRE fittings system is dependent on the resin and shall comply as per BS 5480 and clause 3.1, which states “ The resin shall be thermosetting resin such that when cured according to a schedule representative of that to be used for finished pipe work and then tested in accordance with BS 2782: method 121A, the temperature of deflection of the resin shall not less than 20 degree C higher than the maximum service temperature at which the pipe work component is to be used.” Accordingly, design temperature of the pipe system shall be based on the highest service temperature of 50 degree C (Service temp.) + 20 degree C (Safety factor) = 70degree C,

3.3.A.4 Chemical Requirements

GRE fittings shall not impart any taste, odor or colour to drinking water. GRE pipe/fittings shall be certified and listed for potable water use by the Water Regulations Advisory Scheme (WRAS), U.K., in accordance with BS 6920 or by the National Sanitation Foundation (NSF)- USA in accordance with NSF Standard 14. The certificate shall be submitted for pipes/fittings and fit for cold and hot water upto 70 degree C. If requested by DEWA, testing to comply with BS 6920 at local laboratory shall be carried on sample submitted to DEWA, at no extra cost. All Raw materials to be used such as resins, curing agents, fillers, hardeners, silica etc. shall be suitable for potable water at a minimum of 70°C. Evidence to be provided to DEWA with certificate from WRAS / NSF / equivalent National authority.

3.3.A.5 Dimensions

GRE fittings shall be produced in Metric sizes and shall be classified by their nominal inside diameter (ND). All standard fittings up to and including diameter 600 mm used in the water system shall be filament wound on precision steel moulds (except mentioned in the DEWA standard sketches which shall be provided after award of tender). The fittings manufactured on steel moulds shall be in one piece. The two pieces joined together, is not acceptable. Standard 90 and 45 degree bends of nominal diameter 600mm and smaller shall be of the smooth radius type, having a turning radius of 1.5 times nominal diameter. Fittings diameter larger than 600 mm may be of the moulded or mitered (manufactured from GRE pipe sections) construction and internal surfaces shall be finished smooth. Tangential (invert) spigot/spigot/flanged Tee shall be used in washout chambers and shall have a bottom tangential flanged outlet with main spigot ends. The overall dimensions and other details of standard fittings shall be as per the DEWA standard production shop drawings of fittings, which shall be supplied during evaluation/ after award of tender and shall be complied strictly

1. The tolerance in length shall be +/- 5 mm for 400 mm dia. and below and +/- 10 mm for dia. 450 – 1200 mm.
2. Spigot Joints, where specified, shall have the same Outside Diameter (O.D.) as DEWA-WD Fibre Cement (FC) pipe class 18 or 24 or 40 to which it is to be jointed. Tolerances on the O. D. of the spigot of the GRE/GRE fittings shall be same as tolerance to external diameter of F.C. pipes at calibrated ends mentioned in F.C. pipe specifications such that the joint remains watertight under all normal operating and surge conditions. The spigot ends shall be clearly marked with a "home line" indicating the proper insertion limit for the FC couplings. The spigot width (length) shall not be less than half the FC coupling joint width except in flange / spigot adaptor. In flange/spigot adaptor, the spigot width (length) shall be equal to width (length) of Fibre Cement coupler + 20mm. Spigot ends shall be with beveled edges.
3. The actual fitting inside diameter shall not be less than that shown in the table below:

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Nominal Diameter (ND) (mm)	Minimum Inside Diameter (mm)
50	48
80	78
100	98
150	148
225	223
300	298
400	398
450	448
500	497
550	547
600	594
700	695
900	890
1200	1190

4. GRE Flanges shall be flat faced and drilled to BS 4504 PN 10 drilling pattern for PN 10 pipes/fittings and for 225 mm and 550 mm dia for which ISO 2084 - 1974 / PN 10 for PN10 pipes/fittings shall be applied. Similarly BS 4504 PN16 pattern for PN16 pipes/fittings and BS4504 PN 25 pattern for PN25 pipes/fittings shall be applied. GRE Flange gasket (full face) design and thickness shall be as recommended by the GRE fitting manufacturer. Hand lay-up flanges shall not be acceptable.
5. The thickness of GRE flanges for PN10 shall not be less than shown in the table below:

Nominal diameter (mm)	Minimum GRE flange thickness (mm)
50	35
80-100	38
150-200	44
225	45
300	54
400	60
450	64
500	64
550	68
600	72
700	78
900	93
1200	108

For other pressures rating, detail shall be submitted by the manufacturer to meet the design requirement

6. The wall thickness of GRE fittings shall be determined by the manufacturer to meet the design requirements of this specification but shall in no case be less than the minimum thickness for PN10 as shown in the table below:

Nominal Diameter (mm)	D	Minimum GRE Fittings/Pipe piece thickness (mm)
80 - 300	5.0	
350-500	6.5	
550	7.5	
600	8.0	
700	9.5	
900	12.0	
1200	16.0	

3.03.A.6 Mechanical Properties

GRE fittings and pipes for PN10 used for fabrication shall meet the following minimum strength requirements.

SR NO	Property	Test Method	Minimum Value
1	Hoop Tensile Stress for GRE pipe	ASTM D2290	As per table 10 of AWWA C950 for class 150 psi
2	Axial Tensile Stress pipe	ASTM D 638	Per table 11 of for GRE AWWAC950 for 150 psi
3	Axial Tensile Stress for flange/flange. Fittings	ASTM D 638	70 MPa
4	Initial Hoop Stress failure for molded fittings	ASTM D1599	3.5 x rated Working pressure
5	Initial Pipe Stiffness	ASTM D2412	Dia. \leq 450mm 10000 pa Dia. $>$ 450mm 5000 pa

For other pressures rating, detail shall be submitted by the manufacturer to meet the design requirement

3.3.A.7 Visual Requirements

GRE fittings shall be free from delamination, crazing, dry areas or cracks. Spigot ends shall be free from end delamination, torn edges and gouges and shall be finished smooth to ensure water tightness. All laminates shall be fully cured with a minimum Barcol hardness

of 35 when tested in accordance with ASTM 2583. The inside liner of the G.R.E. fittings shall be free of cracks, voids and air inclusions.

3.3.A.8 Testing

1) Routine Tests

GRE pipes and fittings shall be factory tested by the manufacturer in accordance with AWWA C950 or BS 5480 at the frequency specified below. Test results and certificates shall be submitted to the Engineer for each consignment delivered if requested by DEWA.

<u>SR NO.</u>	<u>Test</u>	<u>Frequency</u>
1	Visual inspection	Every Item
2	Dimensions	Every Item
3	Hydraulic pressure	One per 10 Flg x Flg Items
3a	Hydraulic pressure upto 600mm dia	One per 30 spigot items
4	Pipe Stiffness for dia. > 300mm mitered Items	One per 100 items
5	Barcol hardness (resin cured)	Every Item
6	Pipe Axial and Hoop tensile stress for dia. > 300mm	One per 100 Items
7	Initial hoop failure stress for molded fittings (ASTM D1599)	Once per order on largest size
8	GRE pipe used for fitting fabrication shall be factory pressure tested at 18 bars	Every pipe

2) Qualification (Type) Tests

The following tests shall be carried out on actual pipe/fittings produced by the manufacturer to establish and accept the design basis for the products. These tests are not routine quality control tests.

(a) Long term hydrostatic design pressure of the GRE pipes / molded fittings shall be established on test data extrapolated to 50 years in accordance with AWWA C950 Section 2.4.2. and ASTM D2992 Procedure B at minimum 70 degree C.

The long- term data shall be submitted for:

- Moulded Fittings
- Pipe Designs to resist thrust in flange/flange fittings and branch flanged Tees. The long term testing of such pipes shall be done Bi-axially.
- Pipe with spigot ends to suit FC couplers may be tested Uni-axially.

(b) Short-term hoop tensile strength shall be within the ultimate strength of the pipe, fittings, laminated joints and flanged joints to withstand a hydrostatic test pressure

of 3.5 times the rated working pressure with no signs of leakage or weep. For flanged joints, the flanges shall be blinded and the ends unrestrained during the test.

Testing To Be Witnessed By DEWA / Consultant

- (a) The tenderer/contractor shall intimate when pipes to be used in construction of fittings and full consignment of finished product, is ready for inspection and testing.
- (b) 10% of total quantity shall be inspected and tested in the presence of DEWA's representative / consultant for the tests mentioned under serial no.1, 2 and 5 of routine test. The quantity for testing for serial no. 3,3a, 4,6,7 shall be as mentioned in the column of frequency under routine tests. 10% of total quantity of pipes used for fittings shall be inspected and tested in the presence of DEWA's representative/ consultant for the tests mentioned under serial no.8 of routine test
- (c) 10% of total quantity for G.R.E. pipes required in construction for fittings: - Pressure test shall be witnessed by DEWA's representative / consultant, necessary intimation shall be given to DEWA / consultant to witness the test.
- (d) All tests and related matter shall be carried out without extra charges.

3.3.A.9 Samples

The following samples are to be submitted by the GRE fittings supplier / tenderer if requested by DEWA:

1. 225 x 225x 150 mm GRE Tee spigot / spigot / spigot - 1 no.
2. 150 mm GRE bend 90 °double flanges - 1 no.

Other sizes, if requested by DEWA, shall be submitted.

3.3.A.10 Submittals/Drawings

Prior to start of production, the fittings manufacturer shall submit to the Engineer dimensional drawings of each fitting required for approval. The Engineer may also require design calculations, samples and sample testing for approval at no extra cost to the client.

For flanged fittings, the manufacturer shall submit before delivery, the recommended gasket details, the bolt torqueing sequence and maximum recommended torque for each flange size supplied.

3.3.A.11 Markings

Each fitting shall be indelibly marked with the following:

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- Manufacture's Name or Trade mark
- Nominal Diameter (N.D.) in mm
- Pressure Rating in Bars
- Manufacturing Date, Month and Year.
- Inspection Mark.
- DEWA/CW/Contract no.
- Coupling " home line" position on spigot ends.

Note: The marking label shall be prepared on computer sheet and shall be placed on the fittings/ pipes just before last top layer of glass reinforcements is applied and shall be readable.

3.3.A.12 Submission:

Following are to be submitted along with tender / for approval of material.

- (1) Original catalogue and product technical data**
- (2) Manufacturer's certificate to ISO 9001, 14001 and kite mark**
- (3) Sample as mentioned above.**
- (4) Specification compliance statement paragraph by paragraph showing compliance and deviation, each page stamped and signed by manufacturer, supplier and tenderer.**
- (5) Certificate from Water Regulations Advisory Scheme (WRAS), U.K., /NSF, USA showing fitness to use with hot and cold potable water in accordance with BS6920 for pipes/fittings at minimum temperature of 70 degree C.**
- (6) Detail report of testing carried out for fitness to use with potable water for submission no. (5)**
- (7) Certified agreement copy between manufacturer and technical collaborator**
- (8) Past four years supply record of supplier**
- (9) Past four years supply record of manufacturer**
- (10) Past four years supply record of technical collaborator**
- (11) Result and detail report of long term hydro-static hydrostatic design pressure**
- (12) Result and detail report of short term hoop tensile strength**
- (13) Results and detailed test report of Glass Transition Temperature**
- (14) Copy of all routine test reports**
- (15) Copy of certificate according to ISO 4901**

3.3B GLASS REINFORCED EPOXY (GRE) PIPES AND FITTINGS SUITABLE TO GRE PIPES FOR POTABLE WATER

3.3.1 Scope

This specification covers and defines the minimum technical requirements for Glass Reinforced Epoxy Resin (GRE) pipe system i.e. pipes, pipe pieces suitable to GRE/FC pipes, coupler with two rubber rings, fittings and flanges for underground installations, intended for use in potable water distribution and transmission.

The Manufacturer's design shall satisfy the minimum requirements set herein including stress analysis of the complete piping system. This specification includes the minimum requirements for design, materials, properties, manufacture, workmanship, testing, inspection of standard GRE pipe systems. This specification covers pipe system from 50mm up to 1200mm diameters. The pipes and fittings shall be supplied by one manufacturer.

3.3.2. Applicable Codes and Standards

The following internationally accepted standards are the minimum requirements for the manufacture of GRE Pipe Systems and should be referenced throughout the Project Specification where appropriate. (Latest edition to be used)

ASTM D 3517	Standard Specifications for Fiberglass (Glass Fiber Reinforced Thermosetting Resin) Pressure Pipe.
ASTM D 2310	Standard Classification for Machine made Fiberglass (Glass-Fiber- reinforced thermosetting resin) pipe.
AWWA C 950	Glass Fiber Reinforced Thermosetting Resin Pressure pipes
BS 5480	British Standard for Glass Reinforced Plastics pipes, joints and fittings for use for water supply or sewerage.
ASTM D4161	Standard specification for Fiberglass (Glass-Fiber - Reinforced Thermosetting-Resin) Pipe Joints using Flexible Elastomeric Seals
AWWA M45	Fiberglass Pipe Design
ASTM D 570	Standard test method for water absorption of plastics.
ASTM D 1598	Standard test method for time to failure of Plastic pipe under constant internal pressure.
ASTM D 1599	Standard test method for short-time hydraulic failure pressure of plastic pipe, tubing and fittings.

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ASTM D 2105	Standard test method for longitudinal tensile properties of reinforced thermosetting resin pipe and tube.
ASTM D 2290	Standard test method for apparent tensile strength of ring or tubular plastics and reinforced plastics by split disk method.
ASTM D 2412	Standard test method for external loading characteristics of plastic pipe by parallel-plate loading.
ASTM D 2444	Standard test method for impact resistance of thermoplastic pipe and fittings by means of a tub (falling weight).
ASTM D 2563	Standard practice for classifying visual defects in glass-reinforced plastic laminate parts.
ASTM D 2583	Standard test method for indentation hardness of plastics by means of a barcol impresser.
ASTM D 2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings
ASTM D 3418	Standard Test Method for Transition Temperatures of Polymers by Differential Scanning Calorimetry ¹ .

3.3.3 Manufacturers Pre-qualification

3.3.3.1 Requirements

GRE pipe and fittings shall be manufactured by an established pipe manufacturer in a purpose-built facility for the production of such materials. The Manufacturer shall have an approved Quality Management System complying with ISO 9001 for all activities being undertaken during pipe design, manufacture and supply. In addition the manufacturer shall have an environmental certification program in accordance with ISO 14001. The manufacturer shall have experience in the manufacturing of GRE pipe and fittings of few years, evidence of such experience as well as of technical know how transfer are required for approval. The Manufacturer having Kite mark certification in accordance with BS 5480 shall be preferred.

3.3.3.2 Qualification Types Tests

The following tests shall be carried out on actual pipe produced by the manufacturer to establish and accept the design basis for the products. These tests are not routine quality control tests.

- (a) Long term hydrostatic design pressure of the GRE pipes shall be established on test data extrapolated to 50 years in accordance with AWWA C950 Section 2.4.2 and ASTM D2992 Procedure B. The test should have been performed at a minimum temperature of 70 degree C certified by an independent laboratory.
- (b) Short-term hoop tensile strength shall be within the ultimate strength of the pipe, fittings, laminated joints and flanged joints to withstand a hydrostatic test pressure of 3.5 times the rated working pressure. For flanged joints, the flanges shall be blinded and the ends unrestrained during the test.

3.3.3.3 Manufacturer's Scope of Work

The GRE pipe system Manufacturer will be responsible for the following:

- a) Manufacture and Supply of the GRE pipes, fittings, flanges, pipe make-up and short pieces, coupler with rubber rings to suit OD of GRE pipes/FC pipes/Spigot valves and GRE saddles for instrumentation tapping,. Manufacturer shall also supply the gaskets or recommend type of gasket for use in flange connections, provide recommendations on installation, repair/replacement of pipe/coupler, under pressure tapping, required equipments and associated other accessories and their connection details, such as valves, expansion bellows, nuts and bolts,
- b) Inspection and testing at the Manufacturer's works in accordance with specified requirements herein.
- c) Marking of pipe for identification.
- d) Supervision at site for storage, transport, handling and installation by contractor.

3.3.4 Product Description

3.3.4.1 General

Pipe shall be manufactured by the glass filament winding process as described by AWWA M45. The filament wound pipe shall be made using a steel mandrel.

The pipe shall be constructed so as to include internal and external corrosion barriers of a composition suitable to resist the corrosive effects of the contained and surrounding environments.

The inside diameter (ID) of the finished pipe is fixed by the mandrel outside diameter. The outside diameter (OD) of the finished pipe is determined by the amount of material that is wound on the mandrel.

The pipe shall be produced in one continuous piece with no joints.

3.3.4.2 Material

Resin to be used in the liner pipe structural wall and external layer shall be Epoxy thermosetting type, no styrene monomers shall be present in the resin. Evidence of compliance to the above shall be furnished through catalogue, resin data sheet, additives data sheet and curing agents used.

a Liner

Pipe and Fittings shall have a smooth resin rich internal liner of 0.5mm thickness with a resin to glass ratio of 90:10 by weight. This liner in contact with water shall be reinforced with "C" Glass veil or mat impregnated with epoxy resin.

No dark pigment or resin fillers, such as calcium carbonate shall be used.

b. Structural Wall

The structural wall of the pipe shall consist mainly of reinforced continuous fiberglass roving impregnated in epoxy resin and may contain woven roving, chopped glass or chopped strand mat. No dark pigments or resin fillers such as calcium carbonate shall be used.

For non-restrained pipe applications, fine silica sand, complying with BS 5480 requirements, may be included for diameters greater than DN450.

c. External Layer

Epoxy resin-rich post-coat must be applied to the external surfaces of all the GRE pipes. All external surfaces shall be able to resist the anticipated corrosion imposed by the service and ambient conditions. Approximate thickness of the external surface, shall be 0.25 mm.

No dark pigments or resin fillers such as calcium carbonate shall be used.

Fitness in contact with potable water :

GRE Pipes and fittings shall not impart any taste, odor or colour to drinking water. GRE pipes and fittings shall be certified and listed for potable water use by the Water Regulations Advisory Scheme (WRAS), U.K., in accordance with BS 6920 or by the National Sanitation Foundation (NSF) – USA in accordance with NSE Standard 14 for a design temperature of 70⁰ C as per compliance to BS 5480 clause 3.1. The said certificate shall be submitted along with the detail report given by the WRAS/NSF. If requested by DEWA, testing to comply with BS 6920 at local laboratory shall be carried out on sample submitted to DEWA, at no extra cost. All Raw materials to be used such as resins, curing agents,

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fillers, hardeners, silica etc. shall be suitable for potable water at a design temperature of 70°C. Evidence to be provided to DEWA with certificate from WRAS / NSF

3.3.5 Design Parameters

3.3.5.1 Design pressure

GRE Pipe PN 10 shall meet the following minimum design requirements:

Operating Pressure /	
Design Working pressure (PN)	10.0 Bars
Maximum factory test	20.0 Bars
Surge Pressure (Ps)	40% of 'PN'
Vacuum (Pv)	-1.0 Bar
Minimum Earth Cover	1.0 m
Maximum Earth Cover	4.0 m
Service temperature	50 degree C
Design Temperature	70° C as per compliance to BS 5480 clause 3.1
Pipe Stiffness	(a) 1200mm to 500mm dia. pipes/fittings – Earth Cover to pipe 1.5m to 4.0m – 5,000 N/sq.m. 1200mm to 500 mm dia. pipes/fittings – Earth Cover to pipe 4.0m to 7.0m – 10,000 N/sq.m 1200mm to 500 mm dia. pipes/fittings – Earth cover to pipe more than 7m – As recommended by the manufacturer (b) 450mm dia. pipes/fittings – Earth cover to pipe 1.5m to 4m – 10,000 N/sq.m. 450mm dia. Pipes/fittings – Earth cover to pipe is more than 4m – As recommended by the manufacturer (c) 300mm to 50mm pipes/fittings – Earth cover to pipe – 1m to 4m – 10,000 N/sq.m. 300mm to 50mm pipes/fittings – Earth cover to pipe is more than 4m – As recommended by the manufacturer

If GRE pipes/fittings with a higher PN/stiffness as recommended by manufacturer and approved by DEWA, shall be used. The suitability of the stiffness class to the required burial depth and installation conditions shall be substantiated with AWWA M 45 design calculation by the manufacturer and shall be approved by DEWA.

If it is mentioned PN16/higher pressure rating in BOQ, then the pipes/fittings shall be supplied accordingly. The manufacturer shall submit design parameter, calculation and full detail for PN16 and higher class. If PN is not mentioned in BOQ, it shall be taken as PN10 for earth cover 1.2m to 4m .

The Contractor shall be responsible for implementing / installing the correct design for GRE pipe system.

Buried GRE pipe design shall be established in accordance with AWWA M45. Support requirements for complex above ground piping systems shall be based on computer flexibility analysis (static and dynamic) of the piping systems. Design calculations shall be submitted to the Engineer for review and approval.

Should the site conditions require that the pipe be installed in depth less than 1.2m, manufacturer shall recommend installation and protective measured / stiffness.

3.3.5.2 Design Temperature

The temperature capability of the pipe system is dependent on the resin and shall comply as per BS 5480 and clause 3.1, which states “ The resin shall be thermosetting resin such that when cured according to a schedule representative of that to be used for finished pipe work and then tested in accordance with BS 2782: method 121A, the temperature of deflection of the resin shall not less than 20 degree C higher than the maximum service temperature at which the pipe work component is to be used.” Accordingly, design temperature of the pipe system shall be based on the highest service temperature of 50 degree C (Service temp.) + 20 degree C (as specified in BS5480 clause 3.1) = 70 degree C,

3.3.5.3 Hydrostatic Design Stress

The hydrostatic design stress (HDS) is the estimated maximum tensile stress in the pipe wall in circumferential direction due to internal hydrostatic pressure that can be applied continuously with a high degree of certainty that failure will not occur.

The hydrostatic design stress shall be obtained by multiplying the hydrostatic design basis (HDB) by the service (design) factor. The hydrostatic design basis shall be the extrapolated value of the long term hydrostatic strength (LTHS) to 50 years and shall be determined in accordance with ASTM D 2992. The hydrostatic design stress implies a minimum safety factor of 3, based on the short-time hydraulic test method as described in ASTM D 1599.

3.3.5.4 Pipe Thickness:

The pipe thickness for specified pressure rating shall be based on the Hydrostatic design basis (HDB) obtained using ASTM D-2992 of the pipe with a minimum Safety Factor of 1.8 and minimum temperature 70 degree C.

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Evidence of long term regression curve in accordance with ASTM D-2992 conducted at a minimum temperature of 70⁰ C certified by an independent third party acceptable to DEWA shall be submitted for approval. The allowable stress used must be derived from the above test at 70⁰ C or higher.

3.3.5.5 Mechanical and hydraulic Design (For above ground)

The Contractor shall be responsible for conducting (by a specialized engineering office), a computer based flexibility and stress analysis of the piping system based on static (normal) operating conditions in addition to dynamic (surge / trip) conditions, as per the manufacturer specifications. The dimensions mentioned in next clause are not applicable to pipes/fittings to be installed above ground but pipe wall thickness and other dimensions shall be calculated according to stress analysis. The engineering office shall hold a valid certificate to the approval of the Engineer. A suitable piping support system shall be designed such that all stresses in the pipe, fittings and flanges are within the allowable limit set by the manufacturer. The engineering office scope to include generating isometric drawings showing supports location, loads, types, functions and support detailed design.

The contractor shall be responsible for fabrication and installation of the aforementioned piping support system. The contractor shall also be responsible for supply and installation of any additional auxiliary equipment deemed necessary in the Design Report.

3.3.5.6 Dimensions:

Following dimensions shall be complied for underground pipes.PN10

Table 1:

Nominal dia. DN	Pipe length & tolerance - L	Outside dia. at calibrated end & tolerance - OD	Minimum outside dia. at non-calibrated area of the pipe	Home line distance - mm	Gap between two pipes to be kept during installation
mm	mm	mm	mm	mm	mm
1200	5000 \pm 10	1228.5 \pm 0.5	1229	142.5	15
900	5000 \pm 10	922.5 \pm 0.5	923	127.5	15
600	5000 \pm 10	616.5 \pm 0.5	617	112.5	15
450	5000 \pm 10	463.5 \pm 0.5	464	92.5	15
300	5000 \pm 10	309.5 \pm 0.5	310.8	83	10
225	5000 \pm 10	235.0 \pm 0.5	235.6	83	10
150	5000 \pm 10	160.5 \pm 0.5	160.6	70	10
100	5000 \pm 10	110.5 \pm 0.5	110.6	70	10

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Table 2 :

Nominal dia. DN	Coupler length & tolerance	Coupler thickness & tolerance	Maximum deflection allowed in each coupler	Minimum flange thickness	Pipe stiffness
Mm	mm	mm	Degree	mm	N/Sq. mm
1200	300 ± 3	22 +3	1	108	5,000
900	270 ± 3	20.7 +3	1	93	5,000
600	240 ± 3	19.4 +3	2	72	5,000
450	200 ± 3	15.8 +3	3	64	10,000
300	176 ± 3	15.3 +3	3	54	10,000
225	176 ± 3	15.3 +3	3	45	10,000
150	150 ± 3	14.3 +3	3	44	10,000
100	150 ± 3	14.3 +3	3	38	10,000
80	150 ± 3	14.3 +3	3	38	10,000
50	-	-	-	35	10,000

3.3.6.1 Length

Random short lengths, if supplied, shall be only in length of 4.8m, 4.5m and 4.2m and shall not exceed 5% of the quantity supplied of each size. The tolerance on the Manufacturer's declared laying length shall not exceed ± 10 mm. Pipe length up to 300mm is preferred to be 3 Meter. The pipe ends shall be spigot end with beveled edge and double calibrated i.e., length of coupler + 20mm. The spigot end fittings shall be double calibrated except if straight portion for double calibration is not available for few fittings such as smaller dia. bends.

3.3.6.2 Diameters

Pipe shall be manufactured in standard metric sizes based on the pipe nominal diameter in sizes 50mm and larger. The actual inside diameter shall not vary from the nominal inside diameter by more than 1% or 4 mm whichever is greater.

3.3.6.3 Stiffness

The pipe stiffness shall be determined by the Manufacturer to meet the design requirement with particular regard to installation method, burial depths, deflection limits, buckling and vacuum requirements, in accordance with AWWA M45. The pipe initial specific stiffness (EI/D^3) shall, in no case, be less than 5,000 N/m² for diameters larger than 450 mm and 10,000 N/m² for diameters less than or equal to 450mm, when tested in accordance with ASTM D2412 or BS 5480. It shall comply also for pipe stiffness as shown in 'clause 5.1- Design Pressure' of the same specification

3.3.6.4 Beam Strength

GRE pipe shall meet the minimum longitudinal tensile strength requirements specified in AWWA C950 Table 12.

The above requirements are intended to provide adequate strength for normal handling and under ground conditions. Pipe intended to withstand the end load resulting from internal pressure at changes of direction or the beam load resulting from above ground installation shall require higher longitudinal strengths and a suitably designed, fully restrained, jointing system.

3.3.6.5 Hoop Tensile Strength

GRE pipe systems shall meet the minimum hoop tensile strength requirements specified in AWWA C950 table 10 for Class 150 psi.

3.3.6.6 Hardness – Barcol (ASTM D 2583)

The laminated surface shall have Barcol hardness of at least 35

3.3.6.7 Joints

Flexible Joints (Non restrained)

a.1 Standard buried pipe with unrestrained joints shall be filament wound GRE coupling, with confined two rubber ring gaskets positioned in preformed grooves. Rubber rings shall be of EPDM rubber conforming to BS 681-1 or ASTM F 477 for Potable water service at 50 degree C minimum from WRAS or equivalent authority.

Joints shall allow for deviation as specified in table while remaining water tight at 1.5 times the pipe operating pressure. The rubber rings shall be the sole element depended upon for water tightness. This system will require thrust blocks at changes in direction to accommodate thrust loads. This system shall be used normally for buried application.

a. 2 Mechanical Joints:

Standard mechanical coupling/repair coupling of S.S. 316 with internally rubber lined (rubber fit for potable water to 70 degree C.) such as Tee Kay or equivalent.

a.3 Fiber Cement Coupler class 18 :

This is to be used to connect spigot gate valve (spigot end suitable to class 18 F.C. coupler) and GRE adaptor spigot/spigot pipe piece having one end laminated (Length of lamination shall be length of FC coupler + 20mm) to suit to class 18 F.C. coupler and another end calibrated (Calibration length shall be

length of GRE coupler + 20mm) to suit GRE coupler PN10. FC coupler shall also be used in Butterfly chamber to join Flanged / spigot adaptor (Spigot end suitable Class 18 FC coupler) and GRE pipe piece as mentioned above. In place of FC coupler, contractor can use mechanical coupler approved by DEWA.

b) Rigid Joints (Restrained)

b.1 Flanges

GRE flanges where used shall be machine filament wound. Flanges shall be manufactured with epoxy resin. Flanges shall be flat faced with full or 'O' Ring type gaskets. Gasket material and design shall be per the Manufacturer's recommendations. The pipe Manufacturer shall provide the torqueing sequence and maximum tightening torque as appropriate for each flange size and design. Washers shall be used under all nuts and bolts heads with special spacers to be used at flange to valve connections as required.

Flange drilling and rating shall be as specified on the drawings. Flanged joints shall be tensile resistant for above ground service.

Flange/flange fittings shall be designed for installation above ground (in chambers) without thrust blocks. Flanged branches on spigot tees shall be designed to resist end thrust from closed valves.

b.4 Reinforced Overlay (lamination) Joints (butt & wrap)

Butt & Wrap joint where used only for site modification or repair or road crossing and shall consist of layers of Glass fiber reinforcement impregnated with resin. The wall thickness, tensile and axial strength of the reinforced overlay shall meet or exceed the design strength of the adjoining pipe sections. Butt & Wrap joints on site shall be performed only by or under the supervision of the pipe Manufacturer.

b.5 Adhesive

For all adhesive bonded joints a two component epoxy resin mixture shall be used, depending on the application different types of adhesive are available. The adhesive should be delivered as a kit, containing pre-measured quantities of resin and curing agent and written instructions covering preparation of surfaces, mixing, joining, safety, pot life and curing. The adhesive has to be used before the latest work up date, indicated on the packing.

All of the joint types shall be designed to remain watertight when tested after installation to 1.5 times the pipeline operating pressure for a minimum of one (1) hour.

3.3.6.8 Workmanship

GRE pipe, fittings and joints shall be free from de-laminations, cracks, bubbles, pinholes, pits, blisters, foreign inclusions and resin-starved areas that due to their nature, degree or extent detrimentally affects the strength and Serviceability of the pipe. No glass fiber reinforcements shall penetrate the Interior surface of the pipe wall.

3.3.6.9 Fittings

- 3.3.6.9.1** GRE fittings such as bends, tees, junctions and reducers shall be equal or superior in performance to the GRE pipe of the same diameter and pressure. All fittings shall be having a smooth internal surface with similar wall construction.
- 3.3.6.9.2** For GRE fittings, the deviation from the stated value of the angle of change of direction of a bend, tee, junction etc. shall not exceed ± 1 degree.
- 3.3.6.9.3** The overall dimensions and other details of standard fittings shall be as per drawings available with DEWA, which shall be complied by the manufacturer. The tolerance in length shall be $+\text{-} 10\text{mm}$ for 400mm diameter and below and $+\text{-} 10\text{mm}$ for diameter 450-1200mm.
- 3.3.6.9.4** All GRE fittings shall be fabricated in the factory, by the same pipe manufacturer, to ensure Quality Control (Under no circumstance shall fabrication of fittings be allowed on site by Contractor). Complex fittings arrangements may be pre-assembled by the pipe Manufacturer in the factory such that field joints are kept to a minimum.
- 3.3.6.9.5** GRE fittings shall be produced in Metric sizes and shall be classified by their nominal inside diameter (ND). All standard fittings up to and including diameter 600mm used in the water system shall be filament wound on precision steel moulds. Non-standard items shall be with mitered construction. The fittings manufactured on steel moulds shall be in one piece. “The two pieces joined together”, is not acceptable. Standard 90 and 45 degree bends of nominal diameter 600mm and smaller shall be of the smooth radius type, having a turning radius of 1.5 times nominal diameter. Fittings diameter larger than 600mm shall be of a mitered (manufactured from GRE pipe sections) construction and internal surfaces shall be finished smooth. Tangential (invert) spigot/spigot/flanged Tee shall be used in washout chambers and shall have a bottom tangential flanged outlet with main spigot ends.

GRE Flanges shall be flat faced and drilled to BS 4504 PN 10 drilling pattern and for 225mm and 550mm diameter for which ISO 2084-1974 / PN10 shall be applied. GRE flange gasket (full face) design and thickness shall be as recommended by the GRE fitting manufacturer. Hand lay-up flanges shall not be acceptable.

The minimum thickness of GRE flanges shall be as per table 2 of section 6.0. The total wall thickness of GRE Fittings shall be determined by the manufacturer to meet the design requirements of this specification but shall in no case be less than the minimum thickness of pipe wall.

3.3.7 Mechanical Properties

GRE Pipes & Fittings shall meet the following minimum strength requirements.

Sr. No.	Property	Test Method	Minimum Value
1	Hoop Tensile Stress for GRE pipe	ASTM D 2290	As per table 10 of AWWA C950 for class 150 psi
2	Axial Tensile Stress pipe	ASTM D 638	As per table 11 of AWWA C950 for 150 psi
4	Initial Hoop stress failure for molded fittings	ASTM D 1599	3.5 x rated Working pressure
5	Initial Pipe Stiffness	ASTM D 2412	Dia. \leq 450mm 10,000 pa Dia. $>$ 450mm 5,000 pa

3.3.8 Testing Requirements

The products supplied to this specification shall be subject to verification by the client/consultant or review of documents as needed. The manufacturer shall execute tests and inspections according to the reference standards of this specification.

Quality control procedures shall include, but are not limited to, the followings:

3.3.8.1 Raw Material Inspection:

All raw materials shall be checked for defects or non conformance to specifications upon delivery and prior to utilization to ensure that only materials that meet requirements are used for production.

3.3.8.2 In process Inspection:

All aspects and areas of manufacturing shall be monitored by quality control program on a continuous basis.

3.3.8.3 Hydrostatic Pressure Testing

100% of the pipes shall be hydrostatically tested at factory as per standards. During the pressure test, the pipes shall not show any sign of leakage. Standard and nonstandard fittings with plain ends and prefabricated spools that can not be hydro tested at the manufacturing facility for size above 300mm dia., shall be hydro tested at the jobsite after assembly. In case of leakage/failure due to manufacturing defects, it will be viewed seriously by client and shall be repaired or replaced by the manufacturer without any additional cost.

3.3.8.4 Visual Requirements

GRE Pipe & Fittings shall be free from delamination, crazing, dry areas or cracks. Spigot ends shall be free from end delamination, torn edges and gouges and shall be finished smooth to ensure water tightness. All laminates shall be fully cured with a minimum Barcol hardness of 35 when tested in accordance with ASTM 2583.

The inside liner of the GRE fittings shall be free of cracks, voids and air inclusions.

3.3.8.5 Routine Tests:

GRE Pipes and Fittings shall be factory tested by the manufacturer in accordance with AWWA C950 or BS 5480 at the frequency specified below. Test results and certificates shall be submitted to the Engineer for each consignment delivered if requested by DEWA.

Sr. No.	Test	Frequency
1	Visual inspection	Every item
2	Dimensions	Every item
3	Hydraulic pressure @ 20 bars for flanged Fittings.	One per 20 Flg/Flg items.
3a	Hydraulic pressure @ 20 bars for Fittings up to 300mm diameter	One per 20 spigot items
4	Stiffness for Pipe diameter > 300mm	One per 100 items
5	Barcol hardness (resin cured)	Every item
6	Axial and Hoop tensile stress for Pipe diameter >300mm	One per 100 items
7	GRE Pipe shall be factory pressure tested at 20 bars	Every pipe
8	GRE Pipes and fittings shall have a T_g value of no less than 90°C using the DSC differential scanning calorimetry-ASTM D-3418.	One per 100 items

3.3.8.6 Testing To Be Witnessed By Dewa/Consultant

The tenderer/contractor shall intimate to DEWA when pipes and fittings or full consignment of finished product, is ready for inspection and testing.

10% of the total quantity of pipe and fittings shall be inspected and tested in the presence of DEWA's representative / consultant for the test mentioned under serial no. 1,2 and 5 of routine test. The quantity for testing for serial no. 3, 3a, 4 & 6 shall be as mentioned in the column of frequency under routine tests.

5% of total quantity for GRE pipes shall be tested and witnessed by DEWA's representative at 20 Bars. Necessary intimation shall be given to DEWA/consultant to witness the test.

All tests and related matters shall be carried out without extra charges.

3.3.8.7 Samples

The following samples are to be submitted as a minimum by the G.R.E. Pipes & fittings supplier / tenderer if requested by DEWA:

225x225x150mm GRE Tee spigot /spigot/spigot-1 no.

150mm G.R.E. bend 90⁰ double flange-1 no.

300mm GRE Pipe section

Other diameters pipes and fittings deemed necessary by DEWA.

3.3.8.8 Submittals / Drawings

Prior to start of production, the manufacturer shall submit to the Engineer dimensional drawings of each pipes required for approval. Fittings drawings shall be as per DEWA Standard. Drawings shall be the basis of product dimensions. The Engineer may also require design calculations, samples and sample testing for approval at no extra cost to the client.

For flanged fittings, the manufacturer shall submit before delivery, the recommended gasket details, the bolt torqueing sequence and maximum recommended torque for each flange size supplied.

3.3.8.9 Markings

Each pipes and fittings shall be legibly marked with the following:

- Manufactures Name or Trade Mark
- Nominal Diameter (N.D.) in mm
- Pressure Rating in Bars
- Manufacturing Date, Month and Year
- Inspection Mark
- Contract no.
- Coupling "home line "position on spigot ends.
- BS Or ASTM Kite mark.
-

Note: The marking label shall be prepared on computer sheet and shall be placed on the fittings/ pipes just before last top layer of glass reinforcements is applied and shall be readable.

Submission:

Following are to be submitted along with tender / for approval of material.

- 1.Original catalogue and product technical data
- 2.Manufacturer's certificate to ISO 9001,14001 and kite mark.
- 3.Samples as mentioned above
- 4.Checklist paragraph-by-paragraph showing compliance and deviation.
- 5.Certificate and detailed report from water research center, U.K. or equivalent, showing fitness to use with hot and cold potable water in accordance with BS6920 for pipes / fittings made from only epoxy resin for minimum temperature of 70° C.
- 6.Certified agreement copy between manufacturer and technical collaborator
- 7.Past four years supply record of supplier
- 8.Past four years supply record of technical collaborator and manufacturer
- 9.Result and detail report of long-term hydrostatic design pressure in accordance with ASTM D-2992 at minimum 70° C.
- 10.Copy of Routine Test reports.
- 13.Technical Data Sheet, catalogue of Resin, hardener, and additives used.
- 14.Inspection and Test Plan.

3.3.9 INSTALLATION

Installation shall be carried out as per manufacturer recommendation.

All GRE pipes above 450mm dia. shall be laid with granular surround and geotextile fabric. If the item for installation of GRE pipes above 450mm dia. in BOQ is not mentioned with granular surround and geotextile, the rate for pipe installation shall be deemed to be included for granular surround and geotextile. For all GRE pipes of size 450mm and below shall be laid with sand bedding and sand surround. If the soil bearing capacity is less, then necessary solution is to be provided by the tenderer and to be carried out at site after DEWA approval at no extra cost.

One metre sabkha stank shall be provided at every 50 metre along the pipeline route for pipes with granular surround and geotextile. The sabkha stank shall be compacted to 95% compaction. The rate shall be deemed to be included in backfilling of pipes and no extra payments shall be made.

No spacer of wooden / any other material shall be used during installation of pipes for maintaining gap between two pipes, as recommended by the manufacturer. Installation shall be carried out strictly as per manufacturer's recommendation. Please refer their catalogue.

- Specification of installation, testing, chlorination etc. for FC pipes also applicable to GRE pipe system
- The Contractor shall submit the pipe Manufacturer's Installation Manual and associated Data for Client review upon Contract Award. A site meeting to include Client, the Contractor and Manufacturer is to occur within two weeks from Contract Award to clarify any outstanding issues / questions on the given installation procedures.
- GRE pipe shall be handled, stored, transported and installed in strict accordance to the Manufacturer written instructions.
- The pipe installation procedures and practices chosen shall meet the design requirements specified.
- No stacking of pipe larger than 1.8 m in diameter shall be allowed on site or during transport.
- Reinforced Concrete Thrust Blocks shall be used at all changes in direction, size reduction / expansion, and other thrust locations under ground for unrestrained pressure systems. Thrust blocks shall encase the entire GRE fitting at the directional change and should be constructed to fully absorb all thrust loads. Thrust block sizes may be reduced or eliminated by using an axially restrained piping system utilizing high axial strength GRE pipe and fittings and a suitable restrained pipe joint design subject to approval by DEWA.
- The Contractor shall employ on a full-time basis the services of field representatives from the pipe Manufacturer throughout the pipe off-loading, storage, installation and testing period.
- For standard buried unrestrained pipeline sections, a flexibly jointed short pipe shall be incorporated outside rigid structures to provide pipeline flexibility against differential settlement. A minimum of two (2) flexible joints on either side of a rigid structure is required. The length of the short pipe shall be in accordance with the Manufacturers recommendation.
- Connection between FC Pipe and Fittings or/and GRE Pipe and Fittings shall be carried out using a Double Spigot Adaptor.
- **Backfill and Installation Selection**
The installation type and choice of Pipe Embedment Zone material is normally specified by the design Engineer based on the specified pipe stiffness class (SN), maximum burial depth, vacuum requirements, and native soil conditions.
SN = Specific tangential initial stiffness, N/m²

Most coarse-grained soils are generally acceptable as backfill material for the foundation and pipe embedment zone. Crushed rock/Gravel complying with ASTM D2487 class “SC1” and compacted to 70% RD shall be used in the pipe zone for diameters above 450mm including geotextile. Sand with less than 12% fines compacted to 90% SPD might be used for smaller diameters.

Cover to GRE pipe

Minimum Earth Cover to pipe for 300mm dia. and below – 1.0m

Minimum Earth Cover to pipe for pipes above 300mm dia. – 1.5m

Migration

When backfill materials such as gravel and crushed rocks are placed in a trench adjacent to finer native material, the finer material may migrate into the coarser material under the flow pressure force of the ground water table. Migration can also occur when selected sand is used as backfill in a trench where the native soil is coarser.

Significant hydraulic gradients may arise in the pipeline trench during construction, when water levels are controlled by various pumping or well-pointing methods.

Gradients may also arise after construction, when permeable under drain or when the open graded embedment materials act as a “French” drain under high ground water levels. Migration can result in significant loss of pipe support and increasing pipe deflections that may eventually exceed the design limits of the GRE pipe.

The gradation and relative size of the embedment and adjacent native soils must be compatible in order to minimize migration. In general, where the ground water table is above the foundation or bedding level and when the native soil is finer than the backfill, a geotextile filter fabric should be used to line the trench bottom and sides and for pipe sizes above 450mm dia. whether ground water available or not.

Buoyancy Considerations

Where the pipe is to be installed on-shore within water table level, proper considerations have to be taken to prevent pipe flotation. In general, a minimum soil cover equal to one pipe diameter should be kept above the pipe crown to prevent flotation.

3.4 VALVES AND APPURTEANCE

3.4.1 General

All valves supplied shall be suitable for use with water temperatures up to 50° C and in climatic and soil conditions encountered in the Dubai area. The nominal working pressure shall be 10 bar or as mentioned in the tender. On class 24 pipe line, all valves shall be PN16 even if it mentioned PN10 in B.O.Q./nothing mentioned in B.O.Q.

Unless otherwise specified, all valves and appurtenance shall be externally and internally fusion bonded epoxy coated using electrostatic/fluidized bed process conforming to DIN 30677 or approved equivalent, with a thickness of 300 micron (except wherever specified with different coating/lining) holiday free non-toxic and colour code RAL 5015/5017. Before application of epoxy coating the surface shall be sand blasted to a minimum SA 2.5 and air blown to ensure good bond. A certificate verifying the suitability of the epoxy coating for use with drinking water minimum 50 degree C is required from the manufacturer endorsed by the Water Regulations Advisory Scheme (WRAS), UK or similar independent national body acceptable to DEWA.

The flange valves shall be supplied complete with flange gaskets and stainless steel nuts, bolts and washers of grade 316. Bolts and nuts shall be supplied with 2 washers per bolt. The bolt length shall be such that after the joints are made- up, the bolt protrudes through the nut, but not more than 12 mm. It shall fit to G.R.E. flange.

Unless otherwise detail or specified here in, gate and butterfly valves shall be supplied complete with extension spindles and appurtenances such that the square nut operation is within 500 mm of the top of the chamber cover slab. Where required, special couplings shall be incorporated to absorb the weight of the extension spindle at no extra cost to DEWA.

The dimensions of stem (spindle) cap of all valves fixed on extension spindles or without extension spindle shall be in accordance with BS 5163 table 5 as shown for size 300mm dia. If valve is higher or below than 300 mm dia size, but the spindle cap dimensions shall be as per BS 5163 for 300mm dia. valve. All valves shall be supplied with stem (spindle) cap made from ductile iron. The spindle cap shall be fixed with spindle by a nut bolt of SS 316 passing through it so that spindle cap is tied with spindle. The manufacturer shall fix spindle cap to spindle by a nut bolt before dispatching (not acceptable as loose items).

Unless otherwise specified here in, all internal and external fasteners and hardware of all valves and appurtenances including the nuts, bolts and washers for flanged valves shall be stainless steel 1.4404 to DIN 17440 or approved equivalent.

All valves shall be tested to the appropriate test pressure at the manufacturer's works and shall be supported by a test certificate from the manufacturer. Inspection, function test and strength test shall be made in accordance with DIN 3230 or approved equivalent.

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The Contractor shall supply the manufacturer's test certificate. The certificate shall relate to the individual number cast/written on steel plate on each valve.

Marking of valves shall include the following:

- Manufacturer's Name or Trademark
- Nominal Diameter(s) (N.D) in mm.
- Pressure Rating in Bars.
- Individual Serial Number which relates directly to the Manufacturers test certificate on steel plate
- Date of Manufacture mentioned on steel plate fixed on valve
- DEWA Contract no.
- Weight of valve for sizes above 300mm dia.

All gate and butterfly valves shall be clockwise closing. Where specified, position indicators shall be provided on all gate and butterfly valves and shall have adjustable end limit stops at both open and closed end positions to prevent damage by excessive operating force.

The maximum effort required to operate the valve against the maximum unbalanced head applied at the circumference of the hand wheel or end of tee-key shall not exceed 15 Kg. where necessary gearing shall be provided as specified to achieve this.

All gate and butterfly valves shall be designed to provide 100 % water tight shut off at all specified pressures and suitable for installation of electrical actuators when required. Line valves of 300-mm dia. and smaller shall be double spigot gate valves with beveled ends.

The outside dia. of spigot ends after coating shall fit with the FC pipe coupling supplied to the Contract. While machining spigot ends, the manufacturer shall take into account thickness of epoxy coating. Outer dia. after coating of spigot ends shall be as outer dia. of F. C. pipes with a tolerance of + or - 0.3 mm.

Where flanges are required they shall be drilled to PN 10 in accordance with BS 4504 except for 225 mm & 550 mm dia for which ISO 2084 -1974 / PN10 shall be applied unless specified or directed otherwise.

Hand wheels shall be providing for all valves when installed above ground, when operation is within reach. Valve installed out of reach above ground shall be provided with chain drive or remote control drive as the case may be.

All valves shall be preferably manufactured in and supplied from North American/ EEC former Western European countries. Valves manufactured by other countries, may be approved subject to DEWA approval.

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Valve shall be manufactured by an ISO 9000 series certified company who has had several years of experience in the manufacture of valves and shall have a fully equipped technical back-up and service facility in the U.A.E.

The manufacturer shall provide a warranty of minimum 5 years to DEWA based on a repair / replacement basis at no extra cost. The warranty period shall be counted from the date of issuance of the Take Over Certificate of the project even though the delivery and installation is made earlier. The warranty shall be valid whether the warranty certificate is issued or not by the manufacturer/ supplier/ tenderer to DEWA. The tenderer is responsible of any repair/ replacement of the item during the project defect liability period after which the supplier and manufacturer is responsible for the same.

The manufacturer of the valve shall provide the certificate for fitness in contact with potable water (minimum 50°C) from Water Regulations Advisory Scheme (WRAS), U.K. or equivalent accepted by DEWA.

All types of valves shall have lifting hooks for the sizes 300mm dia. and above.

Before proceeding with any manufacturing, submit shop Drawing for Engineer's approval. Describe the items being submitted. Show dimension, physical configurations, components and their composition, coating systems etc.. Include material specification lists which shall summarize the specification features as called for in these specifications and include such other necessary data as would provide a complete and adequate specification for re-ordering any spare parts or an exact duplicate of the original from the manufacturer at future date.

With every valve, flexible post with marker plate shall be installed. The rate to be deemed included in supply and install of valve if there is no separate BOQ item for the same.

SUBMISSION :

Following are to be submitted along with tender for gate valves, butterfly valves, air valves and check valves separately.

- (1) ISO 9000 series certificate of the manufacturer**
- (2) Sample**
- (3) Check list clause by clause**
- (4) Original catalogue and technical product data**
- (5) Certificate of Epoxy coating for fitness in contact with potable water**
- (6) Certificate of EPDM rubber for fitness in contact with potable water**
- (7) Past Three years supply records separately for U.A.E. , Middle East Countries and Other Countries in the same format as written in schedule of ' Details of Past Supply records'**

3.4.2 Gate Valves - Resilient Seated

Gate valves shall conform to the provisions of DIN 3352 Part 4 A &B or approved equivalent and as further specified herein. The valves shall be inside screw, non-rising stem, and clockwise closing wedge valves suitable for underground use and flow in both directions. The valves shall be with spigot ends. The spigot ends shall be suitable to Fibre Cement Coupling class 18 and outside dia. of spigot ends shall be exactly the same as outside dia. of Fibre Cement pipes at calibrated ends as mentioned in the specification of F. C. pipes or as detailed below.

Nominal Dia. (mm)	Face to Face dimension of Spigot valve i.e. Dia. + 200mm (mm)	O.D. of Spigot valve +/_ Tolerance (mm)	Minimum length of each end spigot area (mm) i.e. Half length of F.C. coupler + 20mm
100	300	126 +/_ 0.6	80
150	350	178 +/_ 0.6	80
225	425	255 +/_ 0.6	95
300	500	344 +/_ 0.6	95
450	650	508 +/_ 1.0	120

Face to face dimensions for flange valves shall be as per BS 5163. For spigot gate valves, the length shall be Nominal Dia of Valve + 200mm. If valves are shown as flanged in the contract drawings/B.O.Q., and then flanged valves shall be supplied.

450mm dia. Valves : For general guidance, If water corridor is less than 1.6m, then 450mm dia. buried type gate valve with extension spindle is to be installed. If water corridor is between 1.6m and 2.7m, then butterfly in vertical position is to be installed. If water corridor is more than 2.7m, then butterfly valve in horizontal position is to be installed.

The minimum designed working pressure shall be 10 bars. The valves pressure rating shall be not less than PN 10. Valves shall be designed for the “Closed End Test”. Gate valves shall be of resilient seal design with bolted bonnet connection and straight - through port. The connecting bolts of body and bonnet shall be of countersunk design (exposed type not acceptable) and top shall be sealed with wax.

The wedge of the gate shall be low clearance - guided in the body and shall have inner core of ductile iron GGG50 conforming to DIN 1693 or approved equivalent, fully encapsulated with a synthetic EPDM rubber covering on the inside and outside by vulcanizing. The rubber covering shall have a minimum thickness of not less than 2.5 mm on both flow sides, on sealing surfaces minimum thickness shall be not less than 4 mm with no body metal exposed. The EPDM rubber shall be approved to be used for potable water from

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WRAS or equivalent acceptable to DEWA to minimum 50 degree C and be selected to meet the chemical properties and temperatures of the fluid being handled by the valves.

Requirement for an EPDM Rubber

Type	EPDM	
Colour	Black	
Hardness	°Sha	70
Tensile Strength	Mpa	13
Elongation at break	%	300
Density	g/cm ³	1.12
Range or temperatures in dry atmospheric air	°C	-4 to 120
Compression set, DIN 53517,24 hours/ 50° C:	%	10

The stem shall be manufactured of stainless steel 1.4462/1.4404 to DIN 17440 or 316L or approved equivalent, stem thread shall be of the rolled type. The stem sealing and bearing shall be maintenance free and shall be designed in the form of a series of 'O' rings of synthetic rubber and stem bearing gap sealed against entry of dust by a wiper rings. The stem sealing should be replaceable when required.

Valves above 150mm dia., shall be supplied with two lifting hooks and major requirement of valve in water network is spigot end valves, however the spigot OD of the valve shall be same as OD of FC pipe at machined end.

The body and bonnet be ductile iron GGG 50/40 to DIN - EN - 1563 or approved equivalent. Stem nut shall be dezincification resistant brass, CZ 132 to BS 2872. Manual operation shall be by hand wheel for valves above ground or by Tee-key for valves below ground.

The valves body and bonnet shall be internally and externally fusion bonded epoxy coated as specified. Prior to assembly, the entire valve body and bonnet shall be holiday tested internally and externally at not less than 3.0 kV to DIN 30677 or approved equivalent.

The end of spigot and flanged valves shall be protected by wrapping bubble plastic and sealed with mastic tape. It shall cover complete spigot area.

One percent of gate valves supplied size wise of total quantity shall be hydro tested at local laboratory in presence of DEWA representative at no extra cost for the manufacturer / supplier who are supplying first time to DEWA and/ or if required by DEWA..

The spindle cap shall be shall be as per dimension shown in BS 5163 and shall be made from ductile iron. The spindle cap of 450mm dia. gate valve shall have outer dimensions same as spindle cap of 300 mm dia valve of BS 5163. The spindle cap shall be fixed with spindle by nut bolt of stainless steel grade 316 and shall pass through spindle and spindle cap.

Buried Gate Valve (resilient seated) with Extension Spindle :

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The valves required under this series, are for buried valve design. The valves shall be supplied with extension spindle, 100 mm dia. PVC pipe piece class C/D/E, watertight adapter to achieve water tightness between neck of valve body and PVC pipe. This type of valve shall be used for 1.5m maximum depth. If depth is more than 1.5m, then standard valve chamber of concrete block work shall be constructed.

Since valve is to be buried fully below ground, extra protection is required over epoxy coating. Only epoxy coating is not acceptable.

Following are to be applied/wrapped except spigot portion of valve where F. C. joint is to be fixed.

- (i) Mastic or tape filler or molding putty, if required, shall be applied by hand pressing to fill the angled / concave section so that exterior surface shall be smooth and free of projection.
- (ii) Immediately after filling with mastic, self adhesive bituminous wrap or recommended by manufacturer and approved by DEWA, shall be wrapped as per manufacturer recommendation.
- (iii) Over the wrapping, self adhesive thin plastic outer wrap shall be applied.

The extension spindle shall be in one piece i. e. the main spindle shall be extended without connecting coupling. Alternatively, extension spindle with connecting coupling shall be supplied. The height of extension spindle shall be such that spindle cap is 300mm from top level of surface box 150mm dia. The size and material of extension spindle shall be as per manufacturer recommendation and to ensure by manufacturer / tenderer that it can withstand heavy torque during operation. The connecting coupling joining to main spindle and extension spindle shall be attached by nut bolt of stainless steel grade 316 and passing through. The spindle cap shall be attached to extension spindle by nut bolt of stainless steel grade 316 and passing through extensional spindle and cap. Round supporting plate of S.S. 316 shall be welded to extension spindle at 100mm below spindle cap and dia. of round supporting plate shall be 4 mm less than internal dia. of PVC pipe. This is required to keep extension spindle in the center of PVC pipe. Extension spindle, connecting coupling and spindle cap shall be epoxy coated in blue colour. The following marking shall be provided on top of round plate: Name Of Manufacturer, Contract No. and year of Manufacturing.

The PVC pipe piece shall be 100mm dia and class C/D/E. It shall have length of 1.3m for valve size 150mm dia. and below and 1.0 m for valve size above 150 mm dia. More length shall be provided if valve is laid deeper than normal depth. PVC pipe piece shall be fitted over the neck of valve with watertight adaptor. The top of PVC pipe shall be cut upto bottom of frame of manhole cover, at site.

Watertight adapter of PVC/Nylon or any other suitable arrangement is to be given which shall be used to connect the neck of valve and PVC pipe. It shall be watertight so that groundwater cannot enter inside PVC pipe after fixing over the neck of valve.

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For every valve with extension spindle installed, Marker plate and post shall be fixed to indicate the location of valve. The rate for supply and installation of marker plates and post shall be included in the rate of surface box chamber. For supply , refer specification mentioned in this section and for installation , refer drawings or as per manufacturer's recommendation.

Two separate samples shall be submitted with tender if requested by Engineer.

- (1) 100mm Gate valve with spindle cap - 1No. - without specified wrapping, extension spindle, PVC protection tube and watertight adaptor
- (2) 100mm Gate valve - 1No. - with specified wrapping, extension spindle and coupling, PVC protection tube, watertight adaptor

Gear Gate Valves

Gear operated valves shall be provided with operating nuts and Tee-keys as specified. Gear cases shall be totally enclosed and designed for full differential pressure of 10 bars and shall be with bevel gear except where specified.

3.4.3 BUTTERFLY VALVES

1. Butterfly valves shall conform to one of the following standards:- BS 5155; DIN 3354; AWWA C504 or ISO 5752.
2. Valves shall be rated for PN 10 (10 Bar) service / as rated in B.O.Q.
3. Valves shall be double flanged with worm type manual operating gear and with stem cap for valves under ground and hand wheel for valves above ground or with electrical actuator including worm gear as mentioned in B.O.Q.
4. They shall be manufactured from the following materials.

BODY AND FLANGE	DUCTILE IRON OR GREY CAST IRON AND FACE TO FACE DIMENSION OF VALVE IN ACCORDANCE WITH B.S. 5155 (SHORT)
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DISC	ALUMINIUM BRONZE TO B.S. 1400 AB2 OR EQUIVALENT OR NIKEL ALUMINIUM BRONZE OR DULEX STAINLESS STEEL FOR PIPELINE AND RESERVOIR PROJECTS AND IT SHALL BE COATED WITH RYLSAN COATING AND SHALL BE FIT IN CONTACT WITH POTABLE WATER UPTO 50 DEGREE C APPROVED FROM WRAS, UK OR EQUIVALENT (CERTIFICATE TO BE ATTACHED). FOR PUMPING STATION PROJECTS, IT SHALL BE OF ONLY DUPLEX STAINLESS STEEL AND POLISHED AND WITHOUT RYLSAN COATING
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INTERNAL BODY LINING

EPDM RUBBER BONDED BY VULCANIZING PROCESS TO TEMPRATURE RESISTANT 100deg.C AND SUITABLE FOR USE WITH POTABLE WATER UPTO 50 DEGREE C AND EXTENDED OVER THE FLANGE. SHORE HARDNESS OF LINER AFTER VULCANISING SHALL BE 70-75 ° (Sh.A)

CERTIFICATE FOR SUITABILITY FOR USE IN CONTACT WITH POTABLE WATER AT 50° C FROM WRAS, UK OR EQUIVALENT ACCEPTABLE TO DEWA, IS TO BE SUBMITTED.

THICKNESS OF LINING SUBJECT TO CASTING ALLOWANCE

DN	SHAFT SEALING AREA	DISC SEALING AREA	NON - CRITICAL AREA
500-600	12MM	9MM	6MM
700-900	16 MM	12MM	7MM
1200	22 MM	14MM	9MM

**SHAFT
SHAFT PIN**

DUPLEX STAINLESS STEEL

SHAFT BEARING

SELF LUBRICATING TYPE WITH EPDM 'O' RING SEALS OR DRY DESIGN HAVING NO WETNESS BY LINE MEDIA FLOWING THROUGH VALVE OR AS RECOMMENDED BY THE MANUFACTURER & APPROVED BY DEWA.

SPINDLE EXTENSION

VALVE SHALL BE WITH EXTENSION SPINDLE UPTO A MINIMUM OF 500 MM BELOW MANHOLE COVER. IT SHALL BE SUPPLIED BY MANUFACTURER OF BUTTERFLY VALVE / LOCAL MANUFACTURER AND SHALL BE STAINLESS STEEL OR ALUMINIUM BRONZE. THE ALTERNATIVE MATERIAL CAN BE APPROVED AFTER MANUFACTURER RECOMMENDATION AND DEWA APPROVAL.

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THE EXTENTION SPINDLE, IT'S SUPPORT ARRANGEMENT AND MATERIAL FOR SUPPORTS SHALL BE AS PER MANUFACTURER'S RECOMMENDATION AND DEWA APPROVAL. FOR DIRECT SUPPLY TO DEWA, EXTENTION SPINDLE SHALL BE OF LENGTH 100 CM.

STEM CAP

STEM CAP SIZE FOR ALL BUTTERFLY VALVE SHALL BE SAME i.e. AS PER SIZE OF STEM CAP OF 300MM DIA. SHOWN IN B.S. 5163 TABLE 5 WHETHER BUTTERFLY VALVE SIZE IS HIGHER OR LOWER THAN 300MMDIA. 3 NOS. OF EXTRA STEM CAP SHALL BE PROVIDED FOR EACH SIZE OF BUTTERFLY VALVE AT NO COST TO DEWA IF REQUESTED BY DEWA

EXTERNAL COATING

THE PAINT (BLUE COLOR) SHALL BE RYLSAN / EPOXY COATING, PRIMER SHALL BE APPLIED. TOTAL AVERAGE THICKNESS SHALL BE 300 MICRON.

GEAR BOX

AS DETAILED UNDER SPECIFICATION
“WORM GEAR BOX”

5. All the valves shall be of high reliability, robust design and tropicalized in accordance to the worst prevailing ambient conditions.
6. All the internal and external fastenings such as nuts, bolts, screws and fittings shall be of stainless steel grade 316.
7. Flanges shall be drilled to BS 4504 PN10 rating for PN 10 valves and PN16 pattern for PN 16 valves and so on.
8. Butterfly valves shall be used as line valves for sizes larger than 300 mm nominal diameter and for 300 mm or smaller if mentioned in drawing and/ or B.O.Q.
9. Valves shall have position indicator and shall have adjustable end limit stops at both open and closed end position to prevent damage by excessive operating force. They shall close clockwise. Position indicator shall be fixed in such a way that it can be seen from top for underground valves.
10. Valves shall be supplied with stainless steel nuts, bolts, washers shall be of standard AISI GRADE 316.

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11. The valves shall have the name of the manufacturer, type, number, working pressure, nominal diameter and month and year of manufacture cast on valve body in an identifiable top or side position.
12. The supplier shall submit full technical data sheets, catalogues of the valve in English language.
13. All the valves shall be designed for no leakage under flow from either direction tested at a differential pressure across the seal of rated working pressure. Each valve shall be subject to a body pressure/leakage test of 1.5 times the design pressure before leaving the manufacturer's works. Test certificate by the manufacturer is to be submitted.
14. A certificate showing that any rubber lining and coating on disc is non-toxic to potable water from WRAS/NSF shall be submitted
15. Nuts and bolts for flange shall be as follows(PN 10 Valves):

Nominal Diameter Of Valve (mm)	Diameter Of Bolts (mm)	No. Of Bolts Per Valve	Length Of Bolts (mm)
550	M27	40	160
600	M27	40	160
700	M27	48	190
900	M30	56	210
1200	M36	64	240

Contractor/supplier shall be responsible to ascertain exact length and dia of bolts as per requirement.

16. Two lifting hooks to be provided for valves above 300mm dia.
17. Valve supporting foot not to be provided.
18. The manufacturer should be approved for quality assurance scheme under ISO 9000 Series /BS 5750 or equivalent national standard.. Necessary certificates from the manufacturers are to be submitted to the Engineer for his approval along with tender/quotation.
19. Following documents are to be submitted to DEWA along with tender/quotation/approval through consultant.
 1. Original Catalogues & full technical data sheet in English.

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- 2 Quality assurances certificate under ISO 9000 Series /BS 5750 or equivalent issued to manufacturer or certificate of approval of kite mark of BS or similar mark from respective country to the manufacturer.
20. Gear Spindle and extension for butterfly valve shall be 50 mm dia. Or recommended by manufacturer and approved by DEWA.
21. The gear design shall be such that they are suitable for operation with electrical actuator if desired at later date. The mounting flange for actuator on manual operated valves shall be available. The design of adapter for that purpose shall be submitted.
22. The gear arrangement for butterfly valve to be installed as an isolating valve below air valve, shall be such that when butterfly valve installed on vertical pipeline, the spindle position shall be also vertical. These butterfly valves shall be installed as an isolating valve before air valve and air valve is installed below ground level.
23. Manufacturer / supplier shall submit pressure testing certificate at the time of delivery.
24. Inspection/testing at manufacturer place shall be carried out. If inspection/testing waiver is given by DEWA at manufacturer place, then inspection shall be carried out locally/ DEWA store.
25. Transport, unpacking and handling can damage the coating. After installation of butterfly valve, the contractor shall arrange to touch-up the coating wherever it is damaged or one coat of coating to the full external surface shall be applied to the satisfaction of the Engineer.
26. Manufacturer to ensure proper packing of the valves. If two or more valves are shipped in one wooden crate, proper protection shall be ensured with suitable partition between the valves. Valve flanges shall be protected suitably to protect the rubber lining extended over the flange.

27. For 450mm dia. Butterfly Valve :

For general guidance, If water corridor is less than 1.6m, then 450mm dia. Buried type gate valve with extension spindle is to be installed. If water corridor is between 1.6m and 2.7m, then butterfly in vertical position is to be installed. If water corridor is more than 2.7m, then butterfly valve in horizontal position is to be installed.

450 mm dia. Butterfly valve is to be fixed in vertical position i. e. disc shaft shall be in vertical position after installation. Accordingly valve manufacturer shall design shaft bearings and other related items. These valves are to be supplied with normal worm gear coupled with bevelled gear so that gear spindle shall be vertical to operate from top level

of valve chamber by a Tee key. The normal worm gear and bevelled gear shall be from same manufacturer. The worm gear of manually operated valve shall have a flange to install actuator at a later date. Normally, it shall be manually operated valve and PN 10 except if mentioned in BOQ as motor operated valve. The worm gear and bevel gear shall be installed in such a way that both are parallel to pipeline. The lifting hook shall be two nos. and fixed in a position so that valve can be lifted in vertical position.

28. Worm Gearbox :

Applicable to all types of valves

Design

- a) The gearbox shall be of worm wheel type, consisting of worm wheel and a worm shaft including adjustable mechanical end stop.
- b) The gearbox shall be self-locking.
- c) If required, the gearbox shall be equipped with a preliminary spur gear box to reduce the required input torque.
- d) In case the gearbox shall be used for motor operation, the actuator supplier shall be consulted regarding torque verification. Preferably the actuator and the gearbox to be manufactured by the same manufacturer.
- e) The gearbox housing shall be made out of GG (grey cast iron) or GGG (ductile iron). Housing materials such as aluminium shall not be allowed.
- f) The gearbox housing shall be completely filled with gear grease to guarantee proper lubrication in any mounting position.
- g) Special dry bearings shall protect the worm shaft from radial forces. An axial ball bearing shall carry the resulting thrust.
- h) Worm wheels shall be made of bronze material.
- i) Gearbox ambient temperature shall be standard i.e. -25 to +80 degree C

Design Features

The design of the worm wheel gearbox shall allow the following:

1. To utilise a splined coupling
2. To operate manually as well as electrically
3. To motorise a manual gearbox at later stage
4. To meet the typical torque / running time requirements for valves and actuators (type of duty)
5. To withstand max. input torque given according to manufacturers technical data sheet

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6. To match with valve mounting flanges and shafts
7. The gear shall be suitable to local ambient temperature.

Mechanical Position Indicator

An adjustable mechanical position indicator to show the valve position shall be available. Gearboxes for buried service shall not be equipped with a mechanical position indication. In this case a protection lid shall replace the mechanical position indicator.

Enclosure

Enclosure shall be minimum IP 68 according to EN60529 against submersion upto 6m head of water for 72 hours. The O-Ring sealed to enable easy dismantling for repair and maintenance.

Coupling/Valve attachment

A separate splined coupling shall be supplied by the gearbox manufacturer, which allows efficient machining and easy placement of gearbox on valve during the mounting, commissioning or maintenance. The gearbox valve attachment shall be according to ISO 5211.

End Stop Principle

The adjustable mechanical end stop shall be available to protect the valve stem from excessive force. To guarantee proper seating of the valve after maintenance works, the mechanical end stop shall be easily adjustable at site.

General

Worm gearbox must be designed for manual operation as well as for operation with electric actuator. Actuator mounting flanges and valve attachments according to DIN/ISO and or US-norm must be available.

Within its torque range, a gearbox must be capable to provide the torque required for opening or closing the driven valve with a considerable safety margin.

Nameplate

Nameplate shall be made of stainless steel showing all relevant gearbox data. The nameplate shall be securely fixed to the gearbox, so that they cannot be removed or scratched off during shipment, installation, operation or maintenance.

Painting and corrosion protection

Corrosion protection shall fulfil the requirements of salt spray tests in accordance with DIN 50021.

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Gearbox painting must be performed in such a way, that no corrosion takes place under the local ambient conditions and extremely aggressive atmosphere. All outside screws or bolts shall be made out of stainless steel grade A2 / 304.

Surface preparation and treatment

Surface preparation	:	Sand blasted, equivalent to SA 2 1/2 according to SIS 0559 000-1967 / DIN 55 928, part 4
Surface treatment	:	
Aluminum parts	:	electro dip coated
Cast iron parts	:	metallic surface protection
Steel parts	:	metallic surface protection

Structure of the painting

Primer coating	:	2-component primer
Finish coating	:	rylsan/epoxy coating
Colour	:	as per actuator
Entire film thickness:	:	300 µm

29. ELECTRIC VALVE ACTUATORS – BLUE TOOTH

Applicable to all types of valve

Design and Construction Requirements

General

The following electric power supply rated values are applied:

		Permanent Variations	Contingency Voltage
Electric motors	400 V - A.C. 50 Hz 3 phase 4 wire	± 5 % ± 2 Hz	± 10 %
Anti-condensation heaters	60V - 250 V - A.C. or D.C. or 12V - 48V - A.C. or D.C.	± 10 %	
Electronic equipment (e.g. position transmitters)	24 V D.C.	± 10 %	+ 15 % - 20 %

Actuators shall be designed for valve operation according to IEC 60034-1 to ensure a proper function. The valve operation shall be complied with modulating / throttling duty

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of S4-50% ED; up to 1200 starts per hour; no. of starts depending on actuator size and output speed.

All actuator shall be equipped with wireless module for diagnostic and log retrieval
i. e. Blue Tooth Arrangement. Blue tooth card shall be included in each valve to enable to use diagnostic capability of the actuator by client. Necessary soft ware for laptop/PC shall be supplied.

All actuators must be suitable for mounting in any position.

The gear shall be suitable to ambient temperature upto 80 dgree C

The design must provide simple setting, testing, maintenance and repair. All materials used shall be suitable to with stand operation under specific environmental conditions.

No plastic part of any type shall be used, except for electric/electronic components, operating knobs/levers and sealing elements.

The design must allow removing the actuator from the valve without disturbing the function of the valve. For rising stem applications, the design must allow to removal of the actuator from the output drive with full differential pressure applied.

Electrical connection of actuators shall be made to allow quick disconnection in case of maintenance or repair.

In order to minimise the amount of spare-parts required, parts like switches, covers, plug/sockets, limit- and torque-switching gears must be interchangeable throughout the model sizes installed.

All valve actuators shall be suitable for intermittent operation in the ambient conditions specified.

Actuators shall be designed in such a way, that exposure to weather will not interfere with the safe operation. All joints shall be properly sealed.

Interface to the remote terminal unit (RTU)/PLC for remote monitoring and control shall be through redundant MODBUS connection. If DEWA requests PROFIBUS, then it shall be supplied accordingly.

In order to prevent loss of screws, all covers, which can be opened for setting and service, shall be equipped with captive screws.

Depending on valve application, actuators shall be self-locking. Self-locking shall remain active even if the actuator is switched into manual (hand wheel)-operation-mode.

Valve mounting dimensions shall be according to ISO 5210 or ISO 5211 for multi-turn or part-turn applications respectively.

Local agent of actuator shall verify the final installation and certificate from him shall be submitted to DEWA stating that the installation is carried out as per manufacturer recommendation.

Local agent of manufacturer shall provide after sales service on urgent basis to the client whenever complain is forwarded to him.

Electric Motors

All motors shall be specifically designed for valve-actuator operation, which is characterised by high starting torque to facilitate unseating of valve, low stall torque and low inertia.

Motors must be thermally protected by thermal contacts, which shall be embedded in the motor windings.

Motors must be totally separated from the lubricant-filled part of the actuator, allowing the replacing of a motor without losing any lubricant regardless of mounting position.

All precautions shall be taken to avoid any type of corrosion and electrochemical effects, taking place between different kinds of metals.

Motor-insulation must be in accordance with IEC 85 Class F (155° C).

Motors shall be suitable for operation in tropical damp locations, for occasional contact with corrosive gases and vapours and for the whole range of ambient conditions specified.

Each motor shall have a rating plate marked in accordance with IEC 60034.1.

Actuator motors must develop full torque as soon as power is applied. All motors shall be of the high starting torque type to facilitate unseating of the valve.

Sizing Criteria

One actuator size (same outside dimensions) shall be available to cover output speeds from 4 to 90 rpm for a given torque range, to avoid over sizing and unnecessary weight load on valve stem, flange and yoke. An increase of actuator size caused by later selection of a higher actuator output speed is unacceptable.

Actuators must be selected to provide sufficient amount of torque required for safe valve operation under all operating conditions. The actuator output torque must be reached with 90 % of the nominal voltage.

The actuator supplier has to provide the current at maximum setting torque, in order to enable proper sizing of applicable electric equipment.

Actuator motors must develop full torque when power is turned on; therefore direct start-up under full voltage is required.

All motors shall be of the high starting torque type to facilitate 'unseating' of the valve.

The required valve torque shall be calculated by using the maximum differential pressure across the valve seat as specified in the data sheet, with sufficient safety margin.

The actuator shall be capable of opening and closing the valve against this differential pressure within the time specified on the valve data sheet.

Limit and torque monitoring

Torque and limit setting devices must be easily accessible for adjustment without the need for any special tools or instruments. The settings once made shall remain stored in a non-volatile memory.

The torque sensing shall be independently settable for 'OPEN' and 'CLOSE' direction. Torque setting shall be adjustable from 40% to 100% of rated torque. Torque

Torque sensing shall also be active when the actuator is being operated via the handwheel.

Position Indication

Actuator shall be equipped with a local indicator, which continuously shows the valve travel from fully open to fully closed and vice versa.

An absolute encoder shall be used to sense the valve position.

Integral Motor Controls

All actuators shall be provided with integral motor controls, which further shall consist of the following features:

- a) Motor control shall be through solid-state THYRISTOR controls.
- b) Programmable control logic in CMOS SMD technology, microprocessor based.
- c) A device to ensure that the motor runs in the correct direction as per demanded direction of valve travel irrespective of the phase sequence of the power supply.
- d) Timer function (extension of total operating time through pulsed travel). Start and end of stepping mode as well as ON and OFF time shall be programmable independently for the directions OPEN and CLOSE. The timer shall be active in both LOCAL & REMOTE control modes.

Communication:

Command and actuator indications shall be transmitted between the actuator and control system (PLC/RTU) via a specified fieldbus protocol.

In the event of fieldbus communication failure it shall be possible to program for the following behaviour:

- Stop in current position.
- Move to end position OPEN or CLOSED.
- Move to any (specified) intermediate position.

Commands transmitted shall be typically:

- OPEN VALVE
- CLOSE VALVE

- Drive to SET POINT VALUE.
- Emergency Shut Down (ESD), In the event of an emergency an ESD signal input shall be available via fieldbus control.

Indications transmitted from the actuator shall be typically:

- Valve position OPEN/CLOSE.
- Continuous valve position.
- Selector switch set to REMOTE or set to LOCAL.
- Over torque in OPEN direction.
- Over torque in CLOSE direction.
- Actuator running (with direction)
- Actuator being operated manually (hand wheel)

Fault indications

- Motor protection tripped.
- Torque switch tripped in mid-travel.
- Phase missing, etc.

All actuator shall have built-in blue tooth connectivity for remote configuration and control. The actuator manufacturer shall provide necessary software for PDA/Laptop.

Local Controls

Local controls shall be with push button type control, selector switch, LCD display and motor controls shall be available. A selector switch with 'LOCAL-OFF-REMOTE', lockable in all three positions, shall be available. The local controls shall be electrically attached to actuator via a plug and socket connection.

For installations inside valve chambers (pits) it shall be possible to separate the local controls from the actuator and install the local controls (including motor controls / electronic components) on a wall of chamber. For this purpose a wall bracket and connecting cables of sufficient length shall be provided. The length of the cable shall be sufficient to:

- A: Ensure mounting of local controls at a distance of between 0.5 meter below the valve chamber cover slab (ceiling).
- B: Ensure the controls can be easily reached by the operator from the chamber access ladder. This solution shall maintain the IP 68 protection grade.

The local control faceplate shall include:

- Push buttons for the relevant operation commands and configuration.

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- Back –lit LCD display with min. 4 lines, each with 20 characters, showing the present actuator status, actuator action, valve position, error messages etc in self-explanatory simple text (English).
- Lockable selector switch with LOCAL-OFF-REMOTE function.
- Min. of three indicating lights red for CLOSED, green for OPEN, Yellow for FAULT. Blinking of respective light for OPEN/CLOSE shall indicate actuator running to open/close.

Monitoring and diagnosis:

- Retrievable and re-settable data logging for motor run time, total number of cycles, number of torque trips in each direction of travel, number of limit switch trips at each end of travel and thermal overloads. All such data shall be stored in a non-volatile memory and shall always be available for use.
- Diagnostic capability, which will store historical actuator operational data for analysis of actuator and valve performance.
- Fieldbus parameters, such as address, baud rate and parity etc.

Access to logged data shall be available both visually at the local controls and through portable computer. This data shall be retrievable without opening the valve using wireless technology (Blue Tooth or similar) and the supplier shall provide software and connecting cable required.

Wiring and Terminal Boxes

All actuator shall be connected with redundant bus to the control system (PLC/RTU). The wiring and customer connection (incoming and outgoing signals) shall be subject to separate approval.

Fieldbus termination resistors shall be available in every actuator. The terminal compartment shall provide sufficient space to accommodate all cables including redundant fieldbus cables.

All cable entries shall be shipped with metal plugs. Appropriate cable entries shall be made available as per the cabling requirement.

Control unit shall be wall mounted with 10m cable between control unit and actuator. This shall be for underground installation of Butterfly Valve. For valves installed above ground, Control unit shall be integral with actuator.

Each actuator shall provide an adequately sized connection for earthing.

Anti-Condensation Heater

In order to prevent condensation, a heater must be installed inside of the actuator, suitable for continuous operation.

Enclosures

Protection class of the actuator housing, including the motor and all covers, shall be IP 68 according to EN 60529 against submersion upto 6m head of water for 72 hours.

Hand Wheel

Actuators must be equipped with a hand wheel for manual operation. Clockwise operation of the hand wheel shall cause the valve to close. The face of the hand wheel shall be clearly marked with an arrow and the word 'Close'.

The hand wheel must be sized in such a way, to allow easy manual operation of the output drive.

Operation of the hand wheel shall require manual declutching. Under manual operation, the hand wheel shall drive the worm shaft to maintain the self-locking. The motor must be disengaged during hand operation. The hand wheel shall automatically disengage when the electric motor is energised.

Bearings and Gears

Bearings shall be of the self-lubricated or pre-lubricated type. Bearings shall not require any maintenance between general overhauls.

Power gears shall be made from heat-treated steel. Worm wheels shall be made of bronze material.

The actuator gear housing shall be filled with sufficient amount of lubricant. Re-lubrication between general overhauls shall not be required.

Enclosure for gearbox shall be IP 68.

Noise Level

Under all operating conditions the noise level of actuators shall not exceed 75 dB (A) at 1 m.

Name Plates

Two nameplates made out of stainless steel shall be attached to each actuator; one on the motor housing, showing all relevant motor data, one on the actuator gear case showing all relevant actuator data. Special information, like the valve tag no., shall be possible to be shown if required.

The nameplates shall be securely fixed to the actuator and motor, so that they cannot be removed or scratched off during shipment, installation, operation or maintenance.

Painting and Corrosion Protection

Corrosion protection shall fulfil the requirements of salt spray tests in accordance with DIN 50021.

Actuator painting must be performed in such a way, that no corrosion takes place under the local ambient conditions and extreme aggressive atmosphere. All outside screws or bolts shall be made out of stainless steel grade A2 / 304.

Surface Preparation and Treatment

Surface preparation:

Sand blasted, equivalent to SA 2 ½ according to SIS 0559 000-1967 / DIN 55 928, part 4

Surface treatment:

Aluminum parts: electro dip coated

Cast iron parts: metallic surface protection

Steel parts: metallic surface protection

Structure of the Painting

Primer coating :

Finish coating :

Structure : rylsan/epoxy coating : DB 701 silver grey (similar to RAL 9007)

Entire film thickness: : 300 µm

Inspection and Testing at Manufacturer's Work

Each actuator shall be factory tested. Tests shall be performed in accordance with IEC standards. A final inspection sheet shall be supplied with each actuator, which shall include the following information:

- a) General actuator data
- b) Nominal current
- c) No load current
- d) Starting current
- e) Power factor at rated torque
- f) Output speed
- g) Torque and limit switch setting
- h) Limit switching (turns/stroke)

- i) High voltage test (1,5 kV)
- j) Functional test (including all accessories)
- k) Visual test

Inspection and installation at site for actuator and interconnection to SCADA work:

The tenderer shall carry out proper installation as per actuator manufacturer recommendation. The step-by-step procedure and points to take care while installation shall be given by actuator manufacturer, which shall be followed strictly by the tenderer. The tenderer shall arrange actuator manufacturer representative or his authorised agent/subcontractor for demonstration at site for his/subcontractor staff and in presence of DEWA representative at the time of beginning of installation. The cost shall be included in the item/chamber. Manufacturer representative/Local agent shall be deputed to certify the installation and commissioning without additional cost to DEWA. Vendor representative shall verify final installation and certificate shall be given accordingly.

3.4.4 Air Valves

Air valves shall be designed to (a) discharge air during filling of pipelines, (b) admit air during emptying of pipelines, (c) discharge air accumulated at high points in pipelines during normal operation.

Air valves of two types are called for: [a] Double Orifice Air valve [b] Single Orifice Air valve.

3.4.4.1 Double Orifice Air Valve

Double Orifice Air Valves which shall combine both large and small orifices within one valve. The large orifice shall be sealed by a buoyant rigid ball fully and automatically. 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, except when air accumulates in the valve chamber.

1. The valve will be flanged drilled to BS 4504 PN 10 pattern for PN10 valves, BS4504 PN16 pattern for PN 16 valves and so on. The valves shall be supplied with rubber Gasket, stainless steel grade 316 nuts & bolts with washers at no extra cost.
2. The valve construction shall be without integral isolating valve.
3. The valve rating shall be PN 10 or as mentioned in B.O.Q. with all integral parts suitable to withstand working temperature of 50°C [max.]
4. The valve shall be dynamic type. The effective sealing pressure required at valve to give effective sealing shall be 0.2 bar.

3.4.4.2 Single Orifice Air Valve

Single orifice valves shall be of screw down type. Single orifice 25mm valves should be supplied and fixed with gunmetal/stainless steel ball valve and gunmetal/s.s. nipple, the cost of which shall be included in that of valve.

3.4.4.3 General Requirements for Both Types of Air Valves

1. MATERIAL OF CONSTRUCTION.

**BODY / COVER /DUST COVER : GREY C.I. OR DUCTILE IRON OR
OTHER APPROVED MATERIAL**

**ALL WORKING PARTS : BRONZE, STAINLESS STEEL GRADE 316 OR
OTHER NON-CORRODING MATERIAL.**

**COATING : 300 MICRON RYLSAN/EPOXY COATING IN
BLUE COLOUR. THE MATERIAL
SHOULD BE CERTIFIED TO BE FIT
FOR USE WITH POTABLE WATER UPTO 50
DEGREE C., BY AN INTERNATIONAL
AGENCY**

DRAIN PLUG : ¾" STAINLESS STEELGRADE 316

2. Detailed catalogues with drawings and graphs showing air inflow / outflow curves need to be submitted for approval.
3. The valves shall be supplied with rubber gasket, stainless steel nuts and bolts grade 316 with washers at no extra cost.

3.4.4.4 Installation

1. Each double orifice air valve shall be fixed with isolating butterfly valve whether or not indicated in the drawings and the gear orientation of isolating butterfly valve shall be in such a way that gear spindle of butterfly valve, is vertical when fixed below air valve.
2. The air valves shall be fixed as per plans or as directed by the Engineer.
3. The valves shall be tested hydraulically after fixing and any leakage shall be rectified and retested.

3.4.5 Check Valves

3.4.5.1 SWING CHECK VALVE

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Check valves shall be with lever and weight operated for sizes above 150mm dia and UPTO 300mm dia. and without lever and weight up to 150mm to BS 5153 or other approved standard, and shall be **resilient seated and flanged**. For sizes above 300 mm dia., it shall have Tilting Disc with hydraulic damping device. Face to face dimensions shall be as per BS5153 short series.

Body, bonnet and disc - Ductile iron

Shaft - Stainless steel AISI 316

Hinge, body seat - Gunmetal or Stainless steel grade 316

Shaft Bearing – self lubricating

Hinge pin retainer, Disc guide pin, Hinge to disk connection – stainless steel grade 316

Elastomer – EPDM for parts in contact with water and NBR/EPDM for parts not in contact with water.

Resilient seat - EPDM rubber bonded by vulcanizing process for swing check valves

Bolt , hinge, washer, fasteners - Stainless steel AISI 316

Coating - 300 micron Electro-statically applied/fusion bonded rylsan/epoxy coating

The alternative materials may be approved at DEWA discretion

It shall have easy change from without to with lever and weight and vice versa.

Check valves shall be flanged in accordance with BS 4504 PN10 pattern/PN16 pattern/PN25 pattern as per pressure rating of valve.

It shall have body tapping and plug of S.S.316.

SUBMISSION :

- 1. Original Catalogue**
- 2. Technical data sheet**
- 3. Shop drawing**
- 4. Manufacturer compliance to the specification paragraph by paragraph. Each page shall be stamped and signed by the manufacturer, supplier and tenderer**
- 5. Head loss graph**
- 6. ISO 9000 series certificate of manufacturer**
- 7. Certificate of epoxy coating for fitness in contact with potable water from Authority of 'Water Regulation Advisory Scheme, UK' or equivalent National Authority**
- 8. Certificate of EPDM rubber for fitness in contact with potable water from Authority of 'Water Regulation Advisory Scheme, UK' or equivalent National Authority**
- 9. Past supply record**

3.4.5.2 TILTING DISC CHECK VALVE

The Tilting disc valves shall comply in all respect with relevant standards as detailed below. All check valves above 300mm dia. or all size of check valves in pumping station projects or as per BOQ shall be tilting disc with external lever and counterweight and hydraulic damping device. The hydraulic damping device shall be effective in opening and in closing direction. If recommended by manufacturer for high pressure valves or PN10 valves, damping device shall be provided on both side of tilting disc.

Body shall be with flanges and drilled as per BS4504 -PN10/PN16/PN25 pattern. If nothing is mentioned in BOQ, it shall be supplied PN10 pattern.

Disc shall be mounted on stainless steel shafts located in PTFE lined self lubricating bearings with synthetic EPDM rubber double shaft seal.

The Tilting disc valve shall be the double offset eccentric type fitted with a non-ageing sealing element held in place by an adjustable one-piece endless clamping ring secured with stainless steel grade 316 adjusting set screws mechanically lock in place - not resin bonded. The profile seal shall provide tight shut off against a solid rolled in body seat ring of Duplex stainless steel or elastomar. The valve disc shall be as streamlined as possible to ensure low head losses and secure movement without disc flutter.

The disc stub shafts shall be manufactured from Duplex stainless steel and positively keyed to the valve disc and incorporate a key securing device to prevent shearing. Valve disc pinned to stub shafts are not acceptable. The stub shaft bearings shall be maintenance-free self-lubricating PTFE lined bushes and shaft seals of EPDM o-rings.

The check valves shall be equipped with lever and counter weight and hydraulic damping device for setting the closing time. The Hydraulic-damping device shall be used to damp closing and opening shocks of the valve and shall act in both limit positions (damped opening range 10 degrees and damped closing range 15 degrees). If recommended by manufacturer, damping device shall be provided on both side of valve.

The coating and elastomer in contact with potable water shall be WRAS or equivalent national authority approved for 50 degree C minimum. Relevant certificate shall be submitted. Manufacturer shall confirm that he will use the same coating and rubber whose WRAS certificate is attached.

Lifting hooks shall be provided for valves for 300mm dia. and above.

For pumping station projects, limit switches shall be installed to report valve status to control system

Head loss graph shall be submitted. Also state the corresponding maximum back pressure during closing for damping device.

Standard : BS 5155/DIN 3354/AWWA/C504-80

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Pressure Rating : PN10 or as mentioned in B.O.Q. If nothing is mentioned in BOQ, it shall be PN10

Material:

Body : Ductile Iron.
Valve Disc : Ductile iron epoxy coated with disc facing ring of duplex stainless steel or resilient precision seal of EPDM rubber
Shaft : Duplex stainless steel
Body seat ring : Duplex stainless steel
Elastomer : EPDM for parts in contact with water and NBR/EPDM for parts not in contact with water
Bearing material : Self lubricating PTFE
Coating : Fusion bonded Rylsan/epoxy coating – Average 300 micron Thick
All fasteners : Stainless steel AISI 316
Counter Weight : Cast Iron

GENERAL:

1. Manufacturer shall have ISO 9000 series certification.
2. Manufacturer and tenderer shall give Five years warranty against defects of materials or workmanship.

Face to face dimensions: For PN10 and PN16

DN	200	300	350	400	450	500	600	700	800	900	1200
L	230	270	290	310	330	350	390	430	470	510	630

SUBMISSION :-

- (i) Original catalogue
- (ii) Drawings
- (iii) ISO 9000 certificate
- (iv) Epoxy coating and rubber - Fitness certificate in contact with potable water for minimum 50 degree C
- (v) Specification compliance checklist of above specifications paragraph by paragraph. Each page shall be stamped and signed by manufacturer and Tenderer.
- (vi) Head loss graph

3.4.6 FLOAT VALVES

All valves supplied shall be suitable for use with potable water temperatures up to 50° C and in climatic and soil conditions encountered in the Dubai area. The nominal working pressure shall be 10 bars.

Float valves and appurtenance shall be externally and internally fusion bonded rylsan coated using electrostatic/fluidized bed process conforming to DIN 30677 or approved equivalent, with a minimum thickness of 300 micron holiday free non-toxic and colour code RAL 5015. Before application of epoxy coating the surface shall be sand blasted to a minimum SA 2.5 and air blown to ensure good bond. A certificate verifying the suitability of the epoxy coating for use with drinking water is required from the manufacturer endorsed by the National water Council, UK or similar independent national body acceptable to DEWA.

Fasteners / nut bolts / studs etc. fixed in the float valve shall be stainless steel grade 316 or equivalent.

All valves shall be tested to the appropriate test pressure at the manufacturer's works and shall be supported by a test certificate from the manufacturer. The supplier shall supply the manufacturer's test certificate. The certificate shall relate to the individual number cast/written on steel plate on each valve.

Float valves shall be designed to provide 100 % watertight shut off after the tank is full.

Where flanges are required they shall be drilled to PN 10 in accordance with BS 4504.

All valves shall be manufactured in and supplied from North American / EEC former Western European countries.

Valve shall be manufactured by an ISO 9000 series certified company who has had several years of experience in the manufacture of valves and shall have a fully equipped technical back up.

The manufacturer of the valve shall provide a warranty of minimum 5 years based on a replacement basis including labour and material at no extra cost. The warranty given by manufacturer shall be endorsed by the supplier/tenderer and supplier will be responsible for fulfilling the same.

Before proceeding with any manufacturing, submit shop Drawing for Engineer's approval. Describe the items being submitted. Show dimension, physical configurations, components and their composition, coating systems etc. Include material specification lists which shall summarize the specification features as called for in these specifications and include such other necessary data as would provide a complete and adequate specification for re-ordering any spare parts or an exact duplicate of the original from the manufacturer at some future date.

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Float Valves shall be of 10 bar pressure rating, double flanged with face to face dimension according to DIN 3202 F32. Float valves shall be angle type i.e. inlet and outlet shall be at 90 degree

Body, bonnet and cone made of cast iron. Float, spindle, seat and cone-pipe - coupling parts made of rustproof stainless steel containing minimum 13 % chromium. Sealing elements made of Food Grade EPDM rubber. Corrosion protection of body components shall be minimum 300 microns Food Grade epoxy.

Float valve shall be single seated suitable for installation in de-pressurized tank and stress relieved for direct mounting on 200 mm diameter pipeline. Valve should be suitably sized to have a minimum float stroke of 500 mm and flow rate in excess of 600 m³/ hr.

Marking of valves shall include the following:

- Manufacturer's Name or Trademark
- Nominal Diameter(s) (N.D) in mm.
- Pressure Rating in Bars.
- Individual Serial Number which relates directly to the Manufacturers test certificate on steel plate
- Date of Manufacture mentioned on steel plate fixed on valve
- DEWA Supply order no.

SUBMISSION:

Following are to be submitted along with quotation.

- (1) ISO 9000 series certificate of the manufacturer
- (2) Check list clause by clause
- (3) Original catalogue, technical product data and shop drawing
- (4) Certificate of Epoxy coating for fitness in contact with potable water

**3.4.7 AUTOMATIC PRESSURE REDUCING
VALVE AND CHECK VALVE ASSEMBLY**

APPLICATION:

- Its main application is to reduce a high inlet pressure into a lower and stable outlet pressure.
- The valve is designed to maintain a stable outlet pressure, regardless of fluctuations in the inlet pressure or flow and also check reverse flow on pressure reversal on the line. The valve shall incorporate a instant action check valve inside the body, which shall prevent any reversal flow from occurring.

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- Valve closes drip tight when the downstream pressure meets the pilot setting or exceed. The pilot check valves direct downstream pressure above the diaphragm to close the valve when the system pressure reverse (i.e. downstream pressure is higher than the upstream pressure).
- During low demand, the valve will operate with a high degree of stability and accuracy.
- Where cavitations may be present, the valve will be supplied with an Anti Cavitations trim, made up of two centered cylinders. The cylinders will be machined out of stainless Steel grade 316 and they will be capable of withstanding a pressure drop of up to 300 PSI, without causing damage to the main valve body. At the same time, these Anti Cavitations cages will reduce the noise associated with cavitations, by 30 to 40%. The anti cavitations arrangement shall be provided without any extra cost to DEWA and it shall be full system of stainless steel grade 316.

OPERATION :

The valve shall sense the outlet pressure and it shall maintain it below the pilot's field adjustable set point. The valve shall also open to allow increased flow when the outlet pressure drops due to the higher user demand, and to start to close, the demand decreases and the outlet pressure reaches and surpasses the pilot's set point.

PARTICULAR SPECIFICATIONS:

The tenderer has to collect the detail from DEWA for minimum flow, normal operating flow range, max. continuous flow, inlet pressure range and outlet pressure range before submission. After getting data, detail of size calculation and other design data, anticavitation graph is to be submitted by the tenderer.

MAIN VALVE CHARACTERISTICS:

- The main valve is globe type, and it is actuated by a diaphragm or membrane, and operated by a pilot control system. Its operation is hydraulic and adjustable with a pilot.
- The main valve diaphragm will never be used as the sealing surface against the seat. This system will allow the valve to operate with a high degree of stability, even with extremely low flows.
- The valve sealing will be done with a Buna-N disc against a stainless steel seat.
- The main valve bonnet shall be manufactured in two parts, in order to allow easy access to the stem and to facilitate maintenance of the main valve.
- The stem will be guided, from the top and bottom, by easily replaceable bushings, which shall ensure the stem will remain vertical throughout its travel.

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- The seat shall be attached to the valve with normal flat screws and washers, making it possible to do maintenance without the need for any special tools. Threaded connection is not acceptable.
- Maintenance of the main valve shall be possible without removing it from the main line.
- Lifting hooks shall be provided for valves 300 mm dia. and above.

MATERIALS OF CONSTRUCTION:

1. Main Valve:	Globe Type
a) Body, Cover (Bonnet)	Ductile Iron
50 cylinder, spring casing	
b) Stem	Stainless Steel AISI 316
c) Stem Nut	Stainless Steel AISI 316 / Bronze
d) Seat Ring / Seat	Stainless Steel AISI 316
e) Bottom / Top Stem Guide	Navy Bronze B-62
f) Disc Retainer / Inner valve	Bronze/ductile iron with epoxy coated
g) Rubber Parts	EPDM or Buna N fit for drinking water upto
50 degree C .	
h) Diaphragm	Reinforced Synthetic Rubber – Fit to drinking water to minimum 50 degree C
i) Coating for Main body,	300 microns Fusion Bonded rylsan/epoxy Coating
1. – Fit to drinking water to minimum 50 degree C from WRAS	
j) Valve Rating and flange Drilling	PN 10 / PN 10 BS 4504 or as mentioned in BOQ
k) Pressure gauge	100mm dia. Glycerin filled stainless steel grade 304
– one no. installed at inlet end with pressure range given by DEWA and one no. installed at outlet end with pressure range given by DEWA	
l) Upper guide, Bushing retaining ring , Anticavitation inlet cage , Anticavitation outlet cage, Resilient disc, Stem nut cotter pin, Locating pins, Stem cap plug, Body bolts, Stem casing cap screws, Seat ring screws, clamp plate screws, Piston pin, Bonnet bolts, Clamp plate washers, Inner valve screws, Stem set screws - Stainless Steel 316	
m) Eye bolt (hook), Eyebolt locknut - Steel	
2. Pilot Circuit:	
a) Tubings, fittings, Strainer, Pilot	
Valves, Needle Valve, Filter Body,	
Filter Screen, ball valve etc.	Stainless Steel AISI 316
i.e. complete pilot system	

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b) Elastomer EPDM /Buna - N

3. Accessories:

a) Valve Position Indicator	Stainless Steel AISI 316
b) Isolation Valve for Pressure Gauge	Stainless Steel AISI 316
c) Nuts, bolts, fasteners, pins, etc.	Stainless Steel AISI 316

PILOT SYSTEM :

- The valve contains a complete pilot system, and it shall be ready to install in line and operate without any modifications.
- The pilot system will be isolated by three ball valves, which are closed when maintenance as to be performed on the pilot system.
- The pilot system shall have a separate stainless steel opening speed control and closing speed control device, which acts as a low flow stabilizer as well.
- The pressure reducing pilot shall have an adjusting spring with the proper range for the adequate set point. It shall be possible to change the pilot range, by simply changing the adjusting spring.

The complete pilot system shall be of stainless steel, AISI 316. Elastomers shall be of EPDM / Buna. Brass valves, strainer, pipes and fittings are not acceptable

• **FACE TO FACE DIMENSIONS:**

PN 10/16

DN	100	150	200	250	300	400	500	600	700	800
L	350	480	600	730	850	1100	1250	1450	1650	1850

MARKING:

Marking of valves shall include the following:

- Outlet pressure range
- Outlet pressure set by factory at the time of dispatch
- Manufacturer's Name or Trademark
- Nominal Diameter(s) (N.D) in mm.
- Pressure Rating in Bars.
- Date of Manufacture
- DEWA Supply order no.

The above marking shall be with big lettering and in top area of valve so that it can be read from ground level

3.4.8 NEEDLE VALVE (FLOW CONTROL VALVE)

Needle valve shall be designed for precise and accurate regulating of flow without causing cavitations damage on valve body/internals or downstream pipes with minimum noise of less than 70 dBA and minimum vibration. Anti cavitations arrangement of stainless steel grade 316 shall be provided without any extra cost to DEWA. Light anti cavitations arrangement must be provided even there are no cavitations as per manufacturer design and shall be as per manufacturer recommendation.

Medium of flow is potable water with max. Temperature 50 degree C. It shall be throttling type and not on-off type. Delta P at full open shall be 0.1bar. It shall be axial flow type and piston operated.

Epoxy coating and elastomer (that are in touch with potable water) shall be fit in contact with potable water of **minimum 50 degree C**. Certificate from WRAS or equivalent authority shall be submitted.

Pressure Rating : PN10 or as mentioned in B.O.Q.

Material:

Body/Gear box : Ductile iron

Vaned Ring/Slotted cylinder/Piston
/Seat/shaft/slide crank/slide rod/bolts/
Seat ring/collar bush : Stainless steel grade 316

Piston guide on rails : Bronze/stainless steel grade 316

Elastomer : EPDM

Coating : Fusion bonded rylsan/epoxy coating of average 300 Micron in blue color

Construction Bolts : AISI - 316

Connection : Flange face.

Flange drilling pattern : BS4504 PN10 for PN10 valves and BS 4504 PN16 for PN16 valves.

Closing direction : Clockwise

Closing by : Modulating actuator. Refer actuator and gear Specifications

Face to Face dimensions for PN10 and PN16

DN mm	200	300	350	400	450	500	600	700	800	900	1000	1200
L mm	400	500	700	800	900	1000	1200	1400	1600	1800	2000	2400

3.5 MANHOLE COVERS WITH FRAMES AND SURFACE BOX

Manhole covers with frames and surface box shall be manufactured from ductile iron materials (Spheroidal Graphite Iron) and complying with BS EN 124: 1994.

Casting shall be smooth, true to pattern and free from projections, sand holes, blowholes or other distortions. Manhole covers and frames shall meet or exceed minimum wheel loading requirements as defined for CLASS D 400. Engineer may request third party certification, if consider it necessary.

The item shall be watertight. The various options for water tightness can be submitted and final approval shall be as per DEWA approval. DEWA suggests with double seal arrangement, rubber seal in each sealing and GRP sealing plate. The supplier/manufacturer shall submit a sample for each option. At some portion on cover and frame shall be machined to achieve water tightness as recommended by manufacturer/DEWA.

The frame with a circular clear opening of 675mm, 600mm, 300 and 150mm dia. or as sized on the drawings/in the description of item. The keyhole shall be of the closed type. The cover shall be in one piece (solid top) and circular. The frame shall be square/circular. Two no. of rising slot shall be provided diagonally to lift the cover if jammed. One no. of unidirectional notch shall be provided.

The cover shall be badged DUBAI ELECTRICITY & WATER AUTHORITY -WATER in English and Arabic and shall also bear the DEWA logo.

The covers are to clearly have the BS no./ class / manufacturer's name and DEWA logo cast thereon.

Covers and frames shall be grit blasted and coated with a suitable heavy duty abrasion resistant solvent free epoxy paint to a minimum Dry Film Thickness (DFT) of 300 microns in black colour.

The manufacturer shall apply greasing material mixed with graphite powder and then it will be delivered.

One set of each size from total quantity to be used in the project shall be load tested locally at no extra cost during submission of sample/delivery if requested by DEWA or as directed by the Engineer.

Also, after installation, the covers and frames shall be again greased (grease + graphite powder) internally particularly in the contact area of frame and cover and contact area between GRP sealing plate and frame by the contractor.

150 mm DIA. SURFACE BOX :

It shall be watertight, The manufacturer/supplier shall forward his proposal to achieve water - tightness. The surface box shall be double seal and with GRP sealing plate. The frame shall be square and cover shall be round with 150mm dia. opening. The cover shall be in one piece (solid top) and one keyhole (standard) for lifting. The marking on cover shall be (i) manufacturer name (ii) 'DEWA' and (iii) 'WATER' (iv) ↔ (arrow mark). The surface box shall be installed in such a way that arrow direction marked on cover is parallel to the pipeline. The specifications for manhole covers and frames are also applicable to the surface box.

SUBMISSION FOR MANHOLE COVER AND SURFACE BOX

- (1) Original catalogue and technical product data**
- (2) Sample of each size**
- (3) Load test certificate for each size**

**3.6 FABRICATED STEEL COVER WITH FRAME INCLUDING
GALVANIZING AND EPOXY COATING FOR WATERMETER
CHAMBER - SIZE OF COVER -1100 x 600 MM , 900 x 600MM and 600
x 450 MM**

Following sizes of cover is to be used as detailed below:

For 15mm and 25mm dia. water meter installed – 600 x 450mm

For 50mm dia. water meter installed where two no. of 25mm dia. polythene pipe connection is given through 50mm dia. Tee – 900 x 600mm

For 50mm dia. water meter where connection is provided without using polythene pipe – 1100 x 600mm

For water meter 80 mm dia. and above – 1100 x 600 mm

The above sizes of cover are clear opening of cover and depth shall be 75mm. The cover shall be twin hinged and made from slip resistant plate (chequered plate) hinged into a steel frame. The cover shall be in two portions with opening from the center for size 1100 x 600mm and 900 x 600 mm. The cover shall be in one portion for 600 x 450mm. Safety arrangement shall be provided to prevent accidental closure i.e. when it is fully open then it shall open up to minimum 120 degree to avoid sudden closure. The lifting handle shall be provided.

The chequered plate shall be 6mm thick and shall be reinforced underneath with support channel / other suitable measures. The angle shall be 75 X 75 X 6 mm.

The hinge rod / screw / fasteners / nut bolts shall be stainless steel Grade AISI 316.

The complete set will be sandblasted to S.A. 2.5 after fabrication. It shall be hot dipped galvanized and then fusion bonded epoxy coating in blue color shall be applied. Submit catalogue of epoxy coating to be applied. Also submit name, address, tel. no. and fax no. of company / companies where you are proposing to carry out galvanizing and epoxy coating

Suitable thickness of 300 x 300mm size brass plate with backing steel plate shall be fixed inside the cover and with following marking in Arabic and English. The marking and logo shall be embossed and shall be coloured in blue.

- (i) DEWA LOGO
- (ii) DUBAI ELECTRICITY AND WATER AUTHORITY
- (iii) WATERMETER

The item shall be as per DEWA sample available in DEWA store. It shall be modified with minor modification if suggested by DEWA Engineer.

3.7 DETECTABLE WARNING TAPE

Detectable Warning Tape shall be of high quality, strong, non-corroding, acid and alkali resistant, tear resistant and resistant to other destructive elements found in the sand / soil. Detectable warning tape shall have long durability to maintain its installed width and message. It shall be free of surface area distortion normally. The width of tape shall be 300mm. Aluminium foil shall be minimum 12 micron thick and 300mm width and laid between the layers of polythene sheets and polyester. The total thickness shall be minimum 250 microns.

The tape shall be Blue in colour and printed with minimum 50mm high black lettering alternatively in Arabic and English. The tape shall be imprinted with "DUBAI ELECTRICITY AND WATER AUTHORITY WITH LOGO - CAUTION - WATER MAINS BELOW" in Arabic and English. The tape shall have printed message in reverse type printing (i.e. on back side of transparent polyester sheet). The manufacturer name shall be printed at every 1m or less distance. The complete wording shall be accommodated in 1m or lesser length of tape in English and Arabic. This will continue for the complete length. The colours shall be vivid, glossy and permanent. The aluminium foil shall be incorporated so that it can be detected from ground surface using a buried cable locator such as RD 400 locator manufactured by Radio Detection Corporation. If requested by Engineer, the demonstration shall be given for detectability of tape by cable locator at site.

The tape shall be supplied in rolls of 250 metres each. The tape shall be supplied on stout reels suitably crated.

Notes:

* 2 meter long sample piece of detectable tape shall be submitted with the Tender.

3.8 NUTS AND BOLTS WITH WASHERS

Nuts & bolts with washers shall be of AISI type 316 Stainless Steel complying with ASTM A276 or equivalent. The grade shall be embossed on bolts. They shall be supplied with two stainless steel grade 316 standard washers. Unless otherwise indicated on the drawings, all stainless steel (whether nut bolts or any other items) shall be Type 316 with a mill finish.

3.9 DISMANTLING JOINTS

The dismantling joint shall have flexibility required for flanged pipe work system and allows longitudinal adjustment in length for installation & maintenance. The dismantling joint shall be flange/flange i.e. double flanged and restrained type. The flange of both faces shall be provided with full face flange sealing area i.e. the flanges shall not have raised face if GRE adaptor is to be installed. The coating and EPDM rubber shall have fitness certificate in contact with potable water minimum 50 degree C from Water Regulation Advisory Scheme (WRAS) or equivalent Authority.

Materials of Construction

- (i) Spigot Piece, Body , End ring, Flange adaptor: Steel BS EN 10025 or ductile iron
- Bolts/Studs/Nuts/Washers/tie bars : Stainless Steel Grade 316/steel with Taflon coated
- Rubber gasket : EPDM Rubber – Fit for potable Water to minimum 50degree C. (Certificate from WRAS or equivalent acceptable to DEWA to be attached)
- (ii) Nominal pressure (PN) : PN10/PN16/PN25 as per item Description/drawing
- (iii) Surface Protection : Rilsan Nylon coating/ Fusion bonded Epoxy minimum thickness - 250 microns and average 300 microns Fit for potable Water to minimum 50degree C. (Certificate from WRAS or equivalent acceptable to DEWA to be attached)
- (iv) Flange Drilling : (i.) BS 4504 PN10 pattern for PN 10 item. (ii) BS4504 PN16 pattern for PN16 item. (iii)BS4504 PN25 pattern for PN 25 item

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(v) Adjustment Length and Other Details:

NOMINAL BORE	PRESSURE RATING	NOMINAL LENGTH	MINIMUM LENGTH	MAXIMUM LENGTH
mm		mm	mm	mm
50 to 300	PN 10 / 16	190	170	210
350 to 900	„	300	275	325
1000 to 1200	„	320	290	350

Installation procedures shall be given in the submittal and shall be followed by the contractor.

Two lifting hooks shall be provided for size 300 mm dia. and above.

It shall have name of manufacturer, PN, DN, month and year of manufacture casted on body in an identifiable top or side position.

All test report shall be supplied with delivery.

Necessary touch up paint will be carried out to damaged area to the satisfaction of Engineer.

The other material of construction can be approved subject to DEWA approval.

3.10 FLEXIBLE - COUPLING AND FLANGE ADAPTORS

Where flexible couplings are required, they shall be of the tied or restrained type, Viking-Johnson flexible couplings or equal. The supplier shall follow the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular, the supplier shall ensure that rubber rings are correctly positioned and free of twists. The rubber rings and any recommended lubricants should be obtained only from the coupling manufacturer.

It shall have lifting hooks for size 300 mm dia. and above.

Flexible couplings and flange adaptors shall be capable of withstanding the test pressure appropriate to the pipes for which they are supplied.

Nominal pressure (PN) PN16/PN10 as per item description

Surface Protection Rilsan Nylon coating to full unit including
internal & external protection studs, nuts, bolts and suitable to for fit in contact
with potable water (certificate to be attached)

{End ring / flange adaptor body /
centre sleeves / spigot} minimum thickness - 250 microns

Studs / Nuts / Bolts / Tie Bolts minimum thickness 50 microns

Drilling of hole (i.) BS 4504 PN10 pattern for PN 10 item.
(ii) BS4504 PN16 pattern for PN16 item.

Details of couplings for incorporation in the works shall be submitted to the Engineer for approval.

3.11 F.C. JOINT LUBRICANT - SOFT SOAP

Soft Soap shall be supplied as a lubricant for Fibre Cement Pipe Joints, which shall be odorless and washable with water and shall have a paste like consistency. The soap shall be vegetable based (petroleum based not acceptable) and free from fish, whale or other animal oils and fats; free from resins and any poisonous materials. Certificate to that effect shall be submitted by the manufacturer at the time of delivery. It shall be supplied in packing of 25 kg net. The packing shall be of good quality (plastic packing is not accepted). The soap shall be certified and listed for potable use by Water Research Center (Water Byelaws Scheme), U. K. or equitable in accordance with BS 6920

Catalogue and technical data, net quantity in each drum, and WRC certificate shall be submitted along with the quotation/tender.

3.12 MARKER PLATES AND POSTS

The marker plate and post shall be provided as shown on the Drawings and where directed by the Engineer. The sign plates shall be 140 mm by 200 mm and mounted on a 48 mm diameter ribbed aluminium post finished with a plastic cap. The sign plate shall have a plastic face with "slot-in" interchangeable plastic numerals and letters, a plastic backing plate and an aluminium mounting plate. The corners of the mounting plate shall be rounded to the same dimensions as that of the plastic plate. The plate colour shall be blue and the figures shall be white.

The material used for the plastic plate, numerals and letters shall be resistant to ultraviolet radiation and suitable for the exposure conditions encountered in Dubai. The numerals and letters shall be as per manufacturer recommendation and DEWA approval.

The design of the marker plate and post shall be subject to the approval of the Engineer.

For every valve with extension spindle installed, Marker plate and post shall be fixed to indicate the location of valve. The rate for supply and installation of marker plates and post shall be included in the rate of surface box chamber i. e. valve access chamber. For installation, refer drawings or as per manufacturer's recommendation.

3.13 A FLEXIBLE INDICATOR POSTS

Flexible indicator post shall be installed exactly above and along the alignment (route) of transmission pipeline i.e. pipe above 450mm dia. at every 100m and on every fitting for pipeline above 450mm dia. If BOQ is shown with separate item for supply and installation of this item, then it will be paid accordingly. If BOQ is not shown with separate item for supply and installation of this item, but the item must be installed and rate shall be deemed to be included in supply and installation of pipeline and fittings and no extra payment shall be made.

The flexible indicator post shall be fiberglass reinforced composite, which shall be resistant to impact, ultraviolet light, vandalism and hydrocarbons and temperature

resistance from zero degree C to sixty degree C. It shall be flexible and can withstand direct vehicle impact and return to its original upright position. Post width shall be 9 to 10cm, length 150cm or more and colour blue.

It shall allow the placement of decals on both side of post to identify buried water services. Warning/Message decals shall be UV resistant and also printing with UV resistant inks. Decals shall be provided on both sides of post. The decals shall be of high quality and reflective at night. The background colour of decals shall be blue and message/warning letter shall be white. The blue colour should not fade in local harsh condition of 50 degree C. The message/warning script shall be as directed by DEWA which will be different for valves, fittings and along the route of pipeline. The samples with different script on decals shall be submitted.

The base shall be concreted with size 300x300x400mm. Its length shall be 1.5m where 1m shall be projected above ground.

The other type, design and material can be submitted and installed subject to DEWA approval.

3.13 B FLEXIBLE INDICATOR POST WITH MARKER PLATE

Flexible indicator post with marker plate shall be fixed to indicate the location of valve/meter. Flexible indicator post with marker plate shall be installed with every valve, water meter and flow meter. The item shall be installed with all sizes of valve and meter installed on transmission or distribution pipeline, with all type of valves and meters i.e. gate/washout/air/butterfly/ watermeter / flowmeter etc and for all type of system i.e. buried or chamber system. If BOQ is shown with separate item for supply and installation of this item, then it will be paid accordingly. If BOQ is not shown with separate item for supply and installation of this item, but the item must be installed and rate shall be deemed to be included in supply and installation of valve / construction of chamber/access chamber for buried valve and no extra payment shall be made.

The flexible indicator post shall be fiberglass reinforced composite/other material upon DEWA approval, which shall be resistant to impact, ultraviolet light, vandalism and hydrocarbons and temperature resistance from zero degree C to sixty degree C. It shall be flexible and can withstand direct vehicle impact and return to its original upright position. Post width shall be 9 to 10cm, length 150cm or more and colour blue. The blue colour should not fade in local harsh condition of 50 degree C.

The marker plate shall be 200 mm by 140 mm and mounted on flexible indicator post by screws of stainless steel 316. The marker plate shall have a plastic face with “slot-in” interchangeable plastic numerals and letters, a mounting plate of polished aluminum and screw/nut bolt of stainless steel grade 316. The corners of the mounting plate shall be rounded to the same dimensions as that of the plastic plate. The plate colour shall be blue and the figures shall be white.

The material used for the plastic plate, numerals and letters shall be resistant to ultraviolet radiation and suitable for the exposure conditions encountered in Dubai. The numerals and letters shall be as per manufacturer recommendation and DEWA approval.

The flexible indicator post with marker plate shall be installed near to chamber/buried valve. It shall be installed in such a way that plate is facing towards the road/proposed road/access road. Following notation shall be used in marker plate.

GV – Gate Valve, HV – Hand Operated Butterfly Valve, MV - Motorized Butterfly Valve, WV – Washout Valve, AV-Air Valve, FM – Flow Meter, WM – Water Meter. The size of valve/meter shall be indicated in appropriate box. The Tee junction shown on plate is for distance of post from valve and proper plastic numerals shall be filled as per manufacturer/supplier recommendation and distances at site. Wherever no distance/ figure is to be written on plate, the space shall be filled with blank plastic insert.

The base shall be concreted with size 300 X 300 X 250 mm. The total length of the post shall be 1.5 m where 1 m. shall be projected above ground.

For installation, refer drawings as per manufacturer's recommendations.

The design of the flexible indicator post with marker plate shall be subject to the approval of the Engineer. The other type, design and material can be submitted and installed subject to DEWA approval.

3.14 NEOPRENE RUBBER WRAP FOR G.R.E. FITTINGS

Neoprene synthetic rubber shall have shore hardness 'A' of 40 - 50. The neoprene wrap shall be supplied in 10 meters long rolls, 10 mm thick, and 100 mm wide. The rolls shall be supplied in closed plastic bags or other packing approved by DEWA.

3.15 INSERTION RUBBER (RUBBER GASKET) FOR FLANGED CONNECTIONS

a. INSERTION RUBBER FOR RUBBERLINED BUTTERFLY VALVE:

Insertion rubber shall be made from EPDM rubber with hardness 70 - 90 for rubber lined butterfly valves. Insertion rubber shall be fixed for flanged connection as an insertion between flanges. The outside and inside diameters of rubber insertion for rubber lined butterfly valves shall be as tabulated below but exact dimension and thickness shall be checked by contractor. The flange hole drilling shall be done as per BS 4504 (PN 10) pattern. For 225 mm and 550 dia. insertion rubbers, ISO 2084 - 1974 (PN 10) drilling pattern shall be followed. The table below is only for rubber lined butterfly valve and indicative. It shall be noted that insertion rubber is not required on the full face of butterfly flange as rubber lining is extended on raised face but to be placed after rubber lining.

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Nominal Diameter Of Butterfly Valve (mm)	Inner Diameter Of Insertion Rubber (mm)	Outer Diameter Of Insertion Rubber (mm)	Thickness Of Insertion Rubber (mm)
1200	1333	1455	5
900	1007	1115	5
600	685	780	5
500	584	670	4
225	225	420	3
200	200	340	3
150	150	285	3
100	100	220	3

The technical data of rubber and dimensional drawing shall be submitted along with tender / approval.

b. NSERTION RUBBER (RUBBER GASKET) with FULL FACE FOR FLANGED CONNECTIONS OTHERTHAN RUBBERLINED BUTTERFLY VALVES:

Insertion rubber shall be fixed for flanged connection as an insertion between flanges. It shall be made from EPDM rubber with Shore Hardness (A) 45 – 60. The hole drilling shall be done as per BS 4504 (PN 10) Table 18 pattern. It shall be full faced. Part face to cover raised face area, is not acceptable. **The rubber shall be with thread reinforcement. The rubber shall be of food grade.**

PN10

Nominal Diameter (mm)	Inner Diameter of Insertion Rubber (mm)	Outer Diameter Of Insertion Rubber (mm)	Thickness Of Insertion Rubber (mm)	PCD (Pitch Center Distance i.e. distance between center of hole to center of diagonally opposite hole) As per BS 4504 PN 10 Table 18 (mm)	Dia of Holes –As per BS 4504 PN 10 Table 18 (mm)	No. of Holes –As per BS 4504 PN 10 Table 18 (nos.)
50	50	165	3	125	19	4
80	80	200	3	160	19	8
100	100	220	3	180	19	8
150	150	285	3	240	23	8
200	200	340	3	295	23	8
225	225	370	3	325	23	8
250	250	395	3	350	23	12
300	300	445	3	400	23	12

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350	350	505	3	460	23	16
400	400	565	3	515	27	16
450	450	615	3	565	27	20
500	500	670	5	620	27	20
550	550	730	5	675	30	20
600	600	780	5	725	30	20
700	700	895	5	840	30	24
800	800	1015	5	950	33	24
900	900	1115	5	1050	33	28
1000	1000	1230	5	1160	36	28
1100	1100	1340	5	1270	36	32
1200	1200	1455	5	1380	39	32

Following is to be submitted.

1. Sample
2. Technical data sheet of rubber
3. Food grade certificate

3.16 G. R. P. LADDER (FIBRE GLASS LADDER)

The ladder shall be of glass reinforced plastic. GRE ladder shall be made by high quality resin, chopped strand mat and C glass veil. The stringers (i.e. handling arrangement) shall be designed with facility for holding hand while going down / up on the ladder. The inner width of ladder be 400mm. The width of steps shall be 80mm and roughened with nonslip surface. The step distance shall be 250mm. The ladder shall be provided with moulded GRE bracket at every 750mm. The ladder shall be fixed on concrete wall by 12mm dia. stainless steel grade 316 rawal bolt with washers and nut . The ladder shall be installed at the slope as mentioned in the drawing or as directed by the Engineer.

3.17 U.P.V.C. PIPES

A. Standards

All materials supplied and all works carried out, shall comply in all respects with the requirements of this specification and such regulations, which may be in force. Except where modified by this specification, materials shall be in accordance with BS (British Standard) 3506 (1969): Unplasticized PVC pipe.

As an alternative to BS Standard indicated above, the Tenderer may quote for materials in accordance with his National or International Standards covering UPVC pipes. In such case difference between BS Standard and that of the National or International Standard shall be clearly indicated by the Tenderer in his offer and one copy of the National standard in English language shall be attached with the offer.

When BS or National /International Standard are refer to, the edition shall be that of current at the date of Tender, together with any amendment issued to that date. The Tender

shall specify when tendering, the standards with which his offer complies. UPVC pipes shall be of class 'C' and the manufacturer shall be certified to ISO 9000 series. Non ISO 9000 certified manufacturers with previous successful direct supply experience to DEWA may be approved at DEWA's sole discretion for similar sizes supplied earlier.

B. Constructions

All details, dimensions and instructions shown on any drawings, diagrams and specifications quoted herein shall be taken as forming part of this specification. The PVC pipes shall be made from Unplasticized polyvinyl chloride (UPVC) generally to the requirements of nominal size 100 mm & 150 mm dia. of BS 3506. The extruded pipe shall be capable of being flattened completely between the plates of a hydraulic press without cracking or splitting. The pipes shall be corrosion resistant and tough. The wall thickness of the pipes shall not be less than 3.4 mm for class 'B' but not less than 6.6 mm for Class 'C'.

The external and internal surface of pipes shall be clean, smooth and virtually free from grooves or other indentations or projections. The smoothness of the internal surface of the pipe shall be such that the pulling through of the cables in long lengths shall be facilitated without risk of damage to the exterior surface of the cable.

Each pipe shall have a tapered socket formed at one end. The socket shall be reasonable concentric with the axis of the pipe. The spigot end of the pipe and the socket shall be sufficiently tight interference fit.

Set of end caps and end plugs if included in the scope of supply shall be made of the same material as shown above for UPVC pipes. The caps are to be used at the spigot end and plugs are to be used at socket end for sealing of respective UPVC pipes when the pipes are not in use.

Note: - Tenderer shall submit representative samples for the UPVC pipes.

C. Markings

All pipes shall be indelibly marked. The marking shall show the following legend:

1. Manufacturer's Name
2. Year of Manufacture
3. DEWA/ WD / Contract no.

Height of the marking shall not be less than 6.5 mm.

Marking along the length of the pipes shall be provided at least at two different locations spaced equally around the periphery of the pipe.

D. Drawings & Samples

The Tender shall provide drawings, samples and catalogues for the UPVC pipes and accessories offered.

E. Testing

All tests as per BS 3506, as applicable to UPVC pipe shall be carried out. The Test certificates for such tests carried out shall be submitted with each consignment. Tenderer will be required to submit 2 sets of test certificates with each consignment.

The Tenderer shall submit along with his offer one copy of test certificate for similar pipes manufactured by the UPVC pipe manufacturer in the past.

3.18 SPECIFICATION OF CARBON STEEL PIPE FOR SLEEVE PURPOSE – FOR F.C. PIPES OR GRE PIPES

The pipe to be used for sleeve purpose shall be of carbon steel pipe or manufactured from carbon steel plate with proper welding from certified welder to the specification API 5L grade B or X-60. It shall have following dimensions:

Nominal Dia. (mm)	Minimum Internal Dia. of Steel Sleeve Pipe (OD of FC/GRE Coupler + 150 mm (minimum) + 150 mm (minimum)) (mm)	Wall Thickness of Steel Sleeve (mm)
1200	1774	14
900	1430	12
600	1068	12
450	896	10
300	715	10

Nominal Dia. (mm)	Minimum Internal Dia. of Steel Sleeve Pipe (OD of FC/GRE Coupler + 100 mm (minimum) + 100 mm (minimum)) (mm)	Wall Thickness of Steel Sleeve (mm)
225	512	10
150	430	10
100	376	10

The external surface to be coated with primer and epoxy coating which is highly abrasive, impact and corrosive resistance to salty sand and salty underground water with a total thickness minimum 250 micron or enamel paint. The internal surface shall be coated with primer. The detail is to be provided at the submission.

3.18A CONCRETE GROUT MIX

The concrete grout mix design is to be applied in sleeve installed to protect pipe.

Mix Design for volume of 1 cum of concrete :

Approximate Parameters:

Free water / cement ratio - 0.60 to 0.70

Cement / Sand / Aggregate ratio in Kg / Cum – 1 / 1 / 3

Estimated Density of Concrete – 2270 kg/cum

Yield – 1 cum

Slump – Collapse

Cement – Sulphate Resisting and 400 kg/cum i.e. 400SRC

Water – Drinking

Max. Aggregate size – 5mm – crushed and washed

The above data can be modified as per recommendation of manufacturer and DEWA approval

Moisture content of aggregate is to be monitored and necessary correction is to be applied whenever required. Admixture and additives dosage shall be as per manufacturer's specification.

3.19 RUBBER EXPANSION JOINTS (RUBBER BELLOWS)

1. The rubber expansion joints shall be used for absorption of vibration in pipes, absorption of all type of movements such as axial compression, axial elongation, lateral and angular deviation, connection of pipes which are not properly lined up, water hammer reduction etc.
2. It shall be PN10/PN16/PN25 as per piping design. Generally it shall be PN10 but tenderer/supplier to verify.

3. TECHNICAL DETAILS:

TYPE:	SINGLE ARC WITH VACUUM RING WITH TIE RODS
FLANGE DRILLING	PN10/PN16 PATTERN TO BS4504
WORKING PRESSURE.	10BAR/16BAR
AXIAL COMPRESSION	AS WRITTEN IN TABLE
AXIAL ELONGATION	AS WRITTEN IN TABLE
LATERAL DEFLECTION	AS WRITTEN IN TABLE
ANGULAR MOVEMENT	AS WRITTEN IN TABLE
TORSION MOVEMENT	1-5°
TIE RODS	8NOS or AS PER REQUIREMENT with LOCKNUT, SPHERICAL WASHERS AND SEATS
VACUUM RING	ONE IN THE ARC and TWO RINGS AT THE CORNER
ORIGIN:	WESTERN EUROPE/ USA

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4. Materials of construction:

Bellow: EPDM rubber combining different layers of fabrics to get the desired flexibility as well as a long resistance to aging. It shall be on full face of flange. Part face on flange is not acceptable

Backing Flange: Carbon steel – with rust preventive treatment of zinc plated.

Tie Rods: Carbon Steel – with rust preventive treatment of zinc plated

5. Flange drilling pattern shall be as per BS 4504 PN10/16/25

6. Nuts, bolts and washers and all fasteners shall be AISI type 316.

7. It shall be single arc designed type double flanged (flange/flange) rubber expansion joint and suitable for flanged pipe work of water pumping stations.

8. The fluid is potable water of maximum temperature of 50°C. The fitness certificate in contact with potable water up to minimum 50 degree C shall be submitted from Water Regulation Advisory Scheme (WRAS), U.K. or equivalent authority.

9. The material shall be high quality Rubber with necessary reinforcement to withstand abnormal sudden pressure change inside the pipeline and vibration.

10. The rubber material shall be suitable for use under direct sunlight associated with ultra-violet radiation and protection against ozone evolved from electrical motors or other sources and special coating for U.V. and ozone protection shall be provided

11. The rubber flange shall be supported from the back by a zinc electroplated/ stainless steel flange. The joints have to be provided with galvanized/ stainless steel Tie rods against the back of the flanges and through to the mating flanges of the pipe. One metal reinforcing ring of stainless steel has to be provided at the base of the arch to add strength between the convolutions and two rings at the corner. All rings shall be embedded inside rubber.

12. The supplier has to provide Hydraulic test certificates during delivery of material.

13. Marking:

The following marking shall be provided on the body of the Expansion Joint.

- Manufacturer name/ origin / Trade mark.
- Nominal Diameter in mm.
- Pressure rating in Bars.
- Date of manufacture.
- DEWA contract no.

14. Submission:

- The supplier have to provide full technical details of the Expansion joints including original catalogues and production shop drawing from the manufacturer along with their offer.
- Details of Tie rods brackets for Tie rods.
- Service, Installation & Maintenance Manual during the delivery of the material.

15. WARRANTY:

The supplier and manufacturer have to provide at least 24 months of service warranty of rubber joints along with their offer. During this period if any failure occurs the supplier /manufacturer/contractor have to replace the same at free of cost to DEWA.

16. It shall have following dimensions and movements

Dia. – DN	face to face dimension - L	Working pressure - PN	Movements			
			Axial compression	Axial Tension	Lateral deflection	Angular deflection
mm	mm	bar	mm (-)	mm(+)	Mm(±)	degree(±)
300	250	10/16	40	20	20	10
450	300	10/16	40	15	30	6
500	300	10/16	40	15	30	6
600	300	10/16	40	15	30	6
700	300	10/16	40	15	30	6
800	310	10/16	40	15	30	6
900	310	10/16	40	15	30	6
1000	310	10/16	40	15	30	6
1100	350	10/16	40	15	30	5
1200	350	10/16	40	15	30	5

This can be revised with DEWA approval.

3.20 Granular Material for Pipe Bedding and Surround

Granular material for pipe bedding shall be free-draining, hard, clean, chemically stable gravel or crushed stone to BS 882 and shall be graded in accordance with BS 882: Part 2, as shown in the following table:-

Granular Material for Pipe Bedding

TEST SIEVE (MM)	PERCENTAGE BY WEIGHT PASSING SIEVE
63	—
37.5	—
20	—
14	100
10	85 – 100
5	0 – 25
2.36	0 – 5

NOTE:

1. Total Acid soluble content of the material when tested in accordance with BS1377 shall not exceed 0.3 percent by weight of sulphate expressed as SO_3 (Sulphur Trioxide).
2. The Material shall have a compaction factor value not exceeding 0.15.

Pipelines on Granular Beds

Where granular bedding to pipelines are detailed the minimum thickness of bedding materials beneath the pipe shall be 200 mm (minimum 100 mm under sockets)

The time interval between placing bedding material on the trench formation and commencing pipe laying be as short as practicable.

The bedding material shall be extended to the full width of the trench and shall be carefully compacted in layers not exceeding 200 mm, to achieve positive deflection and to the specified accepted limits.

Recesses shall be formed in the bedding to accommodate pipe joints while ensuring continuous even support along the length. Bedding material shall be prevented from entering pipe joints. After joints has been made bedding material shall carefully placed and hand compacted beneath the joint barrel to close any void left by the recess.

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Where the formation of the trench is of silt or soft clay and is below the natural water table a 75 mm blinding layer of sand shall be substituted for the specified bedding materials directly above formation and carefully compacted if directed.

3.21 Geotextile Filter Fabric

The Geotextile filter fabric shall be laid for pipes above 450mm dia. The granular bedding and surround to all pipes above 450mm dia. shall be enclosed within a geotextile filter fabric

Filter fabric shall consist of thermal bonded/needle punched synthetic polymer fibers. composed of at least 85 percent by mass polyolefins, polyesters, polypropylene, polyethylene or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages.

The geotextile Manufacturer/supplier shall be certified according to ISO 9001 for quality management and ISO 14001 for environmental management system.

The fabric shall be stabilized against ultra violet light, inert to commonly encountered chemicals in the in-situ soil and saline water and it shall conform to the following minimum requirements

Property	Test Method	Min. Requirements
Grab Strength (N)	ASTM D-4632	800
Puncture Strength (N)	ASTM D-4833	355
Burst Strength (kPa)	ASTM D-3786	2000
Trapezoid Tear (N)	ASTM D-4533	220
Permeability (m/sec)	ASTM D-4491	0.0001
Apparent Opening Size (mm)	ASTM D-4751	0.6 (Max.)
Ultraviolet Degradation (Percent Retained Strength)	ASTM D-4355	70% @ 150 h

Independent laboratory certificate to comply above data, shall be submitted.

Where filter fabric is used to enclose granular pipe surrounds, the fabric will be placed on the prepared trench formation and carefully supported during pipe laying operations. When the pipe has been laid complete with surround to the correct level, the filter fabric shall be closed over the top of the surround by forming a lap of minimum width 500 mm. All membrane joints shall be overlapped a minimum of 500 mm.

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Care shall be taken not to puncture or damage the membrane in any way during installation or during backfilling of the trench. Any fabric damaged or displaced before or during installation or during placement of over laying aggregate material shall be replaced or overlaid to the satisfaction of the Engineer at the Contractor's expense.

During period of shipment and storage, the fabrics shall be maintained wrapped in a heavy duty protective covering and protected from direct sunlight, ultra-violet rays and temperature greater than 70° C.

3.22 LOW DENSITY POLYETHYLENE PIPES FOR HOUSE SERVICE CONNECTIONS

A. General

This specification covers Low Density Polyethylene (LDPE) pipes for normal water service. The outside diameters and pressure class are in accordance with ISO 161/1 - 1978 (E). The minimum wall thickness (e) is calculated using the ISO formula with a working stress (S) of 32 Kg/cm².

$$e = P.d / 2S + P$$

B. Classification Of Pipes

Pipes are classified by maximum sustained working pressure in bars. Pipe supplied shall be class 10. The maximum sustained working pressure shall be based on water at a service temperature of 50 degree C.

C. Dimensions

Pipes shall conform to the outside diameters and wall thickness given here below:

Table 1

Nominal Diameter ND (mm)	Outside Diameter		Wall Thickness Class 10		Coil Length (m)	Minimum Coil Weight kg / coil
	Min. (mm)	Max. (mm)	Min. (mm)	Max. (mm)		
32	32.0	32.3	4.4	4.8	150	53
63	63.0	63.5	8.6	9.4	100	137

D. Visual Requirements

LDPE pipe shall be free from gouges, voids and other defects that would, in the judgment of the Engineer, impair the serviceability of the pipe.

E. Material Composition

Material composition and pipe material shall be in accordance with BS 1972:1967. Recycled raw materials shall not be used in construction of polythene pipe

F. Mechanical Properties

Mechanical properties of LDPE pipe shall be in accordance with BS 1972:1967.

G. Sampling And Testing

Sampling and testing of LDPE pipe shall be in accordance with BS 1972:1967. Copies of factory test reports shall be made available to the DEWA upon request. Witnessing by the DEWA Engineer of factory testing may be required prior to delivery of any consignment. In case, factory test is waved, the supplier shall carry out testing locally without extra charges to DEWA.

H. Marking

All pipe coils shall be indelibly marked in blue colour at intervals of not more than 1 meters with the following:

- Manufacturer's name
- DEWA/CW/Contract no.
- The nominal size and PN as shown in Table 1.

I. Lengths And Weights

The pipes shall be supplied in coils. The coil lengths and minimum weight per coil shall be in accordance with Table 1.

J. Acceptance

Each delivery of polyethylene pipe to the site shall be accompanied by a certificate from the manufacturer certifying compliance with these specifications. Any deviations found on random checks by the Engineer on coil lengths, coil weights, pipe dimensions and any failure in hydrostatic pressure tests shall be considered a cause for rejection of the entire consignment. A sample of 2m length – 3 nos. with marking, shall be provided with tender.

3.23 FITTINGS FOR LOW-DENSITY POLYETHYLENE PIPES

Gunmetal Body (except connector) with internal taper grip ring shall be for end loading resistance and “O” ring for watertight seal. All components coming in contact with potable water, are to be manufactured from UK WFBs listed materials or approved by Water Regulation Advisory Scheme (WRAS), U.K. or equivalent. The seal of the push fit joint is obtained using water pressure as a thrust medium and hence, no tool is used to obtain a watertight joint. Supplier to be approved to ISO 9000 series for supplier quality management systems. Fittings shall be compatible with DEWA, metric 32mm and normal 1” gauge.

Materials Specifications

Bodies

Gunmetal fittings	-	BS 1400:LG2 cast gunmetal
Plastic fittings	-	Threaded: generally Dupont Derlin 107 black 601. Acetal Homopolymer; all other fittings; Hoechst T 1020 black R2 Acetal Terpolymer or equivalent
Components	-	Grip ring - Acetal polymer or EPDM “O” ring or equivalent; EDPM elastomer to BS 681

The fittings shall be designed for use underground and to handle potable water at temperatures up to 50°C. They shall be capable of test operation at factory of pressure of 18 bars and working pressure of 10 bars without leaking. All fittings shall be preferably manufactured in Western Europe or North America. The other countries may be approved if it meets specification and quality.

3.24 FERRULES

Ferrules shall be supplied with a push fit outlet for polythene pipe, screw down swivel type and gunmetal material. It shall be fully of Gunmetal material. The combined material of PVC and Gunmetal is not acceptable. All ferrules shall be consisting of main stem with an inner plug and spindle for valve isolation and a 360° swivel outlet at 90° to the stem with control of water flow via a threaded inner plug. The inlet shall be a male taper threaded to BS 21. The ferrules shall be designed for use underground and to handle potable water at temperatures of up to 50°C. The ferrule shall be capable of working at a pressure of 18 bars without leaking. The ferrule shall be easily “shut off” by means of spindle extending through the top cap. The finishing of internal parts shall be smooth.

The design of the ferrule shall further permit use with conventional drilling machines, which mount on to the ferrule/saddle assembly and drill the main via the ferrule stem waterway, dry or under pressure.

The ferrule stem, inner plug and top cap shall be manufactured of Gunmetal to BS 1400 LG2. The ferrule banjo shall be fully of gunmetal only. Any part/parts of ferrule banjo and ferrule shall not be of acetyl plastic or any plastic material except internal plastic grip ring for holding polythene pipe. The gunmetal banjo shall be in one piece. Two-piece banjo joined to each other by threading, is not acceptable.

The banjo washer and the top cap washer shall be manufactured in EPDM to BS 681 and shall provide the sealing between the outer body and ferrule stem. A sample shall be submitted with tender.

Gunmetal push fit ferrule shall have inlet 25mm (1") dia. male threaded type and outlet shall be push fit type to suit polythene pipe of O.D. 32mm dia.

3.25 STOPCOCKS

Stopcocks shall be BS1010 stop valves supplied with double female threaded ends and Gunmetal. The valves shall be provided with a detachable key operator, with the spindle shielded so as to prevent unauthorized operation with a wrench – lock shied arrangement. The spindle shall have such size that it can be operated by DEWA standard key. The shield will be of sufficient depth so that when the valve is fully open the spindle remains recessed in the shield to a depth of 5 mm. The shield shall have two holes drilled opposite to each other at its open end to allow insertion of a sealing wire. The spindle dimension shall be as per DEWA sample. A sample/samples shall be submitted with the tender. **200 nos. keys for 15mm stopcock and 100 nos. Keys for 25mm stopcock shall be supplied at free of cost for supply tenders invited by DEWA.**

3.26 GUNMETAL PUSHFIT ADAPTOR

Gunmetal adaptors for polyethylene pipe shall be of the mechanical “Push-Fit” type having a gunmetal body to BS 1400: LG2, EPDM rubber ring ‘O’ ring, and a grip ring of Hoechst Hostaform C13031 acetal copolymer or equivalent. The adaptor will be designed to work to a pressure of 18 bars without leaking and at temperatures up to 50° C. A sample shall be submitted with tender. It shall be in single piece and two parts construction is not acceptable. Adapters for connecting polyethylene shall be designed with an inlet for metric size PE pipe and a male threaded outlet to BS 21:1975 or ISO 7/1.

3.27 PUSHFIT CONNECTOR

Connectors shall be of the mechanical “Push-Fit” type with the body manufactured from Hoechst Hostaform T1020 black acetal terpolymer/polypropylene. The grip ring will be manufactured from Hoechst Hostaform C13031 acetal copolymer and the sealing ring from EPDM rubber. The connectors will be designed to work to a pressure of 18 bars without leaking and at temperatures up to 50° C. A sample shall be submitted with tender.

3.28 SADDLE STRAPS (CLIP)

Saddle straps for installation on fiber cement pipes class 18/GRE pipe PN10, shall be of cast gunmetal to BS 1400 LG2 supplied with stainless steel grade 316 nuts, bolts with washer and EPDM gaskets/O-rings. The EPDM rubber shall be approved by WRAS/ equivalent acceptable to DEWA to minimum 50 degree C. It shall have an untapped (Flat) boss on the top surface suitable for installation of the approved ferrule. All saddles shall accept ferrules up to 50mm diameter. Bolts shall be full length threaded and shall be long enough to take O.D. range as mentioned in the table. The O – ring / washer shall be fixed with glue (adhesive) in their groove / required location and not as a loose item. A sample/samples shall be submitted with tender.

The saddle clip shall be suitable to following O.D. range of Fiber Cement Pipes/GRE pipes.

SR. NO.	NOMINAL DIA. OF F.C./GRE PIPE mm	SADDLE CLIP RANGE TO SUIT O. D. OF F. C. PIPE mm	O.D. OF F.C. PIPE AT MACHINED PORTION mm	SADDLE CLIP RANGE TO SUIT O. D. OF GRE PIPE + 4MM RUBBER WRAP mm	O.D. OF GRE PIPE AT MACHINED PORTION mm
1	75	92 - 102	93	-	-
2	80	104 - 116	104	-	-
3	100	124 - 136	126	115 - 123	110.5
4	150	176 - 188	178	165 - 173	160.5
5	200	232 - 244	234	-	-
6	225	253 - 270	255	240 - 248	235.0
7	300	340 - 355	344	314 - 322	309.5
8	450	506 - 520	508	468 - 476	463.5

LIST OF DOCUMENTS TO BE PROVIDED FOR EACH ITEM FOR ALL HOUSE CONNECTION ITEM :

1. ISO 9001 certificate of the manufacturer
2. Manufacturer original catalogue
3. Technical data sheet
4. Specification compliance statement paragraph by paragraph and each page stamped and signed by the manufacturer, supplier and tenderer. A format is attached at the end of this section.
5. Production shop drawing of item showing dimension, components and material of components.
6. WRAS certificate for suitability in contact with potable water
7. Details of past supply records for the last four years in U.A.E., Gulf countries, and other countries, separately.

SAMPLE

The sample complying to specifications, shall be submitted for all items as detailed below:

- (i) Polythene Pipe: 2m length – 3nos.
- (ii) For all house connection fitting items – 3 nos. of each item.

3.29 WARNING TAPE

Warning tape for house connection shall be manufactured from high grade polythene pigmented in bright blue, having a thickness not less than 0.1 mm gauge and a width not less than 150 mm in 250 meter long rolls. The following warning message in Arabic and English shall be printed continuously and longitudinally in a contrasting black colour in characters not less than 20 mm high specially protected against deterioration and fading:

DUBAI ELECTRICITY AND WATER AUTHORITY
CAUTION :WATER PIPELINE BELOW

3.30 STORAGE OF PIPES AND APPURTENANCES

The suppliers/tenderer shall properly unload and stack the pipes and other items in the storage area and stacks shall be laid out a regular pattern as described by DEWA at no extra cost.

3.31 INSPECTION AND TESTING DURING MANUFACTURING/ ON FINISHED PRODUCT

The Engineer shall be entitled during manufacturing to inspect, examine and test on the factory the materials and workmanship of all materials to be supplied under the contract, and if part of the materials are being manufactured on the other factory, the Tenderer shall obtain permission for the Engineer to inspect, examine and test. Such inspection, examination or testing does not release the tenderer/supplier from any obligation under the contract. Facilities shall also be provided to the Engineer to carry out inspection of materials and equipment's prior to dispatch and the suitability of packing methods and packing materials.

The Tenderer shall give the notice for inspection in writing 21 days in advance for overseas manufacturers and 14 days for local manufacturers and information for the date and the place at which any material / equipment will be ready for testing. The tenderer shall collect 'Inspection Application Form' from concerned DEWA Engineer. The form duly filled shall be submitted to DEWA with covering letter addressed to Manager, Inspection and Expediting Department. The Engineer shall attend at the place so named. The Engineer shall give the tenderer/supplier 48 hours notice in writing of his intention to attend the tests.

Where the Tenderer provides witnessing of tests at the factory / laboratory, he will provide assistance, labour, materials, electricity, fuel, stores, apparatus and instruments etc. as may be requisite and as may be demanded to carry out such tests efficiently.

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As and when any material / equipment shall have passed the tests referred to in this clause, the Tenderer shall furnish to the Engineer a certificate in writing to that effect. The Tenderer shall furnish to the Engineer for his approval two copies of the relevant test data in respect of the tests carried out.

All above said work shall be carried out at no extra cost.

SECTION 4

CONCRETE AND REINFORCING BARS

4.01 SCOPE

Concrete below the ground level shall be composed of sulphate resisting cement, fine aggregate, coarse aggregate and water, proportioned and mixed as described in these specifications. Concrete works in the road corridor shall be executed strictly in accordance to the following specifications.

Thrust blocks shall be designed in such a way that the size should not exceed the width of the reserved corridor and shall be supported adequately to withstand both horizontal and vertical movements.

4.02 MATERIALS

4.02.1 General

Aggregates for concrete shall consist of naturally occurring materials, from sources approved by the Engineer, complying with the requirements for fine and coarse aggregates of BS 882 and as specified herein. Approval of aggregates will not preclude subsequent rejection if results of subsequent tests indicate non-compliance with the specified requirements.

4.02.2 Fine Aggregate

The grading of fine aggregate shall be within the limits of Table (5) BS 882.

The amount of deleterious material shall not exceed the following limits when determined by the ASTM Standard tests stated below:

Clay lumps	1% by weight ASTM C142
Coal, lignite & shell	0.5% by weight ASTM C123

Effect of organic impurities shall be less than 10 percent when tested in accordance with ASTM C40 and C87.

The maximum quantity of acid soluble chlorides (Cl) shall not exceed 0.06 percent by weight of fine aggregate when tested in accordance with BS 812 and the maximum quantity of acid soluble sulphates (SO₃) shall not exceed 0.3 percent by weight of fine aggregate when tested in accordance with BS 1881.

When fine aggregate is subjected to five cycles of the Sodium or Magnesium Sulphate Soundness Test, ASTM C88, the loss shall not exceed 10 percent by weight.

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Fine aggregate shall be of such uniformity that the fineness modulus as defined in AASHTO M6 or (ASTM C125) shall not vary more than 0.20 either way from the fineness modulus of the representative samples used in the mix design.

The sand equivalent for fine aggregate (AASHTO T176) shall be a minimum of 70. The water absorption of fine aggregates (ASTM C128) or (AASHTO T84) shall not exceed 2 percent.

4.02.3 Coarse Aggregate

Coarse aggregate shall be prepared as single size aggregates and blended to produce normal size grading. The combined grading of coarse aggregate shall be within the limits given in Table (4) of BS 882 for nominal size of graded aggregate 20 mm to 5 mm.

The proportion of soft and friable particles in coarse aggregate shall not exceed 3 percent when tested in accordance with ASTM C 142. The maximum quantity of acid soluble chlorides (Cl) shall not exceed 0.02 percent by weight of coarse aggregate. The maximum quantity of acid soluble sulphates (SO₃) shall not exceed 0.3 percent by weight of coarse aggregate.

When coarse aggregate is subjected to five cycles of the Sodium or Magnesium Sulphate Soundness Test, ASTM C88, the average weight loss shall not exceed 12 percent when Magnesium Sulphate is used and 10 percent when Sodium Sulphate is used.

The 10 percent fineness values of coarse aggregate determined in accordance with BS 812 shall not be less than 75 KN. The flakiness index and elongation indices of coarse aggregate determined by the sieve method described in BS 812 shall not exceed 30, except that for aggregates used in Class E concrete no limit shall apply. The abrasion loss when tested in accordance with ASTM C131 shall not exceed 25 percent.

The water absorption of coarse aggregate (ASTM C127) shall not exceed 2 percent.

4.02.4 Combined Aggregate

For the combined fine and coarse aggregates, the quantities of acid soluble salts shall not exceed the following:

Chlorides (Cl)	-	Max. 0.3% by weight of cement.
Sulphates (SO ₃)	-	Max. 4% by weight of cement (including the sulphate ion in the cement).

4.02.5 Cement

Ordinary Portland Cement and rapid-hardening Portland cement shall comply with the requirements of BS 12 or ASTM C150 Type II.

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Sulphate Resisting Portland Cement shall comply with the requirements of BS 4027 or ASTM C 150 type V.

Super sulphated Cement shall comply with the requirements of BS 4248 or ASTM C 150 type V.

White or coloured Portland cement shall comply with the physical requirements of BS 12 and pigments shall be inorganic oxide pigments, either natural or synthetic in origin, complying with the requirements of BS 1012 and BS 1014. Pigments whether added just before mixing or by the cement manufacturer shall be incorporated in the proportions agreed by the Engineer.

Each consignment of cement shall be kept separate, identified and used in order of delivery.

Any consignment not used within six months from the date of manufacture will not be allowed to be used in the works.

The source of supply of cement shall be subject to the Engineer's approval and the Contractor shall at all times furnish the manufacturer's certificates and proof that the required specification has been compiled with, together with a note of the date of manufacture, certified by an independent agency in the country of origin. The Engineer shall have the power to reject a part or the whole of any consignment of cement if he considers it to be unsuitable for use in the works.

The chemical composition of the cement shall comply with the standards as stipulated above and in addition with the following requirements:

1. Tricalcium aluminate (C3A) content shall be within the range 4 to 12 percent.
2. The total lime (CaO) content shall not exceed 70 percent unless agreed otherwise by the Engineer.

One brand as approved by the Engineer shall be used throughout the works unless otherwise authorized by the Engineer in writing.

4.02.6 Water

Water for concrete, mortar and curing shall comply to BS 3148.

All water used in concrete & mortar shall be clear, fresh water free from oil, acids, alkali, sugar, vegetable substances, or any other contaminating agent.

If required by the Engineer, Contractor shall provide water quality test results.

Comparison shall be made by means of standard cement test for soundness, time of setting and mortar strength. Any indication of unsoundness, change in time of setting of plus or minus 30 minutes or more, a decrease of more than 10 percent in strength from results obtained with mixtures containing potable water shall be sufficient cause for rejection of the water being tested.

Non-potable water shall not be used in concrete unless written approval to do so is granted by the Engineer. In general, the following provisions shall have to be satisfied.

- A. Selection of concrete proportions shall be based on concrete trial mixes using water from the same source.
- A. Mortar test cubes made with the non-potable mixing water shall have 7 days and 28 days strength equal to at least ninety percent (90%) of strength of similar specimens made with potable water. Strength test comparison shall be made on mortars, identical except for the mixing water, prepared and tested in accordance with "Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or 50mm Cube Specimens)" (ASTM C109).

4.03 CONCRETE GROUT MIX

The concrete grout mix design is to be applied in sleeve installed to protect pipe.

Mix Design for volume of 1 cum of concrete :

Approximate Parameters:

Free water / cement ratio - 0.60 to 0.70

Cement / Sand / Aggregate ratio in Kg / Cum – 1 / 1 / 3

Estimated Density of Concrete – 2270 kg/cum

Yield – 1 cum

Slump – Collapse

Cement – Sulphate Resisting and 400 kg/cum i.e. 400SRC

Water – Drinking

Max. Aggregate size – 5mm – crushed and washed

The above data can be modified as per recommendation of manufacturer and DEWA approval

Moisture content of aggregate is to be monitored and necessary correction is to be applied whenever required. Admixture and additives dosage shall be as per manufacturer's specification.

4.04 CONCRETE MIX DESIGN

1. Mixes for the classes of concrete shown in Table 4.1 shall be designed by the Contractor. The class of concrete is denoted by the minimum 28-day works cube strength and the maximum size of aggregate. For buried concrete the minimum cement content shall be as described in the Contract.

2. The content of sulphate resisting cement in any mix shall not exceed 540 kg. per cubic metre for concrete used in ordinary structures and not to exceed 400 kg per cubic metre for water retaining structures and prestressed concrete. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted in the required location.

TABLE 4.1 - DESIGNED MIXES

Class	Minimum Sulphate Resisting N/sq mm/mm Cement Content	Minimum 28-day Strength		Works Test N/sq mm.
		Trial Mix Test N/sq mm.	Test N/sq mm.	
30/20315	40.0	30.0	
25/20310	35.0	25.0	
20/20305	30.0	20.0	

Nominal maximum size of coarse aggregate shall be not larger than:

- a. 1/5 (one fifth) the narrowest dimensions between sides of forms, nor
- b. 1/3 (one third) the depth of slabs, nor
- c. 3/4 (three quarters) the minimum clear spacing between individual reinforcing bars or wires, bundles of bars.

These limitations may be waived if, in the judgement of the Engineer workability and method of consolidation are such that concrete can be placed without honeycombing or voids.

4.05 TRIAL MIXES

1. No structural concrete shall be placed in the works until the relevant mix has been approved by the Engineer.
2. The Contractor shall, at least 35 days before the commencement of concreting, have trial mixes prepared and tested in a laboratory to be approved by the Engineer.
3. When the mix has been approved, no variations shall be made in the proportions, the original source of the cement and aggregates, or in the type, size and grading zone of the latter without the consent of the Engineer who may require further tests to be made.
4. The Engineer may also require field trials to be made on the site by filling trial moulds to confirm the suitability of the mix for the works. In these tests, the type of plant used for mixing, the method of compaction used, and the formwork face to the mould shall be similar in all respects to those intended for use in the works.
5. When the Contractor intends to purchase factory made precast concrete units, the Engineer may dispense with trial mixes and laboratory tests, provided that evidence is given which satisfies him that the factory regularly produces concrete, which complies with the Specification. The evidence shall include details of mix proportions, water cement ratio, workability and strengths obtained at 7 and 28 days.

4.06 LIMITATION OF WATER / CEMENT RATIO

Except for Class E concrete, no concrete which is required to be in contact with the ground or which is to be surrounded by earth or fill material or which is to be continually submerged in water shall have a water/cement ratio by weight in excess of 0.45. The quantity of water used in mixing shall be the least amount that will produce a workable homogeneous plastic mixture, which can be worked into the forms and around the reinforcement. In no circumstances shall the consistency of the concrete be such as to permit a separation of the aggregate from the mortar during handling. Excess water shall not be permitted and any batch containing such excess will be rejected.

In measuring water for each batch of concrete, allowance shall be made for the water contained in the aggregates. The total water in the batch shall be deemed to consist of the water carried by the aggregates plus the water added.

Frequent tests including the slump and compaction factor tests shall be carried out to ensure that a consistent water/cement ratio is maintained.

In designing and establishing approved mixes of concrete for any part of the works the contractor shall take account of the foregoing requirement and he shall also take account of any other limitations on water/cement ratios which may be shown in the drawings or expressly stated elsewhere as applying to concrete for particular parts of the works.

4.07 WORKABILITY

The workability of each grade of concrete shall be such that satisfactory compaction can be obtained when the concrete is placed and vibrated in the works and that it does not segregate when it is handled, transported and compacted by the methods which the Contractor proposes to use when handling, transporting and compacting that class of concrete in the works.

For reinforced concrete, the compaction, determined by the method described in BS 1881 shall not be less than 0.85 nor greater than 0.92.

4.08 ADMIXTURES

Neither admixtures nor cements containing additives shall be used in the works unless approved in writing by the Engineer.

Chemical admixtures for water reduction and retarding purposes, where their use is approved by the Engineer shall be of a type approved by the Engineer and shall conform to the requirements of Type A, Type D, Type F or Type G as specified in ASTM 494. They shall be used in strict accordance with the manufacturer's instructions. In order to obtain the Engineer's approval, cube strength and other tests shall be carried out on trial mixes using the combination of aggregates, cements and admixtures proposed for use. Further tests shall be carried out if the brand or type of cement is changed.

The Contractor shall be entirely responsible for the use of any approved admixtures.

Waterproofing concrete admixture for water retaining structures shall comply to ASTM C494-81 Type A.

4.09 STORAGE OF MATERIAL

Cement shall be stored in suitable weather-proof buildings in locations approved by the Engineer. Storage buildings shall have capacity for storage of a sufficient quantity of cement to allow sampling at least 14 days before the cement is used.

Aggregates shall be stored or stockpiled in such manner that segregation of coarse and fine particles of each nominal size aggregate will be avoided and also that the various sizes will not become intermixed before proportioning. Aggregates shall be stored on hard clean surfaces with not more than 5 percent slope. Each nominal size of aggregate shall be kept separate at all time. Each heap of aggregate shall be capable of draining freely. Contamination of the aggregates by the ground and foreign matter shall be prevented at all times.

In placing aggregates in storage or in moving them from storage to the weigh hopper of the batching plant, any method which may cause the segregation, degradation, or the combining of materials of different gradings which will result in any size of aggregate at the weigh hopper failing to meet the grading requirements shall be discontinued. The use of suitable devices to reduce impact of falling aggregates may be required by the Engineer.

4.10 COMPOSITION OF CONCRETE

4.10.1 Determining The Proportions And Batch Weights

The proportions and batch weights for concrete shall be determined as prescribed below. The determination shall be made after the materials furnished by the Contractor have been approved.

The Contractor shall determine the proportions on the basis of trial mixes conducted with the materials to be used in the work and shall submit these proportions together with all test results for approval by the Engineer.

The proportions shall be such as to produce concrete of the cement content specified for each class of mix, within a tolerance of plus or minus 2 percent.

If the materials furnished by the Contractor are of such a nature that a workable mix cannot be obtained without exceeding the permissible water content, thereby requiring additional cement above that specified, then the Contractor will bear the cost of such additional cement without being entitled to any compensation.

If the materials furnished by the Contractor are of such a nature that the specified strength cannot be obtained without increasing the cement content above the minimum specified, then the Contractor will bear the cost of such additional cement without being entitled to any compensation.

Once the mix is determined and approved, the Engineer shall designate the weights in kilograms of the different components of concrete and these proportions shall not be changed without his approval.

4.10.2 Adjustment To Proportions

a. Adjustment for Variation in Workability

If it is found impossible to obtain concrete of the desired placeability and workability with the proportions originally designated by the Engineer, he shall make such changes in aggregate weights as are necessary, provided that in no case shall the cement content originally designated be changed except as provided in subsections c and d, which follow.

b. Adjustment for Variation in Yield

If the cement content of the concrete, determined by means of the yield test, AASHTO T121 (ASTM C138) varies more than plus or minus 2 percent from the designated value in the table in Clause 1403, the proportions shall be adjusted as may be permitted by the Engineer to maintain a cement content within these limits. The water content shall in no case exceed the specified amount.

c. Adjustment for Excess Net Water Content

If, when using the designated cement content, it is impossible to produce concrete having the required consistency without exceeding the maximum allowable net water content specified in the table, the cement shall be increased as may be permitted by the Engineer so that neither the maximum water content per bag nor the limitations of Clause 4.03 on cement content per cubic metre of concrete will be exceeded.

d. Adjustment for New Materials

No change in the source or character of the materials shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has approved new mix proportions based on tests on trial mixes.

4.11 PROPORTIONING

Proportioning shall consist of dividing the aggregates into the specified sizes, each stored in a separate bin, and combining them with the cement and water as provided in these Specifications.

At the time of batching, all aggregates shall have been dried or drained sufficiently to result in a stable moisture content such that no visible separation of water from aggregate

will take place during transportation from the proportioning plant to the point of mixing. In no event shall the free moisture content of the fine aggregate at the time of batching exceed 8 percent of its saturated, surface dry weight (SSD).

Should separate supplies, of aggregate material of the same size group, but of different moisture content or specific gravity or surface characteristics affecting workability, be available at the proportioning plant, withdrawals shall be made from one supply exclusively and the materials therein completely exhausted before starting upon another.

Bulk cement shall be weighed in an individual hopper and shall be kept separate from the aggregates until the ingredients are released for discharge. The cement hopper shall be attached to a separate scale for individual weighing.

When the source of any aggregate is changed, the Contractor shall re-design the concrete mix and perform trial mixes as required by Clause 4.03 and 4.04 for the Engineer's approval. The Engineer shall be allowed sufficient time to approve the mix and such aggregates shall not be used until the necessary approvals are given.

For all batches with a volume of one cubic metre or more, the batching equipment shall conform to one of the following combinations:

- A. Separate boxes and separate dial or beam scales for weighing each size of aggregate.
- B. Single box and dial or multiple beam type scales for all aggregates.
- C. Single box of separate boxes and automatic weighing mechanism of all aggregates.

4.12 GENERAL REQUIREMENTS FOR MIXING

All concrete shall be mixed in mechanically operated mixers. All concrete shall be homogeneous and thoroughly mixed, and there shall be no lumps or evidence of undispersed cement. Uniformity of concrete mixtures will be determined by differences in slumps or by variations in the proportions of coarse aggregate.

The difference in slump, determined by comparing slump tests on 2 samples of mixed concrete from the same batch or truck load, shall not exceed 20 mm. Variation in the proportion of coarse aggregate will be determined from the results of tests of 2 samples of mixed concrete from the same batch or truck load and the difference between the 2 results shall not exceed 3 percent.

The Contractor, at his expense, shall furnish samples of the freshly mixed concrete and provide satisfactory facilities for obtaining the samples.

4.13 MACHINE MIXING

Concrete mixers may be either of the revolving drum or the revolving blade type. The mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixers shall be restored or replaced when any part of section is worn 30 mm or more below the original height of the manufacturer's design. Mixers and agitators which have an accumulation of hard concrete or mortar shall not be used.

The temperature of materials as charged into the mixer shall be such that the temperature of the mixed concrete at the time it is placed in final position does not exceed 32°C.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and charged into the mixer by means that will not result either in loss of cement due to the effect of wind, or in accumulation of cement on surfaces of conveyers or hoppers, or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.

The total elapsed time between the intermingling of damp aggregates and cement and the start of mixing shall not exceed 30 minutes.

Mixing may be performed at the site of the work but only with the approval of the Engineer or by ready-mixed methods. When mixed at the site of the work mixing shall be performed completely at a point not more distant than 350 metres by haul route from the position of final placement of the concrete. All concrete that is mixed wholly or partially at a point more distant than 350 metres by haul route from the position of final placement shall conform to the requirements provided in Clause 4.14 "Ready-Mixed Concrete".

4.14 ON SITE MIXED CONCRETE

When mixed at the site of the work the mixers used shall be of the paving or stationary type. The size of batch shall not exceed the rated capacity as determined by the manufacturer.

4.15 READY-MIXED CONCRETE

Ready mixed concrete shall be mixed and delivered to the site of the work by means of one of the following combinations of operations:

- A. Mixed completely in a stationary mixer and the mixed concrete transported to the point of delivery in truck agitators or in non-agitating hauling equipment (known as central-mixed concrete).

B. Mixed partially in a stationary mixer, and the mixing completed in a truck mixer (known as shrink-mixed concrete).

C. Mixed completely in a truck mixer (known as transit-mixed concrete).

Mixers may be stationary mixers or truck mixers. Agitators may be truck mixers operating at agitating speed or truck agitators. Each mixer and agitator shall have attached thereto in a prominent place a metal plate or plates on which is plainly marked the various uses for which the equipment is designed, the manufacturer's guaranteed capacity of the drum or container in terms of the volume of mixed concrete and the speed of rotation of the mixing drum or blades.

Truck mixers shall be equipped with electrically or mechanically actuated revolution counters by which the number of revolutions of the drum or blades may readily be verified. The counters shall be of the continuous registering, non-resettable type, which accurately register the number of revolutions, and shall be mounted on the truck mixer so that the Engineer may safely and conveniently inspect them from alongside the truck.

Truck mixers shall be loaded not to exceed the manufacturer's guaranteed capacity. They shall combine the ingredients of the concrete into a thoroughly mixed and uniform mass and discharge the concrete with a satisfactory degree of uniformity conforming to the requirements in Clause 4.11 "General Requirements for Mixing".

When shrink-mixed concrete is furnished, concrete that has been partially mixed at a central plant shall be transferred to a truck mixer and all requirements for transit-mixed concrete shall apply. No credit in the number of revolutions at mixing shall be allowed for partial mixing in a central plant.

4.16 TRANSPORTING MIXED CONCRETE

Mixed concrete may be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturer of the equipment as agitating speed, or in non-agitating hauling equipment, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place, and provided the mixed concrete after hauling to the delivery point conforms to the requirements in Clause 4.11 "General Requirements for Mixing".

Truck agitators shall be loaded not to exceed the manufacturer's guaranteed capacity. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.

Bodies of non-agitating hauling equipment shall be so constructed that leakage of the concrete mix, or any part thereof, will not occur at any time, and they shall be self cleaning during discharge.

No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point, unless ordered by the Engineer. If the Engineer orders

additional water to be incorporated into the concrete, the drum shall be revolved not less than 30 revolutions at mixing speed after the water is added and before discharge is commenced.

The rate of discharge of mixed concrete from truck mixer agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within 1-1 1/2 hours, or before 250 revolutions of the drum or blades, whichever comes first, after the introduction of the cement to the aggregates. Under conditions contributing to rapid setting of the concrete, or when the temperature of the concrete is 30°C or above, a time less than one hour will be required for the delivery.

When non-agitating hauling equipment is used for transporting concrete to the delivery point, discharge shall be completed within one hour after the addition of the cement to the aggregates. Under conditions contributing to rapid setting of the concrete, or when the temperature of the concrete is 30°C. or above, the time between the introduction of cement to the aggregates and discharge shall not exceed 45 minutes.

Each batch of ready-mixed concrete delivered at the job site shall be accompanied by a ticket showing volume of concrete, the weight of cement in kgs and the total weight of all ingredients in kgs, unless otherwise ordered by the Engineer. The ticket shall also show the time of day at which the materials were batched and for transit-mixed concrete, the reading of the revolution counter at the time the truck mixer is charged.

4.17 TIME OR AMOUNT OF MIXING

Mixing of concrete in stationary mixers shall continue for the required mixing time after all ingredients, except water and admixture if added with the water, are in the mixing compartment of the mixer before any part of the batch is released. Transfer time in multiple drum mixers shall be counted as part of the required mixing time.

The required mixing time in stationary mixers for concrete used for concrete structures, shall be not less than 90 seconds nor more than 5 minutes.

When transit-mixed concrete is furnished, each batch of concrete shall be mixed for not less than 70, nor more than 100, revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment on the metal plate on the truck mixer as mixing speed. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. All materials, including mixing water, shall be in the mixer drum before starting the count of the number of revolutions of mixing.

4.18 AMOUNT OF WATER AND SLUMP TEST

The amount of water used in concrete mixtures shall not exceed the minimum amount necessary to produce suitable concrete according to the approved mix design and within the limitations stipulated in Clause 4.05.

The amount of water added at the mixer shall be regulated in accordance with the free water in the aggregates. Free water is defined as the total water surface-dry conditions.

The amount of water used in the mixture shall be the amount required to produce concrete with a slump within the range shown as nominal slump in the following table. When the slump of the concrete is found to exceed the nominal slump, the mixture shall be adjusted as directed by the Engineer to reduce the slump to a value within the nominal range shown.

Type of Work	Nominal Slump (mm)	Maximum Slump (mm)
Non-reinforced concrete	60-75	80
Reinforced concrete structures, foundations, footings	60-75	90
Reinforced concrete walls, slabs, columns	65-80	100
Precast concrete elements	40-60	75

The equipment for supplying water to the mixer shall be so constructed and arranged that the amount of water added can be accurately measured. Any method of discharging water into the mixer for any batch shall be accurate within one percent of the required quantity of water to be added to the mix for any position of the mixer. All equipment shall be arranged so as to permit checking the amount of water delivered by discharging into measured containers.

Water tanks used to supply water to the mixer shall receive water by gravity from intermediate tanks having vents open to the air. Tanks shall be designed so that water cannot enter the tank while water is being discharged into the mixer and discharge shall be made rapidly in one operation without dribbling.

4.19 DELIVERY

The organization or facility supplying concrete shall have sufficient plant capacity and transporting apparatus to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The rate shall be such that the interval

between batches shall not exceed 15 minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum of rehandling and without damage to the structure or the concrete.

4.20 CONCRETING IN HOT WEATHER

When the ambient temperature reaches 35°C, the concreting operation shall be discontinued unless the Contractor has the adequate means of cooling the ingredients and keeping the temperature of mixed concrete below 30°C. However the concreting shall be discontinued if the atmospheric temperature is more than 44°C

In any event, the surface of freshly placed concrete shall be shaded from the direct rays of the sun and protected against drying by covering it with wet hessian cloth or burlaps and where practical, continuous water curing shall be applied during the first few hours after placement.

4.21 QUALITY CONTROL OF CONCRETE

4.21.1 Sampling and Testing

The Contractor shall sample and carry out a mechanical analysis of the fine aggregate and each nominal size of coarse aggregate in use employing methods described in BS 1881 at least once in each week when concreting is in progress and at such more frequent intervals as the Engineer may require. The grading of all aggregates shall be within the respective limits specified in Clause 4.02 and should the fraction of aggregate retained on any sieve differ from the corresponding fraction of aggregate the Engineer may instruct the Contractor to alter the relative proportions of the aggregates in the mix to allow for such difference.

The Contractor shall provide the equipment necessary to determine the compacting factor of freshly-mixed concrete at each place where concrete is being made and shall determine the compacting factor of the freshly mixed concrete by the method described in BS 1881 on each occasion that a set of test cubes is made and not less than once a day or as the Engineer may direct.

For each grade of concrete a set of nine works test cubes shall be made or additional as the Engineer may require and not less frequently than as follows:

For concrete grade 30,25	one set of cubes per 20
Or 20	cubic metres or part
	thereof, concreted per day.

The cubes shall be numbered consecutively and marked with the date, section of work from which they are taken and any other relevant information and dispatched to the approved laboratory for testing. Three cubes shall be tested after seven days.

If the average of the three, seven day test cubes is below the minimum requirement, the Contractor must immediately stop all concreting until checks are made on the material and equipment and immediately rectify any defect which has become apparent as the result of such checking. If the Contractor elects to remove and replace the defective concrete without waiting for the results of the twenty-eight day test, concreting can then continue entirely at the responsibility of the Contractor. The six remaining cubes will be considered as three individual sets and after twenty eight days of curing shall be tested as specified above. If either of the cubes in any set shows definite evidence, other than low strength, of improper sampling, molding, handling, curing or testing. It shall be discarded and the strength of the remaining cube shall then be considered the test result for that set.

Final acceptance of the concrete works is based on twenty-eight day testing on the three sets of two cubes each. The work is considered in compliance if the average of the three sets of cubes equals or exceeds the minimum specified for the class of concrete being placed, and if the average of the two cubes in any one set does not fall below 85 percent of the specified works test characteristic strengths. If the results of the twenty-eight day testing is unsatisfactory, the Contractor, in accordance with the instructions of the Engineer, shall conduct tests in the suspect parts of the structure.

As and where directed by the Engineer cylindrical core specimens of 150 mm nominal diameter shall be cut perpendicular to the face of the hardened concrete in the works for the purpose of examination and testing. The procedure for drilling, examination, measurement and testing for compressive strength shall be in accordance with BS 1881. Prior to preparation for testing, specimen shall be made available for examination by the Engineer. If the crushing strength of the specimen in accordance with paragraph 114 of BS 1881 is less than the minimum crushing strength given in Table 5.1 or if, in the opinion of the Engineer, the concrete fails to meet the specified requirements in other respects, the concrete in that part of the work of which it is a sample will be considered not to comply with the specified requirements.

4.21.2 Failure to Pass Tests

If the specified values are not obtained for cube tests on any concrete mix, no further concrete of that mix shall be placed in the works and the Contractor shall establish the cause of the failure and apply such remedies as are necessary. The Contractor shall demonstrate by trial mixes and the results of cube tests that the revised mix is in accordance with the Specification.

4.22 FORMWORK

The forms shall be smooth, mortartight, true to the required lines and grade and of sufficient strength to resist springing out of shape during the placing of the concrete.

Dimensional tolerances shall be according to the ACI 347-78 "Recommended Practice for Concrete Formwork".

All dirt, chips, sawdust, nails, and other foreign materials shall be completely removed from forms before any concrete deposited therein. Forms previously used shall be thoroughly cleaned of all dirt, mortar and foreign material before being reused. Before concrete is placed in forms, all inside surfaces of the forms shall be thoroughly coated with commercial quality form oil or other equivalent coating which will permit the ready release of the forms and will not discolour the concrete. Forms may be removed at the convenience of the Contractor and with the prior approval of the Engineer after the concrete has hardened. The concrete surfaces exposed by removing forms shall be protected from damage.

Forms for all surfaces which will not be completely enclosed or hidden below the permanent surface of the ground, or for surfaced where plywood forms are not specified, shall be made of surfaced lumber or material which will provide a surface at least equally satisfactory. Any lumber or material which becomes warped or cracked prior to placing of the concrete will be rejected.

All exposed sharp edges shall be chamfered with triangular fillets not less than 50 mm by 50 mm, to prevent mortar runs and to preserve smooth, straight lines, unless otherwise directed by the Engineer, the triangular fillets or chamfer strips shall be milled from clear, straight grain lumber and shall be surfaced on all sides.

Forms shall be of sufficient strength to support the weight of the fresh concrete, based on a weight of 2400 kg/cu.m. with a maximum deflection of 5 mm.

Form clamps or bolts shall be used to fasten forms. The use of ties consisting of twisted wire loops to hold forms in position during the placing of concrete will not be permitted.

Bolts or form clamps shall be positive in action and shall be of sufficient strength and number to prevent spreading of the forms. They shall be of such type that they can be entirely removed or cutback 25 mm or more below the finished surface of the concrete leaving no metal within 25 mm of the concrete surface and without the need to cut or chase the finished surface of the concrete to remove them. All necessary foot bridges at least 3 ft. wide and inspection platforms around.

Forms shall be complete and inspected by the Engineer before the placing of concrete therein will be permitted. The area to be concreted shall be separately prepared and supported.

4.23 PLACING CONCRETE

All concrete shall be used while fresh and before it has taken an initial set. Re-tampering of partially hardened concrete with additional water will not be permitted. A surface on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete.

Mixed concrete, after being deposited, shall be consolidated until all voids are filled and free mortar just appears on the surface. The concrete shall be placed as nearly as possible in its final position and the use of vibrators for shifting of the mass of fresh concrete will not be permitted. Fresh concrete shall not be permitted to fall from a height greater than 2 metres without the use of adjustable length pipes of "elephant trunks", double belting may be used in lieu of adjustable pipes or "elephant trunks".

All concrete shall be compacted by means of high frequency internal vibrators within 15 minutes after it is deposited in the forms. The vibrators shall not be attached to or held against the forms or the reinforcing steel. The location, manner and duration of the application of the vibrators shall be such as to secure maximum consolidation of the concrete without causing segregation of the mortar and coarse aggregate, and without causing water to flush to the surface. Fresh concrete shall be spread in horizontal layers in so far as practicable and the thickness of the layers shall not be greater than can be satisfactorily consolidated with the vibrators. If additional concrete is to be placed, care shall be taken to remove all laitance and to roughen the surfaces of the concrete to ensure that fresh concrete is deposited upon sound concrete surfaces. Layers of concrete shall not be tapered off in wedge-shaped slopes, but shall be placed with square ends and level tops.

The use of chutes in conveying or depositing concrete will be allowed only with the discretion of the Engineer and wherever they are used they shall be laid at such inclination as will permit the flow of concrete of such consistency as is required. The use of additional water in mixing the concrete to promote free flow in chutes of low inclination will not be allowed. Chutes shall be provided with baffle boards or a reversed section at the outlet to prevent segregation.

Joints in the concrete due to stopping work shall be avoided as far as possible. Such joints, when necessary, shall be constructed as directed by the Engineer.

4.24 CONSTRUCTION JOINTS

Construction joints shall be made only where located on the plans, shown in the placing schedule and/or as approved by the Engineer.

Construction joints shall be made without keys, except when keys are shown on the plans.

After placing of concrete has been completed to the construction joint and before placing fresh concrete, the entire surface of horizontal construction joints shall be thoroughly cleaned of surface laitance, curing compound and other materials foreign to the concrete, and clean coarse aggregate exposed. Hardened concrete surfaces shall be cleaned by abrasive blast methods after the curing period or immediately before placing concrete at the joint. Surfaces of fresh concrete (concrete that has been in place not more than 8 hours) may be cleaned with air and water jets provided surface laitance is removed and clean coarse aggregate exposed.

Surfaces of horizontal construction joints, where expansion joint filler or bond breaking compound is to be placed, shall be cleaned of dirt, sawdust, and other loose materials.

A surface on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete. Moistening with cement grout will not be permitted.

4.25 CURING CONCRETE-WATER METHOD

All newly placed concrete shall be cured in accordance with the following provisions.

The concrete shall be kept continuously wet by the application of water for a minimum period of 7 days after the concrete has been placed. Cotton mats, rugs, carpets or sand blankets may be used as a curing medium to retain the moisture, during the curing period. The cotton mats, rugs or carpets shall be of such character that they will retain water but not prevent evaporation. When cotton mats, rugs, carpets or sand blankets are to be used to retain the moisture, the entire surface of the concrete shall be kept damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed, until the surface of the concrete is covered with the curing medium.

The moisture from the nozzle shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or ash the surface. At the expiration of the curing period, the concrete surfaces shall be cleared of all curing mediums.

When concrete flat slabs are to be cured without the use of a Moisture retaining medium, the entire surface of the slab shall be kept damp by the application of water with an atomizing nozzle as specified in the preceding paragraph, until the concrete has set, after which the entire surface of the concrete shall be sprinkled continuously with water for a period of not less than 7 days.

Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period. When forms are removed before the end of the seven day curing period, specified curing procedures shall be implemented by the Contractor and continued until the end of the seven day period specified.

4.26 CURING CONCRETE-MEMBRANE METHOD

The entire surface of the concrete shall be sprayed uniformly with a non-staining pigmented curing compound immediately after stripping the formwork. Should the film of compound be damaged from any cause before the expiration of 7 days after the concrete is placed, the damaged portions shall be repaired immediately with additional compound.

Surface of newly placed concrete to be cured by the pigmented curing compound method shall be kept moist or wet until the curing compound is applied, and the curing compound shall not be applied until all patching or surface finishing have been completed.

Pigmented curing compound shall conform to the specifications of AASHTO designation M148, type II, white pigmented or ASTM C309 f the U.S. Federal Specifications TT-C-800. The curing compound shall be delivered to the work in ready-mixed form. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. The compound shall not be diluted or altered in any manner. Curing compound that has become chilled to such an extent that it is too viscous for satisfactory application shall be warmed to a temperature not exceeding 30°C. The curing compound shall be applied to the exposed surface at a uniform rate of one litter per 3 square metre area. In the event that the application of curing compound is delayed, the application of water as provided in Clause 5.24, "Curing Concrete-Water Method", shall be started immediately and shall be continued until application of the compound is resumed or started.

4.27 PROTECTION OF CONCRETE

Concrete placed below the ground shall be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground and with water draining therefrom during placing and for a period of three days or as otherwise instructed thereafter. The groundwater around a structure below the ground shall be kept to an approved level by pumping, or the works shall be flooded, or other approved means taken to prevent damage. Approved means shall be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion deleterious ground-water mixing with earth or other materials, floatation and other.

4.28 CONCRETE BLOCK WORK

4.28.1 Concrete Blocks

concrete blocks shall be hard, durable, sound, clean, well defined edges and free from cracks, flaws or other defects. They shall comply with the requirements listed herein.

Table of requirements for concrete blocks

<u>requirements</u>	<u>Values</u>
1. Dimensions	
A. Height, cm.	20 cm. \pm 1%
B. Length, cm.	40 cm. \pm 1%
C. Width, cm.	20 cm. \pm 1%
2. Compressive Strength at 28 days:	

For load-bearing walls:

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I	Average of 12 blocks, N/sq.mm	> 12.5 N/sq.mm
II.	Minimum for any one block N/sq.mm	> 10.0 N/sq.mm
3. Water Absorption		
	Maximum % of dry weight	14%

Sampling and testing of concrete blocks shall be in accordance with ASTM C140.

4.28.2 Mortar

All mortar shall consist of one part masonry cement to three parts loose sand complying with the following requirements.

- A. Sand complying with ASTM C144, grading and colouring suitable for type of masonry and as approved by the Engineer.
- B. Sulphate Resisting Portland Cement shall comply with the requirements of BS 4027 or ASTM C150 type V.
- C. Water Complying with water for Concrete Mixes and curings, of the Specifications Clause 4.02.6.

4.29 REINFORCING

4.29.1 General

Reinforcing shall include plain the deformed bars, welded mesh and tie wire for precast and cast-in-situ concrete and masonry.

4.29.2 Submittals

The Contractor shall submit the following at least two weeks in advance of fabrication:

- A. Shop Drawings. Before ordering reinforcing steel, the Contractor shall submit bar bending schedules for reinforcing steel prepared in accordance with BS 4466 showing layouts, bending diagrams, assembly diagrams, dimensioned types and locations of all bar laps and splice and shapes, dimensions, and details of bar reinforcing and accessories. Layout plans for bar supports and chairs, with typical details shall be included. Engineer's review and approval of shop drawings will apply to the sizes, locations and types of bars, and dimensions of bar splices only. Dimensions shown on the shop drawings are the responsibility of the Contractor and Engineer's approval of shop drawings shall not constitute approval of dimensions thereon.

B. Samples. Representative samples of all reinforcing steel that the Contractor proposes to use in the works must be submitted, before work is commenced, to the Engineer for his written approval, together with manufacturer's certificates stating clearly for each sample the place of manufacture, expected date and size of deliveries to site, and all relevant details composition, manufacture, strengths and other qualities of the steel. In the event a reinforcing steel sample under test fails to meet the specification requirements at any time, or the Engineer considers that samples which were presented to him for test were not truly representative, or if it becomes apparent that reinforcing steel which has not been approved has been used on the works, then the Engineer may instruct the Contractor to break out and remove completely all such sections of the work already constructed using such suspect reinforcing steel.

All testing of reinforcing steel bars shall be carried out in accordance with BS 4449 and BS 4482.

4.29.3 Reinforcing Material

A. Reinforcing Bars. Plain and deformed bars shall conform to BS 4449. The following bar classification and types shall be used unless shown otherwise on the drawings:

For	Use :	
GRADE of CONCRETE	CLASS of Bar	TYPE of Bar
20	U 24	Plain
25 and 30	U 32	Deformed

B. Plain and deformed bars shall conform generally to BS 4449. Plain round mild steel bars shall be graded 250 and is denoted generally by symbol - R on the drawing. Deformed high yield bars shall be grade 425 and is denoted by symble - Y on the drawing.

The Contractor shall note the necessity of protecting the rebar from contamination from time of manufacture to placing in the structure . Under no circumstances shall reinforcing steel be placed directly on the ground. Steel shall be stored on suitable structures min. of 450 mm above the ground surface. Storage facilities shall be such as to permit easy access for inspection and identification. Each consignment of steel reinforcement shall be kept separately and the contractor shall procure reinforcement in such a way as to minimize storage times on site or in other locations.

All reinforcing steel will be sand blasted to remove all deleterious materials as soon as possible before being placed in concrete. If the sand blasting is done in - situ within 24 hours of placing in -situ of the concrete then the following requirement for high pressure washing does not apply.

After fabrication and erection and immediately prior to placing of concrete the reinforcement shall be washed with high pressure potable water jets to thoroughly clean the rebar of all deleterious material and salts.

All floors, tops of walls etc. and other surfaces which are not to be covered with a further finish shall be U3 finish. All surfaces on which further finishing screeds or treatment are to be applied will be U2 finish.

4.29.4 Mesh Reinforcement

Mesh reinforcement shall conform to the specifications of ASTM designation A 185. The gauge of the wire and the dimensions of the mesh will be as shown on the plans or specified herein.

4.29.5 Black Annealed Reinforcing Wire

Black annealed wire used as reinforcing steel, but not including tie wire, in structures as shown on the plans, shall be commercial quality black annealed wire of the gauge designated; the gauge shall be American steel and wire gauge.

Each bundle of steel shall be tagged at the mill with an identifying mill tag, showing the name of the mill and the melt or heat number. This tag shall be a metal tag attached with a lead seal and placed in an exposed position for easy identification by each heat showing physical and chemical analyses, shall be available to the Engineer at the time of sampling. Two or more samples, each 75 cms long, will be taken at random from each size in each melt or heat. The Contractor at his expense shall furnish all test samples.

4.29.6 Storage

The Contractor shall stack separately and label different types of reinforcement for positive identification.

Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust mill scale, oil, grease, earth, paint, or any other material which may impair the bond between the concrete and the reinforcement.

4.29.7 Bending and Fixing

Bars shall be bent in accordance with the provision of BS 4466. All bending shall be done cold with the use of an approved bending machine. Re-bending of incorrectly bent bars shall not be permitted. Bars partially embedded in concrete shall not be bent.

Reinforcement steel bars shall be handled and stored in a manner to prevent damage to bars or the epoxy coating. Bars or epoxy coating damaged in handling or other operations shall be satisfactorily repaired at no additional cost to the Department. All systems for handling the epoxy-coated bars shall have padded contact areas wherever possible. All

bundling bands shall be padded and all bundles shall be lifted with a strongback, multiple supports or a platform bridge so as to prevent bar to bar abrasion from sags in the bar bundle. The bars or bundle shall not be dropped or dragged. Extra care in handling of these bars shall be beneficial to the Contractor reducing or eliminating in-place coating repairs.

Before the reinforcement steel bars are lowered into place and prior to placement of the concrete, the coated bars will be inspected by the Engineer for damage to the epoxy coating. Sheared ends of bars and other areas requiring limited repair due to scars and minor defects shall be repaired, using the specified patching or repair materials.

All reinforcement shall be securely and accurately fixed in positions shown in the Drawings to ensure that the reinforcement steel framework as a whole shall retain its shape, and the framework shall be so temporarily supported as to retain its correct position in the forms during the process of depositing and consolidating the concrete. The ends of all tying wires shall be turned into the main body of the concrete and not allowed to project towards the surface.

Splicing, except where indicated on the Drawings or approved shop drawings, will not be permitted without the approval of the Engineer. Lap lengths shall be as indicated on the Drawings. Correct concrete cover to reinforcement shall be maintained with the aid of approved spacer pieces. Spacing blocks shall be used to ensure accurate cover to the reinforcement steel where necessary, and these blocks shall be of precast concrete of strength at least equal to that of the concrete being placed. They shall be as small as practicable and shall be securely fixed in position by means of wires cast into them. They shall be soaked with water immediately prior to concreting in. Top reinforcement in slabs shall be maintained in position by means of chairs made out mild steel, the diameter and quantity being sufficient to ensure security of the reinforcement in shape and position. Concrete cover to reinforcement shall be in accordance with Clause 3.11.2 of BS CP8110: Part 1:1985 except for (1) water bearing structures which shall have a concrete cover of not less than 50 mm on the water-bearing face, (2) for concrete against the ground or upon blinding concrete which shall have a minimum cover of 80 mm excluding the thickness of the blinding.

No part of the reinforcement shall be used to support access ways, working platform, or the placing of equipment or for the conducting of an electric current.

At the time of concreting, all reinforcement steel shall have been thoroughly cleaned and freed from all loose rust, scale, mud, oil or any other coatings that might destroy or reduce the bond and it shall also have been cleaned of all set or partially set concrete which may have been deposited thereon during the placing of a previous lift of concrete.

Immediately prior to concrete placing the reinforcing steel shall be washed thoroughly with potable water to remove any deposited salts.

The placing of all reinforcement steel bars will be checked by the Engineer and in no case is concrete to be placed around any reinforcement steel that has not been approved by the

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Engineer. The Engineer will not permit the insertion of bars into or the removal of bars from concrete already placed. Reinforcement steel temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer.

All the reinforcements shall be placed straight at the approved spacings. All the joints of reinforcements shall be tied in accordance with the relevant BS.

4.29.8 Welding of Reinforcing

No welding of reinforcing shall be permitted where it is not specified in the Drawings. Reinforcing which is specified to be welded shall be welded by any process, which the Contractor can demonstrate by bend and tensile tests will ensure that the strength of the parent metal is not reduced and that the weld possesses strength not less than that of the parent metal. The welding procedure established by successful test welds shall be maintained and no departure from this procedure shall be permitted.

Following the establishment of a satisfactory welding procedure, each welder to be employed on the works shall carry out welder performance qualification tests on reinforcing bars of the same metal and size as those on the works. The requirements of ASME Code Section IX of 1959 shall be observed.

4.29.9 Binding wire for tying of reinforcement.

Binding wire to be used for tying of reinforcement shall be approved by the Engineer and shall be complying with the relevant B.S.

SECTION 5

LININGS AND PROTECTIVE COATINGS FOR CONCRETE

5.01 GENERAL

5.01.1 Scope

This Section deals with waterproofing protective membranes for cast-in-situ concrete. Other relevant Sections of the Specifications shall form part of this Section where the context so requires.

5.01.2 Work Included

The work of this Section shall include the supply and installation of protective coatings on specified surfaces of concrete and concrete block structures to effectively protect the concrete surface from corrosion resulting from contact with aggressive groundwater.

5.01.3 Requirements

The Contractor shall furnish all tools, construction equipment, materials, labour and supervision to provide an effective lining or coating as specified herein.

5.01.4 Product Delivery, Storage and Handling

The Contractor shall deliver products to the job site in their original unopened containers clearly labeled with the manufacturer's name, brand designation, type and class as applicable.

The Contractor shall store products in an approved dry area with roll goods laid flat, one pallet high, and shall protect them from contact with soil and from exposure to the elements. Products shall be kept dry at all times.

Products shall be handled in a manner that will prevent breakage of containers and damage to products.

5.02 WATERPROOFING TO CAST-IN-SITU CONCRETE, PRECAST CONCRETE AND BLOCKWORK

5.02.1 Materials

a. Waterproof Membrane. Waterproof membrane shall be cross laminated self-adhering sheet membrane consisting of a rubber modified asphalt compound, coated to one side of a polyethylene film. The membrane shall have a minimum overall thickness of 1.5 millimeters and shall in all respects comply with the requirements of British Standard Code of Practice 102.

Performance and testing of characteristics shall be as follows:

Property	Test Method	Typical results
Tape strength	ASTM D636	Long 4.2 N/mm, Trans 4.8 N/mm
Tensile Strength	ASTM D638	Long 42N/Sq. mm, Trans 48N/Sq.mm
Elongation	ASTM D638	Long 210%, Trans 160%
Tear Resistance	ASTM D1004	Long 340 N/mm, Trans 310N/mm
Adhesion to Primed Concrete	ASTM D1000	1.8 N/mm
Adhesion to self	ASTM D1000	1.8 N/mm
Puncture Resistance	ASTM E154	220N 65 mm
Water Resistance	ASTM D570	
After 24 hours		0.14%
After 35 days		0.95%
Environmental Resistance	ASTM D543	Conforms
Moisture Vapour	ASTM E96	3 g/sq m/24 hours Transmission Rate

b. Rubberized Mastic Special compound provided by the self-adhering membrane manufacturer formulated for its intended use.

c. Primer Special compound provided by the self-adhering membrane manufacturer, formulated for its intended use.

d. Protection Board shall be applied in single or two layers with a total installation thickness of 12 mm; it shall be bitumen impregnated fiberboard with treatment to resist fungi and insects, bitumen coated both sides; or alternatively prefabricated composite board consisting of felt and woven glass fabric saturated with bitumen coating both sides

for a thickness not less than 3.5 mm, and approved by the membrane manufacturer, subject to approval of the Engineer.

e. Samples. The Contractor shall submit to the Engineer three samples of each type of the following materials in accordance with the special conditions of the contract.

- Self-adhering waterproofing membrane sheet:
- 300 mm square.
- Bituminous mastic: half-liter container.
- Primer: half-liter container.

The Contractor shall submit to the Engineer certificates that the materials to be furnished comply with specification requirements.

5.02.2 Installation

The Contractor shall coordinate the self-adhering waterproofing membrane work so that the placement of the concrete protection board will follow the waterproofing membrane application by not more than five days.

All faces of concrete or concrete blockwork below and in contact with, ground shall be protected with the waterproofing specified herein.

Surfaces to which the waterproofing materials will be applied shall be surface dry, smooth and free of dirt, grease or oil and shall be free from holes, honeycombing, loose aggregate which prevent satisfactory application of waterproofing materials. All surfaces to be waterproofed shall meet the approval of the Engineer before application of waterproofing materials.

The Contractor shall apply the membrane sheet with 120-mm overlaps at edges and ends, rolled down firmly and completely.

The Contractor shall follow the self-adhering membrane manufacturer's approved written recommendations for specific procedures, details and materials not specified herein.

If the work must be left partially complete, the exposed edges of outside strips of membrane shall be finished with a trowelled bead of mastic.

The waterproofing membrane system shall not be applied to vertical surfaces when the outdoor temperature is less than 10 degrees C or more than 35 degrees C. If a system has been approved and if the outdoor temperature at the proposed time of application is not within these limits, application must be delayed until the permissible temperature range prevails or another system must be submitted for approval complying with these Specifications.

a. Application of Membrane: When the concrete curing is completed to Concrete, over the cleaned concrete surface the Contractor shall apply primer in manner and using quantities in accordance with the membrane manufacturer's printed instructions. It shall

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be allowed to dry before proceeding, but re-primed if not covered with membrane within 36 hours.

After the primer has dried, the Contractor shall apply the self-adhering membrane to the concrete without stretching, with the polyethylene face out. It shall be smoothed down with heavy hand pressure or a small roller. Edges and ends shall be lapped as specified.

The Contractor shall double inside and outside corners by using an initial strip of 300 mm width membrane, centered along the axis of the corner.

This strip shall be covered by the regular application of self-adhering membrane and the exposed edges of the membrane shall have a trowelled bead of mastic over these edges.

The membrane shall be applied in two layers over blinding concrete beneath structures and laps shall be staggered from one layer to the next. Prior to reinforcement being placed, the membrane shall be covered with two layers of protection board on vertical faces and with 50 mm thick cement sand screed supplied by an approved concrete supplier to protect the membrane from damage during construction. Protection board shall terminate flush with the edges of the concrete base slab and overlapping with membrane material shall cover edges. Side wall membrane shall extend down and out to the edge of the previously applied horizontal slab membrane. Where top of membrane terminates at a reglet, the membrane shall be extended therein and the reglet filled with rubberised mastic.

Areas around piping and protrusions shall be double covered with an additional layer of self-adhering membrane for a minimum of 300 mm in each direction. The membrane edges shall be coated and the gap between the membrane and protrusions filled with mastic.

b. Installation of Asphalt Protection Board Courses. Within five days after membrane application, the Contractor shall install asphalt protection board to vertical and horizontal membrane-on-concrete surfaces. The Contractor shall install board with polyethylene face out, in two layers and with butted edges and ends, adhered to the membrane by means of mastic or other approved compound. Joints in second layer shall be staggered in relation to the joints in the first layer. Point up with mastic the exposed edges and gaps between penetrations and edges of the protection board. Protection board on horizontal slabs shall terminate at the outer corner of the concrete structure above. Sidewall protection board shall extend down and out to cover the horizontal slab membrane. Use of tie wires or holing the board shall not be approved for securing the board. The board has to be glued using approved materials only.

SECTION 6

TRANSPORTATION, STORAGE, INSTALLATION OF PIPES, TESTING & COMMISSIONING

6.01 HANDLING AND TRANSPORT OF PIPELINE MATERIALS

A. The Contractor's arrangements for handling, lifting, transporting and stacking pipes, valves, meters and fittings, shall ensure that these articles are installed in the works undamaged and in good order.

Cranes and other appliances approved for use by the Engineer shall be provided wherever it is necessary to lift or lower pipes, valves, meters and fittings. Such articles shall not be dropped and the Contractor shall provide the facilities and supervision necessary to ensure that the ends of pipes prepared for jointing and coating of fittings are not damaged or distorted in transit or in storage.

B. F.C pipes and joints shall be properly and securely transported from the place of manufacture to the job site, in accordance with section 3.02.15.

C. Pipe fittings and specials shall be supported by sandbags or other padding and lashed down as described above so that they are not damaged during storage.

However Contractor has to note that the use of long boom cranes shall not be permitted near the Electricity overhead Transmission lines for safety reasons unless approved by the Engineer.

6.02 STORAGE OF PIPES AND APPURTENANCES

A. The Contractor shall properly stack the pipes in his storage area and the stacks shall be laid out in a regular pattern and the limits of each stack marked so that the movement of cranes and vehicles is restricted to access tracks between stacks and the control of delivery and removal of pipes is facilitated.

B. The number of tiers of asbestos cement pipe stacks shall be as per the Manufacturer's instructions and approval of the Engineer. Each pipe, including those in the bottom course, shall bear evenly upon not less than three timbers with an aggregate width not less than 300 mm. The pipes shall be stacked parallel to each other. Pipes less than 1000 mm dia. may be stacked on site such that stacking heights do not exceed the manufacturer's recommendations.

The timbers supporting each course of pipes in a stack shall be of uniform thickness and stiff enough for the pipes to be rolled across the stack and shall be supplied by the Contractor at his own expense.

The outermost pipes in each course shall be secured against rolling by sandbags or by wedges.

C. Where the pipes are to be delivered and stacked by the Contractor on designated sites lying on the pipeline route, unless it is otherwise specified elsewhere, the areas where the pipes are to be stacked shall, if required, be graded flat by the Contractor at his own expense to provide a firm even surface, and kept free from loose stones, rubble or waste liable to damage the pipes.

D. Jointing materials, valves, glass reinforced plastic fitting and specials, meters, gauges and polyethylene pipe shall be stored in purpose built covered storage areas until required for installation.

E. Joint rubber rings and lubricants shall be stored in a closed and cool storage area shielded from direct sunlight and heat.

6.03 MATERIALS SUPPLIED BY THE EMPLOYER

A. In the event that pipes and ancillary fittings, specials, valves and meters shall be supplied by the Employer, these shall be supplied to the Contractor at DEWA's storage yard. The Contractor shall load, transport and unload the materials so supplied at his own storage area and/or the site of works and shall be responsible for proper unloading, stacking and storing.

B. The pipes shall be unloaded from the trucks in an approved manner and the Contractor shall take utmost care not to damage pipes or any of the materials so supplied. Any materials damaged in loading, transport and unloading at the site of works shall be repaired or replaced by the Contractor at his own expense in accordance with the Engineer's instructions and to his satisfaction.

C. The Contractor will be required to sign vouchers for any materials supplied to him, and shall keep a proper stores record book to show at any time the quantity of materials received and those which have taken from the stores for use in the works. The Engineer shall have the right to inspect at any time the store record books, and to check the materials in the stores and on the site of the works to satisfy himself that everything is in order. The Contractor will be required to account for any discrepancy found.

D. The Contractor shall at his own expense provide and constantly maintain day and night watching and shall be responsible for the theft or loss of any materials supplied to him by the Employer whether theft occurred from the stores or from the site of works. The Contractor at his own expense shall immediately replace any missing materials.

E. On completion of works, the materials used in the works shall be counted and/or measured and the balance shall be handed over by the Contractor to the Employer at his indicated storage yard. The loading, transport, unloading and proper stacking of materials shall be carried out in accordance with the relative clauses of the Specifications and shall be at the Contractor's expense.

Any materials not accounted for shall be replaced by the Contractor at his own expense or alternatively, at the Employer's discretion, shall be charged to the Contractor's account on the basis of current C.I.F. price for delivery to the Employer's storage yard, plus 20% handling fee.

6.04 INSTALLATION OF PIPEWORK

A. The pipe work route shall be determined by the Engineer. The Engineer reserves the right to vary or abandon any part or parts of the routes of pipe work indicated on Drawings and the Contractor shall lay the pipe work in accordance with any such variations which the Engineer may direct, without any extra cost. .

B. The Contract Drawings show the approximate lines and levels to which the pipe work is to be built and are subject to amendment by the Engineer. Before setting out any section of the works, the Contractor or his representative shall make an inspection of the site together with the Engineer and obtain from him his instructions in this respect.

All pipes, bends, fittings, specials, valves and meters shall be installed accurately in accordance with the alignment, levels and gradients so determined, so that the top of the pipe is not less than the minimum specified depth below the finished ground level.

C. The Contractor shall provide the surveying instruments, surveyors, skilled staff and everything necessary for setting out the works to line and level and for checking the accuracy of pipe laying and jointing, and of the installation of valves and meters. He shall provide attendance upon the Engineer and provide him with such assistance as may be necessary to enable him to check the setting out of the works.

D. The finished pipeline shall run straight between bends or fittings and a uniform gradient shall be accurately maintained between changes of gradient shown on the drawings or directed by the Engineer.

E. The bottom of the trenches shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the pipe. A compacted soft sand bedding of 15 cm. depth is to be provided from selected excavated material or brought from outside. "Bell" holes shall be excavated under the F.C. collars location such that the pipe is not supported by the F.C. joints.

The Contractor shall inform the Engineer sufficiently in advance when the formation levels of the trenches are ready for inspection. No installation work will be allowed until the bottom of trenches have been inspected and approved by the Engineer and the depths of the trenches and the kind of excavation have been recorded and agreed upon by both the Contractor and the Engineer. While excavating, soft sand / subkha / rock shall be placed separately on the side of trench.

F. In addition to any inspection and test made when delivery is taken, pipes and valves shall be inspected by the Contractor immediately before and after installation and

any damage shall be repaired by the Contractor as directed by the Engineer before the pipe or valve is installed or jointed as the case may be.

The Engineer may, and without thereby relieving the Contractor of any of his obligations, inspect and test the pipes and valves by any means he considers appropriate and the Contractor as aforesaid shall repair any damage discovered by such inspection.

G. The pipe shall be positioned and bedded in the trenches in an approved manner and properly aligned. Before being positioned, each pipe shall be thoroughly examined to ensure that it is free from defects and shall have all dirt removed from the inside thereof. The Contractor shall cut the pipes if and where needed to the required length and shall thread, chamfer or bevel. The cut ends of pipes as the case may be, all at the place of manufacturer, shall install all fittings, specials and adapters as may be necessary for the proper execution of the works and shall joint the pipes in accordance with the Specifications, the manufacturer's recommendations and to the Engineer's satisfaction.

H. The Contractor shall keep the interior of pipes clean and free from water, dirt, stones or other foreign matter as installation proceeds, and at the end of the day's work or at other times when installation work is not proceeding the open ends of pipes shall be sealed-off by a wooden plug or other approved stopper in order to exclude all foreign materials.

I. Pipes which are required to be cut to form closing pieces in any portion of the pipeline or to terminate in valve chambers or other parts of the works shall not be cut until after all adjacent pipes have been installed and jointed.

The Contractor shall determine the length of each closing piece and the required angle and shape of the cut. The cut shall be neatly performed and the end of the pipe shaped up and trimmed so as to ensure an accurate joint or termination as the case may be.

All cutting and machining of F.C/GRE pipes shall be done at the place of manufacturer only. Pipes terminating in headwalls and the like shall, except where otherwise specified, be cut so that the end of the pipe is flush with the face of the structure into which it is built.

The unused part of any cut pipe shall become the property of **DEWA** and shall be returned to **DEWA** stores unless, subject to the Engineer's approval, it can be used elsewhere in the works.

J. Where flexible couplings for asbestos cement pipes are required to be other than the standard Reka joint, they shall be Viking-Johnson flexible couplings or equal. The Contractor shall follow the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular, the Contractor shall ensure that rubber rings are correctly positioned and free of twists. The rubber rings and any recommended lubricants shall be obtained only from the coupling manufacturer.

Viking-Johnson couplings shall be capable of withstanding the test pressure appropriate to the pipes for which they are supplied. Details of such flexible couplings for incorporation in the works shall be submitted to the Engineer for approval before ordering. Rubber rings incorporated in flexible coupling shall comply with BS 2494.

K. The Contractor shall provide and install detectable warning tape above all pipelines laid 600 mm below ground level / finished level.

L. The minimum cover to pipe from the finished level / ground level shall be as follows:

1. 1.00 M for 300 mm dia. or smaller pipes.
2. 1.5 M for pipes above 300 mm dia.

The pipes shall generally be laid with min. cover except in areas of crossings

6.05 CONNECTIONS TO EXISTING MAINS

Where connections are to be made to existing mains, the Contractor must make all necessary arrangements with the Engineer and the Employer and have all necessary material, plant and labour in readiness on the site and shall complete the work as rapidly as possible with the minimum of inconvenience to consumers. The actual connection to an existing main will be made by the Contractor under the close supervision of the Employer and the Engineer.

6.06 JOINTING OF PIPES

6.06.1 General

The requirements of this clause shall be read in conjunction with the particular requirements specified elsewhere for joints of particular kinds.

Before making any joint the Contractor shall ensure that the interior of each pipe or valve is clean and that it remains clean. Immediately before starting a joint the Contractor shall clean the end of each pipe to be jointed and shall otherwise specially prepare the ends for jointing as may be necessary for the particular kind of joint. All mechanical joints shall be cleaned and have their paint work or coatings made good before assembly.

The Contractor shall use only the proper jointing parts as specified and obtained through the suppliers of pipes, couplings or valves. All joints shall be accurately made and shall be capable of passing tests for individual joints and for the completed pipeline as may be specified.

After completing a joint any protective paint or coating shall be made good, and any metal joint, which is not already coated, shall be cleaned and painted with two coats of bituminous paint. The additional external protection of joints where ordered by the Engineer shall be carried out as specified.

6.06.2 **Deflection at Certain Joints**

Where the Engineer orders, or allows, a change of direction to be achieved by the deflection of a flexible joint of any kind the deflection shall not exceed the maximum value for the size and type of joint as specified in this Section or in the relevant schedules or by the manufacturer.

6.06.3 **Fibre Cement Collars**

Joints between fibre cement pipes shall be made with flexible joints comprising an asbestos cement collar and rubber sealing rings. Only vegetable based joints lubricants approved by the pipe manufacturer shall be used as per section 3.07

In making these joints the Contractor shall take account of the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that rubber rings are correctly positioned and free from twists. The rubber rings and any recommended lubricants shall be obtained only through the pipe supplier. The bucket or any other part of a mechanical excavator shall not be used to apply thrust directly to pipes or collars in order to make joints. The excavator bucket may, however, be used in a stationary position as a backstop for a manually operated hydraulic jack (to be approved by the Engineer) which is used to apply a thrust to pipes or collars.

The pipe shall be marked before pushing into the collar so that a 15 mm gap is left between it and the preceding pipe. The rubber ring location shall be checked to ensure they are correct relative to the pipe ends. **The contractor for joining the pipes shall not use Wood or similar spacers to maintain the specified gap. The contractor shall follow the methods given in catalogues of Fibre Cement Pipes or as recommended by the manufacturer.**

6.06.4 **Flexible Couplings and Flange Adapters**

In jointing fibre cement pipes with flexible couplings and flanged adapters of the Viking Johnson type, the Contractor shall take account of the manufacturer's recommendations as to the methods and equipment to be used in assembling the joint. In particular, the Contractor shall render the end of each pipe perfectly smooth so as to allow the joint sleeve to slide freely and where necessary shall recoat the pipe ends with two coats of quick-drying bituminous solution.

6.06.5 **Flanged Joints**

Flanged joints shall be made with rubber joint gaskets and steel bolts and nuts which shall include two washers per bolts. Joint gaskets shall be provided by the pipe or valve supplier and shall be of such physical properties as to be capable of forming permanent watertight joints against pressures up to the maximum test pressure. The use of jointing paste or grease will not be permitted. The gasket may be fastened to the bolts with cotton

thread. The bores of abutting pipes or fittings shall be concentric and no jointing material is to be left protruding into the bore. All nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then be alternately and progressively tightened with a spanner so as to ensure even pressure all around the joint. BS 4504, BS 3063 and BS 1787 shall apply to flanged joints and flanges shall be PN 10 unless otherwise noted.

6.06.6 **Screwed Joints**

Screwed joints on galvanized steel piping and elsewhere shall be made using PTFE tape.

6.07 **FLOTATION OF PIPEWORK**

The Contractor shall be solely responsible for ensuring that flotation of the pipe work does not occur during construction. The extent of the backfill placed over each pipe after laying and before testing shall be such as will prevent flotation.

Should any section of the pipe work float out of line or level, the section of pipe work so affected shall be removed and re-laid by replacing all the rubber rings, damaged pipes and all sockets in accordance with the Specification and to the satisfaction of the Engineer at the Contractor's own expense.

6.08 **VALVES**

6.08.1 **General**

Gate valves, check valves, air valves, washout valves, fire hydrants etc. shall be in accordance with the Specifications and shall be installed on the pipelines in the positions and in accordance with the details shown on the Drawings or as directed by the Engineer.

6.08.2 **Installation**

The Contractor shall obtain the necessary installation drawings from the manufacturer and shall store, transport, handle and install the valves in strict accord with the manufacturers drawings and recommendations.

6.08.3 **In-place Testing**

Valves and all pipeline appurtenances shall be hydraulically tested on site as specified in Clause 6.14 for the pipeline in which they are installed.

Valves shall be tested for operation and adjusted so that they operate smoothly, seat properly, and are installed to the tolerances recommended by the manufacturer.

6.09 EXTERNAL PROTECTION OF JOINTS

Metallic mechanical joints, flanged joints and ferrule straps shall be protected by a surround of bitumen compound poured hot into a special mould temporarily fixed round the joint. The Contractor shall take account of the pipe supplier's recommendations as to the procedure for forming the moulded surround. The Contractor shall provide sufficient mould boxes and bitumen compound.

6.10 THRUST AND ANCHOR BLOCKS

Thrust and anchor blocks in accordance with the typical details shown on the Drawings shall be constructed at stop-ends, bends, tees, pipelines laid to slopes greater than 1 in 6, and reducers, where directed by the Engineer.

Concrete used in thrust and anchor blocks shall be Class 30/20 and shall comply with the requirements of Section 4 of the Specification.

The workmanship shall be in accordance with the specifications and good practice and to the satisfaction of the Engineer, the dimensions and steel reinforcement shall be in accordance with the typical details shown on the Drawings or as otherwise directed by the Engineer.

The blocks shall, unless otherwise shown or directed by the Engineer, be so placed that the pipe and fitting joints will be accessible for repair.

Before internal pressure is applied to a pipeline, all concrete thrust blocks shall have been constructed and cured for a minimum of 7 days.

Thrust blocks for GRP fittings shall completely encase the fittings except for the joint area. For fittings up to 300mm diameter an 10mm thick and 100mm wide, 150mm wide for larger than 300 mm diameter, rubber wrap shall be provided on the ends of the GRP fitting, such that the rubber protrudes slightly from the encasing concrete. The total wrapped width for sizes above 600 mm shall be 300 mm wide, double thickness wrap shall be provided at section near to the concrete edge.

6.11 VALVE CHAMBERS AND FLOWMETER CHAMBERS

A. Where shown on Drawings, valves and flowmeters shall be located in chambers. The particular types of chambers are indicated on the Drawings which also show the construction details of each type of chamber. GRP flanges shall be provided with washers under all bolts and nuts heads. GRP flange bolts shall be tightened using torque wrenches only, in accordance with the GRP flange manufacturer written instructions. An approved gaskets to be used only.

B. Valve chambers and chambers for flowmeters shall be constructed of Class 30/20/s concrete with the dimensions shown on the Drawings or as instructed by the Engineer to suit the valves, flowmeters and relevant pipe connections on site.

6.12 OTHER WORKS

Works included in the Contract and which do not have specifications herein shall be carried out in accordance with the Engineer's written instructions and Specifications or as specified in the Schedule of Rates (Bill of Quantities).

6.13 CONNECTIONS TO EXISTING MAINS AND SERVICE PIPES

The Engineer will issue to the Contractor detailed instructions regarding each interconnection that has to be made to the existing mains and service pipes. Cutting into an existing main or service pipe and effecting the interconnection shall only be made in the presence of a representative from the Employer's Maintenance Section at the time specified by the Employer. (See also Clause 6.15)

Cutting into the existing main or service pipe and installation of the interconnecting pipe work shall be carried out efficiently and rapidly so as to reduce to a minimum the interruption of the public water supply. It may be necessary to undertake such work at night, when water demands are reduced and/or to schedule such work to be performed during the winter.

Existing mains and service pipes shall only be cut using special equipment approved by the Engineer. The cut shall be perpendicular to the centerline of the pipe and special care shall be taken with respect to the location of the cut to ensure that the new pipe work shown on the Drawings may be installed. The Contractor shall agree with the Engineer the length of existing pipe work to be removed.

The Contractor shall take every care to avoid any dirt or extraneous material entering the existing main or service pipe.

The Contractor shall submit detailed method statement with a program of connection work for Engineers approval prior to any connection/cutting of any existing water main. The Contractor shall have available at the site of the connection sufficient dewatering pumps and equipments before commencing any cut into the existing main or service pipe in order that the excavation remains dry at all times and to reduce the risk of dirty or contaminated water entering the existing distribution system. The work shall be carried out in a clean and efficient manner. The Contractor shall provide at the site of the connection sufficient quantities of clean water containing 10 ppm chlorine in solution. Every item of new pipe work to be installed shall be submerged in the chlorine solution for at least 15 minutes immediately before being installed in the permanent works.

The Employer may put the interconnection into use as soon as possible after its installation and will carry out an inspection to detect any evidence of leakage; any remedial work necessary to eliminate leakage shall be carried out by the Contractor. No pipe work shall be covered or backfilled until the Engineer is totally satisfied that the interconnection is free of all leakage.

6.14 TESTING, DISINFECTION AND CLEANING PIPELINES

6.14.1 General

It shall be a condition precedent to the issue of a Certificate of Completion according to the Conditions of Contract that all parts of the pipe work shall be subjected to a successful hydraulic pressure test and finally disinfected and cleaned out as specified hereafter.

The Contractor shall submit for the Engineer's approval details of his proposed methods and programme for testing (including details of test equipment) and shall arrange for all tests to be witnessed by the Engineer.

The Contractor shall provide all things necessary for carrying out testing, disinfection and cleaning including pumps, gauges, pipes, connections, stop-ends, and all other temporary works.

The Contractor shall remain responsible for the care of the works during testing of the pipe work. The contractor shall replace at his cost any ruptured pipe in the event of test failure if it is proved as improper handling/poor workmanship.

All the existing pipelines/existing crossings forming part of the pipelines laid under this contract shall be pressure tested, disinfected and commissioned by the contractor at his cost, including removal and replacing of any damaged pipes, reinstating the surface etc. Length of pipeline laid for such rectification will only be measured for payment under the relevant items in schedule of prices.

6.14.2 Testing of Pipelines

After completing the installation of a section of the line, as directed by the Engineer and before the joints are covered for buried pipes, a hydrostatic test of the line shall be made by the Contractor.

Concrete for thrust blocks shall be allowed to reach design strength before testing. Backfilling and compaction shall be completed to the pipe centerline and around all thrust blocks as required to assure restraint to the pipeline.

The Contractor shall submit to the Engineer detailed procedures for performing hydrostatic pressure tests of installed piping, fittings, valves, meters and appurtenances for approval. Procedures for performing hydrostatic pressure tests shall indicate the location and capacity of the test pump for each test section, test pressure at the pump and procedure for venting the air from the pipeline.

Before applying the test pressure, all air shall be expelled from the pipe. If permanent air vents are not located at all high points, the Contractor shall install suitable cocks at such points so the air can be expelled as the line is filled with water. After all the air has been expelled, all cocks shall be closed and the test pressure applied. The line shall be filled slowly to prevent possible water hammer.

For hydrostatic testing of pipelines, potable water shall be introduced to the pipeline and the pressure slowly raised to the pressure of 3 bar. This pressure shall be applied for a period of 24 hours before the test begins, to allow for a soaking period. After the soaking period, all joints shall be carefully inspected for evidence of leakage.

Pumping shall then be resumed to the specified test pressure of 10 bars or more bars as directed by Engineer for higher class/PN

The pipeline shall be deemed to have passed the pressure test if no appreciable drop in pressure is noted over a period of 30 minutes.

After performing the specified pressure test, the pipeline shall be subjected to a leakage test. The pressure shall be reduced to the normal working pressure of 9 bars in the pipeline and maintained for a period of 2 hours. Make-up water shall be added by pumping to maintain the working pressure. The pipeline shall be deemed to have passed the test if:

- (a) no water is visible coming out of the pipe or joints at any point;
- (b) the amount of make-up water required during the last one hour of the test period does not exceed the rate of 0.1 liter per millimeter of pipe diameter per kilometer of pipeline per 24 hours for each 30 metres head of pressure applied at the lowest point;
- (c) the maximum drop in pressure (during the last half hour of the test period, when no further make-up water may be pumped in) shall not exceed 10% of the maximum test pressure.

During all testing, the trench generally and the joint pockets in particular shall be kept clear of water and should the trench become unstable due to work or leaking on testing or re-testing it shall be excavated to solid ground and made up with lean mix concrete or such other material as the Engineer may direct, all at the Contractor's expense. Should a test fail, the Contractor shall at his own expense replace defective pipes or fittings or make good leaking joints or otherwise rectify defective work; cleaning, inspection and testing shall then be repeated, until the work is to the Engineer's satisfaction.

The length of the section of pipeline to be tested shall not exceed 500 m. If a line is tested in sections and valves do not close the ends, the line must be provided with secured blind flanges or stop ends. Testing longer lengths not exceeding 1000 m may be considered, at the Engineer's discretion taking into account the prevailing situation at site, without any contradict with any standard.

A simple stop end consists of a section of steel pipe about 0.5-1.0 m long onto which a closing plate has been welded, containing the necessary opening for accommodating in going water and out coming air. The stop end may also include an opening through which the test water may be pumped from the line, if necessary. The stop end may be jointed to the pipe to be tested by means of a standard coupling or other method approved by the

Engineer. Thrust blocks or temporary anchorages must be provided to hold the stop end in place against the test pressure.

6.14.3 **Disinfection of Pipelines**

All potable water pipe, fittings, valves, meters and appurtenances shall be disinfected by the Contractor as specified herein, unless otherwise directed by the Engineer.

All water and chlorine required for disinfection of pipelines shall be provided by the Contractor at his own expense. Bacteriological testing will be performed by the Employer.

The attention of the Contractor is directed to the requirements of these specifications whereby he is responsible for preventing the entry of foreign material of any kind into the pipe work. The Contractor shall take extreme care to keep the interior of the pipe work free of direct and other foreign material. If in the opinion of the Engineer, dirt or other foreign material enters the pipe work, which will not be removed by flushing, then the Contractor shall clean and swab the interior of the pipe work with a five percent hypochlorite disinfecting solution to the satisfaction of the Engineer.

After testing and immediately before commissioning, all pipelines shall be washed out and disinfected as follows:

- (i) All mains shall be flushed out with clean water until there is no evidence of foreign matter or color in the waste flushing water.
- (ii) A stock disinfecting solution shall be prepared by mixing for not less than 5 minutes, in a clean container, Sodium Hypochlorite (12 percent available free chlorine) and distilled water in the proportion of 0.80 litter per cubic meter of water by volume. After mixing, the solution shall stand for a further 5 minutes after which the clear supernatant liquid shall be decanted into another clean container. Stock solutions shall be made up fresh daily.
- (iii) The main to be disinfected shall be filled with potable water at the same time as the stock solution is added through a convenient air valve in such quantities (to be determined by the Contractor and approved by the Engineer) as will result in a final solution containing 50 ppm free chlorine. Care shall be taken to ensure that the stock solution is added at a constant rate, commencing when water is fed into the main and ending as soon as the main is full. Flow meters required for this operation shall be arranged by the contractor.
- (iv) Every main charged with disinfecting solution shall stand for 24 hours, after which a sample shall be taken at a washout valve by the Contractor in the presence of the Engineer, from whom the sampling bottle shall be obtained. If the sample does not show at least 2 ppm free chlorine, disinfection shall be repeated. If the sample is satisfactory the main shall be emptied, flushed out and filled with treated water and allowed to stand for 1 hour.

- (v) Two further samples shall then be taken as before, one for a further determination of free chlorine and the other, in a sterilized bottle, for bacteriological analysis. If the free chlorine determination shows more than 0.4 ppm free chlorine the main shall be flushed out again. If the bacteriological analysis is unsatisfactory disinfection and sampling shall be repeated until satisfactory results are obtained before the main is commissioned.
- (vi) The Contractor shall provide all equipment, materials and testing apparatus, etc., as may be necessary for the effective disinfection of all pipelines.

6.14.4 Cleaning of Pipe work

All pipework shall be cleaned by the Contractor after all pressure tests and disinfection operations have been performed and accepted by the Engineer. However, it is the responsibility of the Contractor to prevent all dirt and foreign matter from entering the paperwork and for cleaning each length of pipe and all fittings, valves, meters and appurtenances, of sand, dirt and foreign matter during the installation. Cleaning of chlorinated lines shall conform to the recommendations of the Chlorine Institute. Flushing shall be carried out in parts and as per the site conditions and as directed by Engineer.

The Contractor will make his own arrangements for water required for testing, disinfection, cleaning and flushing.

Arrangements for disposing of water into lagoon or approved location including providing of required plant, equipment and material shall be at contractor's own expense.

6.15 Disposal of Water Used for Testing, Disinfections and Cleaning

The Contractor shall provide suitable means for disposal of water used for testing, disinfection and flushing such that no damage results to facilities; structures or property. These means shall be subject to the approval of the Engineer and local Authorities. Details shall be submitted to the Engineer upon request. The Contractor shall be responsible for any damage caused by his filling, testing, disinfecting, flushing and wastewater disposal operations.

SECTION 7

MICRO TUNNELING

7.01 DEFINITIONS

For the purpose of this specification the following definition shall apply:

‘Micro tunneling’ : is defined as a miniaturized tunneling technique employing sophisticated mechanical excavation methods within a non-man – entry guided tunnel boring machine.

‘Pipe’ : is defined as the pipe which is jacked in behind the micro tunneling machine

‘Shaft’ : is defined as the excavated thrust and reception pits used for the micro tunneling operation.

‘Auger system’ : micro tunneling where excavated spoil is transported from the cutting face back along the installed pipeline via a flight of helical augers.

‘Slurry system’ : micro tunneling where excavated spoil is converted to slurry and removed by the use of a small diameter discharge pipe.

‘Earth pressure’ Balance : Support of the soil at the cutting face by controlled pressure of the cutting head against the soil face.

PIPELINE BY NON-DISRUPTIVE METHODE AND PIPELINE REHABILITATION

7.02 APPROVED SUB-CONTRACTOR

Where micro tunneling is to be carried out by a specialist Sub-Contractor they shall be approved by the Engineer in accordance with the Conditions of Contract.

7.03 GENERAL REQUIREMENTS

1. The micro tunneling systems shall be capable of remotely installing pipes in varying ground conditions with the presence of ground water and accommodating different joint configurations.

2. Disposal of excavated materials shall be by enclosed remote means using together screw auger, or slurry system.
3. If necessary, facilities for lubricating the external surface of the pipeline being installed shall be provided in order to minimize jacking forces. If required, facilities for grouting any overbreak are to be incorporated.
4. Pipes shall be capable of sustaining all jacking loads and surcharge loads arising from overburden and traffic loading.
5. Shafts shall be sufficiently compact to minimize disruption, be capable of sustaining reactions to jacking loads and be water tight.

7.04 SPECIFIC REQUIREMENTS

1. The normal external cross sectional plan profile of shafts shall not enclose an area greater than 20 m^2 with no dimension of cross section exceeding 5.0 m.
2. The proximity of buildings is such that the driving of steel sheets piles to shafts is not permissible, nor is any construction noise greater than 70 db. All constructional plant forming part of the micro tunneling system is to be electrically driven, either by mains supply or on site generation.
3. Micro tunneling shall not normally be considered where there is a minimum clearance to services of less than 1 meter unless specifically approved by the Engineer.
4. The Micro tunneling system shall conform to the following criteria:
 - a) Face support shall be provided by full earth pressure balance cutting head, or by a pressurized slurry system, as appropriate.
 - b) The equipment must be capable of operating under the prevailing ground conditions including hydrostatic pressure from natural ground level.
 - c) The micro tunneling system shall be manufactured and operated having regard to the provisions of the health and safety at works etc. Act. 1974, including the provisions of the British standard BS 5228 : Parts 1 and 2. This requirement shall include fill environmental monitoring facilities.
 - d) The system shall have automatic steering control by means of a micro processor system with line / level / gradient prediction capability incorporated.

- e) The micro tunneling system shall be capable of installing a pipeline up to 130 meters in length in one operation to an accuracy in line of + or - 50 mm and in level of + or - 25 mm. All joint deflections shall be within 75% of manufacturer's specified tolerance.
- f) Individual pipe length shall normally be in the range 1.5 m - 2.5m.

7.05 SITE INVESTIGATION

The Contractor shall avail himself of all available information's concerning ground conditions to determine the appropriate cutting head compatible with the expected conditions.

The proposed position of drive and reception shafts shall be checked onsite by the Contractor to ensure that the design has provided sufficient working space which will cause the least disruption to the flow traffic.

Any alteration to the designed position of shafts must be approved by the Engineer.

7.06 SURVEY AND SETTING OUT.

7.06.1 Preliminary Survey.

Before commencing the excavation of any shaft or pit from which micro tunneling is to be commence, the Contractor shall without prejudice to any other requirement of the contract and to the satisfaction of the Engineer: -

- ◆ Establish at least four reliable temporary survey stations adjacent to the shaft or pit to facilitate the setting out of the underground works and checking of the setting out.
- ◆ Accurately record initial surface levels for pipelines beneath or across carriage ways. Such records are to be submitted to Dubai Municipality Roads Department, as a record for reference in checking for subsequent settlement.
- ◆ Record and report with supporting photographs the condition of all properties road and footpaths over and alongside each microtunnelling route.

7.06.2 Surveys During construction.

During construction of micro tunneling drive between any two working shafts the Contractor shall observe levels on the predetermined cross section points every fourth day to determine subsidence (if any).

Upon completion of a micro tunneling drive between any two working shafts the Contractor shall, without prejudice to any other requirement of the Contract and to the satisfaction of the Engineer : -

- ◆ Repeat the level survey of the ground surface above the centerline of the pipe jack or heading as described above.
- ◆ Record and report with supporting any changes in the conditions of the properties, roads and footpaths over and alongside the microtunnleing route.

7.06.3 Survey Prior to Completion.

Shortly prior to the substantial completion of the whole of the works and again prior to the end of the Defects Liability Period, the Contractor shall repair the levels surveys and inspection as described above for all the micro tunneling.

7.06.4 Setting Out of the Works.

The Contractor shall provide the Engineer with details of his proposed method of setting out the shafts.

7.07 SAFETY

7.07.1 General

Where work is carried out in microtunnleing shafts, the Contractor shall comply with the recommendations of a recognized Code of Practice to be approved by the Engineer.

7.07.2 Lightning and Other Electrical Equipment

Lightning and other electrical equipment for use within or adjacent to shafts shall be either intrinsically safe or flameproof have any approved type.

7.07.3 Ventilation

All ventilation plant and equipment shall be operated and maintained by competent persons who shall keep a day log of operations in a form approved by the Engineer.

Each shaft shall be ventilated by a fan which shall be suitably situated and connected by ventilation ducting to within 5 meters of the working face.

The fan shall be capable of delivering or exchanging at the end of the ducting at least 15 cubic meters of air per minute per square meter of area of the face to be ventilated.

7.07.4 Presence of Toxic and Inflammable Gases

Where ground conditions indicate that the workings may pass through or are close to materials which could lead to the presence or accumulation of inflammable gases in or adjacent to underground working or where in the opinion of the Engineer there is a risk of this the Contractor shall comply with the following requirements of this Clause.

Each shaft sinking shall be provided with at least one approved automatic gas detector. Continuous monitoring for toxic and inflammable gases and oxygen content shall be instituted with monitors set as near as possible to the most hazardous areas. Regular tests shall also be taken for carbon dioxide content.

All gas detector shall be expertly and regularly maintained.

If gas detection equipment indicates the presence of toxic or inflammable gases approaching hazardous concentrations, all work in the danger area shall cease and all personnel shall immediately vacate the workings, care being taken to avoid sparks from metal tools and studs on boots etc., and the conditions of the workings shall be reported to the Engineer immediately. The contractor shall submit to the Engineer for approval his proposals for sealing the exposed surfaces of the strata from which gas is escaping, for providing additional ventilation and flame proof illumination or such other precautions as may be considered necessary.

If the amount of inflammable gas in any shaft sinking exceeds 1.25 percent by volume, the electrical supply shall be cut off at the surface to all apparatus other than telephones and electric safety lamps.

If the amount of inflammable gas in the main body of the air exceeds 2 percent by volume, all persons in the affected area shall be withdrawn. The nominated competent person shall ascertain the conditions of the area affected and the measures to be taken to render safe the affected area shall be approved by the Engineer, such approval not relieving the Contractor of his obligations under the contract. Personnel will only be allowed to re-enter the area after safe conditions have been restored.

If the Engineer considers that the conditions within the shaft sinking require further restrictions, he will inform the Contractor and the Contractor shall implement such additional restrictions as may be required without delay and, if so required by

the Engineer shall cease any works that the Engineer considers may constitute a hazard to the works or to personnel until the additional restrictions have been implemented.

Nothing in this clause shall be deemed to limit the Contractor's more general obligations under the contract.

7.08 WORKING SHAFTS OR PITS

The Contractor shall construct working shafts or pits at locations to be agreed and approved by the Engineer. Full details shall be submitted to the Engineer for approval before excavation works commences including a plan of the proposed working area at the head of each shaft to scale not less than 1:50. This shall show local topography, the working shaft and arrangement of plant, materials, etc.

The Contractor shall ensure that the area required to set up machinery and equipment together with an allowance for truck access for spoil removal is kept to a minimum and does not cause road closures.

Each working shaft shall have a separate ladder bay for access which shall be isolated from the part of the shaft used for hoisting materials. The ladder will be vertical, rising through staginess not greater than 6 meters apart and offset at each staging level. The ladder at shaft entrance shall have up and over hand rails to assist manual access. All shafts and staginess shall be fully protected by handrails 1 meter high.

The Contractor may apply at any time for approval to changes of design to enlarge or modify any of the chambers or access points that are to be incorporated into the permanent works so as to facilitate their use as working shafts or pits. However, rejection of any such application or delay in issuing approval shall not constitute grounds for any additional payment or extension of time for completion. Any such modifications that is approved shall be carried out to the Contractor's design.

Except as otherwise provided in the contract design changes to enlarge or modify chambers or access points shall not constitute grounds for additional payment.

7.09 EXCAVATION IN SHAFTS

The Contractor shall plan, program and execute the excavation of shafts, in accordance with the specifications and drawings.

Before commencing works the Contractor shall submit such details of his excavation proposals as may be required by the Engineer. No departure from the approved method of working will be allowed without the approval of the Engineer.

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Excavation in shafts shall be carried out in material encountered, true to line and level,. Any miss alignment shall be made good to the satisfaction of the Engineer at the Contractor's expense.

The manner in which the excavation is carried out shall be such as to minimize the extent of any loosening of the ground beyond the limits of the excavations and to ensure that the ground is fully supported at all times.

Any subsidence of the soil or road structure, if noticed shall be immediately brought to the notice of Dubai Municipality Roads Department and all excavation operations shall be completed as soon as possible.

The Contractor shall be at liberty to construct shafts/ pits by any of the established methods of sinking including the use of concrete caissons.

Where the excavation is in water bearing ground the Contractor shall provide means of checking whether any solids are being removed with the water from the excavation. Regular checks shall be made in conjunction with the Engineer to compare the volume of material removed with the calculated volume as a safeguard against excessive loosening or loss of material beyond the shaft dimensions.

7.10 PIPES FOR MICRO TUNNELING

Pipe units to be installed by microtunnleing must be structurally suitable for both permanent loading when in service, and for the temporary loading during construction.

The strengths required for the permanent loading are given in the following table .

Type of Rigid Pipe	Nominal Diameter (mm)	Minimum Crushing strength (kN/m)		
		Class 90	Class 130	Class 170
Rigid	200	-	26	34
	300	27	39	51
	400	36	52	68
	500	45	65	85
	600	54	78	102
	700	63	91	119
	800	72	104	136
	900	81	117	153
	1000	90	130	170
	1200	108	156	203
	1400	126	182	238

Full details of the proposed design, manufacturing and testing of the pipes will be required for approval by the Engineer, prior to manufacture. The tests including crushing strength assessment may be required to confirm the validity of pipe design and to demonstrate its suitability for intended use and shall be provided for in the Contractor's rates for the supply of such pipes.

The strengths specified above relate only to the suitability of the pipes for the permanent loading and do not imply any suitability for the loadings which may develop during installation. It is the responsibility of the Contractor to ensure that the pipes have adequate strength in the longitudinal direction to withstand the longitudinal forces which will develop during jacking without any form of damage, and that they will be in every way compatible with the installation equipment and procedures employed.

Subject to availability in the required sizes and strength classes, pipes of the following materials may be proposed for the construction of pipelines by micro tunneling.

7.11 RIGID MATERIALS

The following particular requirements will apply to pipes of the respective materials: -

Asbestos cement : expect in respect of requirements otherwise specified, the pipes shall comply with Clause 3.01. Jointing shall be by means of rubber ring sealed rebates in the pipe ends, or by means of any external sleeve as detailed below: Asbestos cement pipe without internal liner may be used for drainage only.

Concrete with integral GRP pipe line : The GRP liner pipe shall comply generally with clause 3.01 with minimum stiffness 5000 N/m^2 .

Jointing of the GRP liner pipes shall be by means of rubber ring sealed couplings on the GRP liner pipes. Normally a coupling shall be attached to one end of each GRP liner pipe, and surrounded by concrete integral with the encasement of the liner pipe barrel, so as to effectively form a socket into which the spigot end of the next GRP liner pipe can be entered.

The concrete encasement shall be reinforced and designed as the structural element to provide the required crushing strength and sustain loads generated during installation i.e.

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as a concrete pipe in compliance. and shall completely surround the GPR pipe couplings. It shall extend sufficiently close to the spigot end of the GRP pipes to ensure that a satisfactory gap is maintained between the ends of the two GRP pipe barrels during jacking. The GRP liner pipe shall be regarded as providing corrosion protection only and to be non-structural.

External sleeve The sleeve shall be made from GRP or carbon steel

Rebates shall be provided at the ends of the pipes to accommodate the sleeves and shall extend for a sufficient distance from the pipe ends to ensure that the sleeve end cannot transmit the axial jacking loads.

Sealing of the sleeve against the outside of the pipes shall be achieved either by the provision of rubber ring seals on both pipe ends, or by attaching one end of the sleeve to a pipe end by means of an appropriate adhesive and providing a rubber ring seal at the other end (thereby effectively providing a socket a spigot arrangement).

The integrity of joints against leakage or infiltration and in particular the resistance of stainless steel sleeves to corrosion under the local climatic conditions, ground and groundwater conditions external to the pipeline and the internal environmental conditions of the pipeline in service shall be guaranteed in writing by the Contractor for a minimum period of 20 years for the date of the Maintenance Certificate (Defects Liability Certificate) . Such a guarantee shall be provided at the time of submitting the detailed construction method statement and materials approval request to the Engineer for approval. No approval will be issued unless this condition is satisfied.

All types of joint shall have thrust transmitting surfaces which are square to the pipe axis, flat smooth and free from defects or repairs the distance between the thrust transmitting surface of adjacent pipe ends, when the pipes are correctly jointed together, shall be consistent with the dimension and type of packing ring material to be used. Thrust transmitting surfaces must have packing rings in order to separate the pipe end surfaces to maintain the flexibility of the joint and to efficiently transmit the jacking (axial) forces from one pipe section to another.

Packing rings must be totally square to the pipe axis, flat smooth and free from defects or repairs. Packing rings shall be attached to the pipe ends at the place of manufacture of pipes to ensure that packing rings of incorrect material are not used at site. Packing rings shall be reasonably compressible by having Poisson's ratio equal to zero to eliminate lateral expansion and subsequent end effects. The compressibility of the packing material must be such that damage to the pipe ends will not occur during jacking, and that the subsequent watertightness of the joint will not be impaired. Packing rings shall be made up of high grade wood chipboard or other approved material.

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Recommend thickness of packing rings are as follows:

Jacking Pipe Nominal Size (mm)	Recommend Packing Thickness (mm)
100<DN< 300	15
301<DN <600	18
601<DN<800	24

SECTION 8

SCADA, RTU, COMMUNICATION AND INSTRUMENTATION

8.1 Pipe Line Automation System Scope of work.

The CONTRACTOR shall design, manufacture, factory test, deliver, install, and perform site acceptance test and commission of a state of-the-art pipe line automation system, which includes but is not limited to the following:

- 8.1.1** Install; perform site acceptance test and commission of field instruments as shown in the drawing, BOQ and according to specifications.
- 8.1.2** Design, manufacture, deliver, install, and perform site acceptance test and commission of RTU panels
- 8.1.3** Apply for permanent power, radio license and any required approval for the job.
- 8.1.4** Supply, install & commission dual redundant fault tolerant fiber optic network including:-
 - 8.1.4.1** 2 x 24 GRP Rods armored, Non-metallic single mode (SM) 24 fiber optic cable 1310 /1550 nm wavelength dual windows direct burial under ground fiber optic cable (U/G F.O) parallel to the water pipe line and laid through water proof 100mm diameter as per BS 3506 - class B PVC duct one meter beside and parallel to the edge of water pipe line and one meter under the ground level from the nearest 132kv s/s along the water pipe line covered under this scope.
 - These FO cables along the water pipe line should be terminated in all RTU's on the water pipe line routes. In addition FOC should be terminated in the nearest 132 kV substations
 - Radio communication or other solution shall be proposed if the 132kv substation is not available; the contractor should establish RTU data communication in closed ring configuration.
 - Intermediate joints are not allowed in F.O cables if the distances between two joints are less than four kilometers or one drum length.
 - 8.1.4.2** Supply, install and commission dust proof fiber distribution frames (FDFs) at each RTU location and at the 132kv s/s
 - 8.1.4.3** Optical connectors, adaptors, Patch cords, Joint enclosure and cable lying
Compatible and suitable length of optical pigtails with SC-SC optical connectors as necessary shall be supplied, installed and commissioned. All SC-SC optical adapters must be duplex type. Necessary optical patch cords shall be supplied. The bidder shall adhere to DEWA's direct burial under ground fiber cable installation practice. Cable route approvals and NOC's from the concerned authorities shall be obtained before execution of the works. Fiber optic cable routes and joint enclosure should be plotted in maps with GPS coordinates and submit to DEWA for approval.

8.1.4.4 Splice by automatic arc fusion splicing machine, joint and terminate the U/G fiber cables. Follow the standard test of these fiber optic cables by OTDR, Power Source and Optical Power meter from either side. Submit the test report, hard and soft copy to DEWA engineer, FDFS and joint enclosures to be inspected and approved by DEWA before installation.

8.1.4.5 Optical switch/router/self healing industrial rated module with diagnostics capability to connect RTU's to fiber optics network, same will be provided at S/S MUX.

8.1.4.6 Design, supply to site, install and commission two numbers of Radios one each at the 132kv sub station and at the last RTU location in each end if FO communication ring cannot be established.

8.1.4.7 The contractor should be carried out all the necessary patching to establish the optical equipments network

8.1.4.8 supply, install, commission any required module at the PDH/SDH multiplexer to connect the network to DEWA head office MCC

8.1.4.9 supply all required hardware required at DEWA head office for interface to the existing SCADA system

8.1.5 Software Modifications / Development / Configurations but not limited to the following to make a complete operational System.

- a. MIMICS
- b. DATA MODEL
- c. FEP
- d. TAG DATABASE.

8.1.6 Operation and maintenance Training.

8.1.7 As built drawing as per DEWA GIS requirements

8.1.8 Operation and maintenance manuals

8.2 GENERAL SPECIFICATION FOR AUTOMATION SYSTEMS INSTALLATIONS

8.2.1 Subcontractor

The complete Instrumentation, Control and Automation System, including all sections, i.e., primary elements (Bulk Flow meters, Pressure Transmitter & Water Quality Analyzer, RTU , communication network) etc. shall be installed and commissioned by a single ICA Sub-Contractor to assure system uniformity.

Furnish all tools, equipment, materials, and supplies not furnished vendors and perform all labour required to complete the furnishing, installation, including all instrumentation signal and power wiring and conduits, system validation, start-up and operational testing of a complete and operable instrumentations and automation system as specified herein. Provide all the necessary equipment components and interconnections and the services of the manufacturers'

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engineering representatives for the engineering, implementation, startup, operation, and instruction to insure that the Employer receives a completely integrated and operational ICA as herein specified.

It shall be the responsibility of the qualified single firm as described herein to ensure that the instruments and equipment furnished under this section are compatible with the equipment furnished under other sections of these specifications, and that the signal transmission methods are compatible.

8.2.2 Codes and Standards

The CONTRACTOR shall adhere to the Codes and Standards as applicable from Institutions and Organizations listed below. Equivalent International Standards are acceptable. CONTRACTOR shall adhere to the latest editions of all other Codes and Standards of these organizations, as they may apply.

- 1) International Electrotechnical Commission (IEC)
- 2) International Standards Organization (ISO)
- 3) Instrument Society of America (ISA)
- 4) American National Standards Institute, Inc. (ANSI)
- 5) American Society for Testing and Materials (ASTM)
- 6) British Standard (BSI)
- 7) European Norme (EN)
- 8) Insulated Power Cable Engineering Association (IPCEA)
- 9) National Electrical Manufacturer's Association (NEMA)
- 10) National Fire Protection Association (NFPA)
- 11) Scientific Apparatus Manufacturer's Association (SCMA)
- 12) American Standard Association (ASA)

The following list of standards indicate the requirements as minimum any other standard not listed below or elsewhere in this tender documents shall be subject to review and approve by DEWA'S ENGINEER.

Document No.	Document Title
IEC 60227	Polyvinyl chloride insulated cables of rated voltages
IEC 60331	Fire resisting characteristics of electric cables
IEC 60332	Tests on electric cables under fire conditions
IEC 60770	Methods of evaluating the performance of transmitters for use in industrial process control systems
IEC 61000-4	Electromagnetic compatibility for Industrial Process Measurement & Control Equipment (Supersedes IEC 60801).
IEC 60654	Operating conditions for Industrial Process Measurement and Control Equipment.
Part 1:	Temperature, humidity and barometric pressure

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Part 3:	Mechanical influences
Part 4:	Corrosive and erosive influences
IEC 60584	Thermo couples
Part 1:	Reference tables (584/1)
Part 2:	Tolerances (584/1)
IEC 60751	Industrial Platinum resistance thermometer sensors
IEC 60529	Classification of degrees of protection provided by enclosures (IP code)
IEC 60994	Guide for field measurement of vibrations and pulsations in hydraulic machines
IEC 60625	Interface system for programmable measuring instruments
IEC 60770	Methods of evaluating the performance of transmitters for use in industrial process control systems
IEC 60902	Industrial process measurement and control – Terms and definitions
IEC 60534	CV General Considerations, sizing, dim. etc.
IEC 60839	Alarm and warning systems
ISO 5167	Measurement of fluid flow by means of pressure differential devices
ISO 5168	Measurement of fluid flow – Evaluation of uncertainties
ISA 5.1	Process Instrumentation terminology
ISO 3511/1	Process measurement control functions and instrumentation symbolic representation
ISO 44	Degree of protection of enclosures
ISO 4064/1	Measurement of water flow in closed conduits meters for cold Potable water
ISO 9001	Quality Control
ISO 9002	Quality Control
ISO 9003	Quality Control
ISO 7005/2	Instruments Flange

8.2.3 Units

The instrument ranges and scale calibration shall be in metric units according to the international system of units (SI), unless otherwise is indicated on the Instrument Data sheet, as listed below:

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Flow	liquids and vapour m3/hr gases Nm3/hr
Volume	m3
Pressure	Bar
Head	MWC
Low pressure	MMWC
Pressure Vacuum	Bar
(Low) abs. pressure	mm Hg abs
Temperature	deg. C
Conductivity	Micro S/cm
Rotating speeds	Rpm
Frequency	Hz
Currents	A
Voltage	V

8.2.4 SITE CONDITIONS

The site location of this project has a dust laden atmosphere. The temperature at night drops considerably, resulting in condensation. These conditions attack instrumentation electric terminals, contacts, etc. for which the CONTRACTOR must design protective measures. Any instrumentation shall be supplied with waterproof, dust tight enclosures. In addition, local instrument cabinets shall also be weatherproof and equipped with space heaters.

The following design conditions shall apply.

Ambient Temperature : Short term (<2 hours/day) 65°C max.

Ambient Temperature : 0°C to 60°C

Ambient Relative Humidity : 5% to 100%

Weather: Rain, wind and dust

Provide as necessary, enclosures, sunshields, thermostatically controlled heaters, etc., to assure normal operation under these conditions.

8.2.5 SYSTEM RESPONSIBILITY

Contractor's attention is directed to the fact that the instrumentation system as specified in this Section is an integrated system and therefore shall be provided by a single competent, qualified instrumentation subcontractor (hereinafter in this Section referred to as the ICA Subcontractor) who shall be subject to approval by the Engineer and shall have total responsibility for the work of this Section. Entire system installation including calibration, validation, start-up, operation testing, and training shall be performed by qualified personnel possessing all the necessary equipment and who have had experience performing similar installations. System shall be integrated using the Subcontractor's latest, most modern proven design and shall, as far as practical, be of one manufacturer. Overall system performance shall be guaranteed by the ICA Subcontractor.

The Contractor shall subcontract the work under this Section to a qualified ICA Subcontractor who shall perform said work but it shall be understood that this shall not relieve the Contractor from any responsibility under the Contract. Although many references made herein are to work requirements and responsibilities of the ICA Subcontractor such reference shall only mean that responsibility shall pass through the ICA Subcontractor but in the final analysis shall rest with the Contractor.

The ICA Subcontractor shall be responsible for the correct installation of all hardware and systems specified in this Section.

The ICA Subcontractor shall be responsible to see that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling and alarming devices and all appurtenances, are completely compatible and shall function as outlined and he shall furnish and install such additional equipment, accessories, etc. as necessary to meet these objectives at no cost to the Employer.

8.2.6 QUALITY ASSURANCE

Qualification and Manufacturers.

The ICA Subcontractor shall be a recognized manufacturer of primary elements, panel and field instruments, panels, etc., of the general type specified herein and shall have been regularly engaged in providing this equipment on a single system responsibility basis for similar works. The personnel employed for system engineering, supervision, start-up, operational testing and training shall be regularly employed and factory trained by the ICA Subcontractor. Actual installation may or may not be performed by the ICA Subcontractor's employees, but the ICA Subcontractor shall be responsible for the technical supervision of the installation to insure that it is proper in all respects.

Standard of Quality.

Furnish equipment of the types and sizes specified which has been demonstrated to operate successfully. Wherever on the Drawings and in these Specifications, materials or equipment have been specified by using the name of products or manufacturers, the term "or equal" is always understood to follow immediately. Material or equipment, so specified, have been selected as being most suitable and are regarded as standard and are not intended to eliminate others of equal quality and performance. The order of listed manufacturers shall not be construed as a preference or order of quality.

The burden of proof of equivalency in quality and performance shall rest with the ICA Subcontractor and shall require the Engineer's written approval. The procedure for submission of products for approval as equivalent shall be as specified under submittals below.

All electrical equipment and materials, including their installation, shall conform to Section – Electrical requirements unless specified otherwise in this Section.

8.2.7 SUBMITTALS

8.2.7.1 Pre-submittal Conference

Arrange a conference between the ICA Subcontractor and the Engineer or his representative within sixty (60) days after award of the Contract for the purpose of informally discussing in detail and verifying the correctness of the ICA Subcontractor's system engineering methods and equipment and to generally provide a framework for communication and coordination. This conference shall be attended by ICA Subcontractor's Engineer, and duly authorized representatives of the Contractor and Engineer.

Prepare a draft of the submittal for review. The draft shall include the following, as a minimum.

Listing of major items proposed for this Section. Identify item tag number, description, function, manufacturer, model number, descriptive literature and statement as to whether item is "as specified or equivalent". Items identified, as "equivalent" shall be accompanied by a comparative listing of the published specifications for the item specified and for the item proposed.

8.2.7.2 Shop Drawings

Before proceeding with any manufacturing, submit Shop Drawings for approval. Describe the items being submitted. Manufacturer's specification or data sheets shall be clearly marked to delineate the options or styles to be furnished. Submit only complete systems, not pieces of equipment from various systems. Show dimensions, physical configurations, methods of connecting instruments together, mounting details, and wiring schematics. Schematics shall be complete with tag and terminal numbers. Submit fabrication, nameplate legends and piping schematic drawings clearly showing all equipment and tag numbers on all panels. Include material specifications lists where applicable.

8.2.7.3 Record Drawings

Process and Instrumentation Diagrams.

Prepare and submit "Record" process and instrumentation diagrams for all work included. Without limiting the generality of other requirements of these Specifications, arrange for the submittal, by the ICA Subcontractor, of a reproducible mylar of complete schematics and wiring diagrams or drawings to include all installed field and panel conduit and piping/tubing runs and routing, tray systems, supports,, mounting details, point to point diagrams with a cable, wire, tube and termination numbers. Drawings shall be a record of work as actually constructed and shall be labeled as "Record".

8.2.7.4 Factory Inspection.

Engineer or his representative may inspect fabricated equipment at the factory. The contractor shall give the Engineer 21 days notice in writing of the date on and the place at which any plant will be ready for testing so that factory inspection can be arranged. Factory inspection shall be made only after the manufacturer has performed satisfactory checks, adjustments, tests and operations. Tests shall be made using simulated inputs and

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output loads. Approval of equipment at the factory only allows the manufacturer to ship the equipment to the site, and does not constitute approval by the Engineer.

The Engineer shall indicate on return of the approved submittal each item requiring factory inspection. Lack of such indication by the Engineer shall constitute a waiver of factory inspection.

8.2.7.5 *Instruction Manuals*

Unless otherwise expressly specified furnish ten (10) sets of Instruction Manuals and Part Lists for instrumentation equipment provided. Obtain data from manufacturers, and format and bind as specified. Obtain document distribution instructions from the Engineer.

Schedule.

Deliver 2 copies of manuals not later than the equipment shipment date. The balance of the copies shall be provided to the Engineer within 2 weeks of the Final Operational Tests and shall include all revisions necessary to correct for changes made during installation or checkout.

Submit an "Equipment Specification Data" form for each item of equipment which shall summarize the specification features as called for in these specifications and include such other necessary data as would provide a complete and adequate specification for reordering an exact duplicate of the original item from the manufacturer at some future date. The assigned tag numbers and manufacturer's part numbers shall be included but will not be considered as a substitute for any of the required statement of specifications. More than one tag numbered item may be included on a sheet Contents.

Include in manuals not less than the following information, as applicable, for each instrument, equipment:

General, introduction and overall description, purpose, functions, simplified theory of operations, etc.

Specifications (include equipment specifications data sheet described above under Shop Drawings).

Installation instructions, procedures, sequences, tolerances and precautions.

Operational procedures.

Maintenance, calibration and repair instructions.

Parts list and spare parts recommendations.

Format.

Use drawings and pictorials to illustrate the test to the extent necessary to insure a clear, concise presentation. If manuals have been written to cover a family of similar instruments or equipments, strike out inapplicable information in a neat fashion or emphasize applicable portion by heavily weighted arrows, circles or boxes; whichever provides the clearest and neatest presentation. Where identical instruments are used in more than one control loop or subsystem, include only one instrument manual,

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however, an index by tag number for all instruments shall identify its location in that manual.

Control loop and/or subsystem operational descriptions shall identify the function of each instrument and its relation to the other instruments in the loop.

Binding.

Bind each manual in a cover which indicates the panel or process area to which it applies manufacturer's name, local address and telephone number, and year of purchase.

8.2.7.6 Accessory and Maintenance Materials

Furnish the following items as specified herein. Deliver to Engineer as directed, with itemized list in a letter of transmittal accompanying each shipment.

Special Tools and Accessories.

Furnish special tools, instruments and accessories for maintaining instruments and equipment requiring periodic repair and adjustment as specified elsewhere herein. Also furnish special lifting and handling services for equipment requiring such devices.

Maintenance Materials and Spare Parts.

Deliver in manufacturer's original containers labeled to completely describe contents and equipment for which it is furnished.

8.2.8 ICA Subcontractor's Certified Reports

The ICA Subcontractor, or his authorized representative, shall submit a written report for each control panel and associated field instruments certifying that the equipment (1) has been properly installed under his supervision, (2) is in accurate calibration (3) was placed in operation in his presence, (4) has been checked, inspected, calibrated, and adjusted as necessary, (5) has been operated under maximum power variation conditions and operated satisfactorily, and (6) is fully covered under the terms of the guarantee.

8.2.9 Demonstration and Final Operation Test Plans and Results.

Not later than 30 days prior to the test demonstration a written plan shall be submitted for approval for demonstrating that each system of equipment provided meets the specified operational requirements. The plan shall include procedures to be used in final operation testing of entire systems including a description for each system of test methods and materials, testing instruments and recorders, a list of the equipment involved with the functional parameters to be recorded on each item, and shop drawings of required temporary by-passes and like facilities. Submit three copies of test results and records for all final operation tests.

8.2.10 PRODUCT DELIVERY, STORAGE AND HANDLING

Box, crate, or otherwise enclose and protect instruments and equipment during shipment, handling, and storage. Keep all equipment dry and covered from exposure to

weather, moisture, corrosive liquids and gases or any element which could degrade the equipment.

Protect painted surfaces against impact, abrasion, discoloration and other damage. Repair any damage as directed and approved.

8.2.11 JOB CONDITIONS

Drawings and diagrammatic and show the intended arrangement for system operation, piping, and appurtenances. Conform to Drawings as closely as possible and exercise care (1) to secure neat arrangement of piping, valves, conduit, and like items, and (2) to overcome structural interferences. Verify dimensions and conditions at the place of work, and install materials and equipment in the available spaces.

8.2.12 GUARANTEE AND WARRANTIES

Guarantee all work in accordance with the General Conditions of Contract. With respect to instruments and equipment, guarantee shall cover (a) faulty or inadequate design; (b) improper assembly or erection; (c) defective workmanship or materials; and (d) leakage, breakage, or other failure not caused by Employer's misuse. For equipment bearing a manufacturer's warranty in excess of one year, furnish a copy of the warranty to Engineer with Employer named as beneficiary.

8.2.13 Instrument Mounting and Hook-Ups

The installations shall be designed in such a way that all instruments, their measuring point and their process connections are safely and permanently accessible. All instruments shall be installed, unless otherwise stated, so that they:

Are not subject to excessive vibration or to mechanical stress and not exposed to extreme high temperatures and direct sun radiation.

Can be easily read.

Can be easily mounted and removed.

Provide an accurate representative measurement of the process condition (IP rating).

Are sufficient weatherproofed (IP rating).

For pipelines the branch nipple and isolating valve shall form part of the process piping and shall comply fully with the relevant piping specifications. Instrument piping starts at the first detachable connection (screw thread or flange) downstream of the 1st isolation valve, except for connections installed in control valves and displacement chambers for level instruments, if applicable. All instrument process connections for instrumentation shall be provided with valves with straight through trim to allow rodding out of plugged connections. Type and material of instrument valves shall be ball or gate valve and AISI 316 respectively. Process connections on the surge vessel shall be made by means of 1" flanged branches with minimum ratings ASA 300 lbs, depending on the standards which are applied; stiffened when necessary for strength, branches shall be fitted with isolating valves for the connection of instrument piping. Different connections may be allowed to suit level instruments provided, but require specified DEWA/ENGINEER's approval.

Welding is not allowed on instrument piping and connections. The process connection shall normally terminate in a DN 15 lapped joint flange unless other sizes are dictated by the size of connections on the connections on the instrument. Size and material of instrument piping shall be $\frac{1}{2}$ " and stainless steel AISI 316L/Ti. All pressure instruments shall be installed at the pressure source with a block valve and a vent to facilitate zero checking and to enable the system to be depressurised prior to removal of the instrument. When the pressure instrument is located at a distance from the process connection, an additional block valve and a vent valve shall be placed adjacent to the instrument. For ease of removal of alignment, pressure gauges shall be screwed into unions and not directly into valves or sockets. Pressure piping to instrument shall be such that under no circumstances vapour locks or traps formed, and that piping is completely "full of liquid". Pressure gauges on pump suction and discharge lines shall be easily visible from the relevant pump starter switch as well as from the suction and discharge valves, the gauges should preferably be installed close to the discharge valves. When measuring pulsating pressure, suitable dampening methods shall be provided (dampening devices in the process connection etc.). Where pressure gauges are installed on liquid measurement, allowance must be made for the static head in the instrument line. Pressure transmitters shall be suitable for field mounting and be connected with the process via block and bleed valves. Magnetic flow elements shall be mounted strictly according to the manufacturer's instruction. The flow meter must be oriented with the electrodes in a horizontal line. Precautions must be taken to ensure that the metering tube is filled at all times during measurement. The sensor should be mounted away from turbulence – generation components (e.g. valves, elbows, tsections) whenever possible so that the upstream distance shall be min. (5 to 10) X pipe dia. and the downstream distance shall be min (2 to 5) X pipe dia.

In case of using a remote transmitter unit then the cable type and length shall be according to Vendor recommendations and specifications. Magnetic flowmeters and their converter shall be protected against direct sun radiation. Level gauges shall be installed with a shut-off valve in both the top and bottom process connections. The float for the level switches shall be mounted in an external float chamber which shall be installed with a shut-off valve in both the top and bottom process connection. All liquid level instruments shall be provided with drain valves and vent valves. The DEWA/ENGINEER reserves the right to direct the removal and replacement of any work which, in his opinion, does not present an orderly or reasonably neat workmanlike appearance, provided that such work can be properly installed in an orderly way by usual methods. Such removal and replacement shall be carried out solely at the Contractor's expense. Instruments shall not be installed until heavy construction work adjacent to instruments has been completed to an extent that there can be no damage to the instrument installation by this construction work. After installation suitable guards for the protection of panels, local instruments and enclosures shall be provided to prevent damage during other construction activities.

8.2.14 Instrument Process Tubing

All impulse lines shall be run with a slope of not less than 1:12 except where otherwise stated. The slope shall be down from the tapping point for liquid and condensables, and up from the tapping point for gases. The CONTRACTOR shall ensure that vents are

sited at the highest point of the installation and drains at the lowest. Impulse lines shall be kept as short as possible consistent with good construction practice and accessibility and the number of joints in the impulse lines shall be kept to a minimum. Joints made in adjoining tubing shall be such that the joints are not adjacent at the same level.

All screwed connections shall be sealed off with a sealing compound compatible with the fluid within the tubing. PTFE tape shall not be used. Tubing shall not sag. Adequate support shall be provided at 1 m intervals. Thermally insulating spacer shall be supplied to separate the tubing from the supports. Tubing shall run with a minimum number of changes of direction consistent with good practice and neat appearance. Tubing shall not be supported from handrails.

Tubing shall not be supported from process lines. Due regard shall be given to hot service installation that is subject to expansion, to ensure that sufficient flexibility is allowed for expansion. Where stainless steel tubing with compression fittings is installed, CONTRACTOR shall ensure that the correct procedures, as specified by the fittings manufacturer, are followed. This shall include, but not be limited to, the following:

- Proper cutting of the tube. Only approved cutting tools shall be used.
- Proper installation of the ferrules.
- Checking that the tube is round and free from burrs and distortions.

8.2.15 IDENTIFICATIONS

Labeling and Name Plates

A nameplate with the panel description shall be permanently attached to a prominent position on the front door of the panels. An identical nameplate shall be permanently attached inside the panels. The nameplate shall be indelible, non-removable and with black lettering on white background. All warning or danger labels shall be indelible, non-removable with white lettering on red background. The panel doors shall be fitted with a warning label stating "Isolate before working on equipment". Where voltages exceed 110 V ac, warning labels showing the voltage level shall be attached to the terminals, using nylon screws. The label shall span all the terminals carrying the higher voltage. All wiring shall be ferruled at each end, using slip-on-colour coded markers. All wiring shall be uniquely identified with a number. The markings shall be as shown on the assembly wiring and circuit diagrams. All instruments mounted in field/panel shall be provided with traffolyte nameplates engraved with unique identification tag number and description, which shall be subjected to approval by DEWA/ENGINEER.

Fixing screws of all nameplates, tags or inscriptions shall be non-corrosive type. Each relay, contactors, switch and every other item of equipment within the panel shall be identified by labels permanently attached adjacent to the equipment concerned, indicating circuit reference, description and rating. Where equipment is terminated in a plug-and-socket type connection both the plug and the socket shall have permanently attached identifying labels.

Tag Numbers

All instruments shall have engraved stainless steel nameplates showing their tag number and service in the English language. On the panels these name plates shall be mounted visible near or on the instruments. For station mounted instrumentation equipment the nameplates shall be mounted on a bracket near the equipment. The numbering system standard shall be according to the KKS, AKS or DEWA identification standard.

For each panel mounted instrument an additional stainless steel nameplate shall be provided for mounting at the back; it shall be engraved with tag numbers only. These plates shall be attached to the panel or instrument support near the instrument. Method of fixing nameplates shall be submitted for DEWA/Engineer's approval.

All instruments shall be delivered to job site immediately prior to their installation to minimize the possibility of damage. No instruments, motor operated valves etc. shall be left lying around on the construction site. Materials and equipment not required for immediate installation shall be stored in a separate store protecting them from shock, weather, dust and damage from chemical and construction material. Do not stack instruments in a store unless crated.

Upon receipt check each item for complete compliance with purchase specifications, damage, shortage and shortage of components. Repair, replace or notify vendor of non-conformance as required.

All cover sand plugs on instrument connections shall be left in place until the moment the connection is used. Rubbish and scrap material shall not be allowed to remain at site. This shall be collected daily and removed from the site. Upon completion of the work all tools shall promptly be removed.

8.2.16 Electrical

The construction work shall include all the power supply wiring, instrumentation wiring, interconnecting wiring and equipment grounding as indicated, specified and required and not specifically included under Section 10.

Wiring installations shall include cables, conductors, terminals connectors, wire markers, conduits, conduit fittings, supports, hardware and all other required materials not specifically included.

Provide the materials and complete all the required installations for equipment grounding as specified of these Specifications.

Incidental items, not included in the Contract Documents, that can legitimately and reasonably be inferred to belong in the instrumentation work shall be provided by the ICA Subcontractor.

Field Wiring. Provide 1.0 mm² or larger stranded cable for multiple conductors for instrument signal wiring of low voltage service. Provide shielded conductors if necessary for proper performance and operation of equipment. Use insulation rated for intended service. Ring out signal wiring prior to termination. Provide wire number tags marked in indelible waterproof form of slip-on type or equal for each termination. Provide pre-insulated crimp-on connectors for wire termination. Provide pre-insulated crimp-on

connectors for wire terminations and splices. Use ratchet type crimping tool which does not release until proper crimp pressure has been applied.

8.2.17 EXECUTION

8.2.17.1 Inspection

Inspect each instrument and piece of equipment for damage, defects, completeness and correct operation before installing. Inspect previously installed related work and verify that it is ready for installation of instruments and equipment.

8.2.17.2 Preparation

Ensure that installation areas are clean and that concrete or masonry operations are completed prior to installing instruments and equipment. Maintain the areas in a broom-clean condition during installation operations.

8.2.17.3 Manufacturers' Installation and Supervision

Furnish the services of authorized factory personnel especially trained and experienced in the installation of the equipment to: (1) supervise the installation in accordance with the approved Instruction Manual; (2) be present when the instruments and equipment are first put into operation; (3) inspect, check, adjust as necessary, and approve the installation; and (4) calibrate the instruments, in accordance with the Specifications herein, until all trouble or defects are corrected and the installation and operation are acceptable. Include all costs for representative's services in the Contract Rates.

8.2.17.4 Instrument Calibration

The purpose of instrument calibration is to obtain a permanent record of the equipment precision and to verify that it measures, indicates, and records within the tolerances guaranteed by the manufacturer. Instrumentation shall be calibrated using conventional output signals measured, adjusted to correlate with the relevant input signals. As far as possible instrument re-installation testing and calibration shall be carried out in a dedicated workshop located near to the plant area. This workshop will be equipped with all necessary testing materials, tools and consumable media (clean instrument air, nitrogen, temperature bath oil etc.). Portable calibration equipment will also be available for testing instrumentation not destined to be removed from its site location. All the test and measuring instruments shall be certified with DEWA/ENGINEER recognized testing laboratory. Proposed list of Test and Measuring instruments shall be listed in the bid documents by the CONTRACTOR.

8.2.17.5 Calibration Guidelines

Electronic instrumentation shall be energized for a suitable "warm-up" period prior to calibration tests. All field mounted analogue signaling instruments will be calibrated by simulating an appropriate process signal. Outputs will be recorded at (5) selected intervals corresponding to 0% - 25% - 50% - 75% - 100% of input range. This

calibration will be recorded for rising as well as falling input signals. Digital on/off devices such as pressure switches need only be checked at the required setpoint (with either rising or falling input as specified in the detailed specification). The resetting value will be verified and any hysteresis within acceptable manufacturing limits accepted. All calibrations shall be witnessed by the DEWA/Engineer's representative at his discretion. All the findings shall be properly recorded and signed off with relevant remarks about the status and any "hold" point. Before installation, all the "hold" points shall be fully addressed and approved by DEWA/ENGINEER.

8.2.17.6 System Validation

Provide the services of factory trained and field experienced instrumentation engineer(s) to validate each system to verify that each system is operational and performing its intended function within system tolerance. System tolerance is defined as the root-mean-square sum of the system component published specified accuracies from input to output. Validate each system by simulating inputs at the first element in loop (i.e. sensor) of 10 percent, 50 percent and 90 percent of span, or on/off and verifying loop output devices (i.e. recorder, indicator, alarm, etc. except controllers). During system validation, make provisional settings on levels, alarms, etc. Verify controllers by observing that the final control element moves in the proper direction to correct the process variable as compared to the set point. Verify that all logic sequences operate in accordance with the specifications.

Cause malfunctions to sound alarms or switch to standby to check system operation. Check all systems thoroughly for correct operation. Test equipment for this function shall be as specified under "Instrument Calibration".

Immediately correct all defects and malfunctions disclosed by tests. Use new parts and materials as required and approved and retest. Provide a report certifying completion of validation of each instrument system. This report shall indicate calculated system tolerances, verification that system meets these tolerances, and any provisional settings made to devices.

8.2.17.7 Commissioning

Upon completion of instrument calibration and system validation, test all systems under process conditions. The intent of this test is to demonstrate and verify the operational interrelationship of the instrumentation systems. This testing shall include, but not be limited to, all specified operational modes, taking process variables to their limits (simulated or process) to verify all alarms, failure interlocks, and operational interlocks between systems and/or mechanical equipment.

8.2.17.8 Final Acceptance.

Final acceptance report. Immediately correct defects and malfunctions with approved methods and materials in each case and repeat the testing. Upon completion of final operational testing, submit certified report, with substantiating data sheets, indicating that total ICA System meets all the functional requirements specified herein. The Engineer will countersign this report and it shall constitute final acceptance of the ICA System.

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Testing shall be witnessed and approved by the Engineer. Notify the Engineer in writing a minimum of 48 hours prior to the proposed date for commencing the test. Upon completion of this test the Contractor shall begin or have begun system start-up. The Employer reserves the right to set the schedule.

8.2.17.9 Start-Up Assistance

When specified elsewhere in this section provide the services of a factory trained and field experienced instrumentation engineer to assist the Employer personnel during startup of the system. Purpose of this assistance is to support in making final adjustments of settings on the instrument systems.

8.2.17.10 Instruction of the Employer's Personnel

Provide the services of a trained and field experienced instrumentation engineer to conduct group training of the Employer designated personnel in the operation of each instrument system. This training shall be for a minimum time period of 3 days, one day of which may be performed during the operational testing period. Obtain the Engineer's written acceptance that the training has been adequate. Include instruction covering basic system theory, operating principles and adjustments, routine maintenance and repair, and "hands on" operation. The text for this training shall be the process and instrumentation diagrams and operation and maintenance manuals furnished as per these Specifications.

8.3 GENERAL SPECIFICATIONS FOR FIELD INSTRUMENTS

Field instruments and actuators, which will be installed below ground level shall have metallic glands and be stamped with **IP 68** rating.

8.3.1 ELECTROMAGNETIC FLOW METER

General

The electromagnetic flow meter shall comprise of a flow sensor and transmitter unit. The electronic transmitter shall be supplied as a remote mounting type unless otherwise specified.

The flow meter shall use the principle of electro-magnetic induction to produce a DC voltage proportional to the rate of liquid flow. Coil excitation shall be DC. The coils shall generate a magnetic field, which in turn induces a voltage in the flowing liquid that is sensed by a pair of electrodes in contact with the fluid.

Magnetic flow meter shall incorporate a detector to constantly monitor whether the pipe is full and all electronics, electrodes, sensors and cable connections are operating correctly. Any fault shall be indicated immediately via a relay/status output to any remote device, such as alarm, or signal as directed by the Engineer

The flow meter shall have a feature for on-site validation of sensor, transmitter and interconnecting cable.

Pressure rating of flow meter shall be PN 10 normally but shall be PN 16 if pipeline pressure rating on which it is to be installed is PN 16 even if it is not mentioned in BOQ or as approved by DEWA. Flange drilling pattern shall be BS4504 for the respective pressure rating. The outside coating shall be 300 micron rylsan coating or epoxy coating.

Flow Sensor

The magnetic flow meters shall be of short-form type. Meters shall be designed with end connections of as per BS 4504. The meter tube shall be AISI 304 stainless steel and suitably lined with a hard rubber liner or better material to withstand process temperature of 80°C. The liner material shall be abrasive resistant and approved by WRAS-UK or equivalent internationally recognized organization for potable water use at minimum 50 degree C.

The electrodes shall be made of AISI type 316 stainless steel and shall be provided with a minimum preamplifier input impedance of 10^{12} ohms or greater to reduce errors due to electrode coating to almost zero. Automatic electrode cleaning should be provided. Replaceable electrodes are also not acceptable.

The flow meter sensor shall retain IP 68 rating at 10 meters depth indefinitely. The flow meter shall be robust & fully welded type to prevent entry of moisture to the coils. Sensor of shell-type enclosure with gaskets in between the shells is not acceptable.

The magnetic flow meter shall utilize DC bi-polar pulsed coil excitation, automatically re-zeroing after every cycle. The coils shall be protected from contact with the liquid. The electrodes shall be made of AISI type 316 stainless steel and shall be provided with a minimum preamplifier input impedance of 10^{12} ohms or greater to reduce errors due to electrode coating to almost zero. Any form of electrode cleaning is not acceptable. Replaceable electrodes are also not acceptable.

Transmitter Unit.

The electronics shall be remote mounting type and the flow meter transmitter shall retain IP 67 rating. The transmitter shall be furnished with integral universal wall/pipe stand mounting bracket and minimum of 30 meters of interconnection cable. Additional lengths of cable shall be provided as required for a complete and operable installation at no extra cost.

The transmitter unit shall be microprocessor based and shall be easily configurable through the integral keypads. The electronics shall be of modular construction and shall be interchangeable for any size without requiring testing. In addition to the internal EEPROM or RAM built-in with the flow transmitters, the magnetic flow meters shall have a dedicated sensor memory, which will contain all the characteristics of the sensor (i.e., calibration factor, correction factor, excitation frequency, etc.) as well as the user-configured parameters on site.

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There shall be an EEPROM specifically configured for each sensor. This memory shall facilitate automatic transfer of pre-programmed data to the new electronics in an event of transmitter fault, without requiring renewed calibration or commissioning. A 3 x 16-character alphanumeric display shall indicate user-defined flow units and total flow. All menu advice and commands shall be viewed on this display.

The unit shall have high electromagnetic compatibility to EN 61326 and NAMUR recommendations.

Each magnetic flow meter system shall have an accuracy within $\pm 0.25\%$ of the flow rate over the operating range when the velocity is within 0.3 m/s to 10 m/s. Meters shall have a repeatability of 0.1% of full scale. Accuracy shall be maintained for an ambient temperature range of 0 degree to 60°C. Accuracy shall be verified by calibration in a flow laboratory approved by the Engineer

Outputs shall be isolated 4-20mA dc into 800 ohms plus frequency output selectable from:

- (a) 25/50 ms, 24 Vdc pulse, 0-10 Hz max. 150 ohm min., or
- (b) 50-50 duty cycle 15V peak to peak, 0-1000 Hz max. or
- (c) either (a) or (b) above with open collector.
- (d) Status outputs (2 Nos.) configurable for limit values, flow direction, empty pipe detection, flow direction, error messages etc.

The interface to the RTU/PLC shall be through HARDWIRE/PROFIBUS selectable to DEWA.

The flowmeter shall be inherently bi-directional, and should total forward and reverse and net flow separately.

The flow meter shall incorporate a feature meter software shall incorporate a password, preventing inadvertent program changes. A hand-held programmer is not acceptable.

Field selectable and adjustable circuitry is to be provided as follows:

- a) Low flow cut-off, field adjustable from 0-9% of the full scale.
- b) Current damping to modulate peaks and troughs for the 4-20mA output signal in the event the output signals are spasmodically received.
 - c) Noise suppression to cut-off the inaccuracy in magnetic field and current due to noise created by the liquid flow.
- d) Display damping to steady the reading of the flowrate and total.

Totalized flow and programmed configuration shall be maintained in memory for up to 10 years.

Grounding

The flowmeter shall be equipped with built-in grounding electrodes of the same materials as the sensing electrode. In addition, each magnetic flowmeter shall be provided with two (2)

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numbers full-bore stainless steel grounding rings installed at both ends of the sensor thus providing a grounding circuit for each magnetic meter.

Manufacturer

Flowmeter shall be manufactured by a company who has had several years of experience in the manufacture of flowmeters of the DC pulse type suitable for potable water and shall have a fully equipped technical, marketing and service facility in the U.A.E. The manufacturer of the flowmeters shall confirm the particular application of the flowmeters for the intended use and shall provide a warranty of minimum 5 years based on a replacement basis including labour and material at no extra cost. The warranty shall be issued directly to DEWA.

Installation

The Contractor shall survey the flow meter installation sites and after familiarizing himself with the site conditions, submit working drawings for the installation, instrumentation and electrical works involved for each one of these flow meters, to the Engineer for approval.

The bulk flow meter sensor shall be installed on the pipe mains in a concrete chamber as approved by the Engineer, while the transmitter shall be installed remotely inside a GRP Kiosk. The Contractor shall submit working drawings, showing his proposed method of installation.

Battery Back-up

Flow meter specified for operation from DC power supplies shall be provided with a battery back-up unit to provide uninterrupted power for a maximum period of 8 hours following main supply failure. The unit shall be installed in the GRP enclosure housing along with the flow meter converter. The unit shall comply with the following requirements: -

- a) Combination charger and supply circuits.
- b) Load shed circuit to protect battery from deep discharge.
- c) Rapid charge facility, re-charge 12Ah battery in less than 8 hours whilst simultaneously the primary load.
- d) input voltage 230ac \pm 10%, 50Hz.
- e) Output voltage, nominal 24V dc, maximum 28Vdc.
- f) Low battery alarm at 22Vdc \pm 3%, open collector or volt free contacts.
- g) Low voltage cutout at 21Vdc \pm 3%.
- h) Restore from low voltage cutout at 24Vdc \pm 3%.
- i) Battery pack rated at 12 Ah minimum, maintenance free.
- j) Temperature and humidity, operational, 0 C to + 65 C , 5 to 95 % RH non condensing.

8.3.2 PRESSURE TRANSMITTERS

The gauge/absolute pressure transmitter shall be 12 to 48V loop powered. The pressure transmitter shall use capacitance sensing as its measuring principle.

The transmitter shall be a microprocessor based SMART electronics with a remote display. The display shall be with simple text (English) information. It shall generate output signal of 4-20 mA proportional to the measuring range and must be transmitted over a pair of twisted wires through long distances. Digital communication (HART) for remote calibration and monitoring shall also be provided.

Transmitter accuracy shall be $\pm 0.1\%$ of calibrated span over an entire 100:1 turndown. This accuracy shall include the effects of linearity, hysteresis, and repeatability. The transmitter electronics shall be of modular construction with replaceable display and shall be suitable for continuous operation in ambient temperature up to $+85^{\circ}\text{C}$ and process temperature up to $+100^{\circ}\text{C}$

Electronics shall be housed in SS316L housing with protection IP 68. Process connection shall be $\frac{1}{2}$ inch NPT. Transmitters shall be provided with a stainless steel Type 316 tag plate, identifying the manufacturer, model number, span and calibrated range. A calibration report from the manufacturer shall be furnished for each transmitter. Wetted Parts of the sensor shall be 316L Stainless Steel including flanges and adaptors. A stainless steel type 316L two-valve manifold shall be provided for gauge pressure transmitters.

8.3.3 ANALYZER STATION

A. General

Each analyzer station shall comprise of the transmitters and sensor assemblies for measuring pH, residual chlorine and conductivity.

The analyzer transmitters and associated pipework shall be assembled into a GRP enclosure generally as shown on the Drawings.

The pH, chlorine and conductivity sensors shall be factory preassembled and wired including continuous flow through sensor assembly, provided with an isolation/flow control valve and a flow rate indicator inductive flow switch. The analyzer station shall have a 2" NPT process connection. Analyzer drain shall be piped to an external drainage system. Each sensor shall be clearly identified and labeled in the analyzer assembly.

B. Transmitters.

Each station shall be provided with two transmitters. The first one shall monitor residual chlorine and pH. Residual chlorine measurement shall be compensated for pH and temperature. There shall be separate current outputs for residual chlorine and pH. The second transmitter shall measure conductivity in micro mhos per centimeter. Conductivity measurement shall also be temperature compensated. A separate current output shall be provided for conductivity and temperature.

Transmitter shall be microprocessor based with programmable range and alarm functions. In-built self diagnostics shall provide sensor failure alarms.

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Transmitters shall be suitable for surface mounting. Enclosure protection shall be to IP 65. Power supply shall be 220 Vac, 50 Hz. Transmitter output shall be isolated 4-20 mA. Transmitter shall have a digital display for process variable, temperature, alarm status and fault conditions. Programming shall be through an in-built membrane keypad with tactile feedback. Programming shall be password protected. Transmitter shall be suitable for continuous operation in ambient temperature of up to 65°C and relative humidity of up to 95%. Overall transmitter accuracy shall be $\pm 1\%$ of the range.

C. Residual Chlorine Sensor.

The analyzer shall measure free residual chlorine without using buffers or reagents. Three electrode potentiostatic system with platinum counter and working electrodes silver/silver chloride reference electrode and constant abrasive grit electrode cleaning. The sensor shall have an in-built RTD Pt 100 temperature sensor for temperature compensation. Chlorine measurement shall also be pH compensated. Flow through type sensor shall be provided with a "T" fitting. The analyzer shall normally measure free residual Chlorine without using buffers or reagents. A buffer housing assembly and solid buffer cartridge shall be used in applications where the process exceeds 8.5 pH.

D. pH Sensor.

pH sensor shall measure the hydrogen ion activity. The electrode assembly shall comprise of a glass measuring electrode, reference electrode, solution ground and temperature sensor. Electrode assembly shall be provided with an integral preamplifier.

E. Conductivity Sensor.

Conductivity Sensor shall be suitable for flow through installation. electrodes shall be stainless steel Type 316, in Tefzel housing. In-built temperature compensation shall be provided.

8.3.4 POWER DISTRIBUTION ENCLOSURE (GRP ENCLOSURE) WITH ELECTRICAL REQUIREMENT

a).Materials

Enclosures shall be manufactured from polyester resin and "E" type glass reinforcement. The polyester resins used shall be in accordance with BS 3532 and shall include an Ultra Violet stabilizer.

b).Products

Glass reinforced plastic enclosures shall be supplied in accordance with the drawings, the specifications and approved shop drawings. The enclosure shall be identical at each location and sized to accommodate future telemetry equipment, minimum useable space shall be 900(W) x 470 (D) x 1480 (H) mm. A general arrangement drawing showing the position of internally mounted equipment shall be submitted to the Engineer for approval prior to manufacture of the enclosures.

c).Construction.

The enclosure shall be suitable for outdoor installation with an ambient temperature from 10°C up to 65°C, solar radiation 1200 w/m²., maximum humidity: 99% and shall provide protection against impact energy of 20 joules

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(hammer of 5 kg falling from a height of 400 mm) and with excellent resistance to corrosion and ultra violet rays complying to IEC 68.2.4 and IEC 68.2.5.

Enclosures shall be constructed to the dimensions and general layout shown on the Drawings. The enclosures shall be formed of resin bonded glassfiber inner and outer skins totally encapsulating a rigid core. The core shall be 12 mm thick weather proof plywood or 12 mm thick exterior grade resin bonded compressed pine-strand board. Large panel areas shall be stiffened by encapsulated ribs.

The enclosure shall be constructed to offer fire resistance (retention of stability, integrity and insulation) as required by BS 476: Part 7 Clause 2 and tested to Parts 20 and 23, in excess of 30 minutes. The contractor shall supply 3 copies of the necessary test certificates. The degree of protection of the enclosure against ingress of foreign matter shall be to BS EN 60947-1, IP55. All doors and covers shall be fitted with sealing strips of rubber or other material to exclude dust and moisture.

Doors shall be formed of a GRP/Plywood sandwich with box section steel encapsulated into the edges and frames. Doors shall be hung with hinges of substantial single knuckle non-rusting type and fitted with self locking stays arranged to hold them open at 90°. Door catches shall operate at a sufficient number of points to hold doors firmly closed and secured by externally fitted locking handles together with a securely fitted lock. A micro switch shall be fitted on each door arranged to provide a closed contact when the door is securely closed and an open contact when the door is opened.

Three master keys shall be provided for all cubicles and each enclosure shall be protected with guard rail safety fencing at no extra cost.

Space for DEWA Electrical Division metering equipment, associated protection, power distribution board and battery back-up equipment shall be provided in a separate full height section within the main frame of the enclosure complete with fire resistant mounting panel. Access to this compartment shall be from a separate door to the metering equipment and telemetry compartment. A suitably sized viewing window shall be fitted in the door to permit reading of the electricity meter without the need to open the door. The meter shall be positioned a minimum of 1.2 m from finished ground level. Plain internal holding down flanges at the base of the walls shall be provided for site drilling upon installation.

Anti condensation heaters shall be installed in both compartments, wall mounted and of robust construction. Mechanical guards shall be fitted to protect the heaters from accidental damage. The heaters shall be 220 volt and controlled by internally mounted humidistat and overriding On / Auto switch.

d).Finish.

Enclosures shall be self finished in a semi-gloss titanium oxide white finish providing a high level of resistance to ultra-violet light. The right-hand door of the enclosure shall have the DEWA monogram embossed in its bottom right-hand corner.

All external labels shall be in English and Arabic. Internal labels shall be in English only. A schedule of labels shall be submitted to the Engineer for approval prior to manufacture.

Internal labels shall be rear engraved perspex, backwashed to match the internal colour finish and fixed with countersunk screws. Every internal component shall be identified,

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the function of each circuit breaker shall be clearly identified. The use of stick on labels will not be allowed.

Warning and danger notices shall be engraved labels with red letters on a white background. Compartments with doors or covers, not interlocked with an isolator shall have an external label stating “DANGER LIVE TERMINALS” with flash sign and voltage underneath.

e).Internal Equipment Supports.

Internal equipment supports will be required for control, electrical and telemetry equipment. Such supports shall be designed and provided in consultation with the equipment suppliers and will be subject to approval by the Engineer.

f).Distribution Boards

The distribution board for small power, heating and lighting shall be mounted in the electrical compartment of the enclosure and be fed from a DEWA Electricity Division 380V, 3 phase supply. MCB's and residual current devices shall be fitted as shown on the Drawings

g).Lightning and Surge Protection.

A lightning and surge protection unit shall be installed at the supply termination point to protect the electronic equipment from mains borne surges. The unit shall be of modular construction and designed to meet IEC 801-5 levels 1 - 4 and IEC 364-4-443 AQ2.

h).Installation.

The enclosure shall be installed on a concrete plinth which shall incorporate ducts for incoming and outgoing cables. Separate ducts shall be provided for each service and for incoming and outgoing service. Ducts shall be sized to a maximum fill size of 40% of cross sectional area, minimum size 100 mm diameter, maximum size 200mm diameter.

Install GRP enclosures at such time as approved when construction and finish of adjoining work will permit and in sufficient time to avoid delays to construction progress.

Enclosures shall be mounted on a prepared surface in an approved position and in full compliance with the manufacturer's recommendations.

Holding down bolts shall be of appropriate size and not less than 6 No. The Contractor shall exercise care to avoid damage to reinforcing steel work and any abortive holes shall be grouted with a 3:1 sand cement mixture. Holes shall be drilled to the minimum depth required by the bolt and shall not penetrate a structural slab or cause any undesirable cracking or other damage.

The base of the enclosure shall be sealed to the bearing surface in a manner recommended by the kiosk manufacturer to ensure the designated IP rating is maintained. Existing concrete surfaces shall be carefully cleaned and prepared to ensure a proper bond with the sealing material.

i).Cabling

Cables shall comply with clause 8.6 and it's sub clause under this section.

Cabling shall include installation ducts as specified, laying, glanding, terminating at both ends and testing. Cable routes shall be subject to the Engineer's approval.

A 316 L Type stainless steel plate engraved in English and Arabic with the words "DANGER CABLE ENTRY BELOW" shall be permanently fixed to the outer side of the enclosure plinths above the cable entry location. Segregate power and signal cables.

Cables shall enter the enclosure below ground via pre-cast ducts within the plinth. As a minimum the following ducts shall be provided.

- Incoming power supply
- Fiber optics cable
- Outgoing local power distribution
- Analog signals
- Digital signals

All ducts shall be sealed using an approved sealing compound and to the approval of the Engineer. All ground areas shall be reinstated.

8.4 RTU EQUIPMENT

8.4.1 General requirements and design feature

- 8.4.1.1** *RTU's shall be of a proven design.*
- 8.4.1.2** *RTU shall support the maximum variety of the current available serial and Ethernet based protocols such as IEC870-5-101 IEC870-5-103, IEC870-5-104 master slave DNP3,MODBUS,MODBUS,PROFIBUS ,DH+, TCP/IP , OPC , etc. ,*
- 8.4.1.3** *All the RTU components and communication converters shall be robust modular construction suitable for use in an industrial environment.*
- 8.4.1.4** *RTU's shall be design to accept at least 10% voltage change &5% frequency change without any failure or performance affect.*
- 8.4.1.5** *The RTU shall provide 20% spare of all I/O points and communication ports.*
- 8.4.1.6** *The RTU design shall be compatible with the existing DEWA WATER SCADA CONTROL CENTER (MCC).*
- 8.4.1.7** *RTU's shall have maximum MTBF and minimum MTTR, contractor to provide calculations for MTBF & MTTR.*
- 8.4.1.8** *RTU's shall have the feature to store a unique address at its non volatile memory.*
- 8.4.1.9** *RTU' S design shall meet EES 1980 for Shock and BS2011 Part 2.1 FC & IEC 68.2.6 Test FC for vibration.*
- 8.4.1.10** *As a minimum configuration the RTU shall contain the following :-*
 - *One digital input module.*
 - *Two analog input modules.*
 - *4 pair of redundant MODBUS ports.*
 - *One port of PROFIBUS connection.*

8.4.1.11 *RTU enclosure shall be equipped with temperature monitoring device with two DPDT terminals one for temperature alarm , and the other for safe shutdown of RTU in case of temperature is exceeding design temperature of the RTU.*

8.4.2 RTU Functions

RTU's shall be capable of the following functions as a minimum:

- A. Data Acquisition
- B. Data Recording and Tagging
- C. Alarm Management
- D. Data Handling
- E. Sequence Control
- F. Data Processing (Including Maths Functions)
- G. Self Diagnostics
- H. Communications Control
- I. Local data entry via integral keypad or similar
- J. Local LCD display for the display of plant signals and RTU status.

Each RTU shall have a battery backed real time clock capable of maintaining an accuracy of ± 1 second per day.

8.4.3 RTU enclosure labels

A single scheme identification label shall be securely fastened to the RTU of the RTU enclosure.

The label shall show:

- An appropriate address & phone number to be stipulated by the Engineer.
- RTU type, serial number and any other references necessary to uniquely identify the RTU.
- Operating voltage/frequency/current.
- “Authorized Access Only”

8.4.4 RTU POWER SUPPLIES

Power supplies for RTU's shall be fully protected against reverse polarity, overvoltage, undervoltage and other faults.

Conditioning shall be inherent in the power supply design to protect against voltage transients and mains-borne radio-frequency interference typically found in an industrial environment from entering the processing logic circuits.

RTUs shall be capable of monitoring their power supply as part of the watchdog function, and reporting an incoming power supply failure as an RTU alarm. This shall not utilize any of the signal inputs/outputs.

8.4.5 Voltages

- All mains powered RTU's shall operate on 220 volts $\pm 5\%$, 45 to 65Hz a.c. Any additional enclosures, transformers or circuit-breakers required to meet the relevant standards shall be included in the tender.
- In the event of any supply voltages A.C. or D.C. being outside the allowable range the RTU shall not operate in a non deterministic manner.
- All mains powered RTU's digital inputs shall be sourced from the RTU at not greater than 28 volts D.C. And not less than 15 volts dc. The source supply shall be isolated from all other RTU circuits
- At solar sites the tenderer shall specify the mechanism for optimizing power usage.

8.4.6 Battery Backup

All RTU types shall be provided with an integral battery separate from all other batteries to protect the RTU from loss of data and to maintain the real time clock.

In addition RTU's shall be supplied complete with a battery sized to provide the following minimum functionality for 8 hours following a mains failure.

- Monitoring of all digital inputs, and pulse inputs.
- Scanning all analogue inputs.
- Holding all digital outputs in the same position immediately prior to mains failure.
- Holding all analogue outputs at their values immediately prior to mains failure.
- Receive or initiate 12 calls a day with the masterstation.

The RTU shall transmit a battery low alarm to the masterstation if the battery falls within 10% of its minimum operating voltage. This shall not utilize any of the signal inputs/outputs.

It shall also be possible to automatically load test the battery while under mains supply and report the condition of the battery to the Masterstation.

The battery shall be automatically recharged by the RTU on restoration of the mains supply within 12 hours.

It shall not be possible for this battery backup to be inadvertently switched off.

This battery can either be mounted inside the RTU enclosure or in a separate enclosure. If supplied in a separate enclosure, it shall be supplied complete with 5 meters of cable to connect the battery to the RTU. In all cases the Contractor shall be responsible for the design of the system including venting. The battery enclosure shall be of identical IP rating to the RTU enclosure.

8.4.7 SIGNAL INPUTS AND OUTPUTS

The details in the following sections apply to all RTU types.

All signal inputs and outputs shall be protected to meet as a minimum the requirements of IEC 801. The contractor shall state the performance criteria which the RTU complies with respect to the above standard.

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Local information shall be available to show what I/O modules are fitted and their status. This information shall also be made available to the Masterstation.

1) Digital Inputs

A digital input shall mean the detection of the closure or opening of a remote volt-free and earth-free contact for a software configurable period of at least 250 milliseconds.

If possible any of the digital inputs shall be able to be used as pulse inputs.

Maximum contact resistance (closed contacts) should be better than 180 ohms. Minimum contact resistance (open contacts) should be better than 50K ohms.

Isolation between inputs and incoming 220V supply shall be > 1000V ac peak and > 1000V dc.

Isolation between inputs and all other RTU interfaces shall be > 500V ac peak and > 500V dc.

2) Digital Outputs

This shall be a volt free relay contact configurable for either normally open or closed in the de-energized state, which when driven shall either go to the opposite state continuously or for a software configurable period of time (minimum 2 seconds).

The rating of the contacts shall be 100mA 24 volts D.C inductive load, or 500mA 55 volts 50Hz A.C resistive load.

The relay shall be rated for 10^6 operations.

Isolation to be as for Digital Inputs above.

The relay driver circuit shall be capable of monitoring by the RTU for correct operation.

3) Analogue Inputs

a) Noise Rejection

1. Common mode noise rejection shall be greater than 80 dB, measured at 50 Hz $\pm 1\%$.
2. Series mode noise rejection shall be greater than 40 dB, measured at 50 Hz $\pm 1\%$.

b) Accuracy

A minimum of 14-bit analogue to digital conversion shall be used providing resolution of at least 1 in 16,384. Overall conversion accuracy measured from the RTU terminals shall be linear and better than 0.15% of full scale under operating conditions specified elsewhere in this specification.

c) Input Impedance

Minimum of 200k ohm on any voltage channel. Maximum of 250 ohm on any current channel.

d) Cross-talk

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Better than 50dB at 50 Hz \pm 1% between any channel, no electrical connection between current loops.

e) Ranges

As a minimum the following input ranges shall be provided:

- 0-5 volts and 1-5 volts D.C on voltage channels for mains RTU's.
- 0-20mA and 4-20mA D.C on current channels for mains RTU's.

f) Isolation

As for digital inputs above, and to include channel to channel isolation of $> 500V$ ac PK $> 500V$ dc.

4) Analogue Outputs

a) Ranges

As a minimum the following output ranges shall be provided:

- 0-20mA
- 4-20mA

b) Loop Compliance

The integrity of loop signal shall be continuously monitored and if the loop impedance exceeds the drive capability the fault shall be reported to the masterstation. Such faults shall also be displayed locally.

c) Load Impedance

The output shall be capable of driving into 0 to 1200 ohms independently on each channel.

d) Resolution

D to A converter 16 bits.

e) Protection

Each A.O. shall be capable of withstanding indefinitely short circuiting or open circuiting.

f) Accuracy

Overall conversion accuracy of 0.2% of full scale over the operating temperature range stated elsewhere in this specification.

g) Settling time shall be better than 1 mS.

h) Isolation

To be as for analogue inputs above.

i) Latching.

In the event the analogue signal is lost, the plant (e.g. valve actuator) shall hold the position (fail safe). Each analogue output latching requirements shall be reviewed against actual site operational requirements prior to implementation.

5) Pulse Inputs

Each of the digital inputs will be able to be utilized as pulse inputs i.e. being able to count the number of contact closures or openings.

All pulse inputs should have the following characteristics:

a) Count Rate

Maximum 20Hz.

b) Count Capacity

Up to 9,999,999 plus a roll over count.

c) Reset

Each counter shall be able to be reset to zero or preset to a user selected value from the Masterstation by a suitably privileged user at a workstation or as part of a user program running within the RTU.

d) Filtering

The pulse input shall include the necessary circuits to prevent spurious counts from poor waveforms and spurious line interference likely to be found within an industrial environment.

e) Wetting Voltage

As for digital inputs.

6) Local Keypad/Display

The RTU shall include a keypad/display to provide the following as a minimum:

- Display of RTU I/O in the form of meaningful descriptions with status or units.
e.g. Upstream Pressure 30 bar
- Display of the RTU communications status
- Resetting of RTU

- Diagnostics data
- RTU time

8.4.8 SOFTWARE REQUIREMENTS

- a) RTU Software shall conform to the requirements of IEC 1131-3.
- b) Mains Failure
 - i) In the event of a mains failure and after expiry of the battery back-up , the manufacturer's operating software shall be arranged to provide an orderly shutdown.
 - ii) Upon restoration of the supply, the RTU shall restart in an orderly, operationally safe manner by performing self-check routines in readiness to continue as required by the users programmed instructions without intervention.
 - iii) Upon the detection of failure and restoration of mains power, the RTU shall send an appropriate message to the Masterstation.
- c) Alarms and Events

The system shall be able to detect/generate the following types of alarms at the RTUs.

i) Status Alarms

Each change to status or derived status shall generate an event which, if so configured, shall be reported as an alarm. It shall be possible to assign a separate time delay to each status point for which an event has to persist before being reported as an alarm. This delay shall be configurable from 0 to 900 seconds.

ii) Analogue Value Alarms

Each analogue shall have a minimum of four thresholds or limits. If an analogue or derived value transgresses any one of these limits, an event shall be generated which shall be able to be reported as an alarm. Each threshold transgress shall be a separate alarm e.g. high high, high, low, low low. However, whether the alarm state is higher or lower than the threshold shall be configurable such that any threshold could be a high or low alarm as required. It shall be possible to assign a separate deadband to each analogue point which shall apply to all four associated thresholds. It is desirable that separate deadbands should be assigned to each threshold for each analogue point. These limits are in addition to those in (D) below.

iii) Derived Alarms

The system shall have the ability to test against a combination of values and/or states and detect an alarm, It shall provide detection, for example, of valid pump running combinations.

RTU alarm processing shall enable combined events or alarms to be derived which shall be reported with a different priority than the constituent alarm or events.

iv) Profile Alarms

Profile alarms shall be provided to test analogue values against diurnal profiles i.e. a series of thresholds variable with time.

The facility shall test analogue values (e.g. a level) against a profile of thresholds and shall report alarms when the value transgresses the threshold after a value and time deadband period.

Profile alarms shall take the form of up to four discrete threshold points (high high, high, low and low low) the values of which shall be determined at a configurable interval, typically every 15 minutes, over a 24 hour period. This shall constitute a single daily profiles.

The RTU alarm management process shall compare downloaded profiles with the measured plant parameter and produce an alarm if a violation exists. Normal deadband facilities shall be applied in this case.

Profiles shall be downloaded manually or automatically. There shall be the option to download the previous week's validated data, for each day of the week, with assigned values for each (e.g. 15 minute) increment. Seven days profile data shall be stored at the Masterstation and the system shall maintain between 24 and 48 hours of profile data in the RTU. As a default, on failure to receive an updated profile the RTU shall revert to the start of the existing profile.

Users shall be able to create profiles by copying logged or archived validated operational data to form a single 'baseline' for the set of profile thresholds i.e. one value for each 15 minute interval. The system shall generate the thresholds above and below the baseline profile over the profile duration from either a global difference or a fixed percentage deviation of the full scale, e.g. high high shall be \pm 5% high +3% etc.

The user shall be able to edit the baseline profile and the threshold levels for each interval in order to fine tune the profile. It shall not be acceptable to require users to enter every individual threshold point at each interval.

v) Rate of Change Alarms

There shall also be the facility to generate alarms on the exceeding of a preset change of value with time. It shall be possible to define alarms on any of: rate of rise; rate of fall; minimum rate of change required, i.e. alarm on no change when an instrument has failed. Rate of change alarms shall also be definable for pulse count values.

vi) Receipt of data from a RTU after restoring a communications failure

All active mimics (graphic displays) shall show only the last recorded status and values following a restoration of a communications failure. All active trends shall show current and previous values. Alarm lists shall show present and past alarms that were not recorded during a failure. A facility shall be provided to select past data for display after a restoration.

vii) **Alarm Suppression**

The supplied system shall include facilities within the RTU to prevent the occurrence and subsequent reporting of “nuisance” and spurious alarms. A privileged user shall be able to suppress alarms for a single point and for a whole RTU. Facilities shall also provide such that a primary alarm which is followed by consequential secondary ones can be flagged with an identifier to suppress the secondary alarms when the primary occurs.

RTUs are to record failed attempts at communications with a Masterstation. This data shall be part of the RTU data polled by the Masterstation and used to report and record communications failures to the System Managers.

viii) **Alarm Tagging**

Each alarm shall be tagged in its originating RTU with a source identifier and the time and date of occurrence. Likewise the time and date of the alarm returning to normal shall also be recorded in the RTU for use in the Masterstation.

ix) **Data and Event Tagging**

Data and events for local storage and subsequent transmission from the RTU shall be tagged with the time and date at the RTU.

d) **Data and Recording and Storage**

i) **Analogue Variables**

Sufficient capacity shall be provided to store in a fully tagged form the instantaneous, maximum, minimum and averaged value of each analogue, as well as pulse inputs at each type of RTU.

The period between samples shall be configurable, typically 15 minutes for which storage shall be available for at least 7 days. It shall be possible to increase the sample rate to a maximum of every minute. The RTU shall contact the Masterstation to initiate the transfer of the stored data when the memory allocated to analogues has been 80% utilized since last read by the Masterstation.

ii) **Events**

Sufficient memory capacity shall be provided to store in fully tagged form all events (including alarms). The memory shall be sized to allow a minimum of 20 events per input and output from the RTU or a 1000 events total, whichever is greater, per 24 hours. 7 days storage shall be available. When the event storage is 80% full the RTU shall contact the Masterstation to initiate the transfer of the stored data.

iii) Profiles

It shall be possible to store daily analogue profiles for alarm purposes for 25% (with a minimum of two) of the analogue inputs at the RTU types:

Profiles shall be structured and utilized. Profiles shall be downloaded from the Masterstation and will normally be downloaded daily or on request.

iv) D. Tables

RTUs shall be capable of receiving and storing for operational control, through user sequence programs, tabular data such as look up tables for pumping regimes.

It shall be possible to download the tables from the Masterstation.

v) Memory Expansion and Allocation

Memory allocations for data storage shall be dynamic and not tied to a particular input or output. Memory allocated to user functions shall be user configurable.

Memory allocated to data storage should be used in the form of a circular buffer such that the oldest data is overwritten by the newest data once the buffer is complete. All data shall remain available to the Masterstation or portable terminal users until it is overwritten in this way, irrespective of the number of times it has been read by any device.

8.4.9 Programming

a) General

The user shall have the capability within the software to monitor inputs, control outputs using logical sequences, derive data from monitored analogue and status data, manipulate data (real or derived) such that the Purchaser can operate and monitor his plant in accordance with the requirements and intent of this Specification.

The RTU shall be capable of executing a program created by the user in a high-level language at a portable terminal locally or at any workstation and downloaded remotely by means described elsewhere in this specification.

For ease of commissioning and maintenance it shall be possible to store RTU programmes within E²PROM memory such that the programmes are loaded on powerup of an uninitialized RTU. However, application program changes shall be changeable without the need to change RTU hardware (EPROMS etc).

b) Language Structure

The high level language shall be structured and shall have as a minimum the following attributes:

1. Single statements
2. Combined statements
3. IF..., THEN..., ELSE... type statements
4. Do...WHILE looping constructs
5. Do...UNTIL looping constructs
6. Full arithmetic capability (+, -, x, E, root extraction, logical comparisons, boolean, integration, integer and floating point operations)
7. Scaling functions
8. 30 characters of explanation text for each program line
9. 30 characters of explanation text for each Procedure
10. Timers
11. Remarks
12. Labels
13. Variables, typed according to data types available, including tables as 1 and 2 dimensional arrays. Conditional looping or branching constructs shall be nestable up to at least 3 levels.

8.4.10 COMMUNICATIONS

a) General

It is intended that RTUs shall have flexible communications facilities using industry standards to enable simple future expansion and modifications to networks of RTUs, other terminals and automated plant. Section describes the scheme communications in detail.

b) Local Communications

RTUs shall be fitted with a V24/RS232 port for use with a portable terminal, in addition to ports required for networking with other RTUs and communications with a Masterstation.

8.4.11 MAINTENANCE, CHECKING AND FAULT FINDING FACILITIES

a) General

The Contractor shall offer a portable terminal which can be used for programming, maintenance and test of the RTU's.

b) Self Diagnostics

i) Startup Self Check

Each RTU shall have self check features that shall be performed on start-up of the RTU. These self checks shall include RAM verification and sub-system addressing checks.

ii) Interval Self Check

The RTU shall perform self checks whilst operational. Each check during operation shall be repeated at a minimum rate of once every thirty (30 seconds). The self check shall include ADC over-range checks and overflows or negative totalizer within the applications software.

iii) Self Check Alarm Generation

Failed checks which occur during start-up or at intervals shall be passed to the Masterstation as a system alarm.

iv) Input Check

The RTU shall perform continuous monitoring of inputs during I/O scans to establish that the incoming signals are not out of range. The alarm dead bands shall be user configurable. A failed check shall be passed to the Masterstation as an alarm. Provision shall be made to confirm alarms by repeat input monitoring prior to alarm generation. This facility shall operate on all digital input and individual analogue inputs if so configured.

v) Maintenance Mode of RTU

Facilities shall be provided which will inhibit alarm dial outs when either the RTU itself or instruments connected to it are undergoing maintenance or repair.

This mode shall be initiated by an integral switch, and may be arranged to expire on a timeout if the switch is not reset.

c) Debugging of Programs

The following facilities shall be the minimum:

- i) A debugging facility shall be provided from a local terminal. The facility shall be able to monitor, interrupt and override the programs flow or control.
- ii) Monitor/Trace. It shall be possible for the user to monitor which statements are executed.
- iii) Program Halt. It shall be possible to halt a program at predefined statements whilst under the control of the debugging facility. A message stating clearly the current position in the program shall be displayed whenever a program is halted.
- iv) Skip/Jump. Once the program has been halted, as in (C) above, it shall be possible to jump to any point in the program and commence execution from that point.

- v) Single Step. A single step function shall be provided.
- vi) Variables. The debug facility shall allow monitoring of variables as an online facility. The Contractor shall provide a facility which notifies the user whenever selected variables change their value. The facility shall also specify at what point in the program the change occurred. The user shall be able to select which variables are to be monitored. The debug utility shall also include the facility which allows the user to interrogate any variable. The user shall also be able to alter the value of any variable.

8.5 COMMUNICATION

8.5.1 TYPES OF COMMUNICATIONS MEDIA

The actual type of communication medium for each RTU site will be determined by the Employer and specified for individual RTU's. This sub-section outlines the different communications media that will be used.

- Public Switched Telephone Network (PSTN).
 - 1. The exchange lines to control centers shall be provided with 3 dB guaranteed loss. The Contractor shall use the number of lines required to achieve this for the capacity stated. Lines shall be grouped as incoming traffic only (i.e. alarms), outgoing traffic only, and common. All the incoming and common lines will constitute a joint hunt group. It shall therefore be possible for alarm traffic to be received by the control center on all the incoming and common lines when the later are not in use for polling or other outgoing traffic.
 - 2. The facility shall be available within RTU software for RTU's to be programmed to call the control centers automatically, at periodic user configurable intervals, in order to provide user confidence in the RTU and PSTN availability.
- Leased Lines or Private Wires. Leased line circuits to the following specification shall be provided:
 - 1. ETISALAT standard analog or digital data circuits capable of supporting a data transmission rate of 9.6 kbps shall be provided for RTU communications.
 - 2. ETISALAT approved Digital Terminal Units (DTU) shall be provided for all digital circuits.
- Low Power Radio Telemetry to the MPT1309, 1328/29 Standard. Radio equipment manufactured to these standards shall be used for communications between RTUs over distances up to 5 kms and more i.e. point-to-point.

- **Fiber Optic Network.** The fiber optic network will be utilized for communication with the RTUs to MCC. The data interface and terminal equipment specifications are covered in Section 17.6 - Interfaces & Network Communication chapter as part of the general data communication requirements.
- Network radio links with MCC shall be established for RTU sites where PSTN, leased lines and Fiber Optic networks are not available.
- Other technologies such as GPRS ,GSM, VSAT .
- The Contractor is responsible to conduct the survey for the RTU location and suitable communication media required as mentioned in the Volume 3 of the tender.

8.5.2 RTU COMMUNICATIONS PROTOCOL

- General
RTU should support most common standard protocols including IEC870-5-101 IEC870-5-103, IEC870-5-104 master slave DNP3, MODBUS, MODBUS, PROFIBUS, DH+, TCP/IP , OPC , etc.
The contractor shall propose the RTU communications protocol during the design stage including method of integration to the existing DEWA MCC.
- Error Checking (Error Detection/Automatic Repeat Request).
Error detection, using a Cyclic Redundancy Check (CRC) polynomial will be preferred. The CRC shall be of not less than 8 bits and contain a 'x+1' term. In the case of detection of error in a packet, it shall be possible to request transmission of the faulty packet only, and not retransmission of the whole message.
- Security and Privacy
The protocol shall be devised such as to avoid unauthorized interference to the RTU or control center by a person with a modem set to correct speed, parity and stop bits. The protocol shall use a password key protection system, and data link frame format techniques.
- Interference Rejection
The communications system shall be designed to cope with temporary interruptions on a line caused by interference.
- PSTN Communication
 - 1) **Call Set-up.**
Initiation of routine PSTN calls is to be from the MCC. However the RTU shall also dial the MCC to transfer data on alarms, or perform an RTU on-line functional test.
 - 2) **Signaling.**
Signaling shall normally be loop disconnected at 10 impulses per second with a 1:2 make/break ratio.

3) **DTMF Signaling.**

For all types of RTU's, it shall be possible to change the RTU signaling to DTMF signaling.

4) **Auto Dialing and Answering.**

Auto-answering and auto-dialing shall be provided as standard. The auto-answering sequence shall be to ITU recommendation V.25. The V.25 sequences to be used for PSTN only.

i) **Number Storage.**

The RTU modem shall be capable of storage of not less than 6 pre-coded 16 digit numbers. These numbers shall be remotely configurable, although fall back numbers shall be held in non-volatile memory to be loaded on power-up after sustained power failure.

ii) **Disconnection of Line.**

Automatic disconnection of the line shall take place following loss of Data Terminal Ready (DTR) loss of carrier or loss of data activity, if not initiated by the RTU. In addition, the RTU's shall disconnect the line after an EPROM programmable time regardless of other configuration parameters to prevent holding lines that are noisy.

• Leased Line/Private Wire Communication

1) The protocol shall permit the operation of RTU's in single site configuration in private wires and polled for data via a single port on the MCC.

8.5.3 INTERFACES

• General

a) RTU's connected to the MCC via analogue circuits shall employ integral modems. For certain media a digital interface may be available on the communications circuit equipment e.g. low power radio. For such equipment a digital interface between telemetry RTU's and the communications circuit shall be provided

b) Impedance matching and amplifications shall be incorporated in modems connected for multipoint operations. This is to avoid degradations of signal level.

• Analogue Circuits

1) PSTN.

The termination for the PSTN circuit shall be via an approved standard ETISALAT line connector.

2) Leased Line and Radio Circuits.

Two-or four-wire operation shall be selectable. Termination for circuits shall consist of an approved line termination unit with on board surge protection.

- 3) Termination Impedance
Termination impedance to line shall be 600 ohms \pm 10% balanced.
- 4) Lightning Protection.
PSTN, leased line/private wire communications circuits at MCC, and RTU sites shall be fitted by the Contractor with a self resetting lightning arrestor, approved and in accordance with Clause 18.06 and barrier transformers wherever necessary.

8.5.4 COMMUNICATION EQUIPMENT

- General Considerations
 - 1) Rack Mounting.
Where multiple items exist, the use of standard rack mounting shall be assumed.
 - 2) Enclosures.
All communications equipment shall be installed in suitable equipment enclosures.
 - 3) Safety.
All items of equipment shall confirm to the relevant safety detailed elsewhere in this specification.
- Indication Provided
 - 1) Illuminated indications shall be provided to confirm the presence of the following conditions:
 1. Carrier detect
 2. Data transmit/receive
 3. Diagnostics
 - 2) These indications shall be mounted on the front panel if the modem is rack-mounted, on the PCB if the modem is incorporated with the RTU, or on the radio front panel if the modem is integral to the radio equipment.
 - 3) For stand alone modems a 'power on' indication shall be provided in addition to those indications referred to above.
 - 4) Equipment alarms shall be wired and appeared on the cubicle alarms and reported to MCC.
- Diagnostics

Diagnostic facilities shall be provided on all communications equipment to meet the availability requirements.

8.5.5 CONNECTION APPROVAL TO PUBLIC TELECOMMUNICATION SYSTEMS

- Approval

All modems, DTUs and other line termination equipment shall be approved for use on the ETISALAT network, requests for approval shall be submitted to ETISALAT within 4 weeks of the Contract Start Date, and no installation shall commence until said approval is granted.

- Training

Training shall be given to DEWA staff for the operations and maintenance of data flow through PSTN and dedicated lines.

8.5.6 NETWORK COMMUNICATIONS

- Introduction

The purpose of the communications network is to transport data between the various components of the overall system. The requirements imposed on the communications network are based on the functional requirements. In order to provide reliable, flexible and cost-effective data transport solution to meet the specified diverse requirements, the communications network architecture has been split into the following categories:

- Remote Terminal Unit (RTU) Communication Network.

This is between RTU's and control centers. It is to be based largely on fiber optic, the Public Switched Telephone Network (PSTN), leased lines, and radio links.

The Contractor shall be responsible for making applications and arranging with Local PSTN Provider for provision of the necessary communications links and licenses to operate the equipment.

The Contractor shall make applications as necessary to the Ministry of Communications (MOC) for allocation of frequencies for all radio communications links, as specified. Operating licenses shall also be obtained for all radio equipment to be installed under this Contract.

- Optical Equipment

1. Optical Cables.

Each optical fiber underground cable shall comprise of twelve (24) number of fibers. Optical fibers shall be of Single Mode (SM) type. Each fiber shall be designed for operation for dual window at nominal wavelengths of both 1300 nm and 1550 nm. However, the fibers shall be optimized for operation within 1300 nm single window. Scope of Supply for the optical links shall include, as a minimum, but not be limited to:

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- a) Non Metallic Armored underground optical fiber cable, suitable for direct burial.
- b) Buried splice joint boxes with water proof, heat proof, pressure proof, rust proof and environmental protection enclosures for straight jointing the fiber underground cable.
- c) FDP within each RTU panel/substation, to accommodate fiber splices between underground fiber cable and flexible termination cable. Fiber distribution panel (FDP) shall accommodate fiber splice boxes which join the underground fiber cable to flexible termination cable. Type and details of FDP are subject to DEWA approval during engineering stage..
- d) Flexible termination cables with appropriate optical compatible demountable connectors terminated in optical distribution frames which shall be housed in a cubicle. This shall form the final connection between the splice box and optical terminal equipment.

2. Optical Fibers.

All fibers shall be of the SM type and shall comply with International Telecommunications Union (ITU) Recommendation G.652 and the requirements detailed below (the fibers shall be entirely suitable for jointing by means of automatic fusion splicing technique):

- a) **Fiber Material.**
The fiber shall be manufactured from high grade Silica and doped as necessary to provide the required transmission performance. The chemical composition of the fiber shall be specifically designed to minimize the effect of Hydrogen on the transmission properties.
- b) **Fiber Coating.**
The primary coating shall consist of an inert material which can be readily removed for jointing purposes without damage to the fiber and without necessitating the use of hazardous chemicals. A secondary coating may be applied directly over the primary coating or alternatively a loose jacket may be provided. Where a tight fitting secondary coating is provided it shall consist of an inert material. The secondary coating of loose tube shall be color coded throughout the length of the cable. The secondary coating shall be capable of withstanding normal handling during termination. The fiber coating shall be translucent such that fiber splicing techniques, using optical alignment of cores by means of injection and detection of light through the cladding, shall be supported. In addition, the fiber coating shall be optically matched to the cladding to promote cladding mode stripping. The composition of the cable shall be specifically designed to reduce the production of Hydrogen gas and to prevent the migration of Hydrogen and water into the fiber.
- c) **Fiber Geometry.**
The mode field diameter shall be $10 \mu\text{m}$ with a tolerance of $\pm 1 \mu\text{m}$. The mode field non-circularity shall be less than 6%. The mode field concentricity error shall be stated by the Tenderer and shall fail within the

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limits of 0.5 μm to 5 μm . The fiber cladding diameter shall be 125 μm $\pm 2.4\%$. The cladding non-circularity shall be maximum 2%.

d) **Fiber Attenuation.**

Those optical fibers to be provided within the scope of the Contract shall have an average attenuation co-efficient (per optical path) not exceeding 0.4 dB/km at 1300 nm and 0.3 dB/km at 1550 nm. Variation of fiber attenuation at different temperature profile shall be according to relevant ITU Recommendations.

e) **Cut-off Wavelength.**

The cut-off wavelength of fibers shall lie in the range 1100 to 1280 nm, as measured by the Reference Test Method detailed in ITU G.652.

f) **Dispersion Co-efficient.**

The fibers shall be optimized for operation at 1300 nm such that the total dispersion co-efficient is nominally zero. The dispersion co-efficient at 1300 nm shall not exceed 6 pc/km.nm. The Tenderer shall state the dispersion co-efficient at wavelengths of both 1300 nm and 1500 nm for dual window working.

3. Fiber Joints

a) **Fusion Splices**

- a. All fiber joints shall be of the fusion type, except where demountable connectors are specified.
- b. Fusion splicing shall be carried out by trained personnel using automatic fusion splicing equipment designed for the fiber type. Fiber ends shall be prepared for splicing using methods and tool recommended by the fiber and splicing equipment manufacturers. The cleanliness and accurate cleaving of fiber ends shall be ensured prior to splicing.
- c. The accurate alignment of fiber cores, prior to splicing, shall be verified using a technique that monitors the optical power transmitted across the splice interface. Fusion splicing shall be commenced only after manipulations of fiber alignment have maximized the transmitted power.
- d. Fusion splice optical losses shall average at no more than 0.05 dB per splice.
- e. Splices shall be mechanically strengthened and protected from the environment by means of purpose designed splice sleeves or enclosures. The finished splice shall be supported within the buried splice box by means of suitable clips or restraints. It shall be possible to remove and replace the splice in the support device without risk of damage to the splice or fiber. The cable splice box shall be buried and contained in water and heatproof enclosures.

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f. Each fusion splice shall have spare length of fiber on either side of approximately 1 m associated with it. This excess fiber shall be coiled neatly and clipped (or otherwise retained) within the splice box.

4. Demounted Connectors

- a. Demounted connectors of compatible optical connectors shall be fitted to each fiber at the termination of each optical link.
- b. The connectors shall be factory assembled in strict accordance with the manufacturer's instructions. The completed terminations shall be examined and tested at the factory to verify compliance with the manufacturer's published performance data. Substandard and defective terminations shall be rejected and the fiber reterminated.
- c. Demountable connectors shall be protected against contamination and mechanical damage during shipment and site installation of the associated cable. Fibers terminated in optical fiber distribution cubicle at each site shall be ferruled, named for identification.

5. FDP within Buildings

- a. FDP shall be wall mounted within the building, adjacent to the terminal equipment with which the optical link is associated; the precise location shall be agreed with the Engineer at site.
- b. FDP shall be provided for each optical link and shall accommodate the fiber splices between the fiber cable and the flexible termination cable. It shall be fitted with suitable cable clamping glands at its base for the purpose of cable entry.
- c. The box shall be suitably dimensioned to accommodate the excess loops of optical fiber associated with each splice. Splice cassettes or other approved methods shall be used to provide mechanical support for the splices and to afford a means of neatly retailing the excess fiber.
- d. FDP box shall be of welded sheet steel construction, finished internally and externally using a durable paint system. Access to the box shall be by means of a hinged door or a bolted front panel. Where a hinged door is fitted, access shall be impeded by use of bolted closures. The FDP shall be fitted with an approved identity label (e.g. engraved laminate).
- e. Ends of the armored cable shall be straight jointed in enclosure and buried. The enclosure should be water and heat proof. Ingress of water into the joint box due to breakage by heat expansion is not permissible. It shall be with self-bonding and

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waterproof tapes, heat shrinkable sleeves, clamps, fiber guides and with all necessary accessories. On either side of the splice joint box, sufficient length of optical cable shall be coiled with proper precaution not to damage the cable.

6. Fiber Distribution Panels

Fibers in each fiber cable provided with demountable connectors shall be terminated in FDPs at both ends. They shall be patched at intermediate points with optical patch cords to fibers coming from different directions as specified.

7. Splice Boxes within Substations

Splice boxes shall be mounted within the substation building, adjacent to the terminal equipment with which the optical link is associated; the precise location and type (wall mounted or stand alone) shall be agreed with by DEWA.

A splice box shall be provided for each optical cable and shall accommodate the fiber splices between the fiber cable and the flexible termination cable. It shall be fitted with suitable cable clamping glands at its base for the purpose of cable entry. The box shall be suitably dimensioned to accommodate the excess loops of optical fiber associated with each splice. Splice cassettes or other approved methods shall be used to provide mechanical support for the splices and to afford a means of neatly retaining the excess fiber. The splice box shall be of welded sheet steel construction, finished internally and externally using a durable paint system with the final coat colored RAL 7032. Access to the box shall be by means of a hinged door or a bolted front panel. Where a hinged door is fitted, access shall be impeded by use of bolted closures. The splice box shall be fitted with an approved identity label (e.g. engraved laminate).

Ends of the cable shall be straight jointed in enclosure and buried. The enclosure should be water and heat proof. Ingress of water into the joint box due to breakage by heat expansion is not permissible. It shall be with self bonding and water proof tapes, heat shrinkable sleeves, clamps, fiber guides and with all necessary accessories. On either side

8. Installation in Ducts and on Cable Trays

The optical cables installed under this Contract shall be run in cable ducts. Within the building, the Contractor shall neatly install the major runs of cable upon cable trays or racks. The cables shall be affixed to cable supports using approved ties, clips or cleats at regular intervals. The Contractor shall supply and install all necessary cable ducts and construct joint chambers and hand holes where necessary.

- a. Paying out of optical cable shall be by standard means e.g. roller. Maximum pulling force and bending radius employed during paying out and commissioning shall be according to cable specifications.

- b. On short runs of cable, for which cable supports are not provided, the Contractor shall fix the cable to the structure of the building using approved fixings and cable cleats. Alternatively, the Contractor may supply and install cable supports for his own purpose.
- c. The Contractor shall be responsible for forming holes through walls and floors for the installation for his cables. Any making good and sealing of such cable transits shall also be the responsibility of the Contractor.
- d. Cables existing at the ground or passing through floors shall be protected against mechanical damage for a distance of 450 mm above finished ground or floor level.

9. Termination Cables

- a. A termination cable is defined as that cable installed between the splice box at the end of the armored fiber cable and the optical termination equipment.
- b. The termination cable shall be of flexible and rugged construction, suitable for installation within floor voids at the buildings. The cable construction shall incorporate strength member(s), fiber buffering (bedding) and a tough jacket. The fibers shall be entirely compatible with those of the approach cable to ensure good optical and physical fusion splicing properties.
- c. Each termination cable shall be supplied in a performed length with demounted connector. A minimum allowance of 10 m shall be made for the length of each termination cable.

10. Cable Construction.

The cable core shall be covered with a layer of tape and shielded with Aluminum foil laminated on both sides with PE. Intermediate sheath shall be black PE and armored with a layer of galvanized round steel wires. Outer sheath shall be black PE. The cable shall be suitable for use in the prevailing climate in UAE and for an induced voltage up to 15 kV. The thickness and chemical properties of PE sheath and armor shall be according to relevant IEC standards. Fiber cable construction shall be agreed by DEWA during engineering .

11. Fiber Insulation Colors.

DEWA Standard Color coding system shall be used to mark the fibers. The thickness and chemical properties and color coding of the fiber insulation shall be according to relevant standards and shall be furnished to the Engineer for approval.

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Color Scheme of Loose Tubes:-
Colour Coding

1-	Red	}
2-	Blue	
3-	Green	
4-	White	
5-	Yellow	
6-	Grey	

for 24 fibers cable

Color Scheme of 4 Fibers:-

1-	Blue
2-	Green
3-	Red
4-	Yellow

12. Mechanical Properties.

Such as crush strength, maximum pulling force during installation, minimum bending radius in pulling, final installation and method of paying out the optical underground cable shall be finished by the Contractor.

13. Identification

- a. The PE oversheath shall be embossed in English along two lines equally spaced around the circumference of the cable with the name of the manufacturer and year of the manufacture followed by:
“DEWA (WD) OPTICAL FIBER CABLE”
- b. The PE oversheath shall also be embossed on the circumference of the cable indicating cumulative marking length of the cable wound on the drum. The marking starting with “0000” on the inner end of the cable shall indicate actual length of the cable in drum.
- c. The Contractor shall supply information of drum lengths of the cable supplied unless shorter lengths are specified or are required to complete specific order.

14. Testing.

All testing shall be subject to witnessing by the Engineer. Test results shall be formally documented and submitted for approval.

- a. **Factory Testing.** Factory testing shall be carried out in accordance with procedures defined in ITU G.652 and IEC 793-1. The test shall verify the parameters of dimensions, attenuation co-efficient, mode field diameter, cut-off wavelength and dispersion coefficients. A test shall be carried out to verify the temperature withstand capability of the optical fiber.

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- b. **Site Testing.** Site testing shall comprise the following tests, to be carried out for each individual fiber link:
 - a. Link attenuation at 1300 nm and 1500 nm wavelengths.
 - b. Fiber attenuation profile measurement using an optical time domain reflectometer. This test shall be carried out end to end of each fiber link. Test results shall be presented in graphical form with graduated axes.

8.5.7 RADIO COMMUNICATIONS EQUIPMENT

1. **Introduction**
 - a. Radio communications equipment shall be provided at the locations as specified in the Schedule of Communications links. Each installation shall be complete in every respect and include all antennae, mountings, towers, cabling and fixtures.
 - b. The Contractor shall carry out a detailed survey and establish radio communication with MCC from RTU locations where PSTN, leased lines and fiber optic networks are not available.
 - c. The Contractor shall ensure that all radio equipment is fully compatible with the SCADA System and adequately rated to achieve the specified performance requirements of the system as a whole, including data transmission and bit error rates, transmitter power level and receiver sensitivity.
 - d. Power supply for base station units in a point to multi-point system shall be 220 V AC UPS supply and for all point to point installations shall be 220 V A.C. Remote stations in a multi-point system shall be housed in an IP65 enclosure with an integral mains/D.C battery charger and battery pack rated for 4 hours continuous operation in the event of mains power failure.
 - e. The Contractor shall prepare and submit application for allocation of radio frequencies to the Ministry of Communications (MOC) and obtain all necessary operating licenses on the Employers behalf.
 - f. The Contractor shall supply and install all antennae and support structure and shall provide drawings to show how each type of antenna will be mounted.
 - g. Antenna installation shall include all necessary low loss coaxial down leads, lightning protection of the antenna system and aircraft warning lights where applicable. Transmission cable shall be suitable for direct exposure to the environment. All connections shall be provided with "O" ring seals. The installation shall include all necessary cable hangers, ground kits and surge suppressers. Externally run cables at remote stations shall be enclosed in metal conduit.

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- h. The radio equipment shall form an integral part of the factory and site acceptance tests of the SCADA system

2. POINT TO MULTI POINT RADIO

a. Network radio

- i. All radios shall be capable of accepting a 4-wire audio input or RS-232 with an internal switchable modem operating at 1200 bps, 4800 bps or 9600 bps. The radio shall support these data rates within a 12.5 kHz channel bandwidth using frequency modulator. It shall be possible to upgrade from 4-wire audio or 1200 bps analog input to 9600 bps digital operation. Upgrade to 9600 bps digital operation shall be performed by configuring only the modem module.
- ii. The radio shall operate in the 360-512 MHz or 1.5 GHz frequency bands. The radio shall be able to operate in full-duplex, half-duplex or simplex mode. Radios shall be synthesized and programmable to all frequencies within the band. The above bands are provisional and are subject to UAE M.O.C. approval.
- iii. Each station and its assigned remote units shall operate on a unique transmit/receive frequency pair and on a non-interfering basis with the other master/remote systems.
- iv. The radio shall have redundant transmitters (Tx), receivers (Rx), power supplies, and batteries operating in hot-standby mode. It shall automatically switch-over to the standby equipment upon the detection of an alarm in the on-line system. The radio shall be capable of switching to operate on any receiver/transmitter combination; switch-over shall occur in less than 50 ms. It shall be possible to replace a Tx, Rx or power supply module without interrupting radio communications. Warm Standby operation is not acceptable.
- v. The Network radio shall be mounted in a standard 19" (482.6 mm) rack space. Rack mount hardware shall permit flush front mounting for cabinets or center mounting for Telco style racks.
- vi. The Network radio shall have modular construction. All modules and fuses and all adjustments to these modules shall be accessible from the front of the radio by way of a fold down front panel. The need to remove top or rear covers or remove the radio from a rack to replace the modules or fuses is unacceptable.
- vii. All radios shall use N-type connectors for interface to the antenna and external duplexers.

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- viii. The radio shall operate continuously with both transmitters and receivers operating simultaneously (full duplex).
- ix. The Network radio shall include, as a standard feature, an orderwire jack to accept a telephone handset to permit voice communications between the master and remote radios.
- x. The Network radio shall provide the following alarms and indicators, as a minimum, but not be limited to:
 - 1. Alarms contact outputs:
 - Tx A/Rx A
 - Tx B/Rx B
 - A.C power Fail alarms with relay outputs to drive external annunciator.
 - 2. Indicators:
 - LED indicators for power on.
 - Tx and Rx active.
 - Alarms for Tx, Rx and power supply failures.
- xi. Location of radio repeater for radio links between network radios and base radio at MCC shall be decided on the basis of radio propagation test and in agreement with DEWA.

b. REMOTE STATION RADIO

- i. The radio shall operate in the 360 - 512 MHz or 1.5 GHz frequency bands. The radio shall be able to operate in full-duplex, half-duplex or simplex mode. Each group of remote station radios and their associated master station radio shall operate on unique transmit/receive frequency pairs, on a non-interfering basis with the other master/remote systems.
- ii. The radio shall be synthesized and programmable to all frequencies in the preceding frequency bands.
- iii. The radio shall operate in the half-duplex mode with transmitter keying provided by the associated Remote Terminal Unit (RTU).
- iv. The radio shall have an external orderwire adapter module to accept a telephone hand set. The orderwire handset will be used for voice communication to the master station / Network radio for service functions.
- v. The radio shall provide a “sleep mode” capability. This feature shall enable a command from the RTU to switch the radio between a low power consumption mode and normal operation. When in “sleep mode”, the current draw shall not exceed 7 mA.

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The radio shall provide the following indications:

1. Analog radios - keyline active, Tx ON, squelch open, power ON, out-of-lock, radio disabled.
2. Digital Radios - RTS, CTS, carrier detect, transmit data, receive data.
- vi. All radio Personal Computer (PC) boards including RF, modem and diagnostic PC boards shall be enclosed in a single cast aluminum housing to eliminate interference with data/computer equipment. A plastic housing or a housing with vents which can allow dust into the radio is not acceptable.
- vii. The radio shall be fully synthesized and programmable to all band limited frequencies and 12.5 KHz, 25 KHz channel spacing via a personal computer or hand held terminal without changing internal components. Opening the radio to change modules, frequency crystals, or DIP switches is unacceptable.
- viii. Antenna connectors shall be Type N. Lower quality UHF type connectors are not acceptable.
- ix. The remote radio shall have the ability to monitor its internal operation and diagnostic parameters via a hand held terminal or personal computer plugged into the remote radio. Frequency, transmit power, and deviation shall be remotely adjustable from the master station, repeater, and polling remote. The terminal of PC shall be able to monitor the following functions (functions identified by an "*" shall be user adjustable by connecting a PC or terminal to the radio):

1. Radio Parameters

- a. *transmit and receive frequencies
- b. *time-out timer setting
- c. *soft carrier dekey setting
- d. *loopback code
- e. *squelch tail eliminator
- f. *PTT delay
- g. *CTS delay
- h. *hardware/software rev level
- i. *date of manufacturer
- j. *serial no./model no.

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2. Radio Diagnostics

- a. *transmit power
- b. *deviation
- c. *frequency
- d. regulator voltage
- e. power supply voltage
- f. phase lock loop voltage
- g. internal temperature
- h. reflected power
- i. voltage standing wave ratio
- j. received signal strength

8.6 ELECTRICAL AND CABLING REQUIREMENTS

8.6.1 general

The following shall specify the general contract requirements for the following items

- a) Power supplies and electrical wiring for RTU GRP enclosures
- b) Power distribution from RTU GRP enclosure to valves, meters
- c) Control cables from field instruments to the associated GRP enclosure
- d) Any other cabling & wiring work required to complete the job.
- e) Trenching specification shall be applicable to control cables and fiber optic cables

8.6.2 Qualification of Manufacturers

All the cables, conduits, switch boards covered under this section shall be proven material and shall be subject to DEWA engineer approval.

8.6.3 SUBMITTALS

8.6.3.1 Shop Drawings

Submit, for Employer's approval, shop drawings for electrical work to the extent required under this Section. Drawings shall be accompanied with complete equipment descriptive operation and installation data.

8.6.3.2 Record As-Built Drawings.

Prepare and submit for all work include in this section. Refer to General Conditions for uncovering of uninspected and unrecorded work.

8.6.3.3 Materials Lists.

Submit materials lists to extent required under this Section for the Engineer's review prior to purchase. Within 30 days after receiving the submittal approval, provide the Engineer with evidence that all equipment and materials required to complete the installation have been purchased.

8.6.3.4 Technical Data.

Submit descriptive and instruction manuals to the extent required in this Section.

8.6.3.5 Factory Test Reports.

Submit copies of factory test results, certified by manufacturer. Submit 3 copies unless otherwise specified.

8.6.3.6 Manufacturer's Certified Reports.

To the extent required under this Section, the equipment manufacturer, or his authorized representative, shall submit a notarized written report with respect to his equipment certifying that (1) the equipment has been properly installed, wired, and connected under his supervision, (2) he was present when the equipment was placed in operation, and (3) the equipment is fully covered under the terms of the guarantee.

8.6.3.7 Demonstration and Final Operation Test Plans and Results.

Submit a written plan for demonstration that each item of equipment provided under this Section meets the specified operational requirements. Submit a written plan for procedures to be used in final operational testing of entire systems including a description of each system, test methods and materials, testing instruments and recorders, and a list of the equipment involved with the functional parameters to be recorded on each item. Submit three copies of test results and records for all final operation tests.

8.6.3.8 Accessory and Maintenance Materials.

Furnish items as specified herein. Deliver to Engineer as directed with an itemized list in a letter of transmittal accompanying each shipment.

8.6.4 PRODUCT DELIVERY, STORAGE AND HANDLING

8.6.4.1 Delivery.

Deliver electrical materials and equipment in manufacturers' original cartons or containers with seals intact as applicable. Unless otherwise specified, deliver conductors in sealed cartons or on sealed reels, ends of reeled conductors factory sealed.

8.6.4.2 Storage.

Unless designed for outdoor exposure, store electrical material off the ground and under cover. Prevent corrosion, contamination, or deterioration.

8.6.4.3 Handling.

Handle materials and equipment in accordance with manufacturer's recommendations. Lift large or heavy items only at the points designated by the manufacturer. Use padded slings and hooks for lifting as necessary to prevent damage.

8.6.5 JOB CONDITIONS

Locations of equipment, inserts, anchors, panels, pull boxes, manholes, conduits, stub-ups, fittings, exterior lighting units and ground wells are approximate, conform to the Drawings as closely as possible. Exercise care to secure approved headroom and clearances, and to overcome structural interference. Verify scaled dimensions, field dimensions and conditions at the place of work.

8.6.5.1 Changes

Submit written details and reasons for proposed deviations from the Drawings and Specification, and do not deviate therefrom unless authorized by Engineer. If approved changes requested by Contractor require alteration of structures or related work, make the alterations at no additional cost to Employer.

8.6.5.2 Protection

Protect electrical material and equipment until final acceptance. Protect factory painted surfaces from impact, abrasion, discolouration and other damage. Keep electrical equipment, materials and insulation dry at all times. Maintain heaters in equipment connected and operating until equipment is placed in operation. If partial dismantling of equipment is required for installation, box or wrap the removed parts until reinstalled. Repair or replace damaged work as directed, at no additional cost to Employer.

8.6.5.3 Coordinate

Coordinate electrical work with all trades, public utilities and Employer. Where two or more trades interface in an area, verify that no electrical work is omitted.

8.6.6 RELATED ELECTRICAL WORK

Review entire Contract Documents and provide electrical work required for all trades unless excluded from the sect

8.6.6.1 Power Supply

The power supply to site will be undertaken by the Dubai Electricity and Water Authority/Electricity Division (DEWA/ED).

8.6.6.2 Power Supply Termination.

The DEWA/ED will be responsible for the supply and termination of the supply, and installation of all the LT cables between the service transformers and the LT switchboards.

8.6.6.3 Meters Installation

All kWh meters shall be supplied and installed by the Contractor. Prior to the purchase and subsequent installation of all the kWh meters, approval from DEWA/ED shall be obtained for the type being installed. Cutout fuses, and neutral links may be obtained from DEWA/ED, if available, otherwise the Contractor shall be responsible for their provision. Cutouts and neutral links provided by the Contractor must be of the types approved by DEWA/ED.

8.6.7 DISTRIBUTION BOARDS

8.6.7.1 Distribution Board

All distribution boards shall be metal clad complete with isolators or MCCB and contactors or changeover contacts wherever applicable. Bracing shall be provided on top, bottom, and back. All distribution boards shall be painted admiralty grey. Where necessary the DBS shall be enclosed in metal enclosure with lockable doors.

8.6.7.2 Earthing of the Switchboards

A continuous bare copper strip shall be supplied and installed within the switchboard to run the full length of the structure. Terminals shall be provided for the connection to the metal cladding or armoring of all incoming and outgoing cables and to the main earth.

8.6.8 DISTRIBUTION SYSTEM

8.6.8.1 General

The distribution system consists of PVC/SWA/PVC cable, PVC/PVC and PVC insulated cables and all installation materials to form a completed installation, shall be supplied, installed, connected and tested in accordance with the Drawings and Specification.

8.6.8.2 Cable Routes

The general cable routes will be proposed by the Contractor for the Engineer's approval.

8.6.8.3 PVC Armored PVC Insulated Cables

PVC armored PVC insulated cables (PVC/SWA/PVC) shall be manufactured and tested in accordance with BS 3346.

8.6.8.4 PVC Cables

PVC Cables shall comprise high conductivity stranded copper conductor sized according to the IEC and manufactured to BS 3360 and PVC insulation to BS 2004 and 2746 as applicable. Only PVC cables bearing the manufacturers name shall be used.

8.6.8.5 Insulation Color Codes

Insulation colors shall be in accordance with Table 51(B) of the 16th Edition of the IEE Regulations for the electrical equipment of Buildings.

8.6.8.6 Installation of Cables

For the purpose of this paragraph of the Specification, installation of cables shall include the following:-

1. Measuring, marking off and cutting of all cables to lengths before installation or laying.
2. Temporary sealing, protection and support of cables being installed or laid, and testing of cables for insulation before jointing or termination.
3. Preparation of all necessary materials for the placement, support or carriage or all cable runs. These shall include earth trenches, sleeves, ducts, cable trays, trunking, racks, clamps saddles, etc.
4. Sealing of cables in ducts, sleeves or trenches to prevent ingress of water to GRP cubicle, manholes or flowmeter chamber.
5. Testing of cable insulation and continuity.

8.6.8.7 Jointing of Cables

The Contractor shall be responsible for the sealing and jointing of all cables within the LT network in this work.

Cable sealing and jointing shall be in accordance with the best current practice. Cables with metal sheaths or armouring shall be terminated or jointed with metal sheaths or armouring solidly bonded to the metal joints or terminal boxes to provide a low resistance path under fault conditions. The cost of all jointing materials, labour, etc. shall be included in this work.

8.6.8.8 Cable Pulling.

For armoured PVC cables, mechanized devices may be employed for pulling over trenches and through sleeves or ducts. Cable guides shall be used for pulling cables round a bend.

8.6.8.9 Installation of PVC SWA PVC Cables.

Jointing and terminating of PVC steel wire armoured cable shall be done by experienced jointers who shall provide evidence to the Engineer that he possess the relevant experience for the work. At terminal sealing boxes, cable cores shall be brought through unbroken terminals and the cores shall be sealed rigidly within the cast resin.

No straight joints are encouraged in this work but when proved to be inevitable due to changes or other unforeseen circumstances, this may be allowed following written approval by the Engineer. Straight joints buried underground shall be compound filled and totally watertight. The steel armouring shall be made electrically continuous in such joint and the effective resistance shall be as low as possible. Where necessary, external earthing bond may be added.

Termination shall be by means of glands of the compression type complete with terminating boxes. The glands shall provide a perfect grip on the steel armouring on termination.

8.6.8.10 Cable Trenching.

Where shown, the cable routes shall be as shown on the Drawings. The exact location may be adjusted following the approval of the Engineer. The cable route shall be as straight as possible.

Excavation of trenches for the cables shall be at least 600 mm deep measured from the finished ground level of the site. The Contractor shall be responsible for the establishment of this level at site and arrange to excavate and lay the distribution cables at the appropriate time such that his cables will not be disturbed when installed. Any subsequent damage to the cables after installation, shall be the sole responsibility of the Contractor and he shall make good the damage at his own cost. Trench width shall be adequate for cable spacing for medium volt, i.e., cable spacing of 75 mm min.

8.6.8.11 Cable Protection.

Before the cables are laid, the trench shall be partly filled with sand to a depth of 75 mm. Another 75 mm deep layer of sand shall be filled after laying the cables.

8.6.8.12 Cable Covers.

Cable covers shall be concrete slabs of appropriate size and 50 mm thick and laid above the top layer of sand so as to give direct protection to the buried cable against damage from earth pressure. For identification of the cable route, cable markers shall be installed over the route particularly at the points of change of direction or at the joints where these exist. For long straight runs markers may be installed at appropriate intervals.

8.6.8.13 Backfilling and Reinstatement.

After laying the cable covers, the trench shall be backfilled with loose soil free from stones or other hard particles. The layer of refill shall be firmly compacted to the same finished level as the prevailing ground level.

8.6.8.14 Cable Tray and Supporters.

Cable trays shall be made of perforated hot dipped galvanized steel of not less than 16 swg with upturned flanges on both sides. Tray width shall be as appropriate to accommodate all the cables in the same run. Cable supports shall be steel brackets fixed to ceiling, wall or slab in the manner as approved by the Engineer. Cable support spacing shall be 1 m to 1.5 m.

8.6.8.15 Installation Materials

All wiring, conduits, conduit boxes, drawing-in boxes, junction boxes, saddles, brackets, etc., required for the completion of the sub-circuit installation and wiring shall be included in this work.

Generally, PVC insulated copper conductors shall be used for the wiring of general purpose outlets.

8.6.8.16 Conduits

All conduits, fittings and accessories for use in concealed conduit installation shall be PVC. All conduits and fittings, etc., in any other areas as directed by the Engineer shall be in galvanized steel.

Conduits cast in slab, or floor shall be fixed securely to prevent movement and the joints shall be securely wrapped with tape where necessary to prevent them from coming loose or allowing ingress of concrete during casting. Any defects in the conduit installation shall be made good by the Contractor at his own cost.

Surface conduit in other areas where exposure is permitted shall be galvanized steel with fittings and accessories of similar materials. Conduit saddles shall be spaced at 1 m apart for sizes below 25 mm dia. For bigger sizes, saddles may be 1500 mm apart. Saddles shall be fixed with rawlplugs and screwed in drilled holes.

Conduit run shall be straight as practicable and shall either be vertical or horizontal. Diagonal runs are not permitted. Draw-in boxes shall be added for runs of more than 2 bends or for straight runs of more than 900 mm span. Conduit sizes shall be adequate for the number and sizes of the cables being installed in the conduit. Minimum conduit size to be used shall be 15 mm dia. Number of cables in each conduit shall comply with Table B5 of the 14th edition of the I.E.E. Regulation for the Electrical Equipment of the Buildings.

Termination of PVC conduits in PVC boxes shall be made with the conduit poking deep through the knockouts and securely fastened to prevent the misalignment of the conduits during casting. Conduit ends shall be carefully plugged to prevent ingress of concrete during concreting. Termination of steel conduit in steel boxes shall be by means of threaded conduit joint and brass-made bush. Conduit ends shall be filed free of burrs before termination. Conduit ends shall be carefully plugged to prevent ingress of foreign particles, all metal conduits shall be made electrically continuous. Metal flexible conduits shall not be used as earth continuity lead.

8.6.8.17 Wiring System

The wiring of all final sub-circuits from distribution boards to their respective fittings of lighting and power points shall be in 250/440 volt grade PVC insulated copper conductor.

All cable sizes shall be capable of carrying the full load current of all their respective circuits continuously without overheating or undue voltage drop which shall not exceed 2.5 percent of the nominal supply voltage at the supply terminal. Minimum cable size for low volt wiring shall be 1.5 sq. mm copper and for 13 Amp power outlets, the cable size shall be 2.5 sq. mm minimum.

Wiring code shall be in accordance with the 16th edition of I.E.E. Regulations for Electrical Equipment for Buildings. The switched wire shall in all cases be red cored.

Incorrect wiring code will be rejected and the Contractor shall be responsible for replacement of any part of the wiring rejected by the Engineer for non-compliance with the Specification.

8.6.9 EARTHING SYSTEM

8.6.9.1 Scope

The earthing system shall cover each and every unit facility, consisting of a main earth at the main DB and localized earths where necessary at any other unit facility. All these earths shall be bonded together where possible. The metal sheaths or armoring shall not be used as earth continuity or earthing lead.

8.6.9.2 Earth Electrodes

Electrodes shall be steel cored copper rods driven into the open ground at spacing not less than 3 m apart. The electrodes shall be bonded together and the aggregate earth resistance so formed shall be less than one (1) ohm.

8.6.9.3 Copper Earthing Lead and Bonding

The bonding of the electrodes and the copper earthing leads shall be bare copper conductor with nominal cross-section area of not less than 70 sq.mm. The bonding shall be by means of non-corrosive metal clamps or by brazing.

8.6.9.4 Earth Electrode Inspection and Test Point

All inspections and test points of the earth electrodes shall be boxed up with brick and cement mortar with a removable slab cover. The position of these earth electrodes shall be permanently labelled with the word.
"Safety Electrical Earth. DO NOT Remove".

8.6.10 TESTING

8.6.10.1 Test Manufacturer's Work

All tests or inspection shall be in accordance with the relevant British Standards or such other standards as approved by the Engineer.

All tests or inspection at the Manufacturer's works shall be accompanied with test or inspection certificates showing all the relevant information and details relating to the test or inspection. Four (4) copies of Test certificates signed by the Manufacturer's representative shall be submitted to the Engineer on or prior to the dispatch of equipment to site.

8.6.10.2 Installation Inspection

During installation, or when the Contractor is satisfied that the work is in satisfactory working order, he shall arrange with the Engineer to carry out tests for, or inspection of, the installation or completed work. If any part or equipment is found to be not in accordance with the Specification or relevant Standards, such variance shall be put right by the Contractor to the satisfaction of the Engineer and at no extra cost to the Employer.

8.6.10.3 Test, Inspection by Power Supply Authority.

Prior to the completion of the work, the Contractor shall arrange with the DEWA/ED for the inspection, testing, reading of meters, etc., to obtain clearance for the connection of power to the plant or equipment.

8.6.10.4 Attendance During Testing.

For all the tests and inspection as aforementioned, the Contractor shall provide the necessary tools, labour and skilled technicians as and when required during the period of test and inspection.

All tests and inspections shall be conducted in the presence of the Engineer. Test results shall be obtained and recorded and produced in quadruplicate to the Engineer. Any results showing variation from the efficient performance or manufacturer's test results shall be rectified to the satisfaction of the Engineer and at no extra cost to the Employer.

8.6.10.5 Standard Tests at Site.

The following are the tests required to be carried out and recorded.

1. Earth electrodes impedance and earthing system
2. Insulation resistance test
3. Continuity tests
4. Operation and system tests such as sequence, interlock, etc.
5. Operation of protective gear circuit test by assimilation to check sensitivity and stability
6. Phase rotation list
7. Polarity test to ensure that single switches are installed in the live conductor and not in the neutral conductor
8. Test for ring main circuits
9. Insulation resistance test to earth and between conductors before and after connection of fittings
10. Insulation resistance test on all equipment and apparatus installed, before and after connecting such equipment to the supply circuit
11. Earth continuity test for each final sub-circuit and the completed installation to ensure that earth fault loop impedance is such as to satisfy the requirements of the 16th Edition of the I.E.E. Regulations for the electrical equipment of buildings.

On the satisfactory completion of the tests mentioned above and on presentation of the record of such tests to the Engineer the electrical equipment shall be deemed complete.

8.7 TRAINING

8.7.1 class room training

The contractor shall offer classroom training for 4 engineers to cover all the system component including:-

- a) field instrumentation maintenance

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- b) RTU troubleshooting, maintenance, programming.
- c) communication network trouble shouting ,fault clearing, system expansion

The training shall be organized by a training center certified by the vendor of the supplied equipments, and shall include all the level of training offered by the vendor.

8.7.2 On job training

The contractor shall provide on job training for DEWA employee, contractor shall be responsible to answer all DEWA employee technical questions and make sure he is fully aware of system configuration and troubleshooting steps

8.8 MEASUREMENT

Instrumentation, Control and Automation systems and all work in connection therewith shall be valued by the measurement of only such items as are included in the Bill of Quantities. The cost of Instrumentation, Control and Automation systems not itemized in the Bill of Quantities shall be deemed to be included elsewhere in the Contract Rates to cover the entire Contractor's obligations under the Contract.

SECTION 9

Electrical and Cabling Works

9.1 ELECTRICAL AND CABLING REQUIREMENTS

9.1.1 General

The following shall specify the general contract requirements for the following items

- a) Power supplies and electrical wiring for RTU GRP enclosures
- b) Power distribution from RTU GRP enclosure to valves, meters
- c) Control cables from field instruments to the associated GRP enclosure
- d) Any other cabling & wiring work required to complete the job.
- e) Trenching specification shall be applicable to control cables and fiber optic cables

9.1.2 Qualification of Manufacturers

All the cables, conduits, switch boards covered under this section shall be proven material and shall be subject to DEWA engineer approval.

9.1.3 SUBMITTALS

9.1.3.1 Shop Drawings

Submit, for Employer's approval, shop drawings for electrical work to the extent required under this Section. Drawings shall be accompanied with complete equipment descriptive operation and installation data.

9.1.3.2 Record As-Built Drawings.

Prepare and submit for all work included in this section. Refer to General Conditions for uncovering of uninspected and unrecorded work.

9.1.3.3 Materials Lists.

Submit materials lists to extent required under this Section for the Engineer's review prior to purchase. Within 30 days after receiving the submittal approval, provide the Engineer with evidence that all equipment and materials required to complete the installation have been purchased.

9.1.3.4 Technical Data.

Submit descriptive and instruction manuals to the extent required in this Section.

9.1.3.5 Factory Test Reports.

Submit copies of factory test results, certified by manufacturer. Submit 3 copies unless otherwise specified.

9.1.3.6 Manufacturer's Certified Reports.

To the extent required under this Section, the equipment manufacturer, or his authorized representative, shall submit a notarized written report with respect to his equipment certifying that (1) the equipment has been properly installed, wired, and connected under his supervision, (2) he was present when the equipment was placed in operation, and (3) the equipment is fully covered under the terms of the guarantee.

9.1.3.7 Demonstration and Final Operation Test Plans and Results.

Submit a written plan for demonstration that each item of equipment provided under this Section meets the specified operational requirements. Submit a written plan for procedures to be used in final operational testing of entire systems including a description of each system, test methods and materials, testing instruments and recorders, and a list of the equipment involved with the functional parameters to be recorded on each item. Submit three copies of test results and records for all final operation tests.

9.1.3.8 Accessory and Maintenance Materials.

Furnish items as specified herein. Deliver to Engineer as directed with an itemized list in a letter of transmittal accompanying each shipment.

9.1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

9.1.4.1 Delivery.

Deliver electrical materials and equipment in manufacturers' original cartons or containers with seals intact as applicable. Unless otherwise specified, deliver conductors in sealed cartons or on sealed reels, ends of reeled conductors factory sealed.

9.1.4.2 Storage.

Unless designed for outdoor exposure, store electrical material off the ground and under cover. Prevent corrosion, contamination, or deterioration.

9.1.4.3 Handling.

Handle materials and equipment in accordance with manufacturer's recommendations. Lift large or heavy items only at the points designated by the manufacturer. Use padded slings and hooks for lifting as necessary to prevent damage.

9.1.5 JOB CONDITIONS

Locations of equipment, inserts, anchors, panels, pull boxes, manholes, conduits, stub-ups, fittings, exterior lighting units and ground wells are approximate, conform to the Drawings as closely as possible. Exercise care to secure approved headroom and clearances, and to overcome structural interference. Verify scaled dimensions, field dimensions and conditions at the place of work.

9.1.5.1 Changes

Submit written details and reasons for proposed deviations from the Drawings and Specification, and do not deviate therefrom unless authorized by Engineer. If approved changes requested by Contractor require alteration of structures or related work, make the alterations at no additional cost to Employer.

9.1.5.2 Protection

Protect electrical material and equipment until final acceptance. Protect factory painted surfaces from impact, abrasion, discolouration and other damage. Keep electrical equipment, materials and insulation dry at all times. Maintain heaters in equipment connected and operating until equipment is placed in operation. If partial dismantling of equipment is required for installation, box or wrap the removed parts until reinstalled. Repair or replace damaged work as directed, at no additional cost to Employer.

9.1.5.3 Coordinate

Coordinate electrical work with all trades, public utilities and Employer. Where two or more trades interface in an area, verify that no electrical work is omitted.

9.1.6 RELATED ELECTRICAL WORKS

Review entire Contract Documents and provide electrical work required for all trades unless excluded from the sect

9.1.6.1 Power Supply

The power supply to site will be undertaken by the Dubai Electricity and Water Authority/Electricity Division (DEWA/ED).

9.1.6.2 Power Supply Termination.

The DEWA/ED will be responsible for the supply and termination of the supply, and installation of all the LT cables between the service transformers and the LT switchboards.

9.1.6.3 Meters Installation

All kWh meters shall be supplied and installed by the Contractor. Prior to the purchase and subsequent installation of all the kWh meters, approval from

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DEWA/ED shall be obtained for the type being installed. Cutout fuses, and neutral links may be obtained from DEWA/ED, if available, otherwise the Contractor shall be responsible for their provision. Cutouts and neutral links provided by the Contractor must be of the types approved by DEWA/ED.

9.1.7 *DISTRIBUTION BOARDS and LOW VOLTAGE POWER, CONTROL, AND INSTRUMENT CABLE*

9.1.7.1 Distribution Board

All distribution boards shall be metal clad complete with isolators or MCCB and contactors or changeover contacts wherever applicable. Bracing shall be provided on top, bottom, and back. All distribution boards shall be painted admiralty grey. Where necessary the DBS shall be enclosed in metal enclosure with lockable doors.

9.1.7.2 Earthing of the Switchboards

A continuous bare copper strip shall be supplied and installed within the switchboard to run the full length of the structure. Terminals shall be provided for the connection to the metal cladding or armoring of all incoming and outgoing cables and to the main earth.

9.1.8 *DISTRIBUTION SYSTEM*

9.1.8.1 General

The distribution system consists of XLPE/SWA/PVC cable, PVC CONDUIT and all installation materials to form a completed installation, shall be supplied, installed, connected and tested in accordance with the Drawings and Specification.

9.1.8.2 Cable Routes

The general cable routes will be proposed by the Contractor for the Engineer's approval. in general cable root shall be within DEWA corridor with manholes for easy maintenance of cable system.

9.1.8.3 PVC Armoured & Insulated Cables

PVC armored PVC insulated cables (PVC/SWA/PVC) shall be manufactured and tested in accordance with BS 3346. PVC Cables shall comprise high conductivity stranded copper conductor sized according to the IEC and manufactured to BS 3360 and PVC insulation to BS 2004 and 2746 as applicable.

Power cables insulation shall be extruded solid dielectric cross-linked polyethylene (XLPE). The nominal insulation thickness shall be as per values specified in IEC 60502-1, with respect to voltage rating and cable cross-section.

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The outer sheath material shall be black PVC, type ST2 as per IEC 60502-1. The nominal thickness of the outer sheath shall be as per IEC 60502-1.

The XLPE insulation of the Four-core cable shall be colored, Red, Yellow, Blue and Black. Single core cable shall be with Black XLPE insulation.

XLPE armored (XLPE/SWA) shall be manufactured and tested in accordance with BS 3346. Only PVC cables bearing the manufacturers name shall be used.

9.1.8.4 PVC Cables

PVC Cables shall comprise high conductivity stranded copper conductor sized according to the IEC and manufactured to BS 3360 and PVC insulation to BS 2004 and 2746 as applicable. Only PVC cables bearing the manufacturers name shall be used.

9.1.8.5 Insulation Color Codes

Insulation colors shall be in accordance with Table 51(B) of the 16th Edition of the IEE Regulations for the electrical equipment of Buildings.

9.1.8.6 Installation of Cables

For the purpose of this paragraph of the Specification, installation of cables shall include the following:-

1. Measuring, marking off and cutting of all cables to lengths before installation or laying.
2. Temporary sealing, protection and support of cables being installed or laid, and testing of cables for insulation before jointing or termination.
3. Preparation of all necessary materials for the placement, support or carriage or all cable runs. These shall include earth trenches, sleeves, ducts, cable trays, trunking, racks, clamps saddles, etc.
4. Sealing of cables in ducts, sleeves or trenches to prevent ingress of water to GRP cubicle, manholes or flowmeter chamber.
5. Testing of cable insulation and continuity.

9.1.8.7 Jointing of Cables

The Contractor shall be responsible for the sealing and jointing of all cables within the LT network in this work.

Cable sealing and jointing shall be in accordance with the best current practice. Cables with metal sheaths or armouring shall be terminated or jointed with metal sheaths or armouring solidly bonded to the metal joints or terminal boxes to provide

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a low resistance path under fault conditions. The cost of all jointing materials, labour, etc. shall be included in this work.

9.1.8.8 Cable Pulling.

For armoured PVC cables, mechanized devices may be employed for pulling over trenches and through sleeves or ducts. Cable guides shall be used for pulling cables round a bend.

9.1.8.9 Installation of XLPE SWA PVC Cables.

Jointing and terminating of XLPE steel wire armored cable shall be done by experienced jointers who shall provide evidence to the Engineer that he possess the relevant experience for the work. At terminal sealing boxes, cable cores shall be brought through unbroken terminals and the cores shall be sealed rigidly within the cast resin.

No straight joints are encouraged in this work but when proved to be inevitable due to changes or other unforeseen circumstances, this may be allowed following written approval by the Engineer. Straight joints buried underground shall be compound filled and totally watertight. The steel armoring shall be made electrically continuous in such joint and the effective resistance shall be as low as possible. Where necessary, external earthing bond may be added.

Termination shall be by means of glands of the compression type complete with terminating boxes. The glands shall provide a perfect grip on the steel armoring on termination.

9.1.8.10 Cable Trenching.

Where shown, the cable routes shall be as shown on the Drawings. The exact location may be adjusted following the approval of the Engineer. The cable route shall be as straight as possible.

Excavation of trenches for the cables shall be at least 600 mm deep measured from the finished ground level of the site. The Contractor shall be responsible for the establishment of this level at site and arrange to excavate and lay the distribution cables at the appropriate time such that his cables will not be disturbed when installed. Any subsequent damage to the cables after installation shall be the sole responsibility of the Contractor and he shall make good the damage at his own cost. Trench width shall be adequate for cable spacing for medium volt, i.e., cable spacing of 75 mm min.

9.1.8.11 Cable Protection.

Before the cables are laid, the trench shall be partly filled with sand to a depth of 75 mm. Another 75 mm deep layer of sand shall be filled after laying the cables.

9.1.8.12 Cable Covers.

Cable covers shall be concrete slabs of appropriate size and 50 mm thick and laid above the top layer of sand so as to give direct protection to the buried cable against damage from earth pressure, concrete tiles shall be marked with the text "W.SCADA LV CABLE"

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for power and instrument cable ,while the text "W.SCADA FOC" shall be used for fiber optic cable concrete tiles.

Detectable warning tape shall be used above the tiles. For identification of the cable route, cable markers shall be installed over the route particularly at the points of change of direction or at the joints where these exist. For long straight runs markers may be installed at appropriate intervals.

9.1.8.13Backfilling and Reinstatement.

After laying the cable covers, the trench shall be backfilled with loose soil free from stones or other hard particles. The layer of refill shall be firmly compacted to the same finished level as the prevailing ground level.

9.1.8.14Cable Tray and Supporters.

Cable trays shall be made of perforated hot dipped galvanized steel of not less than 16 swg with upturned flanges on both sides. Tray width shall be as appropriate to accommodate all the cables in the same run. Cable supports shall be steel brackets fixed to ceiling, wall or slab in the manner as approved by the Engineer. Cable support spacing shall be 1 m to 1.5 m.

9.1.8.15Installation Materials

All wiring, conduits, conduit boxes, drawing-in boxes, junction boxes, saddles, brackets, etc., required for the completion of the sub-circuit installation and wiring shall be included in this work.

Generally, XLPE insulated copper conductors shall be used for the wiring of general purpose outlets.

9.1.8.16Conduits

Externally Corrugated pipe, with smooth internal surface of 100mm internal diameter OR higher and shall be used for ducts of power cables, signal cables and fiber optics cable; the conduits color shall be different for each type.

The conduit shall be designed in accordance with EN 50086. The conduit shall have impact resistance equal to or above 750N, with deformation of maximum 5%. The conduits shall be marked with manufacturer name, date of manufacturer and the text "DEWA WATER SCADA". Coupling of two conduits should provide a minimum of IP56.

Conduits cast in slab, or floor shall be fixed securely to prevent movement and the joints shall be securely wrapped with tape where necessary to prevent them from coming loose or allowing ingress of concrete during casting. Any defects in the conduit installation shall be made good by the Contractor at his own cost.

Surface conduit in other areas where exposure is permitted shall be galvanized steel with fittings and accessories of similar materials. Conduit saddles shall be spaced at 1 m apart for sizes below 25 mm dia. For bigger sizes, saddles may be 1500 mm apart. Saddles shall be fixed with rawlplugs and screwed in drilled holes.

Conduit run shall be straight as practicable and shall either be vertical or horizontal. Diagonal runs are not permitted. Draw-in boxes shall be added for runs of more than 2 bends or for straight runs of more than 900 mm span. Conduit sizes shall be adequate for the number and sizes of the cables being installed in the conduit. Minimum conduit size to be used shall be 15 mm dia. Number of cables in each conduit shall comply with Table B5 of the 14th edition of the I.E.E. Regulation for the Electrical Equipment of the Buildings.

Termination of PVC conduits in PVC boxes shall be made with the conduit poking deep through the knockouts and securely fastened to prevent the misalignment of the conduits during casting. Conduit ends shall be carefully plugged to prevent ingress of concrete during concreting. Termination of steel conduit in steel boxes shall be by means of threaded conduit joint and brass-made bush. Conduit ends shall be filed free of burrs before termination. Conduit ends shall be carefully plugged to prevent ingress of foreign particles; all metal conduits shall be made electrically continuous. Metal flexible conduits shall not be used as earth continuity lead.

9.1.8.17 Wiring System

The wiring of all final sub-circuits from distribution boards to their respective fittings of lighting and power points shall be in 230/440 volt grade XLPE insulated copper conductor.

All cable sizes shall be capable of carrying the full load current of all their respective circuits continuously without overheating or undue voltage drop which shall not exceed 2.5 percent of the nominal supply voltage at the supply terminal. Minimum cable size for low volt wiring shall be 1.5 sq. mm copper and for 13 Amp power outlets; the cable size shall be 2.5 sq. mm minimum.

Wiring code shall be in accordance with the 16th edition of I.E.E. Regulations for Electrical Equipment for Buildings. The switched wire shall in all cases be red cored.

Incorrect wiring code will be rejected and the Contractor shall be responsible for replacement of any part of the wiring rejected by the Engineer for non-compliance with the Specification.

9.1.8.18 INSTRUMENT AND CONTROL CABLES

1.0 This specification covers the design, construction, manufacture, testing and delivery of instrumentation signal cables.

2.0 APPLICABLE STANDARDS AND CODES

2.1 Codes and Standards

The CONTRACTOR shall adhere to the Codes and Standards as applicable from Institutions and Organizations listed below.

The following list of standards indicate the requirements as minimum any other standard not listed below or elsewhere in this tender documents shall be subject to review and approve by the

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DEWA/ENGINEER.	
Document Title	Document No.
British Standard BS 5308, Part 1	Multipair PE Insulated Instrumentation Cable
British Standard BS 6360	Specification for Conductors in Insulated Cables and Cords
British Standard BS 6234	Specification for Polyethylene Insulation and Sheath of Electric Cables

The CONTRACTOR/VENDOR shall also note that it is not the intent of this specification to deviate from good engineering practices. The absence of specifications shall imply that the best engineering practices shall prevail, utilising first quality materials and workmanship.

The CONTRACTOR/VENDOR shall seek clarification from the DEWA/ENGINEER of any confusing or conflicting information contained in this specification and the accompanying documents.

Any deviation from this specification shall be indicated by the CONTRACTOR/VENDOR along with his bid. Otherwise the DEWA/ENGINEER shall assume full compliance with this specification while accepting the bid.

2.2 Units

The instrumentation cables specifications and signals shall be according to the international system of units (SI).

3. SITE CONDITIONS

It is the CONTRACTOR's responsibility to design, furnish and install the instrumentation cables and wires to withstand and operate properly under the prevailing ambient conditions as described in the project General Technical Requirements of this Contract. This Specification serves as a guideline to the CONTRACTOR. The CONTRACTOR shall recommend and include all the necessary equipment or protecting devices based on his previous experience on similar installations.

4. DESIGN CONSIDERATIONS / TECHNICAL REQUIREMENTS

4.1 Signal Categories

Signal cables shall be used for carrying low voltage, low power instrumentation signals between various field, plant and control room locations. In general the signals will fall into one of the following categories:

- Analogue, 4-20 mA
- Digital 24V DC
- Resistance Thermometer Device (motor windings)
- Pulsed D.C.

All cables shall be suitable for operation under the following conditions :

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- Directly buried in ground.
- Run in buried P.V.C., concrete or all steel ducts.
- Runs fastened to cable rack or tray in open air.

The cables shall be capable of continuous operation at highest system voltage as specified with maximum conductor operating temperature of 90°C and maximum temperature under fault conditions of not more than 250°C.

4.2 General

This Cable Specification is based on BS5308 Part 1, Type 3.

The insulation of these cables shall be suitable for operation at voltages upto and including 300 V R.M.S. core to earth and 500 V R.M.S. core to core and at a maximum temperature of 65°C.

4.3 Conductors

Conductors shall be standard annealed copper wire in accordance with BS6360 class 2.

4.4 Insulation

The insulation of these cables shall be Polyethylene Type 03 as specified in BS 6234.

4.5 Pairs

Two insulated conductors shall be uniformly twisted together to form a pair. The length of lay shall be such that the two wires forming each pair are not dissociated by normal handling. The maximum pair lay length shall be limited to 100mm (minimum 10 twists per meter).

4.6 Identification

Pairs shall be identified by means of coloured insulation in the sequence specified in the Standard BS5308, Part 1. The cable shall be constructed such that the pairs are in concentric layers.

4.7 Collective Screen and Drain Wire

Laminated Screening Tape shall comprise aluminium bonded to polyester, the tape having a minimum thickness of aluminium of 0.008mm and a minimum thickness of polyester of 0.010mm. The tape shall be applied with a minimum overlap of 25% and with the metallic side down in contact with a tinned Copper drain wire (cross section not less than 0.5mm²) run longitudinally over the Binder Tape.

4.8 PVC Bedding

An extruded sheath of type TM1 PVC Compound in accordance with BS 6746 shall be applied over the collective screen. Sheath colour shall be Black.

4.9 Armour

A single layer of round galvanised steel wire armour with properties in compliance with BS1442 shall be applied spirally over the outer PVC bedding. A plastic counter spiral may be applied over the armour.

4.10 Outer Sheath

PVC Outer Sheath, Type TM1 to BS 6746 shall be provided. In addition outer sheath shall display the following characteristics:-

Min. oxygen index=30%

Max. HCL emission @ 800°C=15%

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4.11 Other Properties

Flame Retardant in accordance with B.S. 4066 part 1. and Part 3.

4.12 Cable Identification:

PE/MS/PVC/LS/PVC/SWA/PVC

Size: No. of pairs x 1.0 mm² (for signal)
 No. of pairs x 1.5 mm² (for control & power supply).

4.13 End Sealing

After completion of the Factory Tests, the ends of the cable shall be sealed to prevent ingress of moisture.

4.14 Marking of Supplies

The external surface of the oversheath shall be embossed and/or printed with :

- Manufacturer's Name
- Year of Manufacture
- Size and Type of cable
- Length marking

This identification is to be repeated at intervals of not more than 1 metre.

The minimum character size shall be 3mm. The accuracy of the length marking shall be within the limits of + 1% The colour of the initial printed marking shall be white. In case of a defective initial marking, the cable shall be remarked in yellow.

5. FABRICATION REQUIREMENTS

Cable Type Signal Cable - 1	
Application	4 to 20 mA signals like, Transmitters, Valve Positioners, Analyzer Signals, Contact signals like Limit Switches, Level Switches, Pressure Switches, Hand Switches and the like.
Size	1 Pair
Voltage Grade	300 VRMS Core to Earth, 500 VRMS Core to Core
Type	PE-MS-PVC-SWA-PVC
Conductor construction	1.0 mm ² , annealed Copper
Conductor insulation	PVC
Inner sheath	PVC
Conductor Identification	one (1) leg black and one(1) leg white
Pair construction	twisted to 10 twists per metre
Pair screening	Yes, as per Clause 4.8
Communications wire	N/A
Overall screen	N/A
Ripcord	N/A
Armor	Galvanised Steel Wire Armor
Outer sheath	Flame retardant PVC
Color, outer sheath	Grey
UV radiation protection	Yes
Cable Dimensions	Diameters under sheath: VENDOR to state Diameter over sheath: VENDOR to state

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Cable Type Signal Cable – 2	
Application	4 to 20 mA signals like, Transmitters, Valve Positioners, Analyzer Signals, Contact signals like Limit Switches, Level Switches, Pressure Switches, Hand Switches and the like.
Size	2 Pairs, 5 Pairs, 10 Pairs, 20 Pairs
Voltage Grade	300 VRMS Core to Earth, 500 VRMS Core to Core
Type	PE-MS-PVC-SWA-PVC
Conductor construction	0.5 mm ₂ , annealed Copper
Conductor insulation	PVC
Inner sheath	PVC
Conductor Identification	one (1) leg black and one(1) leg white
Pair construction	Twisted to 10 twists per metre. If more than one layer, each successive layer shall have the direction lay reversed.
Pair screening	N/A
Communications wire	Required
Overall screen	Yes, as per Clause 4.8
Ripcord	Required
Armor	Galvanised Steel Wire Armor
Outer sheath	Flame retardant PVC
Color, outer sheath	Grey
UV radiation protection	Yes
Cable Dimensions	Diameters under sheath: VENDOR to state Diameter over sheath: VENDOR to state

Cable Type RTD Cable - 1	
Application	RTD Extension Cables
Size	1 Triad or 1 Quad
Voltage Grade	300 VRMS Core to Earth, 500 VRMS Core to Core
Type	PE-MS-PVC-SWA-PVC
Conductor construction (min.)	0.5 mm ₂ , annealed Copper Per BS 1904
Conductor insulation	PVC
Inner sheath	PVC
Conductor Identification	1 Triad: Black, White, Red 1 Quad: Black, White, Red
Core Construction	1 Triad: Twisted to 10 twists per metre
Core screening	Yes, as per Clause 4.8
Communications wire	N/A
Overall screen	N/A
Ripcord	N/A
Armor	Galvanised Steel Wire Armor
Outer sheath	Flame retardant PVC
Color, outer sheath	Black
UV radiation protection	Yes
Cable Dimensions	Diameters under sheath: VENDOR to state Diameter over sheath: VENDOR to state

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Cable Type RTD Cable - 2	
Application	RTD Extension Cables
Size	6 Triads or 6 Quads
Voltage Grade	300 VRMS Core to Earth, 500 VRMS Core to Core
Type	PE-MS-PVC-SWA-PVC
Conductor construction (min.)	0.5 mm ² , annealed Copper Per BS 1904
Conductor insulation	PVC
Inner sheath	PVC
Conductor Identification	1 Triad: Black, White, Red 1 Quad: Black, White, Red
Core Construction	1 Triad: Twisted to 10 twists per metre 1 Quad: Layed up in quad formation
Core screening	N/A
Communications wire	Required
Overall screen	Required
Ripcord	Required
Armor	Galvanised Steel Wire Armor
Outer sheath	Flame retardant PVC
Color, outer sheath	Black
UV radiation protection	Yes
Cable Dimensions	Diameters under sheath: VENDOR to state Diameter over sheath: VENDOR to state

6. INSPECTION AND TESTING

Performance and acceptance tests for electrical power and control cables shall be carried out at manufacturer's works which shall be witnessed by DEWA/ENGINEER or alternatively subject to DEWA/ENGINEER'S prior approval, factory test certificates shall be accepted.

The required tests, test conditions and acceptance criteria for the cables shall be in accordance with the latest edition of the standards as per Clause 2.0.

The required tests on the cables shall include but not limited to the following :

- High Voltage Test
- Conductor Resistance Test
- Armour Resistance Test
- Thickness of Insulation
- Test for Flame Retardance
- Insulation Resistance Test

Test certificates must be approved by DEWA/ENGINEER before cables are despatched from place of manufacture.

7. SEALING AND DRUMMING

Both ends of every length of cable shall be sealed properly immediately after tests at manufacturer's premises.

The cables shall be rolled on suitable wooden or steel drums. The drum shall be marked to indicate the direction of rolling, type of cable, voltage and cable length. For all cut lengths of cables which are to be delivered to DEWA/ENGINEER, approved sealing caps of correct size shall be supplied and properly mounted immediately after the respective cable length is cut.

8. PACKING AND SHIPMENT

The cable wooden or steel drums shall be packed in wooden type seaworthy crates having sufficient strength to withstand normal ship handling and transport.

The crates shall be marked with DEWA's name and address, order number, type of equipment,etc.

Enclosed with the instrument the following documents shall be included in suitable wrapping:

- List of the shipped material and equipment
- Installation Instruction.

9. VENDOR DOCUMENTATION

- i) Cable Data Sheets
- ii) Vendor Test Reports

9.1.9 EARTHING SYSTEM

9.1.9.1 Scope

The earthing system shall cover each and every unit facility, consisting of a main earth at the main DB and localized earths where necessary at any other unit facility. All these earths shall be bonded together where possible. The metal sheaths or armoring shall not be used as earth continuity or earthing lead.

9.1.9.2 Earth Electrodes

Electrodes shall be steel cored copper rods driven into the open ground at spacing not less than 3 m apart. The electrodes shall be bonded together and the aggregate earth resistance so formed shall be less than one (1) ohm.

9.1.9.3 Copper Earthing Lead and Bonding

The bonding of the electrodes and the copper earthing leads shall be bare copper conductor with nominal cross-section area of not less than 70 sq.mm. The bonding shall be by means of non-corrosive metal clamps or by brazing.

9.1.9.4 Earth Electrode Inspection and Test Point

All inspections and test points of the earth electrodes shall be boxed up with brick and cement mortar with a removable slab cover. The position of these earth electrodes shall be permanently labelled with the word.

"Safety Electrical Earth. DO NOT Remove".

9.1.10 TESTING

9.1.10.1 Test Manufacturer's Work

All tests or inspection shall be in accordance with the relevant British Standards or such other standards as approved by the Engineer.

All tests or inspection at the Manufacturer's works shall be accompanied with test or inspection certificates showing all the relevant information and details relating to the test or inspection. Four (4) copies of Test certificates signed by the Manufacturer's representative shall be submitted to the Engineer on or prior to the dispatch of equipment to site.

9.1.10.2 Installation Inspection

During installation, or when the Contractor is satisfied that the work is in satisfactory working order, he shall arrange with the Engineer to carry out tests for, or inspection of, the installation or completed work. If any part or equipment is found to be not in accordance with the Specification or relevant Standards, such variance shall be put right by the Contractor to the satisfaction of the Engineer and at no extra cost to the Employer.

9.1.10.3 Test, Inspection by Power Supply Authority.

Prior to the completion of the work, the Contractor shall arrange with the DEWA/ED for the inspection, testing, reading of meters, etc., to obtain clearance for the connection of power to the plant or equipment.

9.1.10.4 Attendance during Testing.

For all the tests and inspection as aforementioned, the Contractor shall provide the necessary tools, labor and skilled technicians as and when required during the period of test and inspection.

All tests and inspections shall be conducted in the presence of the Engineer. Test results shall be obtained and recorded and produced in quadruplicate to the Engineer. Any results showing variation from the efficient performance or manufacturer's test results shall be rectified to the satisfaction of the Engineer and at no extra cost to the Employer.

9.1.10.5 Standard Tests at Site.

The following are the tests required to be carried out and recorded.

1. Earth electrodes impedance and earthing system
2. Insulation resistance test
3. Continuity tests
4. Operation and system tests such as sequence, interlock, etc.

5. Operation of protective gear circuit test by simulation to check sensitivity and stability
6. Phase rotation list
7. Polarity test to ensure that single switches are installed in the live conductor and not in the neutral conductor
8. Test for ring main circuits
9. Insulation resistance test to earth and between conductors before and after connection of fittings
10. Insulation resistance test on all equipment and apparatus installed, before and after connecting such equipment to the supply circuit
11. Earth continuity test for each final sub-circuit and the completed installation to ensure that earth fault loop impedance is such as to satisfy the requirements of the 16th Edition of the I.E.E. Regulations for the electrical equipment of buildings.

On the satisfactory completion of the tests mentioned above and on presentation of the record of such tests to the Engineer the electrical equipment shall be deemed complete.

9.2 TRAINING

9.2.1 Class room training

The contractor shall offer classroom training for 4 engineers to cover all the system component including:-

- a) Field instrumentation maintenance
- b) RTU troubleshooting, maintenance, programming.
- c) communication network trouble shooting ,fault clearing, system expansion

The training shall be organized by a training center certified by the vendor of the supplied equipments, and shall include all the level of training offered by the vendor.

9.2.2 On job training

The contractor shall provide on job training for DEWA employee, contractor shall be responsible to answer all DEWA employee technical questions and make sure he is fully aware of system configuration and troubleshooting steps

9.3 MEASUREMENT

Instrumentation, Control and Automation systems and all work in connection therewith shall be valued by the measurement of only such items as are included in the Bill of Quantities. The cost of Instrumentation, Control and Automation systems not itemized in the Bill of Quantities shall be deemed to be included elsewhere in the Contract Rates to cover the entire Contractor's obligations under the Contract.

9.4 THREE PHASE SOLAR POWER SYSTEM

9.4.1 General

The solar power three phase power supply is intended to be used for remote area where utility power supply is not provided, and shall be used to power the RTU units including the power supply to the connected load “Flowmeters, Valves, pressure transmitters, and water quality analyzers”.

The unit shall be designed for sever environmental condition and shall be inclusive of all required solar panels, Solar DC batteries, inverter enclosures, etc.

The unit shall be installed outdoor, and the enclosure design shall locking scheme that prevent unauthorized access to the unit.

9.4.2 Scope of work

Design, supply, install, commissioning of 5 KW Solar power three phase power supply unit (number of units shall be as mentioned in the BOQ). The scope of work shall include any required civil foundation, wiring and cable connection to the RTU unit.

9.4.3 Design features

1- The unit shall be capable of providing a minimum of two hours backup of continuous 5 KW three phase power supply to the load irrelative of the sun condition without discharging the battery more than 50%, the same shall be tested at workshop as well as on site using 5 KW 3 phase motor provided by the contractor for testing purpose

2- Solar Panels modules should be multicrystal solar cell with an efficiency of over 14%. Modules construction shall use tempered glass front, EVA pottant and a PVF backing to provide maximum protection from the most severe environmental conditions.

The entire laminate should be framed in a heavy-duty anodized aluminum frame to provide structural strength and ease of installation.

- a) UL listed and should have a +10/-5% power tolerance
- b) Low iron, tempered glass, EVA encapsulant and anodized aluminum frame construction
- c) 25 year output warranty
- d) Weather resistant junction box
- e) the solar panel shall be test for the following :

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- Thermal cycling test
- Thermal shock test
- Thermal/Freezing and high humidity cycling test
- Electrical insulation test
- Hail impact test
- Mechanical, wind and twist loading test
- Salt mist test
- Light and water exposure test
- Field exposure test

The typical test results shall be attached along with the proposal for DEWA reference

- 3- The inverter should produce pure sine wave, three phase power supply with same specifications as DEWA GRID “50 HZ, 380V”.
- 4- The inverter shall protect the battery from deep discharge with programmable setpoint
- 5- The system provides complete real-time performance data as well as long-term historical system data and graphs. Including environmental and weather station capabilities (if requested). This information is stored and processed on a remote web server and is available from anywhere on the web through local LAN or cellular modem. The monitored value shall include “
- 6- Batteries shall be rated for 3200 cycles at 50% depth of discharge with life time of 10 years

STANDARD SPECIFICATIONS

**10.1 CURRENT REQUIREMENTS OF DUBAI MUNICIPALITY FOR
SAFETY MEASURES TO BE TAKEN DURING EXCAVATIONS**

GENERAL

Please be informed that the safety measures stated in the Circular are for the safety of pedestrian and motorists and must be implemented immediately. Failure to implement these safety measures will result in legal action being taken against the offenders.

SAFETY MEASURES

1. All excavations must be barricaded off from the public. The barricade must encompass the trench and the excavated material.

Barricades may be formed by bollards or mixi-cones painted red and white and interlinked with planks or reflective tape coloured red and white. Any other form of barricade system must have the approval of Dubai Municipality before it may be used.

2. Flashing warning lights must be affixed to the barricade system at regular intervals and be operated continually during the off hours of darkness.
3. Traffic signs giving advance warning of the excavation works must be of the fully reflective type. Signs painted on plywood will not be accepted.

The number, type and disposition of the signs must have the approval of Dubai Municipality before they may be erected.

4. No part of a road or defined track may be blocked without provision of an adequate signed diversion or alternative route approved by Dubai Municipality.
5. No part of any footpath may be blocked without provision of an adequate alternative protected passage for pedestrians.
6. Pedestrian and vehicular access to buildings and roads must be maintained at all time by the use of pedestrian bridges and boiler plates. Pedestrian bridge must be to a design approved by Dubai Municipality.
7. When work is being carried out at a manhole, a barrier must be erected round the manhole at all times when the manhole cover is removed.

Particular attention must be paid that the manhole cover is fully and correctly seated and does not extend above the frame when replaced.

Dubai Municipality expects your full co-operation for the safety of the public.

**Administrative Orders No:16 for the year 1987 & No:22
for the year 1990 for the issue of Regulations of the
Local Order No: 29/1986 amending Local Order No: 21/1981
respecting Excavation & Re-instatement of Trenches
on Public Roads**

The Director of the Municipality

Having reviewed the Decree of the establishment of Dubai Municipality and the Local Order No: 16/1987 amending the Local Order No: 21/1981 respecting Excavation and Re-instatement of Trenches on Public Roads.

And based upon the information submitted to us by the Head of the Roads Section,

It has been decided:

Article (1) : The Service Authorities or their agents may open trenches within the road corridor for the purpose of laying new apparatus or renewing existing ones only after obtaining the Municipality approval.

Article (2) : The Service Authorities or their agents should fill in Form No.(1) attached to the regulations and comply with the general conditions stated therein.

Article (3) : A decision shall be made on the applications submitted by the Service Authorities within a maximum period of 7 days from the receipt date of the application and the documents stated in the Regulations.

Article (4) : On notification of approval, the applicant shall submit to the Municipality a Bank Guarantee or pay to its treasurer if requested to do so, a cash deposit covering the value of the initial cost as determined by the Municipality. The said guarantee or deposit shall, after work completion, be returned to the concerned party, in full or in part, or shall be totally confiscated as explained in the Local Order and Regulations.

Article (5) :

5.1 The Service Authorities shall carry out the temporary reinstatement either directly or by employing a Dubai Municipality registered Contractor. The Municipality shall undertake the permanent reinstatement works provided the costs thus incurred will be charged to the Service Authorities which carried out the temporary reinstatement.

5.2 Where the reinstatement is carried out by Dubai Municipality Road Maintenance Section on behalf of the Service Authority, then a single full reinstatement shall be undertaken to standard commensurate with a permanent reinstatement.

The Service Authority being charged on the basis of a single fee which shall cover both the temporary and permanent reinstatement charges within one fee.

In the event of subsequent defects arising from this reinstatement carried out by Dubai Municipality Road Maintenance Section, then no further charges will be levied against the Service Authority.

Article (6) : Timing

6.1 The Municipality shall give the Service Authorities to commence its excavations, a period not exceeding 3 months from the date of approval of its application. The maximum time required to complete the work should be specified in the application form. It is to be observed, however, that backfilling should be completed as soon as the apparatus has been installed. If testing or a special inspection is necessary, this has to be done within 48 hours from the laying completion date. If a period greater than 48 hours is required for testing or inspection, this period should be stated in the application form for approval by Dubai Municipality.

6.2 The lengths of trenches open or of those whereon work is ongoing should, at any given time, be kept to the minimum practically possible.

6.3 The opening, laying of apparatus, testing, if any, backfilling and temporary reinstatement, should follow each other without gaps of idleness. If this sequence is not followed promptly, Dubai Municipality reserves the right to intervene and take whatever action deemed necessary.

6.4 Within 2 days from the time of completion of the temporary reinstatement of the surface, Dubai Municipality should be informed in writing by completing the appropriate form for the Reinstatement Inspector to visit the site and issue his approval.

6.5 Temporary and Permanent Reinstatement:

For estate roads, which are reinstated in accordance with the revised proposal for surface thickness (see Appendix I - Amendment), then the requirement for permanent reinstatement is without defect.

6.6 The D.M. Horticulture Section should complete planting the affected area with trees and carry out permanent reinstatement of grassed verges and planted area

within 12 months of the completion of reinstatement dependent on the growing

Article (7) : Approval and Maintenance of Traffic Diversions:

Any proposed diversions for vehicular or pedestrian traffic shall be approved by D.M. and Dubai Police prior to implementation. All the specified requirements must be adhered to strictly and the diversion maintained throughout its period of operation. Details of the diversion including all signing and lighting shall be submitted with the application to D.M. in two copies of drawing prepared to a scale of 1:1000 or other suitable scale to be agreed on. The two copies of the drawing shall be clearly marked to show the location and extent of the trench, in line with the provisions of sub-article 12.1 of the Regulations. Besides, the Service Authorities should inform the Police prior to commencement of work on site and obtain their approval of the programme in all cases where the works intervene with the roadway.

Article (8) : Activities Affected:

These regulations will apply to excavations associated with thrust boring activities or any other excavations within the road corridor including trenches.

Article (9) : Emergency Works:

In urgent cases where it is necessary for the Service Authorities to proceed with the work in anticipation of formal approval from the concerned authorities, the formal application should be submitted within 48 hours of the work commencement, even if the work had already been carried out and temporarily reinstated.

Article (10) : Consultation with other Service Authorities:

- 10.1** A Service Authority proposing excavations within the road corridor will submit details of its proposed excavations to the other Service Authorities in the form of a plan on which the location and layout of the proposed project are clearly marked. The other Service Authorities will be required to indicate the locations of their equipment in the vicinity of the proposed works on the plan, and return it together with a 'No Objection' Certificate. The plans so presented shall be based on the latest edition of 1:2000 or 1:1000 scale standard Dubai Municipality survey sheets.
- 10.2** Objections, if any, shall be resolved in consultation with the Service Authorities.

10.3 The Service Authority submitting an application for excavation works should provide each of the other authorities with 3 copies of the proposal, two of which will be returned to the applicant duly marked to show the locations of the other Authority's equipment. A copy of each marked up plan and 'No Objection' Certificate from each of the other Authorities will be attached to the application form submitted for approval to the D.M. Roads Section.

Article (11) : Excavation and Supporting of Trenches and Excavations:

11.1.1 The surface course of the carriageway or surfaced footpath shall be saw cut along a well defined line which shall define the outer limit of all work involving excavation. Where any subsequent excavation works causes undermining of the remaining surface course, then a new line shall be marked and the surface saw cut back to this new line.

11.1.2 Where the surface course is in interlocking block or paving slabs, then these shall be carefully removed, properly stacked and be stored for reuse. They shall not, however, be stacked or stored in such a manner as to block or reduce the adjacent carriageway or footpath to a width for which it cannot be used for its designated function.

11.2.1 All excavation below the surface level of the road or footpath shall be undertaken in such a manner that under cutting, collapse or secondary effects such as settlement due to dewatering shall be avoided.

11.2.2 Where the nature of the in-situ material is likely to give rise to the above defects, then suitable measures shall be adopted such as trench sheeting excavation by stepped vertical or battered faces, the batter being to a minimum of 1 horizontal to 3 vertically shored excavations or similar such means.

11.2.3 Battering or trenches will not be permitted in the carriageway and either vertical sheeted trenches or stepped excavations shall be adopted.

11.2.4 Where the sides of trenches, pits and other excavations are supported, then guidance for loads to be taken by the supports shall be based on BS 6031 - Code of Practice for Earthworks.

11.2.5 Dewatering shall be employed in such a manner that the water table is controlled to an appropriate profile adjacent to the excavation. On no account is the rate of draw down or pumping to be such that fines are drawn from the in-situ soils.

In the event that it is shown that fines are being removed from the naturally occurring materials, then the rate of abstraction of water shall immediately be reduced, and suitable alternative measures shall be employed to control the water table level.

Article (12) : Backfilling and Reinstatement:

12.1 Trenches can be opened within the road corridor in four types of ground.

12.1.1 In paved carriageways.

12.1.2 In footpaths and other paved areas (other than carriageways).

12.1.3 In grassed verges and planted areas.

12.1.4 In unmade ground which does not fall into any of the above three categories.

12.2 Backfilling in accordance with the requirements below is applicable to the above four categories in sub-article 12.1. Temporary and permanent reinstatement are applicable to paved road corridors only.

12.3 The Service Authority or its Contractors shall remove all surplus excavated materials off site to a Municipality assigned tip site and the working site shall be left in a clean and tidy condition on completion.

12.4 The Service Authorities may not borrow soil materials from any area within the road corridor.

Article (13) : Backfilling and Compaction of Trenches in Paved Carriageways upto Subgrade Level

13.1 All excavated materials is deemed unsuitable and should be removed from the job site to another location assigned by the Municipality. These materials can be exceptionally used if they satisfy the following requirements:

a) If they consist of natural sands, gravel or crushed rocks.

or b) If they are well graded and satisfy the grading limits as determined by BS.1377:

 B.S. Sieve 3" 1.5" 3/16: No:25 No:200

 % passing 100 85-100 45-100 8-45 0-10

c) The material passing B.S. Sieve No:36 when tested in accordance with BS.1377 has a plasticity index of less than 6.

13.2 All unsuitable materials shall be replaced with materials complying with the requirements stated in sub-article 13.1 hereabove.

- 13.3** The materials to be used immediately around the laid apparatus shall be to the Service Authorities' own requirements and specifications. These materials shall be filled around the apparatus and be compacted so that settlement is prevented as much as possible. The moisture content of these materials should be adjusted in order to ensure adequate compaction. Compaction within 300 mm of the apparatus can be carried out by hand.
- 13.4** The materials to be used as backfill above the first 300 sq.mm. over apparatus are to be placed and compacted in layers which shall each result in a maximum compacted thickness of 150 mm. Compaction shall be carried out by approved mechanical compacting equipment capable of producing an effect equivalent to a dead-weight roller weighing not less than 6 tonnes. Each layer shall be compacted until no further compaction is observed and the field densities specified in Appendix 2 are attained.
- 13.5** All trench side supports shall be carefully removed as the filling proceeds. All gaps which have been formed behind the supports shall be carefully filled and compacted.
- 13.6** Backfilling around manhole and other structures should be achieved using materials and methods of laying and compaction identical to those described for trenches hereabove. If the space between the manhole construction and the excavation face is not wide enough or for any reason proper compaction cannot be obtained, the backfilling should be carried out with Concrete Class (E).

Article (14) : **Backfilling and Compaction of Trenches in Footpaths and other Paved Areas upto Subgrade Level:**

- 14.1** Excavate materials, if judged suitable by the Service Authority representative and Dubai Municipality Roads Inspectors, may be used for backfilling, provided they are at the optimum moisture content and will permit compliance with the requirements of compaction. If judged suitable, then suitable materials allowing compliance with the compaction requirements should be used.
- 14.2** The provisions of Sub-articles from 13.3 - 13.6 shall apply to the backfilling and compaction of trenches and excavations in footpaths and other paved areas.

Article (15) : **Backfilling and Compaction of Trenches in Grassed Verges and Planted Areas**

- 15.1** After the removal of all surface vegetation and plants and roots, the top soil is to be removed and stored for reuse.
- 15.2** The provisions of Sub-article 14.1 - 14.2 shall apply to backfilling and compaction of trenches and excavations in grassed verges and planted areas.

- 15.3** The top of the last layer which is the subgrade of normal backfill should be lower than the original ground level by 150 mm or the thickness of the top soil layer whichever greater.
- 15.4** The top soil which has been removed shall be placed without compaction to a thickness greater 20% than the final thickness required.
- 15.5** If the recovered top soil is contaminated or is not sufficient, additional top soil is to be improved and used whilst the contaminated top soil should be removed to tip off site.

Article (16) : Backfilling and Compaction of Trenches in Open Unmade Ground:

- 16.1** In certain type of ground e.g. subkha flats, it may be necessary to remove the top 100 mm of material and dispose of it to tip off site.
- 16.2** The provisions of Sub-article 15.2 shall apply to the backfilling and compaction of trenches and excavations in open unmade ground.
- 16.3** The final layer should bring the surface of the trench proud of the surrounding area by about 150 mm.

Article (17) : Reinstatement of Pavement Layers in Carriageways:

- 17.1.1.** Temporary Reinforcement Pavement layers shall be placed as soon as practicable after backfilling has been completed in line with the explanations given in Article 6 of the Regulations.
- 17.1.2** Using mechanical means, the edges of the trench shall be cut to a uniform line consistent with the varying width of the trench. Any part of the pavement damaged beyond the trench must be cut out and made good in accordance with this specification.
- 17.1.3** A vertical joint shall be formed between the new work and the existing road surface. This shall be painted with suitable bituminous binder. The pavement layers shall be stepped by a minimum of 75 mm or the thickness of the pavement layer, whichever is greater. The finished levels of the completed reinstatement shall conform to the adjoining carriageway surface.
- 17.2.1** Depths of pavement layers - the required thickness of the pavement layers are shown in Appendix 1, which also shows that roads are classified into four types and their requirements for both temporary reinforcement to be carried out by the Service Authority and permanent reinstatement to be carried out by D.M.

17.2.2 The specification for materials used in temporary reinstatement (sub-base aggregate road base, wet mix, prime coat, tack coat and asphaltic surface course) are shown in Appendix 2.

17.2.3 Mixing, transporting, laying and compacting the materials used shall be in accordance with the accepted practices in road construction.

17.3 Permanent Reinstatement

D.M. will permanently reinstate the pavement to the requirements of Appendix 1. The temporary asphaltic surface layer and sufficient depth of the road base material shall be removed to permit the placing of the required numbers and thickness of pavement layers, subject to removal of material laid in temporary reinstatement above the dotted line shown in Appendix 1.

17.4 Reinstatement of Hard Shoulders

The reinstatement of hard shoulders shall be similar to the reinstatement which would be carried out in the adjoining carriageway subject to the final surfacing being such that it matches the general surface of the hard shoulders.

17.5.1 Reinstatement of Kerbs and Footway Edging

Kerbs and footway edging disturbed or damaged by the Service Authority's works shall be relaid with units of similar texture, colour and type, conforming as nearly as possible to those adjacent. The units shall be laid on a concrete bed and backed with concrete class 30/20 SR. They shall not deviate from line or level by more than 3 mm in 1 m.

17.5.2 In-situ concrete kerbs and edging shall be reinstated to conform with adjoining kerbs and channels in sulphate resistant concrete class 30/20 SR.

Article (18) : Reinstatement of Footpaths and Paved Areas

18.1 Incase the footway or paved area has an asphaltic surface course, backfill material shall be finished and compacted to a level of 130 mm below the level of the adjacent pavement. 100 mm sub-base material shall then be placed, compacted and primed to be followed by 30 mm of asphaltic surface course.

18.2 Where the footway or paved area is finished off in concrete slabs or interlocking blocks, backfill material should be finished and compacted to a level of 125 mm plus the thickness of the concrete slab or interlocking block below the level of the adjacent pavement. The concrete slabs or interlocking blocks shall be added on 50 mm of sand/cement mixture (ratio 10:1) on top of 75 mm of sub-base material.

18.3 The specification of materials used in the two preceding subarticles are shown in Appendix 2. All damaged concrete slabs and interlocking blocks shall be placed by units or texture, colour and type, conforming as nearly as possible to those being replaced. In all cases, laying compacting and finishing off of all materials should be in accordance with the accepted good practices in road and footpath construction.

Article (19) : Incase the applicant (Service Authority) or his agent fails to carry out the temporary reinstatement to the required technical specifications, the Municipality shall undertake to do the works and the cost so entailed shall be to the applicant's account plus all administrative charges and a penalty equivalent to 75% of the original cost.

The Director of the Municipality shall have the right of exemptions from the penalty value or part thereof.

Article (20) : This Order shall be implemented as of its date of issue and shall be published in the official Gazette of the Emirates of Dubai.

**DIRECTOR
DUBAI MUNICIPALITY**

LOCAL CONDITION

1. LOCATION

The Site is located in various parts of the Emirate of Dubai.

The elevation of the site is approximately as shown in the tender drawings.

Conditions

The plant Site conditions shall be assumed to be as follows for the purpose of tendering:

a) Ambient Air Temperatures:

- Maximum outdoor shade ambient 48 ° C
- Minimum 2 ° C
- Maximum average over 24 hr. 37.8 ° C
- Maximum average over 1 year 26.9 ° C

b) Maximum Relative Humidity 100%

c) Seismic Co-efficient 0.07 g

2) RELEVANT INFORMATION

The following relevant information is provided as an aid to construction. Particular attention should be paid to concrete curing and corrosion conditions. In the event of the Tender being accepted, the Contractor shall satisfy himself as to the accuracy of the information provided.

Climate

The climatic information given is based on records of the local Meteorological stations.

a) Temperature

Shade temperature ranges from approximately 3 °C to 48 °C. The coldest month is January and the hottest month is August.

b) Humidity

Relative humidity of 85% is reached almost everyday and very often 100% is experienced.

c) Rainfall

As is usual in areas of low precipitation, distribution of rainfall is very erratic. Heavy storms are common in winter and thunderstorms in late afternoon/evening are common place.

d) Fog and Dew

During certain periods of the winter months, night and early morning fog is common. This may persist from two hours after sunset until two hours after dawn.

Heavy dew can be expected most mornings at any time of the year.

e) Winds

The records give no information of long term maximum gusts. The estimated wind speed for a 3 second gust likely to be exceeded once in 50 years is 44 m/s. Gusts upto 35 knots are commonly experienced.

f) Sandstorms

Sandstorms are occasionally experienced mainly between January to March and August to October.

10.2

GOVERNMENT OF DUBAI

Act No.(2)/1994
Concerning Protection of Safety of the General Network
of Electricity and Water Services

We, Maktoum Bin Rashid Al Maktoum, Ruler of Dubai
After perusing Decree No.(1) of 1992 concerning the establishing of
Dubai Electricity & Water Authority.
Hereby issue the following Act :

Chapter (1)
Definitions

Article 1 : In implementing the provisions of this Act, the following words and phrases shall have the meaning assigned in front of them unless otherwise implied :-

Authority : Dubai Electricity & Water Authority

General Network : All Stations, Equipment, Installations, Systems of Electricity & Water and accessories owned or operated by the Authority.

Service Lines : Water lines and electricity lines and ground, overhead and onshore cables and accessories.

Person : Any natural person or person with legal personality.

Schedule : Complementary Punishment Schedule attached to this Act.

Chapter (2)
Protection of Safety of Network and Services System Lines

Article 2 : Any person who works near the general network or near the routes of service lines belonging to the Authority, must take all the necessary preventive measures that prevent causing damage to these lines or network facilities.

Article 3 : Any person who wants to work near the General Network or near the routes of service lines of the Authority must obtain a "No Objection Certificate" prior to commencement of the work, and should abide by the terms and conditions stated therein.

Article 4 : Any person whose work necessitates the crossing of the General Network or route of any service line, must initially notify the Authority, and shall be forbidden to commence on with his work before the arrival of the Authority's representative to determine the way of work or supervise it.

Article 5 : Any person shall be strictly forbidden to cause any damage to the General Network or any of the service lines, either by destruction, cutting or exposure, and in case the same has occurred, he should immediately notify the Authority.

Chapter (3)
Punishment

Article 6 : Notwithstanding any other punishment provided for by any other Act :

(A) Each person who contravenes any clause of this Act whether being a direct doer, a joint participant or as Contractor, commits a crime punishable with imprisonment for a period not exceeding 3 months and fine not less than Dhs.5000/- and not exceeding Dhs.50000/- or with any of these two punishments.

(B) To be subject to a complementary punishment equivalent to the damage caused by him as per the attached Schedule.

(C) The Court may order the confiscation of the equipment used in committing the crime.

Article 7 : Any person who embosses, steals, transfers or unlawfully utilizes water or electricity or any other services of these two Utilities, will be punished with imprisonment for a period not exceeding 6 months or with fine not exceeding Dhs.10000/- or with both punishments.

Chapter (4)
General Provision

Article 8 : The value for complementary punishment as per the attached Schedule should be transferred to the Authority.

Article 9 : This Act shall be published in the official gazette and shall come to take effect as from the date of its publication.

Maktoum Bin Rashid Al Maktoum
Ruler of Dubai

Issued at Dubai on 16 February, 1994
06 Ramadhan, 1414

10.3

COMPLEMENTARY PUNISHMENT SCHEDULE

FIRST:- WATER

	<u>Amount (Dhs.)</u>
A- 1/2" TO 2" Polythene pipe (per Meter)	600.00
B- F.C. Pipe, (upto 5 meter)	
F.C. Pipe 3"	9,000.00
F.C. Pipe 4"	10,000.00
F.C. Pipe 6"	11,000.00
F.C. Pipe 9"	18,000.00
F.C. Pipe 12"	24,000.00
F.C. Pipe 22"	30,000.00
F.C. Pipe 24"	35,000.00
F.C. Pipe 36"	150,000.00
F.C. Pipe 48"	190,000.00

SECOND : ELECTRICITY

1- Single Phase Meter	1,000.00
2- Three Phase Meter	5,000.00
3- L.V.Cable	20,000.00
4- PVC Cover of 33 kV Cable	20,000.00
5- 11 kV H.V. Cable	40,000.00
6- 33 kV H.V. Cable	150,000.00
7- Pilot Cable of 33 kV	40,000.00
8- Overhead Line Pole 11 kV(Per Pole)	40,000.00
9- Overhead Line Pole 33 kV(Per Pole)	100,000.00
10- Oil Cable HV 132kV (Per pole)	500,000.00
11- Pilot Cable of HV 132kV	50,000.00
12- Substation (Having one Oil transformer 1000 kVA)	600,000.00
13- Substation (Having Two Oil transformer each of 1000 kVA)	900,000.00
14- Substation (Having one Oil transformer 500 kVA)	550,000.00
15- Substation (Having one Oil transformer 1000 kVA with H.V. Meter)	750,000.00
16- Pocket Substation 1000 k VA	500,000.00
17- Pocket Substation 500 k VA	400,000.00
18- Ppcket Substation (2 Nos. transformer of 1000 kVA each)	900,000.00