Energy Audit of Water and Wastewater Utilities in 6 towns of Moldova

Construction of Selected Water Supply Pipelines and Pumping Stations

TECHNICAL REQUIREMENTS

for
construction works of water supply pipelines and pumping stations
in Balti, Causeni and Orhei

GENERAL SPECIFICATIONS

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1 PROJECT GENERAL REQUIREMENTS

1.1 SCOPE OF THE WORKS

1.1.1 Scope of the Contract

1. The Project includes preparation of detailed design and technical drawings, furnishing of all labor, plant and equipment, materials required to complete the entire works, pre-commissioning, commissioning, testing, reinstatement of the Sites, preparation of working, shop and as-built drawings, training of operation and maintenance staff.

2. The Project aims to achieve the following basic objectives:

- Reduced energy consumption;
- Reduced amount of leakages and consequently cost of supply;
- Sustainable and reliable water service to all area water consumers;
- Adjusted network pressures.

3. All the works are as determined in detail in the Particular Specifications.

2 DETAILED DESIGN. GENERAL REQUIREMENTS

2.1 SCOPE OF THE DESIGN WORKS

2.1.1 Scope of the design works

1. Prior to proceeding with construction works, the Contractor shall prepare detailed design for the relevant infrastructure.

2. All the design works are as determined in detail in the Particular Specifications.

3. The Contractor shall assemble a task force of specialist engineers and technicians who would be assigned to carry out the detailed design. Design activities should, preferably, be carried out simultaneously for all project towns.

2.1.2 Field Surveys/Investigations

1. The Contractor shall carry out the necessary physical surveys and/or inspections of the existing facilities and measurements within the proposed projects boundaries and determine the physical condition of the existing project assets (pipes, equipment, permanent works etc) and sites (geological and topographic surveys etc.). Some of these surveys/inspections for underground/ surface pipelines, etc. may require the use of TV Inspection Camera for viewing inaccessible locations. The required service in relation to the TV Inspection Camera may have to be outsourced by the Contractor from specialized agencies.

2. The Contractor shall find all basic data related to geological investigations in volume, which is necessary for design. If available data is not sufficient for design works, Contractor shall perform geological investigations in the volume needed for detailed design purposes.

3. The Contractor shall collect all necessary field measurements/sampling data in volume, which is necessary for design. If available data is not sufficient for design works, Contractor shall perform additional measurements/sampling.

4. Based on the results of the surveys/inspections (as necessary) determine the physical condition of the existing project assets and sites and jointly agree with the Engineer on the need for new construction, repairs, replacement or rehabilitation or a combination of both.

2.1.3 Design

1. In the design, the Contractor shall make decisions regarding exact locations/layouts, size, slope, materials of constructions and other technical features with due regard to Good Design Engineering Practice and taking into account all necessary Safety Margins. The designs must ensure that a minimum operating life of 30 to 35 years is achieved.

2. The Plant shall be designed in all respects to confirm with the latest current Project Management practice. The philosophy of preparing designs shall be simplicity and reliability, so that the equipment will provide long and trouble-free service with low maintenance costs, low energy consumption and low disturbing impact on the environment.

3. The Detailed Design shall comply with local construction norms and National legislation in force.

4. Where necessary, the Contractor shall carry out hydraulic network calculation for required segments for the present water demand.

4. The Contractor shall select proper and economically most sustainable route for new pipes laying or placement of pipe in case of reconstruction/new construction.

5. Prior to route approval, the Contractor shall check the land availability and ownership.

2.1.4 Drawings

1. The Contractor shall produce comprehensive engineering and construction drawings to the highest standards of accepted practice. These drawings shall cover all features of the work and be adequately detailed for bidding purposes and contract execution

2. The design drawings will be an integral part of the final contract documentation and in case of uncertain interpretation or ambiguities in Technical Specifications, the indications on the Detailed Design Drawings would prevail. All relevant design calculations, route maps, schedules, charts and drawings/design documentation shall be provided to the Engineer, as required.

The drawings of the water networks should be done on a 1:500 or 1:1000 scale topographic map.

Drawings should contain at least but not limited to:

- The water and wastewater lines included in the rehabilitation, and their coordinates referred to the axes of the buildings, and other utility networks that have an influence on the installation of the newly designed networks;
- Diameters, lengths, types of materials, pressure ranges etc. of the designed networks;
- The structures to be installed on the networks (such as manholes, traverses on piers, etc);
- The details of junctions and manholes.

The profiles should contain at least but not limited to:

- Aboveground structures (such as piers);
- Level of the surface – as designed and in natural state;
- Depth of the laying of the pipes (per norms) measured from the level of the surface – as designed and in natural state;
- Level of the surface water;
- Intersections of the railways, roads, underground municipal networks that have an influence on the laying of the designed pipes, indication of the overall size and levels;
- Information about the soil along the pipelines. The data will be shown for separate points;
- Protection tubes for the pipes indicating the diameters, lengths and their position referred to the axes of the road, or designed networks and structures.
- Lengths of the pipes, distance between manholes, points of turning, angles of turning for the designed pipes, and the depth of installing.
- Tables under the profiles should contain information about the laying beds for the pipes.

The longitudinal profiles should be drafted for all the rehabilitated networks, including service pipes to water consumers (except for connections for 1-2-3 story buildings). The drawings should be done in the scale of 1:500 or 1:1000 for horizontal representations.

The drawings for PS shall include all necessary cross-sections, materials and structural description.

All mechanical equipment and internal pipelines/valves shall be indicated on drawings. Electrical schemes shall be provided.

If necessary, external power supply (transformers) shall be designed.

The drawings should be drafted in AutoCAD 2004 or later version and the tables should be presented in MS Excel in both Romanian and English languages.

2.1.5 Coordination

1. The Contractor shall coordinate the designs with all municipal network services (natural gas supply networks, phone cables, heating supply, power supply and street lightening, etc) authorities (environmental department, fire prevention and control, civil protection, center of public health, etc).

2. Before submission of the designs to the Engineer, the Contractor shall obtain authorization from the Department of Supervision and Expertise of Construction Technical Designs, eliminate all mentioned nonconformities and deviations, in accordance with the Law on Quality in Construction of the Republic of Moldova.

3 CONSTRUCTION WORKS. GENERAL REQUIREMENTS

3.1 SCOPE OF THE WORKS

3.1.1 Scope of the Contract

1. The works include furnishing of all labor, plant and equipment, materials required to complete the entire works, pre-commissioning, commissioning, testing, reinstatement of the Sites, preparation of working, shop and as-built drawings, training of operation and maintenance staff.

2. Tentative works are as determined in detail in the Particular Specifications.

3. The works could be adjusted/changed during detail design phase basing on strong argumentation/constrains, on Engineer's agreement.

3.1.2 Relations between Different Contracts

1. The Contractor shall determine if any other establishments, organizations are or will be carrying out any work or activity simultaneously with the work of the Contractor and shall co-ordinate his work with this.

2. The Contractor shall as required deliver all necessary information and measures in the form of detailed design/working drawings to ensure correct location of embedded items, dimensions of structures etc. and other necessary information for carrying out the works of the other related contracts.

3. The Employer shall pay no extra compensation for possible inconvenience incurred by the Contractor in relation to this matter.

3.2 GENERAL INFORMATION

3.2.1 Power, Current and Voltage

1. Nominal operating voltage is 380/220V AC and frequency 50 Hz. Voltage fluctuation is common in the Site.

2. The Contractor shall remain responsible for supplying temporary power to the entire extent of the works. The Contractor shall obtain and pay for all permits related to electrical work, arrange for all electrical inspections covering his work, pay all fees and charges, and make all deposits that are in any way connected with the installation of the systems included in the Contract. He shall give all necessary notices to authorities having jurisdiction and shall be responsible for complying with all applicable public ordinances.

3. The materials, equipment and installation shall comply with the regulations laid down by the Electricity Authorities.

3.2.2 Offices and Services Provided by the Contractor

3.2.2.1 Contractor's Own Staff and Personnel

The Contractor shall provide all necessary offices, social premises, accommodation and other necessary facilities for his own and any other personnel under his control working on the Contract.

3.3 INFORMATION AND OBLIGATIONS RELATING TO SITE ARRANGEMENTS

3.3.1 Working Conditions

(1) The work shall be carried out during normal working hours and if the work is temporarily performed as over-time work, the performance and supervision of work has to be agreed upon with the Engineer in advance;

(2) First-aid facilities shall be provided by the Contractor;

(3) The Contractor shall provide safety and protective clothing for persons under his control on the Site;

(4) The Contractor shall organise the Site and his methods of working such that all are safe;

(5) Adequate lighting of the work places and Sites shall be provided by the Contractor; and

(6) Fire-fighting equipment shall be arranged by the Contractor.

3.3.2 Safety Regulations and General Order of the Site

1. The Contractor shall be fully responsible for complying with the safety regulations and requirements for general order on Site in accordance with the applicable laws, regulations, instructions of the local authorities and as provided in these Specifications.

2. The Employer will notify the Contractor in full of the safety regulations which the Employer imposes on his own employees and the Contractor shall comply with such regulations.

3. The Contractor shall inform the Employer in writing in full of any special risks anticipated during the execution of the Works.

4. For each working area the Contractor shall designate a foreman who will, besides supervision of the work in progress, be responsible for safety and security in the working area.

6. The following noise levels measured at a distance of approximately 1m from mechanical and electrical facilities are permitted for the following standards and regulations:

(1)	Hydraulic and pneumatic equipment	max. NR 80
(2)	Gears and drives	max. NR 80
(3)	Water pumps	max. NR 80
(4)	Rotary piston blowers	max. NR 85

where NR 80 and 85 are noise rating numbers of the EN ISO 8253 Standard 1998.

3.3.3 Standards, Weights and Measures, Abbreviations, Labelling and Symbols

1. All material and equipment shall be referred to in the metric/SI international standards with regard to their weights and measures.

2. All Plant, materials and workmanship unless otherwise specified shall be in accordance with EN standards where such standards or recommendations exist.

3. In the absence of applicable EN standards or recommendations, the workmanship and material shall comply with the relevant and latest editions of the standard specifications and codes of practice issued by the following organisation:

Name of Organisation International Organisation for Standardisation

In the absence of applicable EN and ISO standards or recommendations, the workmanship and material shall comply with the relevant equivalent Standards of other European countries, eg BS, DIN, ONORM, etc.

4. The Moldovan standards shall, however, be applied in lieu of the international standards in case the Moldovan standard is more stringent than the respective international standard specified in the Technical Specifications. The products of similar material shall be compatible and interchangeable with each other without the use of special adapters.

5. The Contractor shall provide on Site within 28 days after the Works Commencement Date, English versions of all international standards and codes to be used in the implementation of the contract. For Moldovan standards to be used the Moldovan version provided on site. Upon completion of the Contract these standards shall remain the Contractor's property.

6. Pipes and valves shall be labelled to indicate the direction and type of flowing substance in the system. The size and shape of the label shall be as defined in EN standards. All text shall be in English and Moldovan.

7. Machines, equipment, control valves and panels shall be fitted with a non-corrosive label setting out the item number, make, model, serial number, key performance data and the like.

8. Warning signs and colours shall be no substitute for protective appliances and devices. The warning signs and colours shall all be approved by the Engineer. Warning signs and colours where used shall warn about:

(1) danger of explosion or fire in the area;
(2) noise which exceeds safety levels;
(3) poison or toxic substance if stored in the area, including first aid instructions;
(4) automatically started and operated appliances;
(5) appliances having moving parts which can cause accidents;
(6) structures which obstruct the walkways; and
(7) danger of slip or fall.

3.4 Setting out

1. The Contractor will prepare Detailed Design and use all data relating to the bench marks.

2. The Contractor is responsible for setting out all additional traverse points and bench marks required in the working area at the commencement of his work.

3. The Contractor shall take care that the location and level of the traverse points and bench marks are not changed during the construction. When the traverse points or bench marks occur in areas to be built up, the Contractor shall establish new traverse points and bench marks before abandoning the old ones. The Contractor shall to submit the calculations and measurements of the new traverse points and bench marks for the approval of the Engineer and no original traverse points or bench marks shall be destroyed without approval by the Engineer.

4. The accuracy of the new points shall be the same as that of the original traverse points and bench marks.

3.5 PROTECTION REQUIREMENTS

3.5.1 General

The Contractor shall be responsible for protection against vandalism, theft or malicious mischief of all of the Facilities at all times from the start to completion of the facilities.

3.5.2 Underground Services

3.5.2.1 General

1. Before starting any construction at the Site the Contractor shall arrange with the Engineer and owners of the underground services to show and/ or locate their services so as to avoid damage during construction.

2. The Contractor shall temporarily support all underground services during the excavation of and whilst working in trench and also provide permanent and adequate support for services as required and all costs associated with this are deemed to be included in the Contractor's rates and prices.

3.5.2.2 Unknown Underground Services and Installations

1. The Contractor shall take all reasonable precautions, including but not necessarily limited to the use of cable detection equipment, to ensure that unknown underground services within and near the confines of excavations are detected and safeguarded from damage.

2. If, despite such precautions having been taken, damage to unknown underground services occurs, the Contractor must take appropriate measures to minimise such damage and immediately inform the Engineer and the owner or Responsible Authority.

3. If the Engineer so instructs, after consultation with the owner or Responsible Authority, the Contractor shall make good the damage in a manner and at times to be approved by such Authority or owner or the Engineer. Payment for such additional work will be made in accordance with the Contract, provided always that the necessity for such repair work has not arisen due to the fault of the Contractor.

4. However, if the Contractor fails to take appropriate precautions and damage to unknown underground services occurs as a result of such negligence, then the Contractor will be held responsible for making good the damage, as if presence of the service had in fact been known beforehand.

3.5.2.3 Known Services and Installations

1. The Contractor shall take every precaution to ensure that all known existing services, pipes, culverts, cables, boundary walls and fences, retaining walls, drainage and irrigation ditches and the like, within and near the confines of excavations are located, supported and safeguarded from damage. Any damage caused to any such services, pipes, culverts, cables, boundary walls and fences, retaining walls, drainage and irrigation ditches and the like attributable to the Contractor's operations, his constructional traffic or his negligence shall be made good by or for the Contractor at his own expense to the satisfaction of the Engineer, owner or Responsible Authority.

2. In the event of the owner or Responsible Authority electing to repair such damage, the Contractor shall pay the cost of doing the work. Should the Contractor fail to pay the cost of the said work within a reasonable period of the account being presented, the Employer reserves the right to settle the account and deduct the sum paid by him from money due or which may become due to the Contractor.

3.5.3 Temporary Removal of Existing Services

1. If it should become necessary for the proper execution of the work to temporarily remove or divert any existing pipe, sewer, field drain cable, drainage or irrigation ditch or other service, the Contractor shall obtain permission from the Responsible Authority or owner or Engineer and shall carry out the work at his own expense in a manner and at times to be approved by such Authority or owner or the Engineer and shall subsequently reinstate the work to the satisfaction of such Authority or owner or Engineer.

2. In the event of the owner or Responsible Authority or Engineer electing to arrange for the temporary removal of an existing service, the Contractor shall pay the cost of his or their doing the work. Should the Contractor fail to pay the cost of the said work within a reasonable period of the account being presented, the Employer reserves the right to settle the account and deduct the sum paid by him from money due or which may become due to the Contractor.

3. The Contractor's attention is particularly drawn to the requirement to maintain drainage and irrigation ditches in order to avoid any interruption of flow of water therein to the satisfaction of the Engineer, owner or Responsible Authority and the Contractor shall be deemed to have included in his rates and prices for all temporary works so required.

3.5.4 Permanent Diversion of Existing Services

1. If, in the opinion of the Engineer and / or of the Responsible Authority or owner, it should become necessary to permanently remove or realign any existing pipe, sewer, field-drain, cable, ditch or other service, other than allowed for in the Bill of Quantities, the Contractor shall obtain permission, where necessary from the Engineer or Authority or owner and shall carry out and complete the work to the satisfaction of the Engineer and such Authority or owner. Payment for such additional work will be made in accordance with the Contract, provided always that the necessity for such permanent diversion has not arisen due to the fault of the Contractor.

2. In the event of the owner or Responsible Authority electing to arrange for the permanent diversion of an existing service, the permanent diversion of which has become necessary due to the fault of the Contractor, the Contractor shall pay the cost of them doing the work. Should the Contractor fail to pay the cost of the said work within a reasonable period of the account being presented, the Employer reserves the right to settle the account and deduct the sum paid by him from moneys due or which may become due to the Contractor.

3.5.5 Permanent Support for Existing Services, etc

If, in the opinion of the Engineer and / or the Responsible Authority or owner, it should become necessary to provide permanent support for any existing pipe, sewer, cable, structure or other things exposed or injured during or after the execution of the Works, the Contractor shall carry out promptly such additional works as the Engineer may require to provide such permanent support.

3.5.6 Responsible Authority or Owners May Carry Out Work

Any of the work involving repair, replacement or realignment of existing pipes, sewers or other services may be carried out by the Responsible Authority or owner if they so desire. In such case, the Contractor shall allow them the facilities and assistance they may require and shall bear the full expense of work except in the case of permanent removal or re-alignment which will be paid for by the Employer, provided that the necessity for such removal or re-alignment has not arisen due to the fault of the Contractor.

3.5.7 Care of Boundary Walls and Fences

1. The Contractor shall not cut through or remove any section of any boundary wall or fence without the prior approval of the Engineer who will determine the limits of such cutting or removal.

2. Approval for the cutting through or removal of boundary walls and fences will normally be limited to those crossing the route of mains and pipelines and the Contractor shall so conduct his operations as to minimise the extent of such cutting through or removal.

3. The Contractor shall repair and reinstate in a manner similar to the original or by other approved means any wall or fence which he may have cut through or remove with or without the approval of the Engineer or damaged during his operations and all such repairs and reinstatement shall be the Contractor’s sole liability and shall be carried out to the satisfaction of the Engineer and the Responsible Authority.

4. The Contractor shall, at his own expense, provide temporary fencing and security measures at all times to protect any affected properties.

3.5.8 Protection of Property

1. The Contractor shall be responsible for the preservation and protection of property, private or public, on or adjacent to the work Site against damage or injury as a result of his operations under this Contract.

2. Any damage or injury occurring on account of any act, omission or neglect on the part of the Contractor shall be restored in a proper and satisfactory manner or replaced by and at the expense of the Contractor to an equal or superior condition than previously existed.

3. The Contractor shall restore all surfaces and property damaged or disturbed by his operations and shall bear full responsibility for the protection of all finished exterior and interior surfaces, fixtures and equipment from stains, marks, dirt or damage of any kind whatsoever from the time of their construction, finishing or installation until the time of handing over.

4. In the event of any claims for damage or alleged damage to property as a result of work under this Contract, the Contractor shall be responsible for all costs in connection with the settlement of or defence against such claims. Prior to commencement of work in the vicinity of property adjacent to the work Site, the Contractor at his own expense shall take such surveys as may necessary to establish the existing condition of the property. Before final certificate can be made, the Contractor shall furnish satisfactory evidence that all claims for damage have been legally settled.

3.5.9 Pre-inspection/Approval Requirements

Before requesting an inspection of the completed works, the Contractor shall do all necessary cleaning, making good, and touching up that may be required to leave all finished surface, fixtures and equipment in accordance with the full intent and meaning of these specifications.

3.5.10 Open Excavations

1. All open excavations shall be adequately safeguarded by providing temporary barricades, caution signs, cones and warning lights to prevent accidents to persons, and damage to property. All signs with script shall be in both Moldovan and Russian languages and shall comply with regulations of the local authorities.

2. The Contractor shall take precautions to prevent injury to the public due to open trenches. All trenches, excavated material, equipment, or other obstacles which could be dangerous to the public shall be well illuminated from half an hour before sunset until half an hour after sunrise and other times when the visibility is poor. The position and the number of lamps shall be such that the extent and position of the works is clearly defined.

3.5.11 Fire Protection

1. Contractor shall take all necessary precautions to prevent fires at or adjacent to the work, buildings, etc, and shall provide adequate facilities for extinguishing fires which may occur. No burning of trash or debris will be permitted at the Site.

2. When fire or explosion hazards are created in the vicinity of the work as a result of the locations of fuel tanks, or similar hazardous utilities or devices, the Contractor shall immediately alert the local authorities and the Engineer of such hazards. The Contractor shall exercise all safety precautions and shall comply with all instructions issued by the local authorities and the Engineer to prevent the occurrence of fire or explosion.

3.5.12 Explosives and Blasting

1. The Contractor shall be allowed to use explosives only in open, rural areas and with the express permission of the Engineer. After having obtained the said permission, all blasting shall be done only by

properly trained and qualified workmen under the supervision of an experienced foreman, who shall be in possession of an official and authenticated current blasting certificate.

2. The Contractor shall provide a special store for explosives in accordance with existing regulations. Transporting and storing of explosives and blasting shall also be in accordance with the Laws regulating their use.

3. The greatest care shall be taken when blasting to protect persons, the works and any other property. No blasting shall be done within 10 m of any existing structure. The last 15 cm of rock above foundation level shall be removed by use of power tools or by hand.

3.5.13 Tree and Green Area Protection

The Contractor shall not be allowed to remove, relocate, or cut down any trees located in public areas without the approval by the Engineer and local authorities. It shall be the Contractor's responsibility to protect all existing trees and green areas located in his working area. If in the opinion of the Engineer a tree or a green area has been unnecessarily destroyed or damaged to any degree by the Contractor then the Contractor shall replace the damaged tree and/ or green area with a new one of equal quality and characteristics.

3.5.14 Safety Precautions

3.5.14.1 Safety Programme and its Implementation

1. Within fourteen (14) calendar days from the date of receipt of Notice to Commence the Contractor shall submit in writing his proposal for a comprehensive safety programme covering all aspects of the Works.

2. This safety programme shall detail policies, procedures, and plans which the Contractor intends to implement to insure the safety and health of his employees. It shall comply with the standards listed below.

3. The Contractor shall designate a competent engineer especially trained and experienced, to act as Safety Officer, who will administer and be responsible for the implementation of the Safety Programme. He shall carry out frequent and regular safety inspections on the working areas, materials and equipment. The name and qualifications of the Safety Officer shall be submitted for approval to the Engineer prior to his appointment.

4. The Contractor shall be responsible for enforcement of the health and safety provisions by his subcontractors, if any, to be employed at the Site.

3.5.14.2 Safety Standard

In addition to the requirements specified herein, the Contractor shall comply with the safety requirements of the following bodies and / or documents:

(1) Labour Safety Organisation of the Republic of Moldova

3.5.14.3 Personal Safety Equipment

1. The Contractor shall provide his personnel and visitors with appropriate safety equipment, such as helmets, safety footwear, gloves, waterproof clothing, dust masks and safety belts. The use of such safety equipment shall be compulsory.

2. Emergency equipment such as explosion proof lamps, gas masks, signalling devices, flashlights in good working conditions, etc. shall be stored in the Contractor's office.

3.5.14.4 Power Supply and Lighting

1. All working sites in the open, transit areas, excavation sites, etc. shall be adequately illuminated during night work, as specified above.

2. Electrical cables shall be well insulated, protected and firmly fixed by means of adequate insulators. Lamps shall be well protected against damage.

3. All equipment and appliances which are exposed to lightning shall be earthed electrically, and the effectiveness of such earthing shall be periodically checked by the Contractor's specialised personnel.

3.5.14.5 Fire Precautions

The Contractor shall organise a fire brigade equipped for the fighting of any fires which may break out on the construction sites, in temporary structures, stores, residential quarters, etc. An adequate number of fire extinguishers shall at all times be available at each construction site or camp and shall be maintained in satisfactory working order. Fire protection facilities shall be of the gas, dry powder or other suitable chemical or pumped water type. Their number, type and location will be subject to the approval of the Engineer.

3.5.14.6 Dust Abatement

During the performance of the works and any operations appurtenant thereto, the Contractor shall carry out proper and efficient measures, such as sprinkling by water or by other means, whenever and wherever necessary to reduce the dust nuisance, and to prevent dust which has originated from his operations from damaging crops, cultivated fields and dwellings, or causing a nuisance to persons. The Contractor will be held liable for any damage resulting from dust originating from his operations.

3.6 MATERIALS AND EQUIPMENT, APPROVALS AND SUBSTITUTIONS

3.6.1 General

The Contractor shall state the particular materials and equipment offered to satisfy the Specifications and Detailed Design. Manufacturer’s catalogues, technical data and samples when appropriate, shall be submitted. This technical documentation will assist for approval of the Engineer for materials and equipment to be supplied/ built in.

3.6.2 Substitutions

1. Unless otherwise specified, all materials and equipment incorporated in the work under the Contract shall be new.

2. Whenever specific references are made in the Specifications, to manufacturers or brand names, or standards, the intent is to establish a standard of type, quality and function of the required material or equipment. The products of the manufacturers must be equivalent to the product so specified. The fact that one or more manufacturers might be listed in a List of Approved Sub-contractors, Suppliers and Vendors, shall not relieve the Contractor of the responsibility for providing materials complying with the Technical Specifications. The fact that manufacturers' names are specified or approved for any item shall not be construed as implying that such item need not comply with the performance, construction or other requirements specified for the item. In all cases, the Technical Specifications requirements shall take precedence over the manufacturers’ standard.

3. Only those products originally specified and/ or approved upon the Contractor’s requests as substitutions may be used in the work. Whenever requests for substitutions are approved, it shall be understood that such approval is conditional upon strict conformance with all requirements of the Contract and further subject to the following:

(1) Any material or article submitted for approval in accordance with the above procedure must be equal, in the sole opinion of the Engineer, to the material or article specified. It must be readily available in sufficient quality and quantity not to delay of any work, inspection or

tests; it must be available in a reasonably equivalent range of colours, textures, dimensions, gauges, types and finishes as the material or article specified; it must be equal to the specified item in strength, durability, efficiency, serviceability, compatibility with existing systems, ease and cost of maintenance; it must be compatible with the design; its use must not impose additional work, or require changes in, the work of any other Contractor without the written agreement of such Contractor.

(2) Request for all substitutions shall be accompanied by all information needed for the Engineer to make an evaluation, including manufacturer's brand or trade names, model numbers, description or specification of item, performance data, test reports, designs, calculations, samples, history of service, and other data as applicable.

(3) Additionally the Contractor shall revise and provide to the Engineer for approval all drawings that are affected by any request for substitution.

(4) All requests for substitution of materials or other changes from the Specifications and Detailed Design, shall be accompanied by an itemised list of all other items affected by such substitution or change. The Engineer shall have the right, if such is not done, to rescind any approval for substitutes or changes and to order such work removed and replaced with work conforming to requirements, all at the Contractor's expense, or to assess and charge all additional costs resulting from the substitution to the Contractor.

(5) All substituted manufactured articles, materials and equipment shall be applied, installed, connected, erected, used, cleaned and conditioned in accordance with the manufacturer's printed instructions, unless otherwise specified.

(6) The Contractor shall have and make no claim for an extension of time or for damages by reason of the time taken by the Engineer in considering a substitution proposed by the Contractor or by reason of the failure of the Engineer to approve a substitution proposed by the Contractor. Any delays arising out of consideration for an approval of a substitution shall be the sole responsibility of the Contractor requesting that substitution and he shall arrange his operations to make up the time lost.

(7) Acceptance of any proposed substitution shall in no way release the Contractor from any of the provisions of the Contract Documents.

3.6.3 Storage and Protection of Equipment and Materials

The Contractor shall minimise the storage periods for material and equipment at the Site by scheduling deliveries to coincide with construction needs. The Contractor shall not store unnecessary materials or equipment at the Site and shall take care to prevent any structure from being loaded with a weight which will endanger its integrity or the safety of persons. The Contractor shall post and follow regulatory signs for allowed loading on structures and other safety precautions. The Contractor shall obtain from the manufacturers information detailing the method of storage and the maintenance of the stored items and shall comply with these requirements. Any costs associated with the storage and protection of materials and equipment shall be deemed to be included under the Contract and no additional payment will be made. No material shall be brought to the Site until the following conditions are met:

(1) The manufacturer's recommendation for Site storage have been received by the Engineer; and

(2) The area in which the material is to be stored is identified and approved by the Engineer.

3.6.4 Installation and Testing of Equipment and Construction Work

3.6.4.1 General

1. The Contractor shall have on hand sufficient qualified personnel, proper equipment, and machinery to facilitate the work.

2. The Contractor shall be responsible for locating, aligning and levelling and shall employ an experienced surveyor to set all lines and levels to the accuracy required.

3. Complete manufacturer's installation instructions, including permissible tolerances, shall be furnished with the shop drawings.

4. All work shall be installed in accordance with the drawings; inclusive of manufacturer's specifications, drawings and tolerances.

5. Testing procedures and methodology to be adopted shall be submitted to the Engineer for approval before any tests commence.

3.6.4.2 Damage During Tests and Training Periods

The Contractor shall be fully responsible for the proper operation of the Works during tests that are carried out on it and during the training with it.

3.6.4.3 Services of Manufacturers' Specialists

The contract price shall include when required by the manufacturer all costs of furnishing manufacturer's specialists to the Project Site for:

(1) Assisting the Contractor to install, adjust and/ or test the necessary equipment; and

(2) Supervising start-up operations and adequately instruct the employees of the Beneficiary in the proper operation and maintenance procedures.

3.6.4.4 Tests in General

1. Various clauses of the Technical Specifications state the types of tests which the Contractor shall carry out for the quality control of the Works, together with the frequencies at which each type of test shall be conducted. The Contractor's attention is drawn to the fact that the frequencies of testing specified in the relevant clauses are intended to represent only a general guide. Subject to SCC and GCC the Engineer shall be empowered to vary the frequencies at which tests are conducted should he deem this necessary for the proper control of the quality of the Works.

2. For manufactured materials or goods the Contractor shall obtain Test Certificates which are representative of the delivered materials or goods from the suppliers of such materials and shall send two copies of certificates to the Engineer. Such certificates shall certify that the materials or goods concerned have been tested in accordance with the requirements of the Contract and shall give the results of all tests carried out. The Contractor shall provide adequate means of identifying the materials and goods delivered to the Site with the corresponding certificates.

3.6.4.5 Testing of Mechanical and Electrical Equipment

(1) General

1. Testing of all equipment shall be carried out in accordance with the requirements of all the relevant standards.

2. Where tests and inspection have been completed to the Engineer's satisfaction and when the test certificates, curves, etc. have been checked, the Engineer will confirm approval in writing and none of the equipment shall be incorporated in the Facilities or delivered until this approval has been received.

3. Two copies of all test certificates and curves shall be supplied to the Engineer within two weeks of any witness tests.

4. Where witness tests are not required the test certificates and curves shall be forwarded to the Engineer within four weeks after the decision to waive witness tests has been received.

5. All apparatus, instruments and connections required for the tests of the Facilities shall in all respects comply with the appropriate safety regulations and/ or requirements regarding electrical apparatus for the safety of the Facilities and the persons working thereon.

(2) Site testing and commissioning

In the field the vibration amplitude due to the physical imbalance of rotating parts of the pumps, measured at top of electric motor and pump bearings, shall not exceed the requirements of the Hydraulic Institute Standards for horizontal, centrifugal and vertical turbine pumps. The vibration shall be measured at rated speeds and within plus or minus ten percent (10 %) of rated capacity. Sound levels shall not exceed 85 decibels for the motor measured at a distance not exceeding 1.5 m from any point of the motor.

3.7 CLEANING

3.7.1 General

1. The Contractor shall remove from the Site and dispose of, all debris and rubbish resulting from his work at least once a week and more often if the same interferes with the work under any contract or the work of other service, or presents a fire or accident hazard.

2. The Contractor shall thoroughly clean and eliminate mortar droppings, marks of concrete leakage, formwork marks, tar spatters and paint droppings.

3. All debris, rubbish and scrap pieces resulting from clean-up operations shall become the property of the Contractor and shall be removed from the Site in such a manner as to create no nuisance in the streets nor to the adjoining property owners and legally disposed of.

3.7.2 Final Cleaning

After completing and testing a section of the Facilities the Contractor shall remove all rubbish and excess material from and about the Site including all temporary structures, construction signs, tools, scaffolding, materials, supplies and construction machinery or equipment which he or any of his subcontractors may have used in the performance of the work. The Contractor shall clean all the Works and leave the Site in a neat condition.

3.7.3 Employer's Right to Clean

Should the Contractor fail, refuse or neglect to remove rubbish and waste materials and temporary work or clean the paved areas or pedestrian sidewalks as required herein, then the Employer may or shall, without obligation to do so, remove and dispose of the said rubbish, waste materials and temporary work, clean the paved areas or pedestrian sidewalks and deduct the cost thereof from any money due, or to become due to the Contractor under this Contract.

3.7.4 Pipe Network Final Cleaning Timing Constraints

Final cleaning of work areas shall be finished within seven (7) days of reinstatement of the surfaces.

3.8 SITE RECORDS AND PROGRESS PHOTOGRAPHS OF THE WORK

1. The Contractor shall ensure that records to the Works are kept up to date. These records shall include labour, plant, material on site, excavation, additional work ordered, price fluctuation if applicable, etc.

2. The Contractor shall take a series of colour photographs illustrating the progress of the work for each 200 metres length of pipeline. The number of photographs taken for each 200 metres length of pipeline shall show good views of the Work before commencement, once during progress and at completion. The views to be taken shall be decided by the Engineer.

3. The film negatives shall be properly labelled and submitted to the Engineer. In case a digital camera is used, the electronic files in JPEG format shall be supplied on a CD or memory stick, together with a Word file including a complete listing of all photographs and captions, as required below.

4. Each photograph, of minimum size 130 mm x 90 mm, shall have a paper label attached to the backing material (or in case of digital photographs, a suitably captioned hard copy) containing thereon in neat lettering:

(1) photo number and date when taken;

(2) short description of view including location;

(3) Contractor's name;

(4) project name and contract number.

5. All photos should be numbered consecutively throughout.

3.9 AS BUILT DRAWINGS

1. The Contractor shall carry out a detail design and prepare a set of electronic (Compact Disk or memory stick) editable (that contain the Drawings prepared in AutoCAD® or similar) Drawings.

2. The Contractor shall maintain a set of prints of the construction drawings. A daily record in red shall be kept on these prints of the work installed and all modifications or changes therein. This set of prints shall be available at all times for inspection. In addition to the new construction the Contractor shall record on these prints all other information encountered during excavation. During the progress of the Works the Contractor shall transfer once a month all information from the aforementioned set of prints or Auto-CAD® files and submit to the Engineer two prints showing the work completed and highlighting the changes made.

3. All additional work installed shall be shown on as-built drawings to a scale of at least equal to the scale of the Drawings. The sheet size of the additional drawings shall be maximum A1.

4. Upon completion of all work the Contractor shall produce drawings and sign them indicating that the work was installed as shown. Two sets of paper prints from these drawings shall be submitted to the Engineer for approval. Upon receipt of the Engineer's approval the Contractor shall submit the drawings, two sets of CDs containing the Auto-CAD® digital files of the as-built drawings and four sets of paper prints stamped "As Built Drawings".

5. The "As Built Drawings" shall include all information recorded on the aforementioned set of prints and any other modifications that occurred during the Contract. The prints of the "As Built Drawings" shall be maximum A1 size. If not otherwise agreed the Works shall not be considered to be completed for the purposes of taking over until As-Built Drawings have been submitted to and approved by the Engineer.

3.10 TEMPORARY WATER, POWER AND SANITARY FACILITIES

3.10.1 General

1. All temporary facilities shall be provided by the Contractor in a manner as hereinafter specified. The Contractor shall co-ordinate and install all temporary facilities in accordance with the requirements of the local authorities or utility companies having jurisdiction and in accordance with all local codes and regulations.

2. All costs in connection with the temporary facilities including but not limited to, installation maintenance, relocation and removal shall be borne by the Contractor.

3.10.2 Temporary Water

1. The Employer will make water available for construction purposes.

2. The Contractor shall bear all the related costs.

3.10.3 Temporary Wastewater Piping

The Contractor shall provide and pay for all temporary piping arrangements including pumping, if any, for temporary conveyance of wastewater during the construction works to the satisfaction of the Employer. The arrangements shall be submitted in advance to the Employer for approval.

3.10.4 Temporary Power

The Contractor, at his own expense, shall furnish install, operate and maintain all necessary temporary power system required for construction, field offices and testing purposes. The Contractor shall make all the arrangements with the local Electrical Network Company for the temporary electrical power. The Contractor shall pay the local Electrical Network Company for all charges for service connection and furnish all labour, material and equipment for the installation of the temporary power supply. The Contractor shall de-energise and remove the temporary power supply system in co-ordination with the local Electrical Network Company upon the completion of the work in the area. When the temporary power system utilises engine generators stations, then these stations shall be acoustically shielded with special enclosures from neighbouring residences.

3.10.5 Sanitary Services

The Contractor shall provide and pay all costs for temporary toilet and washroom facilities in sufficient numbers for his employees. The facilities shall be maintained in clean condition and drained in a satisfactory manner.

3.11 PROJECT PLANNING

3.11.1 Form of Progress Planning Schedule

1. A schedule shall be prepared based on a Network Analysis Critical Path Program or equal in the form of a bar chart showing in detail the proposed sequence of the work and identifying construction activities for each structure.

2. The schedule shall be time scaled, identifying the first day of each week, with the estimated date of starting and completion of each stage of the work.

3. The schedule shall be comprehensive and shall cover all portions of the work. The Contractor shall supply information including work activity descriptions, sequence of work and time estimates for each activity.

3.12 ENVIRONMENTAL ISSUES.

The construction works will cause nuisances and disturbances to the public. This fact shall be recognised by all parties involved in the Project. As a consequence it is an essential requirement that the Contractor shall minimise and mitigate the negative impacts of the construction.

3.13 TRAINING

3.13.1 General

1. The training of the Employer's staff on the installed facilities shall be performed by the Contractor during the erection and commissioning period of the facilities. The training shall be divided into two different level overall groups and into practical and theoretical training periods. The training programmes as well as individual training programmes shall be delivered for the approval of the Engineer.

2. The objective is that by working in close co-operation with the Contractor's own employees the Employer's staff will gain basic knowledge and on-the-job training for operation and maintenance activities.

3.13.2 Training of Operation and Maintenance Staff

1. The operation staff of pumping stations shall be trained during the construction and installation period. The Employer will assign suitable staff to work under the Contractor's supervision. The educational level and training requirements shall be advised by the Engineer.

2. The Employer's staff shall also be given theoretical instruction in Moldovan in the main components of the facilities and the main component operation and maintenance activities by a professional trainer employed by the Contractor. The duration of the theoretical instruction shall be at least one working day.

3. The Contractor shall report the attendance of the trainees to the Engineer.

3.14 OPERATION AND MAINTENANCE MANUALS

Submission of complete operation and maintenance manuals of the installation to the Engineer upon delivery of plant and equipment.

Four copies of fully detailed manuals in English (vital parts of the manuals shall be translated into Russian/Romanian) for the operation and maintenance of the equipment are to be provided in a durable form for approval by the Engineer or the Engineer's Representative.

The Contractor’s attention is drawn to the need to ensure that the following items are included in the Maintenance Manuals:

- Contents
- General description
- Safety instructions
- Design criteria
- Main data
- Functional description
- Special conditions
- Control description
- P+I-diagram. This drawing, together with the arrangement drawing and numbered item list, shall be framed and hung up on the wall in the pumping station
- Operation and maintenance description of the system. Description of preventive maintenance of the system, how to register parameters that in the long run can give the staff indication for the development of condition of the system’s components.
- Maintenance instructions
- Installation and start up instructions for all items, such as
    - Safety instructions for all items during operation and maintenance.
    - Schedule for intervals between maintenance of all items
    - Calibration of instruments
    - Oil change
    - etc.
- Schedule of supplied equipment giving the producer’s name and appropriate Model No,Type,
- Other necessary information for positive identification of the component
- Schedule of routine maintenance for all supplied equipment.
- Schedule of supplied spares.
- Schedule of supplied tools and lubricants.
- Sectional arrangement drawings of major items of plant, i.e. pumps, valves etc., with dismantling instructions.
- Plant layout drawings showing the “As Erected” installation.
- General arrangement and schematic diagrams of the “As Installed” control boards and switch gears.

- "As Wired" diagrams of all electrical connections, between the control boards, switch gears and installed loads.
- Full and comprehensive instructions for all items of supplied equipment.
- The documentation for each item shall as minimum contain the following:
  - Contents
  - Brochures and /or data sheets stating the address of the manufacturer
  - Performance guaranties and warranties
  - Characteristics (curves, diagrams, test certificates etc.)
  - Description of functions
  - Wiring diagram
  - Arrangement drawing with detailed items list
  - Installation and start up instructions
  - Maintenance instructions
  - Trouble shooting
  - Repair guidelines
  - Complete list of spare parts
  - Summary of supplied spare parts
  - Direction for maintaining stock of spare parts
  - General plan and cross sectional drawing
  - Coating specification
  - Application methods of coating and safety precautions.
  - Guidelines for repairing damage coating
  - Specification of surface treatment. Methods for repair, specifications for contents, application methods and safety precautions.
  - Conservation instructions for storage
- Trouble shooting instructions
- Special conditions
- Safety instructions
- Test certificates for motors/pumps/pressure vessels/lifting equipment for both works and site tests and for transformers/electrical installation and other items, where appropriate.
- Pump and blowers performance curves as tested.
- System Curves.
- Schedule of recommended lubricants and their equivalents.
- Thus, the manuals shall contain all relevant information in order to properly maintain and repair the equipment, and obtain correct spare parts wherever and whenever necessary.
- A lubrication schedule shall be provided, containing a recommended lubrication schedule for all equipment and shall indicate comparable qualities of lubricant and grease.
- Recommendations of special tools and spare parts sufficient for 3 years of operation shall also be elaborated. Prices for tools and spare parts shall be included in the tender.

4 DEMOLITION AND SITE CLEARANCE

4.1 SITE CLEARANCE

1. The scope of Site clearance work is to remove from the Site all obstructions, which may affect the execution of the Works. Any pipeline route or other site to be excavated shall be cleared and grubbed of bush, roots, stumps, vegetation and surface obstruction.

2. Clearing and grubbing up shall consist of clearing the Site of all trees, bushes, other vegetation, roots and other objectionable material.

3. No trees shall be felled, destroyed or interfered with by the Contractor without the approval of the Engineer. Trees shall be uprooted or cut down as near to ground level as possible only where directed by the Engineer. Branches and foliage shall be removed and burnt to ash or disposed of off Site. Useful timber shall remain the property of the Employer and shall be cut into suitable lengths and stored properly at the Site.

4. Stumps and roots whether existing or remaining after tree felling shall be grubbed up and disposed of off the Site. The resulting pits shall be filled with approved material and compacted to the same dry density as the surrounding soil.

5. Material suitable for landscaping shall be stockpiled at the Site. Other material shall be disposed of by the Contractor. All debris shall be removed from the Site and disposed of by the Contractor in a satisfactory manner. The Contractor is responsible for all costs associated with disposal of materials.

6. Materials and structures temporarily removed for later reinstatement and restoration shall be properly stored and protected.

4.2 DEMOLITION of STRUCTURES

1. The Engineer must be given 14 days notice in writing of any proposal to demolish or dismantle all or any part of any existing structure on the site which is necessary for the completion of the works.

2. The Contractor shall give the Engineer an explanation of the method and order of demolition and the steps taken to ensure the safety and stability of any remaining structure affected thereby.

3. Unless the due notice is given, the Contractor shall not be entitled to any claim for delay in his construction programme owing to the refusal of permission to demolish or dismantle the said structures.

5 EARTHWORKS – EXCAVATION, FILLING, COMPACTION, DISPOSAL AND LANDSCAPING

5.1 Scope of Work

Under this section the Contractor shall furnish all labour, equipment and materials required to complete all excavation, backfill, drainage layers beneath and around structures, embankments, removal of all surplus excavated material, compaction beneath foundations and roadways, site grading, construction (or reconstruction) of road pavement, in-situ compaction, disposal of all unsuitable materials and the like and all other related and incidental work as required to complete the work in an acceptable manner, in accordance with the Detailed Design and as may be required by the Engineer.

5.2 LEVEL OF THE COMMENCING SURFACE

Before any excavation work commences, the Contractor shall agree with the Engineer the level(s) of the Commencing Surface (usually the original ground level(s)).

5.3 FOUNDATION METHODS

5.3.1 Excavation for foundations

1. All excavations for foundations, shall be carried out to the lines and limits shown on the Detailed Design Drawings, or defined in the Detailed Design. Said lines and limits may be amended by the Engineer to suit soil and other conditions encountered during actual excavation and field inspection. When excavating in any material other than rock for formation levels under any structure, the last 15 cm of excavation shall be taken out not more than 24 hours before placing of foundations. The bottoms of excavations shall be levelled and trimmed to full width to required lines and levels and shall be well watered and rammed before placing of concrete.

2. The Contractor shall well and effectively hold up the sides and ends of all trenches and excavations wherever necessary with strong, close timbering, and shall prevent any fall or run of earth or sand from any portion of the ground outside of the excavation. If, despite such precautions, or by reason of their neglect, any portions of the bottoms sides or ends of any excavations shall give way or be excavated without instructions from the Engineer, the Contractor shall at his own expense excavate and remove all the ground thereby disturbed both within and without the limits of the excavation.

3. Should the Contractor exceed in depth or extend the excavation of the formations or be ordered to take out extra excavation for the reasons given above, no payment will be made for such extra excavation, and he shall, if ordered by the Engineer, make it good with well rammed fill or in such class of concrete as may be ordered by the Engineer and at the Contractor's expense.

4. Should any existing subsoil or field drains be uncovered during any excavation, the Contractor shall carefully replace them when backfilling or, if this is impossible, he shall divert them to new drains or ditches, otherwise relay them as the Engineer may direct.

5. Before commencing any building work, all shattered and loose material must be removed by hand, the excavation being performed in such a manner as the Engineer shall direct so as to ensure that the work sits on an absolutely solid and clean foundation or abuts tightly against solid ground. In no case must concrete be placed in an excavation until the surface onto which such concrete is to be placed has been approved by the Engineer.

5.3.2 Preparation of Foundation

1. The Contractor shall prepare the areas of excavations against which concrete is to be placed or on which pipes are to be laid, in a manner suitable for forming a foundation. Foundations in earth upon which concrete is to be placed shall be finished accurately to the dimensions shown on the Detailed Design Drawings or prescribed by the Engineer, brought to proper moisture content by sprinkling as required, and thoroughly compacted with suitable tools. No boulders shall be left projecting within the minimum excavation lines shown on the Detailed Design Drawings.

2. Foundations for concrete on bedrock shall be trimmed to the prescribed lines, thoroughly cleaned of mud and debris, and moistened in advance of placing concrete. All foundation surfaces shall be free from pools of water at the time of placing concrete. Wherever any excavation in earth has been made below grade without the Engineer's instructions, it shall be refilled at the Contractor's expense.

5.4 TESTING FACILITIES

1. The Contractor shall perform the tests required by the Contract, at his own expense, at the frequencies specified therein and he shall be responsible for his own quality control of the works. Two copies of the results of each test performed by the Contractor in a form approved by the Engineer shall be submitted to him. The third copy of the test results of each test shall be retained on Site for as long as the Engineer may require.

2. The Contractor shall provide on the Site, maintain and remove as provided elsewhere in the Contract a laboratory including all necessary materials, equipment and tools needed for his own testing of materials. The Contractor's site laboratory shall be provided with all equipment needed to carry out the testing required under this Contract. The testing that cannot be performed in the Contractor's site laboratory shall be carried out in other laboratories, which must meet the Engineer's approval.

3. The laboratory shall be adequately staffed and so equipped that no interruption occur to the progress of the Works as a result of the need to carry out tests required under the Contract. The laboratory staff shall include a technician suitably qualified and experienced in the testing of soils, concrete and bituminous materials and a sufficient number of assistants.

4. Without relieving the Contractor of his responsibilities under the Contract, the Contractor shall perform any additional tests, which the Engineer may require and/ or repeat tests the results of which, in the opinion of the Engineer are not representative.

5.5 EARTHWORKS

5.5.1 Working Width or Area

In working in existing roads or streets the working width shall not exceed one half the total width of the road including any sidewalks or verges of the road and not withstanding this requirement, the traffic flow shall be maintained at all times unless approved detours are provided by the Contractor.

5.5.2 Embankments and General Fill Areas

1. Where the filling of the Site is needed to achieve the final levels, all necessary clearing and grubbing up shall have been carried out and loose and soft material shall be removed before filling commences. Embankments shall be made to the lines and grades or levels as shown on the working drawings. The fill material shall be placed in horizontal layers not exceeding 200 mm thick. The layers shall be compacted by methods appropriate to the degree of compaction required.

2. In areas that are to receive permanent work the elevation of general fill shall be the underside of such permanent work. In areas not to receive permanent work filling shall be to the levels shown on the Detailed Design Drawings.

3. The material for embankment and general fill shall be granular, suitably graded for the specified compaction required and shall not contain organic matter or more than 15% clay or silt by weight.

5.5.3 Excavation

1. Excavation shall include the excavation of all materials of whatever nature encountered as required to complete the work. The construction methods used shall be to the approval of the Engineer.

2. Excavation shall be carried out to the lines, levels, dimensions, and depths indicated on the Detailed Design Drawings or in the Technical Specifications or as directed by the Engineer.

3. The Contractor may carry out trial pits excavation as he considers necessary. The work involved in test pits shall include the digging and reinstatement of the test pits and the determination of the position and elevation of existing pipes, sewers, conduits and the like, and shall be at his own expense unless specifically instructed in writing by the Engineer.

4. All excavation shall be carried out in such a manner as to create a minimum of inconvenience and interference with traffic and with access to buildings or other properties. All excavated material shall be piled in a manner that will not endanger the work or the personnel engaged therein or third parties and will avoid obstructing sidewalks and driveways or rest on permanent structures.

5. To provide the public with the necessary safety and protection, the Contractor shall at his expense provide barricades, lights, warning signals, guard rails and crossings over trenches to the satisfaction of the Engineer and in accordance to the other applicable sections of the Specifications.

6. Where required, and where otherwise necessary to prevent caving in of trench sides or to protect adjacent utility services, excavation shall be adequately supported.

5.5.4 Excess Excavation

1. Excess excavation is defined as excavation outside the measurement lines as indicated on the Detailed Design Drawings or as specified herein. The Contractor shall not be entitled to any payments for such excess excavation or filling of excess excavation unless such excavation was required by the Engineer.

2. Where excess excavation occurs the Contractor shall fill volume of overbreak with approved backfilling material compacted as specified for the material or with concrete as approved by the Engineer on a case by case basis.

3. Where the Engineer instructs the Contractor to vary the depth of excavations below the depth shown on the Detailed Design Drawings or specified herein in order to obtain a sound and satisfactory foundation, the extra volume of material excavated and the extra volume of crushed, granular bedding or concrete fill shall be measured and an extra payment will be made based on the appropriate rates in the BoQ.

4. In the event excavation collapses in any manner due to any unforeseen reason it shall not be considered as excess excavation but the Contractor remains responsible for reinstating the excavation as specified. The Contractor is also responsible for making good any settlement of existing or reinstated road, street and/ or sidewalk surfacing as a result of similar unforeseen reasons.

5.5.5 Keeping Excavations Free of Water

The Contractor shall maintain all excavations or trenches free from water, including ground water, river water infiltration, surface water run-off or sewage and the like, regardless of the source and at his own expense. Water prevented from entering excavations by the Contractor shall be disposed of in a manner approved by the Engineer.

5.5.6 Backfilling and Surplus Excavated Material

1. Surplus excavated material shall be used for backfilling only with the approval of the Engineer.

2. If required all backfill material shall be piled neatly along the sides of excavations or trenches provided they do not unduly obstruct traffic or access to buildings or other properties.

3. Surplus excavated material shall be disposed of at the Contractor's expense.

5.5.7 Testing of Backfill Material and Backfilling

1. For each class of backfill material to be used representative samples selected by the Engineer shall be used for testing purposes. The tests shall be carried out at the Contractor's expense.

2. During backfilling, soil samples shall be taken as required by the Engineer to determine the density of the compacted backfill. If the density of the compacted backfill is less than that specified, additional compaction shall be carried out and no further backfill material shall be placed until satisfactory compaction of the material previously placed is achieved. If compaction is still not acceptable, the backfill material shall be removed to within 150 mm of the level of the last successful compaction test and additional compaction shall be carried out until a successful test is achieved. Only then additional backfill material shall be placed. Density tests shall be made as directed by the Engineer at the Contractor's expense.

3. Compaction tests on trench backfill shall be conducted by the Contractor at intervals of 50 m on average. For coarse materials the density may be tested with plate bearing tests.

5.6 EXCAVATION, BACKFILLING AND COMPACTION FOR STRUCTURAL WORKS

5.6.1 Buildings and Structures

1. Filled areas shall be compacted so that the density is not less than 95 % of maximum dry density obtained from the modified Proctor Compaction Test. In addition the material shall be such that the bearing modulus is at least E_1 = 25 MPa as measured by plate bearing tests on the surface of the fill.

2. When natural sub-soil is fine-grained (clay, silt or silty sand) a geotextile filter membrane shall be installed between the filling material and the natural soil.

3. Foundations shall be excavated to the lines and grades or elevations as shown on the Detailed Design Drawings. These shall be of sufficient size to permit the construction of the structures. Compacted gravel or a crushed material layer shall be placed under the footings and slab-on grades. The gravel or crushed material shall be uniformly graded with a grain size between 1 and 100 mm.

4. Final trimming of excavations to the final grade and level shall only be done immediately before foundations are to be placed in order to protect the final bottom of the excavation from adverse effects. The bottom of the excavation shall not be allowed to become flooded. Unsuitable material at the bottom of the excavation shall be replaced with compacted sand or gravel. This fill shall be placed and built up in horizontal layers not exceeding 150 mm depth per layer. Each layer shall be thoroughly compacted with mechanical tampers. No backfilling shall be carried out until authorised by the Engineer.

5. Backfilling around structures shall be in horizontal layers not exceeding 150 mm depth per layer. Each layer shall be thoroughly compacted with mechanical tampers. Backfilling shall be completed raised evenly around structures.

5.6.2 Subdrains to Structures

Where required a subdrain system will be installed to structures as shown on the Detailed Design Drawings. Subdrains shall be perforated plastic of diameter not less than 100 mm and manholes shall be either of thermo plastics or concrete. The initial backfill around the pipes shall be at least 100 mm thick and comprise of a uniformly graded gravel/sand of maximum grain size 20 mm and with grains < 0.5 mm in size not exceeding 10% by weight.

5.6.3 Excavation and Filling for Subgrade

1. Work includes excavation, filling and compaction needed to construct the sub-grade of roads and other trafficked areas. All excavation and filling shall be made in accordance with the sections above.

2. Where excavation is required to permit pavement construction, the bottom of the excavation shall be graded so that the thickness of the pavement will be uniform.

3. The allowable tolerance of the level of an embankment and the bottom of an excavation is ± 50 mm. Fill material shall be sand having at least the following properties:

(1) fraction passing the 0.002 mm sieve shall be not be greater than 10%;

(2) fraction passing the 0.425 mm sieve shall not have liquid limit greater than 25% and plasticity index greater than 6%.

4. Fill material shall be compacted to a density of 90% of maximum dry density obtained from the modified Proctor Compaction Test.

5.7 EXCAVATION, BACKFILL AND COMPACTION FOR PIPE LAYING WORKS

5.7.1 Excavation of Trenches

1. Trenches and excavations for underground pipe networks, manholes and chambers shall be excavated to the lines and grades or elevations shown on the Detailed Design Drawings or as directed by the Engineer. The width of trenches on the centreline level of the pipe shall be at least equal to the outside diameter of the pipe plus 0.6m (measurement lines) unless otherwise shown on the Detailed Design Drawings.

2. Before commencing trench excavation the Contractor shall mark out the route of the pipelines accurately and jointly survey the natural ground level along the pipeline route with the Engineer.

3. Trenches shall be excavated to such depths as is required to obtain a minimum cover over the pipe. The depth of cover shall be measured from the final established grade to the top of the pipe.

4. The excavation for trenches shall not only be of sufficient size to accommodate the pipes and bedding material, but also to allow the provision of supporting the trench and making possible the use of formwork as necessary.

5. Where road, street and sidewalk surfaces, as well as gutters and kerbs, are to be broken for trench excavation the Contractor shall first cut the surfaces etc. in neat and straight lines and shall remove and dispose of the pavement or other surface material to the satisfaction of the Engineer.

6. The surfaces etc. shall be cut and removed to the full width of the trench and to the full depth of the pavement in such a manner as to leave undisturbed the adjacent surface etc. and any other work to be left in place. The edge of the surface etc. left in place shall have a sharp, even, vertical face and be true to line.

7. Boulders, organic or any other objectionable materials encountered on the bottom of the excavation shall be removed to leave the finished surface true to line, level and grade.

8. The bottom of the trench shall be filled level with a compacted sand layer of thickness not less than 150 mm.

9. Excavation for pipe trenches shall not be started until all necessary piping materials are on Site. Unsuitable material at the bottom of the excavation shall be replaced with compacted sand or gravel. This fill shall be placed and built up in horizontal layers not exceeding 150 mm depth per layer. Each layer shall be thoroughly compacted with mechanical tampers.

10. After excavation is complete the Contractor shall notify the Engineer to that effect and no pipes shall be placed until the Engineer approves the depth of the excavation and nature of the foundation material.

5.7.2 Backfilling of Trenches

1. No backfilling shall be carried out until all debris and other objectionable materials have been removed from the excavation. The trenches shall be backfilled without delay but not before pipes and structures have been inspected and approved by the Engineer.

2. After the pipes, structures and bedding have been installed and approved, the initial backfill material shall be placed around and over the pipe in 150 mm thick layers.

3. In placing backfill, the material shall be placed simultaneously to approximately same elevation on both sides of the pipe, manhole, abutment, pier or wall. The pipe or the manhole shall be maintained at the intended line and grade. The backfilling shall be carried out carefully and in not more than 150 mm thick layers. Each layer shall be separately compacted to a dry density not less than 95% of maximum density obtained in Modified Proctor Test, where the pipeline is under existing roads and to 90% where the pipeline is not subject to vehicular traffic and under new roads included in the Contract. The initial filling shall extend to a distance above the pipe as shown on the Detailed Design Drawings.

4. The remainder of the backfilling up to ground level shall be placed and compacted in layers not exceeding 300 mm thick. Heavy tampers shall not be used within 300 mm above the top of pipes of diameters < 200 mm and within 500 mm above larger pipes. Under vehicular trafficked areas backfilling shall be performed in layers not exceeding 200 mm.

5. Care shall be taken to ensure that the pipes will be uniformly supported on the bedding and under no circumstances shall large stones, rock projections or other hard objects be permitted to come in contact with the pipe. The bedding material shall be constructed so that adequate socket pits are provided beneath each socket pipe joint.

5.7.3 Backfill Material

5.7.3.1 General backfill

Excavated or borrow material used for general backfilling, shall be free from cinders, ashes, organic matter and debris or other contamination and shall be granular and suitably graded to obtain the required compaction and shall not contain stones or crushed rock larger than 75 mm in the largest dimension. Additionally backfill material for trenches shall conform to the following requirements:

Uniformity Coefficient	6 minimum
Plasticity Index	15 maximum
Liquid limit	35 maximum

5.7.3.2 Backfill in vehicular traffic and other surfaced areas

Surfaces such as roads, streets, sidewalks and the like pavements that are removed shall be reinstated over their original depth or as directed by the Engineer.

5.7.3.3 Initial backfill

Sand shall be used for initial backfilling of trenches. Material shall be sound, clean, uncontaminated granular material, uniformly graded and maximum size of particles 20 mm and particles smaller than 0.02 mm less than 10 %. In addition material shall be free from organic and deleterious matter and shall not contain more than 15 % by weight of clay or silt, individually or in combination.

5.7.3.4 Pipe bedding

Pipe bedding shall be granular material in accordance with the requirements of EN 12620, or equivalent for the range of grain size between 0 and 16 mm and with compaction fraction of not exceeding 0.15. Testing for the bedding material shall be in accordance with EN 882, or equivalent. Bedding material shall be placed to a depth of 150 to 200 mm below the level of the underside of the pipe.

5.7.4 Manholes and Chambers

Materials and the construction of manholes and chambers shall be in accordance with the relevant Technical Specifications.

5.7.5 Underground Cables

Cable trenches shall be in accordance with the Technical Specifications for the Electrical Works.

5.7.6 Compaction

Compaction is expressed in percentages and in all cases refers to the optimum dry density according to the modified Proctor Test or the BS 1377-4:1990 (Test 13), or equivalent. In case the requirements of compaction are not met by the Contractor all the affected work including backfilling material, installed pipe and bedding material shall be removed and reconstructed by the Contractor at his expense.

5.7.7 Grassing

1. Areas re-covered with top-soils shall be grassed in accordance with the instructions of the Project Manager. The grassed areas shall be irrigated by the Contractor until growth and spread of the grass is achieved. Appropriate fertilizer shall be applied to assist the spread and growth of planted grass. The Contractor shall undertake the first cutting of grassed areas.

5.8 DEWATERING

5.8.1 Scope of Work

1. The Contractor shall furnish all labour, materials and equipment, perform all work necessary to lower and control the groundwater levels and hydrostatic pressures to permit all excavations and construction to be performed in dry conditions.

2. The work shall include the testing, operation, maintenance, supervision, dewatering and final dismantling and removal from the Site of the dewatering system as described herein.

3. The Contractor will be responsible for the cost of dewatering. He will also be responsible for all costs for claims by third parties and costs of any replacement or rehabilitation of the subgrade, buildings, structures and services damaged during the process of dewatering. The responsibility covers also all costs for damages due to dewatering system failures or Contractor's negligence. The Contractor shall comply with all local regulations relating to the dewatering works.

4. Dewatering shall include the diversion, collection and removal of all surface runoff from the work areas; removal of groundwater from new excavations to permit construction in a dry pit/trench.

5.8.2 General Information

1. Prior to any excavation, the dewatering system shall be placed in operation to lower the water level, as required. Thereafter, the system shall be operated continuously twenty-four (24) hours per day, seven (7) days per week until all structures have been satisfactorily constructed, including placement of fill materials and dewatering is no longer required.

2. Both primary and standby power for the dewatering system shall be provided by the Contractor, including all costs for installation, energy and fuel. For any fuel powered system the Contractor shall maintain adequate fuel supply on Site. The Contractor shall make all necessary arrangements for the temporary power service and provide all necessary accessories required.

3. Prior to starting dewatering operations the Contractor and the Engineer shall make a joint inspection of the condition of all existing structures on or adjacent to the Site that is to be dewatered to establish their present condition. Photographs shall be taken to record any details that may become subjects of possible damage claims. The Contractor shall include in his Tender the cost for adequate photo coverage of such existing structures. The Contractor shall supply the Engineer one set of copies of all photographs taken which shall be annotated with adequate reference details.

5.8.3 Submittals

1. The Contractor shall submit for the Engineer's approval a detailed description of the sequence of dewatering operations. The description shall include but not be limited to:

(1) plans showing the methods and location of dewatering and discharge. The drawings shall include sufficient details to clearly illustrate the work;

(2) lists of materials and equipment to be used; and

(3) calculations for the design of the dewatering system.

2. The Engineer shall verify that the general scope of work is adequate and that the Contractor is qualified to perform the work as shown on the dewatering drawings. Review of the Contractor's plans and methods of construction by the Engineer shall not relieve the Contractor in any way from his responsibility for the successful performance of the dewatering work.

3. The Contractor shall also submit daily operating logs which shall include results from water quality tests for suspended matter at the discharge point including time of day and elapsed times of tests, daily discharge rates, installation and removal of wells and general observations on the system such as equipment running times and failure.

5.9 ROADS AND YARDS

5.9.1 General

5.9.2 Aggregate Sub-base and Road Base

1. Aggregate road base and sub-base shall be placed and compacted in accordance with these specifications and to the lines, levels, grades, dimensions and cross-sections shown on the Detailed Design Drawings. The material of sub-base shall be separated from natural sub-soil with a filter fabric (geotextile) when the soil is fine graded (fine sand, silt or clay).

2. All material shall be free from organic matter and lumps of clay particles. Sand aggregate for sub-base shall spread and compacted in layers not more than 200 mm. The bearing modulus value E_2 shall be 90 MPa or more measured by plate bearing tests.

3. The road base of crushed material shall be compacted in one layer to a density so that the bearing modulus E_2 is 120 MPa or more measured by plate bearing tests. The Los Angeles value and crushing value of crushed base material shall not exceed 25%.

4. The ratio of the second and first loading stages, E_2 / E_1, shall be less than 2.2 both for sub-base and road base courses and individual values shall not differ by more than 30% from specified values.

5. In addition the material of sub-base shall conform with the requirements of Table 5-1.

6. Fill material shall be compacted to a density not less than 90% of Modified Proctor Density.

7. Compaction of sub-base material shall be completed as soon as possible after the material has been spread.

8. If water-bound Macadam is used as roadbase the material shall conform to Table 5-2.

9. The material shall be mixed in a stationary mixing plant which shall be of a power driven paddle or pan type of the batch or continuous type. The Engineer may at his discretion allow the Contractor to employ other measures as the Contractor may propose for the mixing of constituent materials for the production of the roadbase.

Table 5-1: Requirements for sub-base

(i)	Grading (BS1377 Test 7A)	BS 410 Sieve Size	% by weight passing (Sub-base material)
		75 mm	100
		37.5 mm	85-100
		10 mm	45-100
		5 mm	25-85
		600 micron	8-45
		75 micron	5-45
(ii)	Liquid Limit (BS1377 Test 2a)		30 max.
(iii)	Plasticity Index (BS1377 Test 3)		6 max.
(iv)	Plasticity Modulus (product of Plasticity Index and % by weight passing 425 micron sieve)		250 max.
(v)	California Bearing Ratio (BS1377), Test 16 sample at 95% Maximum Dry Density BS1377 Test 13 4.5 kg rammer with 2 day soak		30 min.

Table 5-2: Requirement for water-bound Macadam used as roadbase material

Grading (BS1377 Test 7A)	BS 410 Sieve Size	% by weight passing
	50 mm	100
	37.5 mm	95-100
	20 mm	60-80
	10 mm	40-60
	5 mm	25-40
	2.36 mm	15-30
	600 micron	8-22
	425 micron	5-20
	75 micron	0-8

10. The moisture content at the time of compaction shall be within the range of 1.0% above and 0.5% below the optimum as determined in accordance with BS 1377 Test 13.

11. Water-bound macadam roadbase material shall be placed and spread evenly.

12. Compaction of crushed stone macadam roadbase material shall be started immediately after spreading to achieve a relative density of at least 95% of the maximum dry density determined by BS 1377 Test 13. At least three tests in accordance with BS 1377 Test 14 shall be carried out on each day's production run of roadbase laying to ascertain compliance with the above requirement and such tests shall be made at more frequent intervals if deemed necessary by the Engineer. Test holes shall be filled with properly compacted materials to the satisfaction of the Engineer at no cost to the Employer.

5.9.3 Bituminous Road Base

1. Prior to starting to lay bituminous road base the base course shall be inspected and approved by the Engineer.

2. The asphalt concrete base course shall comprise hot-laid and plant mixed asphalt-concrete in accordance with local approved standards and mechanically spread and rolled.

3. Aggregates shall be free from vegetable or organic matter, loam, clay, chalk dust or other material which could prevent thorough coating or which might adversely affect the strength or durability of the surfacing.

4. Aggregates shall also be free from sulphates, chlorides and other materials (including the products of decomposition) which may be liable to break down during drying or mixing or subsequently when exposed to the weather.

5. Fine aggregates shall be crushed rock and shall be free from loosely bonded aggregations and other foreign matter.

6. The aggregate of bitumen Macadam road base shall be according to Table 5-3.

Table 5-3: Grading of aggregate

BS Sieve Size	Percentage by weight passing		
	28 mm Nominal Size	20 mm Nominal Size	37.5 mm Nominal Size
50 mm	--	--	100
37.5 mm	100	--	95-100
28 mm	90-100	100	70-94
20 mm	71-95	95-100	--
14 mm	58-82	65-85	55-75
10 mm	--	52-72	--
6.3 mm	44-60	39-55	44-60
3.35 mm	32-46	32-46	32-46
300 micron	4-21	7-21	7-21
75 micron	2-8	2-8*	3-8*
* The material passing the 75 micron BS 410 sieve shall include hydrated lime or Portland cement or crushed limestone only where the fine aggregate is solely of limestone origin.			

5.9.4 Wearing Courses of Roads and Yards

5.9.4.1 General

1. Roads and yards shall be graded and paved with granular or bituminous material as shown on the Detailed Design Drawings or as directed by the Engineer. Before starting surfacing works the base course shall be inspected and approved by the Engineer.

2. The wearing course shall be laid to the shapes and levels as shown on the Detailed Design Drawings and shall meet the specified bearing capacity.

5.9.4.2 Granular Surfaces

Granular surfaces shall be of gravel or crushed gravel with particle size from 0 to 20 mm. The thickness of the granular layer shall be 100 mm and it shall be levelled in one layer and well compacted to 95 % relative density.

5.9.4.3 Bituminous Surfaces

Asphalt-concrete surface course shall comprise hot-laid asphalt-concrete mechanically spread and rolled to minimum thickness 50 mm all in accordance with local approved standards.

5.9.5 Tolerances

1. The surfacing material shall be laid to an accuracy such that the maximum allowable difference between the surface and the underside of a three (3) metres straight-edge, when placed parallel with and at right angles to the centre line of the road, at points decided by the Engineer shall be as in Table 5-4.

Table 5-4: Tolerances for surfacing material.

Surfacing material	Maximum distance under 3 m long test straight-edge (mm)	
	Along road	Across road
Wearing courses	3	5
Base courses	5	8
Bituminous road bases	8	10

2. An adequate number of 3 m long test straight-edges shall be provided by the Contractor.

3. If any specified tolerances or limits are exceeded the full extent of the area concerned shall be removed and replaced with new material that conforms with the requirements.

4. Testing of the wearing course shall be carried out as soon as possible after completion of the surfacing and any remedies completed before the road is opened to traffic. No attempts whatsoever to correct the surface accuracy with any dressing or the like shall be allowed. The rejected areas shall be rectified at the Contractor's expense.

5.9.6 Kerbs and Gutters

Kerbs and gutters shall be stone or pre-cast concrete and they shall be bedded on Concrete. Curved kerbs shall be used when the laying radius is less than 12 m.

5.10 GROUND IMPROVEMENT MEASURES

5.10.1 Geotextiles or Filter Fabric

Geotextiles shall be spread between fill material and natural soil when the soil is fine graded (silty sand, silt or clay) to prevent the inter-penetration of fine sub-soil with the fill material or coarse aggregates. Geotextiles shall be installed according to the specifications of the manufacturer.

The geotextile shall be manufactured from durable synthetic polymers and shall have the following properties:

- max. pore size diameter O_{95} = 0.05 mm
- weight category > 200 g/m^2
- permeability, k-value within ranges 10^{-3} and 10^{-4} m/s
- tensile strength (breaking load) > 150 kN/m.

5.11 FINISH GRADING AND LANDSCAPING

5.11.1 General

The work specified here covers the filling, finished grading and landscaping of unsurfaced areas not specified elsewhere. The Contractor shall prepare drawings for this work for the approval of the Engineer.

5.11.2 Grading of Unsurfaced Areas

After the completion of the construction Works the areas not shown to be paved on the Detailed Design Drawings shall be graded to provide smooth surfaces. Suitable excavated material shall be used for the finish grading. The finish grading shall be shaped as directed by the Engineer.

5.11.3 Soft Landscaping

1. The Contractor shall furnish all labour and materials necessary for topsoil, seeding, planting and miscellaneous work for soft landscaping.

2. The type of soft landscaping to be planted on the unpaved areas and the planting period shall be as directed by the Engineer. The Contractor shall schedule his supply of plant and fertiliser material and shall give the Engineer at least 14 days notice before making any delivery and planting. Fertiliser shall be deliver in standard bags marked with weight, analysis of the contains and the name of the manufacturer.

3. Soil used for soft landscaping shall be free of stones, lumps, plants, roots, and other extraneous matter and shall contain no waste oils, materials and the like that will be detrimental to plant growth.

4. All plants shall be healthy, sound, free of any defects, sunstroke injuries, abrasions of the bark, broken or dead branches and be nursery-grown stock of minimum one year old. The trees to be planted shall be not less than 2.5 m in height. Plants shall have normal well developed branch systems and vigorous root systems. The Contractor shall provide stakes and stake out all tree locations and planting areas as directed by the Engineer.

5. The Contractor shall excavate tree pits to a depth equal to the tree ball plus 500 mm. The diameter of each pit shall be at least twice the size of the tree ball. Care shall be exercised to set plants truly vertical. Before backfilling all debris, stones and the like shall be removed from the pits. Backfilling shall be soil improved with fertiliser.

6. The Contractor shall be responsible for protecting and watering the soft landscaping after planting, seeding and the like up to the Completion of the Works. The Contractor shall replace according to the original specifications any planting, seeding and the like that dies, becomes unhealthy or is likely to die up to the end of the Defects Liability Period. The Engineer shall be the sole judge of the condition of the planting, seeding and the like in question.

7. The soft landscaping affected by the laying of pipes or cables shall be reinstated by the Contractor to the same condition as before the commencement of the works.

6 CONCRETE WORKS

6.1 GENERAL

1. The standard of materials and workmanship shall be not inferior to the recommendations of:
   (1) EN 206-1:2000 Concrete - Part 1: Specification, performance, production and conformity;
   (2) ENV 13670-1:2000 - Execution of concrete structures - Part 1: Common;
   (3) British Standard Code of Practice BS 8110 - The Structural use of Concrete, or equivalent and all work shall be carried out in accordance with the recommendations given in this code except where modified by these Technical Specifications;
   (4) British Standard Code of Practice BS 8007 - Design of Concrete structures for Retaining Aqueous Liquids, or equivalent; and
   (5) Appropriate European, British and Moldovan Standards.

2. As and when required by the Engineer the Contractor shall prepare and submit, before commencing the work, a time-chart detailing the various operations for concrete work. At least 48 hours notice shall be given to the Engineer by the Contractor prior to any concrete works of any type being carried out. No concrete shall be poured without the prior written approval of the Engineer.

3. No material shall be used in the works until prior approval for its use has been given by the Engineer.

4. Test certificates shall be supplied as soon as possible to the Engineer.

6.2 MATERIALS

6.2.1 Cement

1. The Contractor shall submit to the Engineer for approval the name(s) of the manufacturer(s) of the cement he proposes to use. Cement shall be ordinary Portland Cement and shall conform to EN 197-1:2000.

2. Sulphate resisting cement shall comply with BS 4027:1996, or equivalent. If the Contractor elects to use a Pulverised Fuel Ash (PFA) or Ground Granulated Blast Furnace Slag (GGBS) mix he shall only be able to do so with the approval of the Engineer.

3. Cement shall be fresh when delivered to Site and the consignments shall be used in the order of their delivery. If the cement is delivered in bags it shall be stored in a waterproof shed or building at a temperature of not less than 8°C and the bags shall be placed on dry boards above the floor to prevent deterioration or contamination from any cause.

6.2.2 Aggregates

1. Fine and coarse aggregates shall be as defined by the quality and nature required by EN 12620, or equivalent. In addition they shall be chemically inert to alkali reaction unless appropriate adjustment can be made to the concrete mix in order to prevent such reaction.

2. Except where aggregates have been otherwise specified the grading of coarse aggregates shall be as follows :
   (1) 10 mm max. size, graded, for all “fine” concrete.

(2) 20 mm max. size, graded, for all reinforced concrete in beams, and for walls and slabs not greater than 400 mm thick.

3. The water absorption of aggregates for concrete designed to retain water shall not exceed 3% when measured in accordance with EN 1097-3:1998, EN 1097-3, or equivalent.

4. If required by the Engineer, the Contractor shall submit the results for the following tests:

(1) Sieve analysis

(2) Test for clay, silt and dust content

(3) Test for organic impurities

(4) Test for salt content

(5) Shape and Porosity

(6) Strength

5. Tests (1) and (2) with test of moisture content shall be carried out on the samples used for each trial mix. In test (4) the percentages given by the following table shall not be exceeded.

Table 6-1: Shell content

Nominal size of aggregate (mm)	% by weight of dry aggregate of shell as Calcium Carbonate	
	Normal reinforced concrete	Liquid retaining structure
20	10	5
10	15	15
Fine aggregate	45	30

6.2.2.1 Water

The water for use in concrete and mortar shall be from potable water supply or source approved by the Engineer. Water for washing and curing shall be such that it will not impair either the strength of the finished concrete nor its appearance.

6.2.2.2 Admixtures

1. Admixtures shall be used only when and as specified herein or approved by the Engineer. Approval will only be given for the use of admixtures which can be administrated in fixed calibrated amounts through a mechanical dispenser, and which are added directly to the mixing water. Where the approval is given for the use of more than one type of admixture for the same concrete mix they shall be dispensed separately.

(1) Water-reducing - the Contractor shall include an approved water-reduction admixture (plasticiser) where, in the opinion of the Engineer, the workability of the mix is otherwise inadequate to achieve an acceptable compaction and /or surface finish, or where excessive bleeding of the concrete is in evidence.

(2) Set-retarding admixtures - where large quantities of concrete are to be placed or where concreting is undertaken under hot conditions, the contractor may include for approval a set-retarding admixture to reduce the heat of hydration.

(3) Set-accelerating admixtures - the Contractor shall not use set-acceleration admixtures except for cold weather concreting and after the approval of the Engineer. The set-accelerating admixtures shall not be used for the thrust blocks of PVC or PE pipes.

2. To ensure a maximum impermeability and density of the concrete appropriate admixtures may also be used with the Engineer's approval.

6.2.2.3 Strength of Concrete

The basis for assessing the strength of concrete shall be related to the characteristic strength, defined as the strength of the concrete at 28 days as determined by the standard method of testing.

6.2.2.4 Concrete Mixing

1. The concrete mixes are designed mixes to be supplied in accordance with EN 206-1:2000, or equivalent.

2. Details of the compressive strength grades are:

(1) Concrete mix C15 - Lean concrete.

- Compressive strength grade C1
- maximum size of aggregate 10 mm
- aggregate and cement see above
- minimum cement content 180 kg/m^3
- maximum free water/cement ratio 0.8

(2) Concrete mix C35A - Water retaining structures.

- Compressive strength grade C35
- maximum size of aggregate 20 mm
- aggregate and cement see above
- minimum cement content 325 kg/m^3
- maximum cement content 400 kg/m^3
- maximum free water/cement ratio 0.55

(3) Concrete mix C25 - Other concrete structures.

- Compressive strength grade C25
- maximum size of aggregate 20 mm
- aggregate and cement see above
- minimum cement content 275 kg/m3
- maximum free water/cement ratio 0.65

3. Where Drawings refer to C35 grade concrete for water retaining structures this shall be deemed to be C35A as specified above.

6.2.2.5 Quality Control

1. The principal basis of control shall be by comparison of the results of the compression cube tests at 28 days, except for small quantities of concrete work whose strength can be otherwise derived and which is permitted for use by the Engineer. Forty sample cubes shall be made initially in eight samples each day for five days of concreting to establish the suitability of the design mix.

2. Cube test results will be examined individually in 10 consecutive sets of four and the mean strength of each set will be calculated. The concrete mix proportions will only be acceptable if all of the EN 206-1:2000, BS 8110 and BS 8007, or equivalent requirements are fully complied with.

3. Where the results do not conform to the above requirements the mix proportions shall be modified to obtain the required specification requirements.

4. In the event of failure to meet the requirements by the 28th day, the Contractor shall be responsible to produce evidence that the related element of structure is satisfactory. This can be achieved by taking samples of a type and location approved by the Engineer from the affected part of the structure and having them tested by Testing Material Laboratory approved by the Engineer.

5. In the case where concrete does not meet the requirements even after the Laboratory testing, all the affected structural elements shall be demolished and reconstructed by the Contractor at his own expense.

6. In order to determine and therefore maintain the consistency of the mixed concrete for a particular structure and/ or section of the work, the Contractor shall carry out a slump or compacting factor test in accordance with EN 12350-2:2000 at all of the following intervals:

(1) For every mixer lorry load arriving on Site,

(2) For every 6 m^3 of Site batched/mixed concrete produced by each Site mixer,

(3) As requested by the Engineer.

6.2.2.6 Reinforcement

(1) Steel

Steel reinforcement shall comply with the relevant provisions of the appropriate British Standards, as set below, or equivalent:

Table 6-2: Standards for reinforcement

Type	BS
Carbon steel bar	4449 (EURONORM 80)
Cold reduced steel wire	4482
Steel fabric	4483

All reinforcement shall be Type 2 high yield deformed bars complying with BS 4449 or equivalent unless otherwise noted on the Detailed Design Drawings. The characteristic strength shall be 460 N/mm².

(2) Submittals

The Contractor shall provide in addition to mill test certificates which must be provided in advance for approval, a certificate confirming that samples, taken from the bars delivered to the Site, pass the tensile strength test. The frequency of sampling and the method of quality control shall be as and when required by the Engineer in accordance with the provisions elsewhere in the Contract.

(3) Fabrication and Storage

1. All reinforcement shall be cut and bend cold accurately to the dimensions approved. Bends shall be made in accordance with EN ISO 4066. If shipped to the job fabricated, steel reinforcement shall be properly bundled and tagged so that it can be handled without damage and readily with the approved placing diagrams.

2. Reinforcement shall not be straightened or rebent.

3. Reinforcing steel shall be stored above ground on platforms or other supports and shall be protected from the weather at all times by suitable covering. It shall be stored in an orderly manner and plainly marked to facilitate identification.

(4) Cleaning and Placing

1. Before being placed in position, the reinforcement shall be thoroughly cleaned of all loose scale and rust and of any dirt, coatings, or other material that might reduce the bond of concrete to the reinforcement.

2. All reinforcement shall be placed in the exact positions and with the spacing shown on the Detailed Design Drawings, or as otherwise directed. It shall be so securely fastened in position by saddle tying at intersections with annealed wire or by suitable clips, that no displacement will occur for any reason. Where splicing is permitted, bars shall overlap at least 45 diameters unless otherwise noted. Precast concrete blocks or metal chairs as approved by the Engineer shall be used for supporting horizontal reinforcement in slabs, beams and footings. No reinforcement shall be placed so that there is less concrete between it and the finished concrete surface than the minimum cover shown on the Detailed Design Drawings or specified in BS 8110, or equivalent.

(5) Welding of Reinforcement

Reinforcement shall not be welded on the Site except where described in or permitted under the contract. All welding procedures shall be subject to the prior approval of the Engineer in writing.

(6) Built-in Items

Where pipes, sleeves, water bars or other items are built into concrete, they shall be rigidly secured in position to prevent movement and shall be free from external coatings witch might reduce the bond. The

Contractor shall take precautions to prevent the formation of air pockets, voids or other defects whilst the concrete is being placed.

6.3 EXECUTION OF WORK

6.3.1 General

1. Forms for concrete shall be of wood, plywood, steel or other approved material. Type, size quality, and strength of the materials from which forms are made shall be subject to the approval of the Engineer. However the design of formwork its construction and removal shall be responsibility of the Contractor. No falsework of forms shall be used which are not clean and suitable. Deformed, broken or defective falsework and forms shall be removed from the Site.

2. Forms for concrete shall be true to line and grade, and shall be mortar-tight and sufficiently rigid to prevent displacement and sagging between supports. Forms shall be smooth and free from surface irregularities. Bolts and rods used for internal ties shall be arranged in such a manner that all metal will not be permitted where the concrete surface will be exposed to either water or weathering. All forms shall be constructed in such a manner that they can be removed without hammering or prying against the concrete. Suitable mouldings shall be placed to bevel or round all exposed corners and edges of beams, columns, walls and slabs.

3. All shuttering shall be sufficiently light, without plugging, to prevent loss of grout during the vibration of the concrete. When required by the Engineer joints between shutter facing boards shall be sealed with foam rubber sealing strips or other approved material.

4. Shuttering which as a result of prolonged use or general deterioration does not, in the opinion of the Engineer, conform to the particular requirements, shall not be used. Boxes for forming holes shall be constructed so as to be easily removable without damaging the concrete during removal. They shall be properly vented to permit the escape of entrapped air, and shall be capable of being sealed, subsequently, to prevent the loss of grout. The use of polystyrene blocks for the forming of holes, sinking, etc. will not be allowed except by the Engineer's permission.

5. Before concreting, the areas which are intended to receive the concrete shall be cleaned by getting with compressed air, and all water and extraneous material removed.

6. Shutter ties which provide a direct leakage path or leave an open hole through any structural element of any water retaining structure or beneath the finished ground level of any structure shall not be used.

6.3.2 Formwork

6.3.2.1 Sawn Formwork (Type A)

This shall be designed formwork or moulds of closely jointed sawn boards or other approved material. Small blemishes due to entrapped air or water shall be allowed but the surface shall be free from voids, honeycombing or other large blemishes.

6.3.2.2 Wrought Formwork (for "Fair Face" Finish) (Type B)

1. Where concrete is described as having "Fair Face" finish it shall have a smooth finish of uniform texture and appearance. This finish shall be a high quality hard smooth finish resulting from a high quality concrete with forms or moulds having a hard smooth finish.

2. The concrete surface shall be smooth with true clean arises and only very minor surface blemishes shall be allowed with no staining or discoloration from release agents. Whilst the concrete is still green all surface blemishes shall be filled after Engineer's permission with a fresh specially prepared cement and fine aggregate paste.

3. For circular columns metal formwork shall be used.

6.3.2.3 Tolerances

Concrete surfaces in the final work shall have no abrupt irregularities to an extent observable by eye. Subject to retaining the required concrete cover to reinforcement, other deviations from the surfaces described in the Contract shall be no more than the permissible amounts given in Table 6-3.

Table 6-3: Permissible deviations in concrete surfaces

Type of finish	Deviation from line, level, verticality, cross section dimension or length (mm)	Any abrupt irregularity (mm)
Sawn formwork	10	5
Any other	5	3

6.3.2.4 Striking and Removal of Shuttering

1. Formwork shall be removed without shock or to disturbance of the concrete.

2. Formwork to vertical surfaces or sloping formwork not supporting concrete in flexure shall not be removed until, the concrete strength shall be sufficient to meet any wind load upon the concrete likely to arise at the time when the formwork is removed; and

(1) The concrete strength (as confirmed by tests in cubes cured under representative conditions) has reached 5 N/mm2; or

(2) For concrete containing Portland cement only, in the absence of cube test results a minimum period shall have elapsed since the concrete was poured equivalent to 11 hours at 15 0C for unsealed plywood forms, or 8 hours at 15 0C for impermeable forms

3. Formwork supporting concrete in flexure shall not be removed until:

(1) The concrete strength (as confirmed by tests in cubes cured under representative conditions) has reached 10 N/mm2; or twice the stress to which the concrete will then be subjected, whichever is the greater, or

(2) For concrete containing Portland cement only, in the absence of cube test results or any formal procedure agreed with the Engineer, the periods before striking calculated from the relevant formula as given in Table 6-4 shall be used.

Table 6-4: Periods for striking formwork

Type of formwork	Period calculated for mean ambient temperature (t) between 5 and 25°C
Soffit form to slabs and beams	100 ÷ (t + 10) days
Props to slabs and beams	250 ÷ (t + 10) days

6.4 CONCRETING

6.4.1 General

1. Before any major concrete pour is started, the Contractor shall prepare and submit to the Engineer for approval a schedule of his proposed operations. Approval of the schedule by the Engineer shall not relieve the Contractor of his responsibility for producing concrete work of the highest quality.

2. No concrete shall be placed until the depth and character of the foundation soils have been inspected and approved by the Engineer.

3. Water shall be removed from the trenches before casting the concrete. Loose particles and other impurities shall be removed, washed and/ or blown away from forms and from inner surfaces of mixing and casting equipment with pressurised air.

3. No concrete shall be placed until all reinforcing steel, anchor bolts, pipes, conduits, sleeves and other work required to be built into concrete have been inspected and approved by the Engineer.

4. All concrete shall be placed during the daylight hours except with the consent of the Engineer, the placing of concrete in any portion of the work shall not be started unless it can be completed in daylight. If special permission is obtained to carry on work during the night, and adequate flood-light system must be provided.

5. In the event of the Contractor electing to carry out site mixing of concrete the batching plant shall be to the approval of the Engineer. Aggregates and cement shall be proportioned by weight batching and water by volume. Batch mixing machines shall comply with the requirements of EN 1305 and shall be provided in such numbers and of such capacity to ensure a continuous supply of fresh concrete. The contractor shall, if required by the Engineer, arrange to have all gauges of his batching plant tested and calibrated. The tests shall be carried out at a frequency required by the Engineer and the cost borne by the Contractor.

6. The transport of and delivery times for ready mixed concrete shall be in accordance with the requirements of EN 206-1:2000.

6.4.2 Pouring

1. Concrete shall be placed in forms as soon as practicable after mixing, and in no case shall any concrete be used which does not reach its final position in the forms within 30 minutes of discharge from the mixer, unless carried in a purpose-made agitators operating continuously, when the time shall be within 2 hours of the introduction of the cement to the mix and within 30 minutes of the discharge from the agitator.

2. The method and manner of placing concrete shall be such as to avoid the possibility of segregation of the concrete materials or the displacement of the reinforcement.

(1) Dropping the concrete a distance of more than 2.0 m or depositing a large quantity at any point, running or working it along the forms will not be permitted.

(2) Placing of concrete shall be so regulated that the pressure caused by wet concrete shall not exceed that used in the design of the forms.

(3) All concrete shall be deposited in approximately horizontal layers. Each part of the form shall be filled by placing the concrete as near to its final position as possible. The coarse aggregate shall be worked back from the face and the concrete forced under and around the inserts, piping and reinforcing bars without disturbing them.

(4) All concrete shall be consolidated by continuous working with suitable tools and also by the use of approved mechanical vibrating devices.

(5) Mechanical vibrators shall be of an approved type transmitting vibrations directly to the concrete with sufficient intensity to cause flow and settlement. Their operation shall be carefully controlled to give sufficient duration to accomplish thorough compacting without over-agitation which will cause segregation of the materials. Every effort shall be made to ensure that all concrete work is solid, compact, watertight, and smooth to prevent the formation of laitenance.

(6) If concreting is interrupted for any reason for a long enough time for a cold joint to be likely (30 minutes) then a stop-end will be introduced to produce a well compacted, square, formed construction joint, to the approval of the Engineer, at the point where concreting must stop. Any concreting which is allowed to cure on a feather edge without a stop-end

thus producing poor quality uncompacted concrete will be chopped back to sound concrete before continuing the pour.

6.4.3 Hot Weather Concreting (for Temperature above +20°C)

Concreting shall not be permitted if its temperature of placing is in excess of +38°C. In order to maintain the temperature of the concrete below this value the following precautions shall be taken:

(1) All aggregate stockpiles, water lines and tanks as well as the mixer shall be protected from the direct rays of the sun;

(2) Coarse aggregate shall be cooled by constant watering where possible;

(3) Mixing water shall be cooled by the addition of ice to the storage tanks where necessary;

(4) Rapid-hardening cement shall not be used;

(5) Where the above precautions are inadequate concreting shall be carried out during the cooler parts of the day or during the night as may be approved by the Engineer;

(6) When the air temperature is above +20°C loss of mixing water by evaporation shall be considered in arriving at the amount of water to be added to the mix. In order to maintain the water/cement ratio within permissible limits an approved water-reducing agent shall be included in the mix;

(7) In order to reduce premature drying of the concrete during transporting and placing, all chutes, shuttering and reinforcement shall be cooled by watering when possible, or shall otherwise be protected from the direct rays of the sun.

6.4.4 Wet Weather Concreting

1. Concreting during periods of constant rain shall not be permitted unless aggregate stockpiles, mixers and transporting equipment, and the areas to be concreted are adequately covered.

2. During raining weather, the Contractor shall ensure the work can be concluded at short notice by the provision of stop ends. Adequate covering shall be provided to protect newly placed concrete from the rain.

6.4.5 Cold Weather Concreting

1. Concreting at ambient temperatures below +2°C may be carried out only if the following conditions are met:

(1) the aggregates and water used in the mix shall be free from snow, ice and frost

(2) before placing concrete, the formwork, reinforcement and any other surface with which the fresh concrete will be in contact shall be free from snow, ice and frost and shall be at a temperature above 0 °C

(3) the initial temperature of the concrete at the time of placing shall be at least +10 ºC

(4) the temperature at the surface of the concrete shall be maintained at not less than +10 °C at any point until the concrete reaches a strength of 5 N/mm², as confirmed by tests on cubes matured under similar conditions, and

(5) temperatures at the surface of the concrete shall be measured where the lowest temperature is expected.

2. The contractor shall take precautions to prevent the temperature of any concrete falling to 0ºC during the first five days after placing.

6.4.6 Protection and Curing

1. Careful attention shall be given to the proper curing and protection of all concrete in the structures. The work shall be protected from the elements, flowing water and from defacement of any nature during construction operations.

2. After placing and finishing of concrete, concrete shall be cured and protected in accordance with BS 8110, or equivalent.

3. Finished surfaces and wall edges located where travel and further construction work is necessary shall be suitably protected from damage by temporary guards or covers as directed by the Engineer.

4. The curing time shall be the number of days given in Table 6-5.

5. Where a curing compound is used the Contractor must be able to demonstrate adequate coverage of the concrete by the compound. The compound to be used by the Contractor must be approved by the Engineer.

Table 6-5: Curing time

Type of cement	Ambient conditions after casting	Minimum period of curing and protection (days)	
		+5°C to +10°C	Above +10°C
EN 4027 or equivalent	Average	4	3
	Poor	6	4
Others	Average	6	4
	Poor	10	7

6.4.7 Construction Joints

1. Except where construction joints are shown in the approved drawings, the Contractor shall obtain the Engineer's approval to the positions and details of such joints before any work is commenced.

2. Concreting shall be carried out continuously up to construction joints.

3. The surface of any concrete against which new concrete is to be cast shall be free from laitenance and shall be roughened to the extent that the large aggregate is exposed but not disturbed. The joint surface shall be cleaned immediately before the fresh concrete is placed against it.

4. Where practicable, such preparation of joints shall be carried out when the concrete has set but not hardened.

6.4.8 Waterstops and Jointing Materials

6.4.8.1 Waterstops

1. A waterstop of stainless steel strip 2 mm thick, h = 200 mm, shall be located in every joint in water retaining structures.

2. Waterstop shall be located and maintained accurately in correct position. On no account shall any waterstop be secured by nails or by any other means involving puncture of or damage to the waterstop materials unless purpose made nailing flanges are incorporated in the design of the waterstop.

3. All waterstop joints shall be welded.

6.4.8.2 Installation of Joint Fillers and Sealants.

1. Joint fillers and sealants shall be installed in accordance with manufacturer's recommended procedures. Joint filler that will be exposed after removal of forms shall be cut and trimmed to ensure a neat appearance and shall completely fill the joint except for the space required for the sealant. The filler shall be held securely in place and no concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.

2. A bond breaker of polyethylene film shall be used between filler and sealant. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied.

1. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surfaces shall present a clean and even appearance.

6.4.9 Internal Epoxy paint for wastewater treatment concrete works

1. Two component epoxy modified paint based on hydrocarbons resins and special additives: for the protection of sewage treatment plants, cisterns and concrete sewer pipes in contact with aggressive chemicals such as acids, alkalis, hydrocarbons, detergents and sewage.

2. The epoxy paint is design for contact with sewage and is also resistant to frost and sunlight, and creates a vapour barrier.

3. Application procedure:

- Substrate preparation: substrate must be thoroughly clean, solid and dry. Completely remove loose materials, dust, traces of formwork, release agents, paints and varnishes by sandblasting. Fill any cracks and repair degraded sections. Seal and level any irregularities in the substrate.
- Mixing: the paint's two component must be mixed together. Pour part B (hardener) into part A (resin) and mix at low speed with a mechanical stirrer until completely homogenised.
- Application: the paint can be applied using conventional techniques, brush, roller, or spray, in at least two coats. Wait from 6 to 24 hours between coats, depending on ambient conditions.

6.4.10 Concrete Finish without Formwork

6.4.10.1 General

1. All exposed faces of concrete unless otherwise specified shall be hard, smooth and free from honeycombing, air and water holes and other blemishes.

2. All projecting imperfections shall be rubbed down with carborundum stone or by other approved means and grit and dust therefore shall be thoroughly washed off with clean water.

6.4.10.2 Surface finishes.

1. Wood float finishes - shall be formed by smooth floating the accurately levelled and screened surface. Care shall be taken to ensure that the concrete is worked no more than is necessary to produce a uniform surface free from screed marks.

2. Steel trowel finishes - shall be formed when the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitenance from being worked to the surface, the surface to the wood float finish shall be steel-trowelled under firm pressure to produce a dense, smooth, uniform surface free from trowel marks.

3. Where the type of finish is not given it shall be wood float finish.

6.4.10.3 Repairs

Honeycombed or damaged surfaces of concrete, which in the opinion of the Engineer, are not such as to warrant the cutting out and replacement of the concrete, shall be made good as soon as possible after removal of the shuttering as follows: 1:1½ Portland cement and sand mixture shall be worked into the pores over the whole surface with a fine carborundum float in such a manner that no more material is left on the concrete face than is necessary completely to fill the pores so that a uniformly smooth and dense concrete of uniform colour is finally presented.

6.4.11 Removal and Replacement of Unsatisfactory Concrete

The Contractor shall on the Engineer's instructions to do so cut out and replace any concrete in any part of the structure if in the Engineer's opinion :

- the concrete does not conform to the specifications; or
- deleterious materials or materials which are likely to produce harmful effects have been included in the concrete; or
- the honeycombed or damaged surfaces are too extensive; or
- the finished concrete sizes are not in accordance with the Drawings with permissible tolerances; or
- the setting out is incorrect; or
- the steel cover has not been maintained; or
- the protection, including curing, of the concrete during the construction was inadequate, resulting in damage; or
- the work of repairing or remedial measures the Engineer may indicate are not carried out to his satisfaction, or
- undue deformation of or damage to the works has taken place due to inadequate shuttering, or to premature traffic or to excessive loading; or
- any combination of the above points has taken place resulting in unsatisfactory work.

6.4.12 Test of Water-Tightness of Finished Structures

1. All water retaining structures shall be made watertight by the production of a well compacted dense concrete. The Contractor shall be responsible for the water-tightness of the concrete and all water-containing structures shall be tested for water-tightness when the concrete has achieved its design strength, the Contractor providing all labour, water drain stoppers, water, energy, etc. for conducting the test. All water retaining structures shall be tested before the placing of the backfill, banking, etc.

2. The exposed faces shall be deemed to be watertight if they show no signs of leakage and remain visibly dry during the test period of seven days.

3. Covered structures, the surface of which are not accessible for inspection, shall be filled with water for a period of twenty-one days. On the expiry of this period, the level of the water surface shall be recorded and further measurements be taken at 24 hour intervals for seven days. Consideration shall be given to losses resulting from absorption and evaporation. The structure may be deemed to be watertight if the total drop in surface level does not exceed 1/500 of the average water depth of the full tank or 10 mm, whichever is less, in seven days after due consideration has been given to absorption and evaporation.

4. For open reservoirs, due regard should be paid to atmospheric conditions throughout the test period.

5. All observed leakages due to cracks or honeycombing etc in water-retaining structures shall be repaired by the injection of epoxy resins, watertight epoxy plaster or any other approved method. The cost of all repair works, as well as the new water-tightness test after repair works, shall be borne by the Contractor.

6.4.13 Concrete protecting coating

1. The protective coating to all buried concrete surfaces shall be heavy duty bituminous coating.

2. The bituminous coating shall consist of penetrating bituminous primer and a three-coat high build bituminous base coating capable of being brush, trowel or spray applied to give a total dry film thickness of 1 mm. The coating shall be capable of being applied to a vertical surface without running.

6.4.14 Tolerances for prefabricated concrete units

The tolerances for prefabricated concrete units shall be as follows:

- **columns**

length:	±10 mm or L/1000, whichever greater
cross-section:	±10 mm
curvature:	±10 mm or L/750, whichever greater

- **beams**

length:	±15 mm or L/1000, whichever greater
cross-section:	±10 mm
curvature:	±10 mm or L/500, whichever greater

- **walls**

length, height:	±10 mm
thickness:	±5 mm

7 SPECIFICATION FOR UNDERGROUND PIPEWORK

7.1 GENERAL

7.1.1 Scope of Work

The complete construction of pipelines as stated hereunder is included in the scope of underground pipe work. The works shall include but not limited to clearing of the Site, excavation, foundations of pipework and auxiliaries, furnishing and installing to the required elevation all specified underground piping with all fittings (including valves etc.) and appurtenances, backfilling, embankments, connections to manholes and chambers, crossings in general, pipe supports, testing of pipelines and cleaning of Site all as required for a complete installation.

7.1.2 Quality Assurance

7.1.2.1 Shop Tests

All pipe materials, fittings, sealing rings and other materials for pipeline network covered by these specifications shall be tested in accordance with the applicable standards.

7.1.2.2 Witnessed Shop Tests

Visits and inspections of a manufacturer's facilities before and /or after the approval of materials may be required as set out in the Special and General Conditions of Contract and Detailed Design.

7.1.3 Submittals

7.1.3.1 General

No material furnished under these specifications shall be shipped to the Site until all submittals have been approved.

7.1.3.2 Product Literature etc.

1. Each submittal shall be complete in all aspects incorporating all information and data listed herein and all additional information required to evaluate the compliance of the proposed piping material(s) with the Contract.

2. Data to be submitted shall include but is not limited to:

(1) Catalogue data consisting of specifications, illustrations and a parts schedule that identifies the materials to be used for the various components and accessories. The illustrations shall be in sufficient detail to serve as a guide for assembly and disassembly;

(2) Complete assembly drawings of fittings etc. with clearly marked dimensions. This information shall be in sufficient detail to serve as a guide for assembly and disassembly and for ordering parts;

(3) Listing of all lubricants required for the equipment with a minimum of four equivalent and compatible natural and/ or synthetic lubricants produced by different manufacturers. The listing shall include the estimated quality of lubricant required for one year of operation;

(4) Lists of spare parts and special tools;

(5) Weight of all component parts;

(6) Tabulated pipe schedule, which shall include the following information for all pipe and fittings: service, pipe size, working pressure, wall thickness; and

(7) Manufacturer's instructions for transporting, unloading, storing and installing pipes, fitting and other pipe accessories.

7.1.3.3 Certified Shop Test Results

Copies of current authenticated test results in accordance with the manufacturing standard shall be submitted in accordance with the Contract provisions.

7.2 MATERIALS

7.2.1 General

1. All pipes, fittings, couplings and the like shall be marked with the manufacturer's name or trademark, size, pressure, class, date of manufacture, angle of bends etc. and additionally all as required in the applicable manufacturing standard.

2. All bolts, nuts and washers and the like shall be as specified herein.

3. Acceptable standards for pipes and fittings are as follows all to the latest editions:

(1) Ductile Iron (DI): EN 545:1994, EN 1092-2:1997, or equivalent;

(2) Steel: ENV 10220:1993, EN 10240:1997, EN 1092-1:2001, or equivalent;

(3) Polyethylene (PE): EN 10284:2000, or equivalent;

(4) uPVC pressure (PVC): EN 1452-1:1999, EN 1452-2:1999, or equivalent;

(5) uPVC gravity (PVC): EN 1401-1:1998, or equivalent;

(6) Reinforced concrete: EN 639:1994, EN 640:1994, EN 641:1994, or equivalent; and

(7) Unreinforced concrete: BS 5911-100:1988, or equivalent.

7.2.2 Pipes and Pipe Fittings

7.2.2.1 Ductile Iron Pipes and Fittings

1. Unless otherwise specified these shall be suitable for minimum PN10 working pressure.

2. Ductile iron pipes and fittings shall be cement-mortar lined and seal coated to ISO 6600:1980, or equivalent and shall have an outside asphalt coating not less than 0.25 mm in thickness. Other standards shall meet ISO 4179:1985, or equivalent. Cement-mortar lining shall be standard thickness. Materials, mix and workmanship for the cement mortar lining shall be:

(1) sulphate resisting cement to EN 197-1:2000, or equivalent

(2) sand, inert granular material of hard durable uncoated grains, to EN 12620, or equivalent

(3) water from the public supply, containing no constituents that adversely affects the quality of cement or the water to be carried in the pipe

(4) mix, at least 1 part by weight of cement : 3.5 parts by weight of sand

(5) cement mortar lining to be applied by centrifugally or by a centrifugal applicator head.

3. The insides of sockets and the faces of flanges shall be free from cement mortar.

4. Small areas of damaged pipe lining may be repaired by cutting back the lining to the metal surface, thoroughly wetting the exposed surface of the metal and the adjacent sound lining and by patching with stiff fresh cement mortar worked in thoroughly to ensure a good bond with exposed surfaces.

5. Thickness of lining shall be as set out in Table 3-1 below.

Table 3-1: Thickness of cement mortar lining

DN (mm)	Nominal thickness (mm)	Minimum arithmetical mean value of thickness (mm)	Individual minimum thickness (mm)
100 - 300	3	2.5	1.5
400 - 600	5	4.5	2.5
800 - 1,000	6	5.5	3.0

6. Joints shall be Tyton-type, spigot and socket, push-on with preformed gasket. Gaskets shall be according to EN 545, or equivalent and shall be obtained from the pipe manufacturer.

7. Joints shall be capable of taking the allowable deflection per joint as given in Table 3-2 below.

Table 3-2: Minimum requirement of allowable deflection per joint

DN (mm)	Deviation angle - degrees
100 to 150	5
200 to 300	4
400 to 600	3
800 -	2

8. All pipes shall be not less than 5 m net laying length unless otherwise specified.

7.2.2.2 Steel Pipes and Fittings

The pipes shall be made by either:

- longitudinally butt welding internally and externally preformed carbon steel plate or strip, by automatic submerged metal-arc welding process and circumferentially butt welding these shells internally and externally by the same process, into standard length pipes with a maximum of five circumferential welds, or
- rolling a strip, sheet or plate so that a helical seam is formed around the circumference of the pipe. The helical seam shall be butt welded internally and externally by an automatic submerged metal-arc welding process.

2. The weld metal shall have a smooth finish and shall not stand more than 1.5 mm proud of the pipe shell internally and externally.

3. The weld metal on the external surface of the ends of all plain ended pipes and fittings shall be machined flush with the external surfaces of the pipe shell for a sufficient distance to facilitate jointing with couplings or collars. At the spigot ends of spigot and socket pipes, the welded metal shall be similarly machined externally to suit the socket end of the pipe.

4. Steel pipes and fittings shall be made from carbon steel plate to grade ST360 of ISO 559, or equivalent with minimum yield stress of 225 N/mm^2 suitable for minimum PN10 working pressure: pipe dimensions shall comply with ENV 10220:1993.

5. The designation of the pipes shall be ISO 559 - 4.3, or equivalent as appropriate.

6. The minimum thickness of steel plate for pipes corresponding to various nominal diameters of the pipes shall be as specified in ENV 10220:1993, or equivalent.

7. All carbon steel fittings to be installed inside the valve chambers shall be corrosion protected with an epoxy system internally and externally, minimum dry film thickness 300 microns. The fittings to be embedded in concrete and provided with an anchoring flange shall have an outside uncoated section of 150 mm on both sides of the anchoring flange.

8. The steel pipes to be laid underground shall be coated externally with an epoxy system, minimum dry film thickness (DFT) 300 microns. Steel pipes should be lined with cement internally.

7.2.2.3 Polyethylene (HDPE) Pipes and Fittings

1. HDPE pipes and fittings shall be manufactured according EN 12201-2.

2. PE pipes and fittings shall conform to outside diameters as stated in standards. Pipes and fittings shall have the working pressure (PN) as shown on drawings.

3. The pipe and fitting will be PE100 types according ISO/TR 9080 (Mpa 10). The polyethylene pipes shall satisfy all current applicable health and safety requirements with regard to suitability for use in potable water services.

4. HDPE pipes manufacturer shall have a Factory Conformity Certification according UNI 10910, and Quality System Certification according UNI ISO 9001 or equivalent. Outside diameters and wall thickness shall comply with EN 10001-2 sheet 1 1and 2.

5. Pipes shall be supplied with plain ends either to fit couplings or suitable for welding. The pipes couplings shall be manufactured according UNI EN 12201-3, and the welding coupling shall be according UNI 10520. In addition Pipe manufacturer's specifications shall be strictly followed for butt welded and electro-fusion joints.

6. All the fittings shall be as shown on drawings.

7. Eventual connections into steel pipes and fittings shall be made with threaded adapters or flanged joints.

8. Minimum bending radius shall be in accordance with Table 3-3 below.

Table 3-3: Minimum bending radius of PE pipe

Material type	Minimum radius (x outside diameter)
PE-HD	50
PE-MD	40
PE-LD	30

7.2.2.4 Unplasticised Polyvinyl Chloride (uPVC) Pipes and Fittings

1. uPVC pipes and fittings shall conform to outside diameters as stated in standards. Unless otherwise specified pipes and fittings shall be suitable for minimum PN10 working pressure.

2. Pipes and fittings shall be jointed with spigot and socket joints with elastomeric sealing rings. Solvent cement type joints shall not be used.

3. Fittings of steel or iron coated and lined with an epoxy system or, aluminium alloy with nylon or equal coating and lining are also acceptable.

4. Connection into steel pipes and fittings shall be made with flanged socket or spigot fittings manufactured of iron, steel or aluminium alloy. Corrosion protection of the iron or steel fittings shall be with an epoxy system.

7.2.2.5 Unplasticised Polyvinyl Chloride (uPVC) Pipes and Fittings for Gravity Sewers

1. uPVC sewer pipes and fittings shall conform to outside diameters as stated in standards.

2. Minimum wall thickness shall be as specified in EN 1401-1:1998, or equivalent.

3. Pipes and fittings shall be jointed with spigot and socket joints with elastomeric sealing rings. Solvent cement type joints shall not be used.

7.2.2.6 Concrete Pipes and Fittings

1. Unreinforced and reinforced concrete pipes and fittings with flexible joints shall comply with BS 5911, or equivalent. Reinforced concrete pipes and fittings shall comply with EN 639:1994 and EN 640:1999 or EN 641:1992, or equivalent, as appropriate.

2. All pipes and fittings shall have gasket-type joints of spigot and socket.

3. Concrete pipes for pipe jacking, if any, shall comply with the relevant provisions of BS 5911, or equivalent. The Contractor shall ensure that the pipes can withstand the jacking loads to which they will be subjected during installation, without cracking or spalling. A certificate shall be supplied, confirm that the pipes are suitable for jacking and stating the distributed jacking loads for which they were designed.

7.2.3 Pipe Jointing, Saddles and Repair Clamps

7.2.3.1 Joint Seals and Lubricants

1. Elastomeric joint seals shall comply with the relevant provisions of EN 545, or equivalent.

2. Joint lubricants shall have no deleterious effects on either the joint rings or pipes, and be unaffected by the liquid to be conveyed. Lubricants to be used for jointing water mains shall not impart taste and/ or colour to the water to be conveyed, or any effect known to be injurious to health, and shall be resistant to bacterial growth.

3. Lubricants shall be as recommended by the pipe manufacturer.

7.2.3.2 Flanges for Pipes and Pipeline Fittings

Flanges for pipes and pipeline fittings shall comply with EN 1092-1:2001 for steel flanges or EN 1092-2:1997 for cast iron flanges, or equivalent.

7.2.3.3 Gaskets for Flanged Joints

Gaskets for flanged pipe joints shall be of the inside-bolt-circle type. The material and dimensions of gaskets shall comply with the provisions of ENV 1591-2:2001, or equivalent.

7.2.3.4 Pipe Saddles and Repair Clamps

1. Pipe saddle body shall have female thread or be undrilled and material shall be cast iron or ductile iron and coated with an epoxy system. Saddle strap shall be stainless steel. Bolts, nuts and washers shall be stainless steel. Rubber insert and O-ring shall be EPDM rubber or similar.

2. Alternatively for disconnection work stainless steel pipe repair and coupling clamps can be used. The clamp to be equipped with EPDM gasket seal or similar. Bolts, nuts and washers shall be stainless steel.

7.2.4 Valves

Valves shall be as specified in the Mechanical Specifications.

7.2.5 Miscellaneous Fittings and Appurtenances

7.2.5.1 Manhole Covers and Frames

Manhole covers and frames shall comply with the relevant provisions of EN 124:1994, or equivalent having a minimum clear opening of 600 mm. Manhole covers shall have closed key-slots. In vehicle traffic areas, covers and frames shall be designed for 40 ton load and outside vehicle traffic areas for 25 tons respectively.

7.2.5.2 Extension Spindles and Protection Tubes

Valves not in chambers and valves to be operated from outside the chamber shall be fitted with extension spindles and spindle support/guides. Valves installed in the ground shall be fitted with extension spindles and equipped with protection tubes. The material of the extension spindle shall be galvanised steel and the protection tube shall be PE.

7.2.5.3 Surface Boxes

Surface boxes shall comply with the relevant provisions of BS 5834, or equivalent.

7.2.5.4 Nuts, Screws, Washers and Bolts

1. Mild and high strength nuts, screws, washers and bolts shall comply with the relevant provisions of the appropriate British Standard, or equivalent, as set out below in Table 3-4.

Table 3-4: Requirements for mild and high strength nuts, screws, washers and bolts

Type	BS
Black hexagon bolts, screws and nuts Metal washers for general purposes High strength friction grip bolts, nuts and washers	4190 4320 4395

2. Bolting for pipes and fittings shall comply with the relevant provisions of EN 1515-1:1999, EN 1515-2:2001 and EN 1092-1:2001 or EN 1092-2:1997 or equivalent, except that bolts for use with ductile iron fittings shall be manufactured from metal complying with the provisions of EN 1563:1997 for Grade 500/7 or equivalent.

3. All carbon steel bolts, nuts and washers shall be hot dip galvanised.

4. Stainless steel nuts, screws, washers and bolts shall be manufactured from Grade 316S31 steel complying with EN 10130:1991 + A1:1998 or EN 10085, or equivalent.

7.3 EXCAVATION, BACKFILLING AND RESTORATION

7.3.1 Excavation

Trenches for underground network, manholes and chambers shall be excavated to the lines and grades or elevations shown on the Detailed Design Drawings and as required in the Particular Specification. The Contractor shall avoid unnecessary opening of the pipe excavation before installing the pipe.

7.3.2 Backfilling

Backfilling shall be carried out as specified in Section 3.7.2.

7.3.3 Surface Reinstatement

Surface reinstatement shall be carried out as shown on the Detailed Design Drawings and specified in Section 3.9.3.

7.4 INSTALLATION

7.4.1 General

1. All precautions shall be taken to protect the pipes and prior to installation all pipes shall be checked for soundness and cleanliness. Any material found to be defective shall be marked and removed from the Site. Pipes, fittings and other accessories shall be stored as recommended by the manufacturer.

2. Proper and suitable tools and appliances for the safe and convenient handling and laying of pipes shall be used and shall comply with manufacturer's recommendations. Should any pipe be discovered to be defective after being laid, it shall be removed and replaced with sound pipe by the Contractor at his expense.

3. Pipes shall be lowered into the trench in such a manner that neither the pipe nor the trench will be damaged or disturbed and so as to prevent earth or debris from falling into the previously prepared pipe bed or gaining entrance to the pipe. Under no circumstances shall pipe materials be dropped or dumped into the trench.

4. Pipes, fittings and other accessories shall be laid to conform with the lines and grades shown on the Detailed Design Drawings. Invert levels to be set to a tolerance of plus or minus five (±5) millimetres.

5. Socket and spigot pipe shall be laid with the socket ends facing the direction of laying.

6. After each pipe is installed the interior of the pipes shall be cleaned of all dirt and superfluous materials. Where cleaning after laying is difficult because of small pipe size, a suitable swab or drag shall be kept and pulled forward past each joint immediately after the jointing has been completed.

7. Trenches shall be kept dry and pipes shall not be laid when the condition of the trench is unsuitable. Under no circumstances shall water be allowed to run through the pipes during construction.

8. Whenever pipe laying is stopped the open ends of pipe and fittings shall be securely and satisfactorily closed with caps so that no water, earth or other substance will enter the pipe or fittings. The pipe shall be secured and protected to prevent displacement of the pipe by any movement of the backfilling. In case water or any foreign material enters the pipe or the pipe is displaced from its position, the Contractor shall clean the pipe and reinstall it at its correct position at his expense.

9. Free distance between the top of one pipe and/ or service and the underside of another shall not be less than 100 mm.

7.4.2 Thrust Blocks for Pressure Pipelines

1. Thrust blocks shall be provided at all bends, caps, tees, valves, etc. Thrust blocks shall be cast between undisturbed ground and the fitting to be anchored/supported. A bituminised membrane with a nominal thickness of 3 mm shall be placed between the pipe fitting and the concrete. The Contractor shall provide the thrust block designs in accordance with the soil conditions.

2. Thrust blocks may be replaced with an anchored joint system with the approval of the Engineer. The anchoring fittings shall be manufactured of carbon steel, hot dip galvanised and protected against corrosion with factory made epoxy coating. Bolts, nuts and washers of hot dip galvanised carbon steel.

7.4.3 Welded Joints in Steel Pipes

This shall be in accordance with the General Mechanical Specification.

7.4.4 Cutting of Pipes

Pipe shall be cut to provide a clean square profile without splitting or fracturing the pipe wall and with minimal damage to any protective coating and lining. Where necessary, the cut ends of pipes shall be formed suitable for the type of joint to be used and protective coatings and linings shall be made good and the ends of the cut sealed.

7.4.5 Chambers

Cast in situ reinforced concrete chambers shall be constructed where shown on Detailed Design Drawings.

7.4.6 Step Irons and Miscellaneous Ironwork

The steps shall be securely installed in perfect alignment, both horizontally and vertically and shall comply with BS 1247, or equivalent.

7.5 TESTING

7.5.1 General

1. The Contractor shall furnish all necessary labour, materials and equipment necessary for carrying out the tests. The Contractor will be responsible for arranging water as necessary for flushing and testing, including any charges levied by the local water utility for water used as well as for all temporary piping, storage and / or transportation of the water.

2. The Contractor shall provide all means and apparatus necessary for introducing the water into the pipelines for flushing and testing including all pumps, gauges, meters, plugs, caps, blow off piping, etc, as well as necessary strutting, thrust blocks etc to prevent pipe movement during the flushing and testing. All pressure pipelines shall be flushed and tested in lengths not exceeding 500 m. The Contractor shall give at least one week's notice of testing of pipelines.

3. The Contractor shall be responsible for ensuring the testing has no adverse affect on the design concrete strength of the thrust blocks.

7.5.2 Testing of Non-Pressure Pipelines

7.5.2.1 General

1. Non-pressure pipelines laid in open trench shall be tested after they are jointed, and before any backfilling is commenced, other than such as may be necessary for structural stability whilst under test.

2. The pipelines shall be tested by means of an air or water test or by visual inspection in lengths determined by the course of construction, in accordance with a programme approved by the Engineer.

3. A further test shall be carried out after the backfilling is complete.

7.5.2.2 Water Test for Non-pressure Pipelines

1. The test pressure for non-pressure pipelines up to and including 800 mm nominal size shall be not less than 1.2 m head of water above the pipe soffit or ground water level, which ever is the higher at the highest point, and not greater than 6 m head at the lowest point of section. Steeply graded pipelines shall be tested in stages in cases where the maximum head, as stated above, would be exceeded if the whole section were tested in one length.

2. The pipeline shall be filled with water and a minimum period of two hours shall be allowed for absorption, after which water shall be added from a measuring vessel at intervals of 5 minutes and the quantity required too maintain the original water level noted. Unless otherwise specified, the length of pipeline shall be accepted if the quantity of water added over a 30 minute period is less than 0.5 litre per lineal metre per metre of nominal size.

7.5.2.3 Air Test for Non-pressure Pipelines

Non-pressure pipelines to be air tested shall have air pumped in by suitable means until a pressure of 100 mm head of water is indicated in a U-tube connected to the system. The pipeline shall be accepted if the

air pressure remains above 75 mm head of water after a period of 5 minutes without further pumping, following a period of stabilisation. Failure to pass the air test shall not preclude acceptance of the pipeline if a successful water test, ordered by the Engineer, can be subsequently carried out in accordance with the relevant clause of these Technical Specifications.

7.5.2.4 Infiltration

1. Non-pressure pipelines and manholes shall be tested for infiltration after backfilling. All inlets to the system shall be effectively closed and any residual flow shall be deemed to be infiltration.

2. The pipeline including manholes shall be accepted as satisfactory if the infiltration, including the infiltration into manholes, in 30 minutes does not exceed 0.5 litre per lineal metre per metre of nominal size.

3. Notwithstanding the satisfactory completion of the above test, if there is any discernible flow of water entering the pipeline at a point which can be located either by visual or CCTV inspection, the Contractor shall take such measures as are necessary to stop such infiltration.

7.5.3 Testing of Pressure Pipelines

7.5.3.1 General

1. Pipelines shall be tested after the completion of the pipeline with the exception of any backfilling not necessary for the stability and safety of the work and shall be tested before backfilling over joints and fittings.

2. The section of pipe shall be slowly filled with water and air expelled completely from the pipe and all pipeline fittings to be tested. The specified test pressure, based on the elevation of the lowest point of the section under test, shall be applied by pumping. The Contractor shall arrange for the pressure gauges to be used in the test to be independently checked and a dated certificate of its accuracy shall be provided to the Engineer.

3. The volume of water that must be added is converted into litres/metre/hour and shall not exceed the quantity which is obtained by the formula:

$$Q=(LxDx\sqrt{P})/71,526$$

where:

Q = allowable leakage in litres/hour
L = length of pipe tested in metres
D = inside diameter of the pipe, in millimetres
P = average test pressure during the test, in bar

4. As an example, an allowable leakage in litres per 100 m of pipeline at test pressure 8 bar is as set out in Table 3-5 below.

Table 7-1: Example of allowable leakage

DN (mm)	100	150	200	250	300	400	500	600
	0.39	0.59	0.80	0.99	1.19	1.58	1.97	2.38

5. If defects are found during the tests the Contractor shall immediately make the necessary repairs at his own expense. The Contractor shall then repeat the test until no defects are found and until the test is within the result limits stated above.

6. Irrespective of test results, visual inspection of the pipeline shall be carried out with the Engineer during the test and any defects made good.

7.5.3.2 Plastic Pipes

1. The pipe section shall be subject to an internal pressure corresponding to the nominal working pressure (normally 6 bar). This pressure shall be maintained for 2 hours by adding water as soon as the pressure has dropped 0.2 bar.

2. After the initial 2 hour period the pressure is increased to 1.3 x nominal working pressure and maintained for a further 2 hours by adding water as soon as the pressure has dropped 0.2 bar.

3. After 4 hours the pressure is reduced to the nominal working pressure and the test pump valve closed. After a further 1 hour the quantity of the water is measured that is needed to increase the pressure back up to the nominal working pressure.

7.5.3.3 Iron and Steel Pipes

1. The pipe section shall be subject to an internal pressure corresponding to the nominal working pressure (normally 6 bar). This pressure shall be maintained for 2 hours by adding water as soon as the pressure has dropped 0.2 bar.

2. After the initial 2 hour period the pressure is increased to 1.5 x nominal working pressure and maintained for a further 2 hours by adding water as soon as the pressure has dropped 0.2 bar.

3. The pressure is kept at 9 bar by adding water every 1/2 hour. The amount of water needed to restore the pressure is measure. The test shall be continued for 2 hours.

8 STRUCTURAL WORKS

8.1 GENERAL

8.1.1 Work Included

1. The Contractor shall furnish all labour, equipment, materials and services necessary for the manufacture, transportation and placement of all plain and reinforced concrete work of the Works.

2. Works under section Metal Works include the following:

(1) fabrication, installation and maintenance of all structural steel work and metal fabrications;

(2) fabrication and installation of those minor items which are necessary for the proper completion of the works; and

(3) installation of metal foundations and frames in concrete cast in situ for mechanical, electrical, instrumentation and automation and underground pipe works.

8.2 STRUCTURAL STEEL WORKS

8.2.1 General

1. The standard and materials and workmanship shall be not inferior to the recommendations of EN 10155 and BS 5950. The Use of Structural Steel in Building', or equivalent and all work shall be carried out in accordance with the recommendations given in these codes except where modified by this specification.

2. As and when required by the Engineer the Contractor shall prepare and submit, before commencing the work, a time-chart detailing the various operations for steelwork.

3. No material shall be used in the works until prior approval for its use has been given by the Engineer.

4. Test certificates shall be supplied as soon as possible to the Engineer before commencing work.

8.2.2 Materials

Structural steel shall conform to the requirements of current Moldovan standards. The bolts shall conform to the requirements of current Moldovan standards.

8.2.3 Fabrication and Manufacture

8.2.3.1 Shop Construction

1. Shop drawings including all details needed for construction shall be provided by the Contractor.

2. Steel structures shall be divided by erection joints in parts of practical length to facilitate transport and storage.

3. Components with Site welded joints shall be test erected in the workshop to ensure that structural parts will align properly on Site.

4. All shop fabrications and connections shall be welded. Any structural connection shall be either welded or bolted, no mixed connections will be allowed.

5. The Contractor shall satisfy the Engineer as to the ability of each of his welders to make welds on Site all as set out in the Mechanical Specification.

6. Before commencing welding work the Contractor shall submit his proposal for the method of welding and the welding procedure to the Engineer for his approval. The accepted method and procedure shall be adhered to throughout the entire welding work.

8.2.3.2 Surface Protection

This shall all be in accordance with the Mechanical Specification.

8.2.3.3 Inspection

All material and workmanship shall be subject to inspection in the workshop and after arrival on Site. Access at all times shall be provided for the Engineer to all parts of the fabricator's shop for inspection. However, such inspection shall not relieve the Contractor from the responsibility of complying with any requirements specified herein.

8.2.4 Installation

1. Prior to erection work the Contractor shall submit to the Engineer a description of the methods, employed, sequence of erection and type of equipment he proposes to use for erecting the steel structural work. This submission or approval shall not relieve the Contractor of his responsibility for providing the proper methods, equipment, workmanship, or safety precautions.

2. All temporary flooring, planking and scaffolding necessary in connection with the erection of the steel structure shall be provided as a part of the erection work.

3. All steel shall be properly aligned and braced and shall be kept in alignment as work progresses.

4. The use of a gas-cutting torch in the field for correcting fabrication errors will not be permitted on structural members except by specific approval of the Engineer.

5. Framing shall be set up true and plumb and temporary bracing shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment and its operation load. Such bracing shall be left in place as long as required for safety. It shall be finally removed by the Contractor as a part of his equipment.

8.3 MISCELLANEOUS METAL WORK

8.3.1 General

1. Design, furnish, fabricate, assemble and install all miscellaneous metal work not specifically included under other sections. The Contractor shall furnish all material, labour and equipment required for the completion of the work, as shown on the Detailed Design Drawings, specified herein, and as directed by the Engineer.

2. The final location of any pipes embedded in walls or other structural members, maintenance access doors and covers or any other fixed metalwork, plant or equipment shall be assigned in co-ordination with the Mechanical and Electrical Works.

3. Miscellaneous metal work shall include, but not be limited to, the following:

- Ventilation pipes
- Pipes and sleeves embedded in walls or other structural members
- Stainless steel steps
- Maintenance access doors, frames and covers

8.3.2 Materials

1. Bolts, nuts and inserts shall be of galvanised carbon steel, except for underground bolted joints where stainless steel bolts, nut and washers are required. Bolts shall have hexagonal nuts. All nuts and bolts shall be of locally available metric sizes.

2. Structural steel profiles shall be locally available standard sizes and shapes.

8.3.3 Pipes and Sleeves Embedded in Walls or Other Structural Members

The Contractor shall install all embedded wall pipes shown on the Detailed Design Drawings. The material for the embedded pipes shall be as shown on the Detailed Design Drawings. All sleeves and wall transmission pipes to be installed within structural members shall be installed prior to the pouring of any concrete. Openings or cavities in concrete walls for later installation of the pipes and sleeves will not be allowed.

8.3.4 Maintenance Access Doors, Frames and Covers

1. Maintenance access doors, frames and covers shall be designed for a uniform live load of 500 kg/m^2. They shall be furnished complete with frames, anchors, lifting handles and flush head screw fastenings.

2. Supporting seats and tie straps shall be at least 6 mm thick.

8.4 MASONRY AND BRICKWORK

8.4.1 General

1. This specification covers the technical requirements for the furnishing of all labour, supervision, materials, tools, equipment and services necessary for or incidental to the construction and completion of all masonry work in accordance with the Drawings and as specified herein.

2. The work shall include furnishing and installing all masonry units, lintels, precast sills, copings, canopies and beams, and the building-in of all the miscellaneous metal items as applicable.

3. The work shall include the furnishing and installation of all anchor bolts, anchors and ties indicated to be embedded in the masonry work unless specifically excluded by the Drawings.

4. The work shall include the installation of all sheet metal items such as metal flashing and counter flashing, control joint covers, etc., as applicable, when indicated to be built into the masonry construction, unless otherwise directed by the Drawings.

8.4.2 Materials

8.4.2.1 Bricks

Locally available silica bricks shall be used for the works.

8.4.2.2 Mortar

Mortar shall consist of 1 part cement, 1 part lime and 6 parts sand accurately measured by volume and thoroughly mixed until evenly distributed throughout the batch by mechanical mixer. The actual mixing time shall not be less than two minutes. Mortar shall be used within 2 hours of the addition of water.

8.4.2.3 Concrete Masonry Lintels

1. Masonry lintels shall be of proprietary reinforced precast concrete lintels as manufactured by an established company with a good reputation in the field.

2. Where an indicated lintel is to be exposed, the surface of the lintel shall match concrete in texture and finish as closely as possible. Lintels shall have not less than 200 mm bearing at each end.

8.4.3 Masonry Work

1. Under brick foundations one layer of lean concrete, min. thickness 100 mm, shall be placed.

2. Footings for masonry with a minimum height of 100 mm shall be placed in all walls at finish floor level with anchoring of vertical reinforcing bars.

3. All masonry shall be laid into full, flat beds of mortar and have full buttered ends. All joints shall be solidly filled with mortar. Courses shall be level, walls shall be straight, plumb and grouted tight around framing members.

4. Masonry shall be protected at all times during laying. When work is not in progress, walls shall be kept covered with timber or tarpaulins.

5. Rapid drying of masonry work will not be permitted and the work shall be kept moist, by whatever means necessary, until the mortar has set thoroughly.

6. Built -in work shall be installed as work progresses. Other trades shall be consulted in advance and provision made for the installation of their work to avoid cutting and patching Any cutting or patching of masonry required to accommodate work of others, shall be done by bricklayers using matching materials.

8.4.4 Samples

Three samples of each type of material proposed for use shall be provided for approval by the Engineer. Material used shall be identical to approved samples.

8.5 HANDRAILS, STAIRS AND PLATFORMS

8.5.1 Handrails

8.5.1.1 Handrail

1. Handrails and posts shall be constructed of a minimum of 40 mm nominal tubular anodised aluminium. All joints in situ in pipe railing shall be bolted or riveted. Bends shall be neatly made to the correct radius required without deforming the pipe locally. Expansion joints shall be provided in railings where required. The centreline of the top rail shall be located 1m above the grading or mounting slab elevation and shall be designed to resist a horizontal force of 800 N/m. An intermediate rail shall be located 0.5m above the slab. Post spacing shall not exceed 1.5 m.

2. Shop drawings showing fabrication and installation details with all dimensions and methods of fixing shall be submitted to the Engineer for review.

8.5.1.2 Wall Brackets

Wall rails shall be fastened to walls with wall brackets. All terminations of wall rails shall be turned 90^{O} toward the wall and be held 10 mm from the wall.

8.5.2 Metal Stairs and Platforms

8.5.2.1 General

Main steel columns and beams, see Section ‘Structural Steel Works’.

1. All metal stairs and platforms shall be hot dip galvanised steel construction type open steel flooring with treads and gratings as shown on specified herein and in accordance with EN ISO 14122, or equivalent.

2. The open steel flooring consists of parallel load bearing bars and transverse square bars pressure welded to upper edge of the load bearing bars. The centre-to-centre distance for the load bars shall not exceed 33 mm and the transverse bars 75 mm. The flooring shall consist of panels of nominal width 800 to 1,000 mm. The entire assembly shall be constructed to support a minimum live load of 250 kg/m^2.

3. Welding shall not be used for joining pieces together unless otherwise shown or specified. Only bolting is accepted. Units shall be fabricated so that bolts and other fastenings do not appear on finished surfaces. All joints shall be true and tight, and connections between parts tight. Continuous welds shall be provided and ground smooth where exposed.

4. Stair units shall be constructed to conform to sizes and arrangements on the Detailed Design Drawings.

5. All nuts, bolts and washers for fastening shall be galvanised steel.

6. Stair treads shall have a 30 mm wide abrasive nosing.

8.5.2.2 Fabrication

1. Structural calculations and detail design drawings including all dimensions and details needed for construction shall be provided by the Contractor and submitted to the Engineer for approval.

2. All steel shall be hot dip galvanised to EN 729, or equivalent after fabrication. The parts shall be cleaned, thoroughly pickled and galvanised before any rusting begins.

8.5.2.3 Installation

Detail drawings needed for installation shall be provided by the Contractor and submitted to the Engineer for approval.

9 ARCHITECTURAL WORKS

9.1 ARCHITECTURAL WORKS

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9.1.1 Submittals and Approval of Materials

1. The Contractor shall submit to the Engineer for approval the following prior to ordering and or manufacturing materials and items:

- Samples as requested by the Engineer including necessary description of materials
- All installation and furnishing drawings prepared by the Contractor showing construction details, materials, door furniture and the like;
- Material test certificates signed by the manufacturer; and
- Material, goods and workmanship shall be of best quality of their respective kind and those for which there is a Standard referred shall comply therewith.

9.1.2 Doors and Windows

9.1.2.1 General

1. Doors and windows shall be factory assembled and standard type. The size of doors and windows shall be as shown on the Detailed Design Drawings and the materials and types as specified herein.

2. Doors shall be within the tolerances set out in Table 9-1 below.

3. Door and window fittings shall be as shown on the manufacturer's drawings and approved by the Engineer. The locking systems shall be according to the Employer's requirements.

4. Fastening of frames shall be made according to manufacturer's instructions.

5. Doors and windows shall meet the fire resistance requirements as directed by the local Authorities. External doors shall be designed to resist a wind load of 75 kg/m^2.

6. Joints between door and window frames and the buildings shall be continuously jointed with gun applied approved non-setting mastic.

Table 9-1: Door tolerances

Feature		Tolerance (mm)
Main	Secondary	
Dimensions	---	± 2
Cup or bow	in width	2
"	in length	4
"	at diagonals	5
Twist corner points	from vertical plane	4
	for a distance of 500 mm	1

9.1.2.2 Aluminium Windows

Aluminium doors and windows shall be made of anodised extruded aluminium sections with double glazing. Windows together with surrounds and fixings shall comply with BS 4873, or equivalent.

9.1.2.3 Steel Doors

The construction of the doors shall be of a frame of steel hollow sections and seamless steel sheet on both sides. The frame shall be of steel sheet profiles embedded in the wall or fixed by anchor bolts.

9.1.2.4 Glazing

1. All glass delivered to the site shall be of the same quality. Minimum thickness of glass is 4 mm and glass shall comply with BS 952, or equivalent.

2. Glazing to metal doors and windows shall be performed with beads or mastic as recommended by the manufacturer.

3. Glazing shall comply with the requirements of BS 6262, or equivalent.

9.1.3 Locking system

All doors shall be provided with locks, for the lock make to be provided service shall be available locally. Padlocks shall be provided for all manholes and valve chambers. The locks shall be provided with a master key system to be approved by the Engineer.

9.1.4 Finishes

9.1.4.1 General

1. Wall surfaces shall have painted finish as described in section Painting 9.1.6.

2. All finishes shall be executed by specialist tradesmen experienced in carrying out the relevant work.

3. Contractor shall submit two samples of each type and colour of finishes to the Engineer for approval as regards colour, pattern and finish.

4. All surfaces to receive finishes must be firm and stable, free from grease and completely inert so that materials can be properly applied in accordance with the product manufacturer's instructions.

5. Working conditions such as temperature and humidity must be observed according to product manufacturer’s requirements.

9.1.4.2 Plaster

1. Material used for plaster shall consist of cement, sand and clean, fresh water.

2. Plaster for keying coat shall be prepared by mixing one part cement and two parts sand and the consistency shall be adjusted according to the background. The keying coat shall form a uniform coat not less than 3 mm and not exceeding 6 mm in thickness. The keying coat shall be cured for at least 3 days by wetting it continuously before applying the following plastering coat.
3. Mix for the undercoat shall be prepared as set out in **Table 9-2**.

Table 9-2: Plaster undercoat mixes

		Mix proportions (parts)		
		Cement	Lime	Sand
Internal plaster	Walls to be smooth	1	2	9
Plastered wall to receive	Ceramic tiles	1	0	3 to 4
	External plaster	1	1	6

4. Before application the walls shall be suitably wetted.

5. The nominal thickness of the undercoat shall be 10 mm and shall nowhere be less than 8 mm and not more than 12 mm. If it is necessary to apply a thicker undercoat than 12 mm due to irregularities several undercoats shall be applied to bring the wall surface to a even level.

6. Completed plasterwork shall be cured at least for 24 hours after the completion and shall be covered to protect it against sun and wind as necessary.

7. A drying period of at least seven days shall be allowed before the application of next coat.

8. Mix for the finishing coat shall be prepared as set out in Table 9-3.

Table 9-3: Plaster finishing coat mixes

	Mix proportions (parts)		
	Cement	Lime	Sand
Internal plaster	1	2	9
External plaster	1	1	6

9. Finishing coat is not applied if the wall is to receive tiles, but shall be applied on all walls which are to be covered by fixed or loose furniture or equipment.

10. Before the application of the finishing coat the wall shall be suitably wetted down.

11. The nominal thickness of the finishing coat shall be 8 mm and shall nowhere be less than 6 mm not more than 10 mm.

12. After application the surface shall be ruled to a true finish and shall receive a wood float finish. Plasterwork shall be cured for at least 24 hours after the completion and shall be covered to protect it against sun and wind as necessary.

13. The finished flat surfaces shall not vary more than +/- 6 mm at a distance of 2500 mm. This shall be also applicable to walls which shall receive tiling.

9.1.4.3 Ceramic Tiling,

1) Wall tiling

1. The tiles shall be fixed to cement and sand mortar to a true and vertical face with continuous straight joints vertically and horizontally. All joints shall be grouted with white cement and the finished work shall be free from cracked, crazed, broken or imperfect tiles.

2. Fixing tiles with adhesive shall be in accordance with recommendations of adhesive manufacturer.

3. The finished surface shall have tolerances from a plane not more than ± 5 mm in any direction per 3 m.

2) Floor Tiling

1. Water absorption of tiles shall not exceed 4 %.

2. Tiles shall be fastened with 20 - 40 mm thick cement plaster or with prefabricated adhesive material according to manufacturer's instructions.

3. For wet conditions non-slip finished ceramic floor tiles shall be used. In the laboratories acid resistant ceramic tiles shall be used.

4. All rooms, except rooms with ceramic tile walls shall have 100 mm high skirting with skirting tiles.

5. Tiles shall be pressed down firmly, bedded with straight lines square to wall joints not less than 6 mm wide and grouted with mortar matching the colour of the tiles.

6. Surface tolerances of finished floor tiles shall not be more than ± 2 mm per 2 m.

9.1.5 Sheet Metal Works

1. Window sills, walls roof parapets and exhaust fan foundations will have steel sheet flashing. Roof parapet flashing shall be extended from parapet top to 20 mm above the tile layer. The flashing material shall be of PVF2-coated galvanised steel sheet, minimum thickness 0.6 mm.

2. Flashing details shall be subjected to the Engineer's approval.

9.1.6 Painting

9.1.6.1 General

1. This painting specification, instructions of the paint manufacturer on the painting and drying conditions, work performance and orders concerning safety at work shall be followed.

2. Sample area of not less than 2 m^2 of each finish type of painted surface shall be accepted by the Engineer before work can commence.

9.1.6.2 Paint Materials

1. Paint materials approved by the Engineer shall be used. The factory-made paints shall be delivered to site in original cans, shut by the factory.

1. Instructions given by the paint manufacturer for storing and for the safety in work shall be followed.

9.1.6.3 Paint Work

1) Surface treatment.

1. The surface to be treated shall be undamaged homogenous and evenly dry so that the paint adheres properly and fulfil the demands of the paint manufacturer.

2) Cleaning and Pre-treatment

1. Grease and oils on the surfaces to be painted shall be removed according to paint manufacturers instructions.

2. Loose dust, sand and other substances shall be removed from stone material and concrete surfaces carefully by brushing and or compressed air to achieve dust-free result.

3. The holes, crack, rough places etc. shall be repaired with a sand filler according to the Engineers approval.

3) Painting

1. The painting shall be carried out according to the paint combination, code and a treatment schedule with paint products, approved by Engineers.

4) Painting and Drying Conditions

1. During the painting work the temperature of the air, the surface to be painted and the paint shall be at least + 12 ^{0}C but not exceeding + 35 ^{0}C.

2. The minimum drying time between paint applications given by the paint manufacturer must be followed.

9.1.6.4 Painting of Plastered Surfaces, Stone Material and Concrete

For internal and external painting a fungus and alkali resistant emulsion latex paint shall be used.

9.1.6.5 Painting of Board and Wooden Surfaces

The surface shall be painted with a alkyd paint.

9.1.6.6 Paint Film Thickness

1. For all external painting work the minimum ration of paint application is three. For internal painting two applications are required.

2. Manufacturer's instructions can be followed upon the approval of the Engineer.

9.1.6.7 Colours

The colours to be used shall be approved by the Employer.

9.1.6.8 Repair Painting

Repair paintings shall be done using paints, which are delivered to the site in correct colour shades. All repair work shall be subjected for approval of the Engineer.

9.1.6.9 Temporary Storing, Packing, Transfer and Transport

Painted objects must not be moved before paint is sufficiently dry.

10 MISCELLANEOUS WORKS

10.1 GABIONS AND MATTRESSES

10.1.1 General

The position and dimensions of gabions and mattresses shall be as shown on the Detailed Design Drawings.

The gabions shall be of the case type, manufactured in the workshop or outside the place of erection. They shall have a rectangular prismatic shape with faces made of heavily zinc coated mild steel net framing, and shall be filled with cobbles or fragments of rock on the site where they are to be used.

10.1.2 Wire

1. Dimensions: the opening of the mesh "D", i.e. the distance between the axes of the twists, and wire dimensions shall be as follows:

	GABIONS		MATTRESSES	
Type	6x 8	8 x 10	5 x 7	6 x 8
Mesh opening "D" (mm)	60	80	50	60
Wire (mm)	2.7	2.7	2.0	2.2

2. Tensile strength: the wire used for the manufacture of both gabions and mattresses and lacing, shall have a tensile strength of 38-50 kg/mm2.

3. Elongation: determined by testing (before manufacture of the mesh) a sample at least 300 mm long, shall not be less than 12 %.

4. Zinc coating and dimensional tolerance of the wire shall be as follows:

	GABIONS		MATTRESSES	
Wire diameter (mm)	2.7	n.a.	2.0	2.2
Wire tolerance (± mm)	0.08	n.a.	0.06	0.06
Quantity of zinc (g/m^2)	260	n.a.	240	240

5. The adhesion of the zinc coating to the wire shall be such that, when the wire is wrapped six turns around a mandrel having four times the diameter of the wire, it does not flake or crack when rubbing it with bare fingers.

10.1.3 Rockfill

1. Material for filling shall be composed of cobbles or rock fragments, dense, sound and resistant to abrasion, non-porous; it shall be free of cracks, seams, shale partings, conglomerate bands and other defects that would tend to increase unduly its susceptibility to destruction by erosive action.

2. The shape of the individual rock pieces shall be positively rounded; fragments having too flat a shape shall not be used as rockfill for gabions.

3. The individual cobble or rock fragment shall be reasonably well graded with minimum size not less than dimension D of mesh and maximum size approximately 2.5 times D.

4. Bigger cobbles shall be acceptable, provided that their total volume does not exceed 5 % of the total cell volume.

10.1.4 Installation

1. The gabions and mattresses shall be generally placed on horizontal surfaces, with their bottom and sides slightly embedded into the ground. Excavation and trimming to regularize the foundation of gabions and mattresses shall be carried out where necessary, in conformity with the instructions issued by the Engineer.

2. The surface slope of buttress fill (protected by mattresses) shall be carefully flattened.

3. Depressions and protrusions of the finished surface shall not exceed 100 mm from the lines shown on the Detailed Design Drawings.

4. Gabions and mattresses, already sewn in their box shape and placed according to the outlines shown on the Detailed Design Drawings, shall be linked by means of lacing wire, after which filling operations shall take place.

5. The gabions and mattresses which are gradually added shall be strongly sewn to those already in place. The various layers of gabions shall also be connected to each other. The connection shall be carried out between full gabions as well as between full and empty gabions. The filling material shall be introduced into each gabion by hand, placed so as to fill it completely and without compaction.

6. Once the filling operations are completed, the gabions shall be closed by dropping the lids and sewing all around their edges.

10.2 PERVIOUS FELT

1. The filter fabric shall be of a non-woven melded fabric consisting of a mixture of polypropylene and polythene or other similar materials. The grade of fabric shall weigh not less than as shown on the Detailed Design Drawings expressed in gr/mq and have a thickness of 0.5 mm. The fabric shall be resistant to ultra violet rays and sunlight.

2. Where overlapping of fabric is required, the overlap shall not be less then 500 mm and shall be sewn with a lock type stitch in such a manner that it produces a joint as durable as the fabric.
3. Storage and handling of the fabric shall be in accordance with the manufacturers's recommendations, except that in no case shall the geotextile be exposed to direct sunligth, ultra violet rays, temperatures greater than 60°C (140°), mud, dirt, dust and debris, to the extent that its strength, toughness or permeability characteristics are diminished.

4. The rolls have to be placed in parallel and overlapped at least 10 cm.

11 GENERAL MECHANICAL SPECIFICATION

This Specification is intended to indicate the minimum standard of design, workmanship and materials acceptable in this project. The itemised specific requirements are given in the Particular Mechanical Specifications.

11.1 GENERAL REQUIREMENTS AND WORKMANSHIP

1. All supplied parts shall be designed and constructed for the maximum stresses occurring during fabrication, erection and continuous operation. All materials shall be new and both workmanship and materials suitable for the service the units are to be subjected and shall conform to all sections of the Specifications.

2. The general mechanical and electrical design of the Works and particularly that of the bearings, contacts, and other such wearing parts shall be governed by the need for a long period of service without frequent maintenance and attention.

3. Unless otherwise specified, all items of the Works shall be rated for continuous service at the specified duties under the prevailing atmospheric and operational conditions of the Site.

4. All parts subject to wear shall be readily accessible. Provision shall be made for taking up wear in all bearings and other wearing parts or for easy replacement if adjustment is not practicable.

5. Wherever practical the Contractor shall ensure the maximum interchangeability of similar items from alternative suppliers.

6. Suitable packers, shims, adjustment and the like shall be fitted for ease of adjustment and realignment of all machinery units with particular attention given to combined sets.

7. All pipes shall be checked for alignment and mating of connections before being secured and pipes shall be in straight line and grade.

8. Pumps shall be designed to meet the operational duties under the Site conditions as specified. Pumps shall be designed to keep constant performance. Waterways through the pump and impeller shall be smooth and free from recess and projections.

11.2 PUMPS

11.2.1 General

1. This specification refers to pumping equipment and fittings.

2. Pumping equipment shall be constructed as shown on the Detailed Design Drawings with all the necessary equipment for installation and operation.

3. Each pump shall be capable of operating on its own or in parallel with one or all of the pumps in a particular group. Performance curves shall be continuously rising from maximum discharge to shut off head and free of any unstable points. Pumps shall be selected so that their capacity at the design points is less than or equal to the capacity at the best efficiency point.

11.2.2 End Suction Centrifugal Pumps

1. Centrifugal pumps shall be horizontal or vertical design and stable performance characteristics. Horizontal pumps shall be mounted together with the motors on common bedplates. Vertical pumps shall be mounted on a bed plate.

2. Each pump and motor shall be provided with a suitable coupling secured by parallel keys and coupling guard fitted with easily accessible screws.

3. Casings and impellers shall be of cast iron, gunmetal or stainless steel. Casings for horizontal pumps shall be provided with manually operated gunmetal air release cocks. Suction sealing and keying to the stainless steel shafts shall be as specified for the split casing pumps. Glands shall be made of leaded gunmetal and soft packed with internal lantern rings.

4. Bearings for horizontal pumps shall be grease lubricated ball and/ or roller bearings.

5. Each pump discharge branch shall be equipped with one 100 mm diameter pressure gauge with isolating cock.

6. Nylon or copper gland bowl drainage pipework shall be provided for each pump. It shall not be less than 13 mm nominal bore and shall be led into the drainage channel or pipe. Water seal pipework, if necessary, shall be made up from copper with gunmetal valves and shall connect the possible pressure volute with the locking ring cavity.

7. The pumps shall operate at a maximum rotational speed of 1500 rpm.

11.2.3 Testing of Pumping Equipment

1. The pumps shall be tested in the factory as follows: The pump casings and/ or column and head assemblies shall be subject to a hydrostatic test pressure of twice the maximum operating head or 1.5 times the shut off head, whichever is the greater. Certified pump test performance curves shall be submitted.

2. The Contractor shall conduct non-witnessed performance tests on each pump.

11.2.4 Installation of Pumping Units

1. Installation of pumping units shall be in strict accordance with the manufacturer's instructions. Any damage resulting from either failure to observe the installation instructions or as result of proceeding with the work without complete knowledge of how it is to be done, shall be the Contractors responsibility.

2. Equipment installation and required connections shall be made by skilled tradesmen to the best standard. The work shall be accurately carried out to produce a neat, accurate, secure, functional installation. Under no circumstances will there be allowed any stress to be imposed on any pump flanges or equipment. Under no circumstances will "springing" of piping to correct misalignment be allowed.

3. The anchor bolts and concrete bases for the pumping units cast iron or steel bases shall be prepared in advance. The pump and motor bases shall be set in place and shimmed to correct elevation. The bases shall be grouted in place with non-shrink grouting.

4. Upon completion of installation of the pump equipment, the Contractor shall fill, add to, and check equipment requiring oils, coolants, greases etc.. The types and amount used shall be in strict accordance with the manufacturer's instructions.

11.3 PIPE WORK

11.3.1 Piping

11.3.1.1 General

1. This specification gives general guidelines to be applied in piping and support design, manufacturing and installation.

2. Each part of the piping system shall be complete in all details and provided with all valves and accessories necessary for satisfactory operation.

3. All piping shall be grouped wherever practical and shall be erected to present a neat appearance. Pipes shall be parallel to each other and parallel or at right angles to structural members and shall give maximum possible headroom.

4. Pipes erected in pumping stations and valve chambers shall be arranged to provide maximum access.

5. Sufficient space is to be allowed for accessibility for servicing. No mechanical joints shall be embedded.

6. Adequate allowance shall be made for expansion and contraction in pipes by the inclusion of flexible, proprietary joints in the piping system.

7. All reductions in sizes shall be by the use of proprietary fittings or fabricated sections.

8. Pipe connections to equipment and valves shall be arranged for easy dismantling and removal.

9. All pipework shall be free of corrosion and without any signs of scaling, pitting or excessive weathering to the satisfaction of the Engineer. Pipes stored on Site shall be kept clean and off the ground and stored under cover. Pipes corroded or distorted beyond standard tolerances shall not be used.

10. The Contractor shall ensure that all pipes are free from internal obstructions. All burred and cut ends of pipes shall be well reamed and filed to ensure that the full bore of the pipe is maintained. The Contractor shall take special care to prevent dirt or rubbish entering the open ends of all pipework during storage and erection. Screwed iron caps or plugs or plastic caps shall be used for this purpose. Wood, rag, paper or other inadequate material shall not be considered as adequate protection. Should any stoppage in the circulation occur after the various systems have been put into operation which proves to be due to non - compliance with these requirements the Contractor shall rectify the matter at his own expense.

11. The Contractor shall ensure that at no part of any installation dissimilar metals are include, which will promote chemical or electro-chemical action, causing a weakening or failure of the service. This applies not only to the internal surfaces but also the external surfaces of all pipes, fittings, valves, plant, vessels, pumps and any other item of equipment in the installation.

12. Any pipework which does not conform as to material and workmanship with this specification shall be removed and replaced at the expense of the Contractor.

13. Adequate supporting and anchoring arrangements for all pipes shall be designed and installed by the Contractor.

14. All pipes connected to pressure vessels, pumps, compressors and the like shall have flanged connections.

15. The Contractor shall ensure that the design and layout of his pipework shall be such that no torque or other loads from the starting of the equipment shall be transmitted into the pipework and shall provide additional joints or supports as may be necessary.

16. The joints and connections in pipes shall be made either with flanges or by welding. Flexible couplings shall be used only in flexible joints and dismantling joints. The pipes shall be supported on both sides of a flexible joint.

17. Drilling of flanges shall comply with EN 1092, or equivalent. The gaskets shall be of reinforced nitrile rubber, thickness 3 mm.

18. Threaded joints shall be avoided and the use shall be limited to sizes smaller than DN 65. For dismantling conical connectors shall be used.

19. All nuts, bolts, washers, flanges, gaskets, flanges tied adapters, drain valves, special connection pieces, supporting hangers, brackets or clips and temporary supports for the pipework, together with all terminal point connection materials shall be supplied and installed under this contract.

11.3.1.2 Nominal Dimensions

DIN standards ISO recommendation (DIN 2458 and DIN 17100, or equivalent)shall apply.

Table 11-1: Nominal Size (DN) and Outsize Diameter (Do) of Carbon Steel DIN and ISO, Fe 37B and stainless steel

DN	6	10	15	20	25	32	40	50	(65)
Do	10.2	17.2	21.3	26.9	33.7	42.4	48.3	60.3	(76.1)
DN	80	100	(125)	150	200	250	300	350	
Do	88.9	114.3	(139.7)	168.3	219.1	273.0	323.0	355.6	
DN	400	(450)	500	600	700	800	1000	1200	1600
Do	406.4	(457)	508	610	711	813	1016	1220	1620

Pipe sizes shown in brackets should be avoided if possible.

11.3.1.3 Stainless Steel Pipework

1. The material of the pipe and pipe specials shall be EN 1711 or equivalent.

2. The stainless steel pipes shall be fabricated by longitudinally welding according to EN 2234 or equivalent.

3. The Tee- pieces shall be factory made. The flange joints shall be with weldable collars of stainless steel and loose flanges of hot dip galvanised carbon steel. The gaskets shall be of

4. The minimum wall thicknesses of the stainless steel pipe barrel and the pipe fittings shall be as shown in the Table 11-2 below.

Table 11-2: Wall Thickness for Stainless Steel Pipe

Nominal size	Wall Thickness of Pipe Barrel mm *
Upto and including DN 80	1.6
DN 100upto and including DN 250	2.0
DN 300 and 350	2.6
DN 400	3.2
DN 500 and 600	4.0
DN 700	5.0
DN 800	6.3

5. The wall thicknesses of non-standard Tee-pieces and cross pieces shall be calculated by the Contractor and submitted to the Engineer for approval. Full internal vacuum shall be taken into account in the dimensioning calculations of the fittings.

6. A 2 mm thick weld-on puddle flange shall be provided in all embedded wall transition pieces. The diameter of the puddle flange shall be not less than 150 mm + the pipe outside diameter. All puddle flanged pipe specials shall be prefabricated by the Supplier. The stainless steel wall transition pipes shall not be connected to the reinforcement.

11.3.1.4 Supports and Fixings

1. Recommended max. free spacing between supports for stainless steel pipes shall be as Table 11-3.

Table 11-3: **Maximum span between supports for stainless steel pipes**

DN	10	15	20	25	32	40	50	65	80
Span (m)	2.0	2.2	2.4	2.7	2.9	3.1	4.0	4.3	4.7
DN	100	125	150	200	250	300	350	400	500
Span (m)	5.2	5.5	5.9	6.4	6.8	7.5	7.8	8.1	9.0
DN	600	700	800						
Span (m)	9.5	10.3	10.7						

2. The table is valid only for straight pipe runs. Pipe headers furnished with valves or other heavy components must be adequately supported at each heavy component such that no excessive stresses or deflections are developed to the piping or connected equipment.

3. Unless otherwise specified all supports, anchor bolts, screws, straps, clips, brackets, steelwork, etc. and other fixings shall be provided by the Contractor. Where applicable the manufacturer's instructions shall be followed. They shall be of ample section to withstand the forces created by operation of the equipment.

4. All piping shall be supported away from the building structure.

5. Hanger inserts to be set in place before concrete is poured.

6. Anchor bolts less than M 12 size shall not be used for fastening of mechanical equipment (pumps, compressors, gears, pipes etc.).

7. All submerged supports, anchor bolts and fasteners shall be of stainless steel. Washers and nuts of the same material shall be used in bolted joints. Other supports, anchor bolts and fasteners shall be of hot dip galvanised steel. Washers shall be provided under all nut and bolt heads, material shall be same as for the bolts. The overdrive of the bolt in an assembled joint shall not be less than one mm over the nut nor more than one height of the nut.

8. The anchor and foundation bolts shall be completed with hexagonal nuts and washers.

11.3.1.5 Welding

1. The welding of the pipes and other appliances shall be performed according IIW (International Institute of Welding) recommendations and regulations.

2. The seams shall be visually inspected on the Site for the smoothness, height of the seam, ridge and root faults and cracks and the uniformity of the seam with the basic material shall be detected.

3. The Engineer may, in order to guarantee the quality and safety of the work require the Contractor to take random x-ray exposures of the seams (about 10 % of all seams), at the expense of the Contractor. The quality codes utilised shall be according to IIW classification. The exposures shall be taken from the seams chosen during the visual inspection. The inspection concerns both factory made and Site welded seams. The manufacturer of the pipes is not required to submit x-ray certificate of his products. During the site inspection the following procedures will apply:

1) If faulty seams are found, the Contractor shall be obliged to cut out the joint and reweld the seams properly on his own expense.

2) X-ray exposures of the rewelded seams shall be taken at the expense of the Contractor. Additionally each faulty seam found will lead to the taking of one penalty exposure of the same welders work as the faulty one. The cost of this shall also be at the Contractor's own expense.

4. All the welders on Site shall be experienced and adequately trained on the working methods (e.g. for carbon or stainless steel, for pipe or sheet welding on the valid material and for arc, MIG or TIG welding separately) and their qualifications shall be submitted to the Engineer for review.

5. The Contractor shall submit to the Engineer for approval in advance the welding methods he intends to use.

6. Welding rods shall be stored and used dry. If necessary they shall be dried with heat of 150 to. 250 ^{o}C if found to be moist or wet and unsuitable for use. Rods shall be suitable for the base material. The thickness of the seam shall not exceed the thickness of the base. The slag and scale shall be removed with the tools suitable for the material (e.g. stainless steel tools are required for stainless steel welding). The mechanical cleaning of the seams shall be done with steel brush after chipping off the slag.

7. The welding arc shall be lit so that no cracks are left visible outside the weld. When scratches occur they shall be ground of to the clean material and afterwards covered by welding if the grinding has gone too deep.

8. With stainless steel welding the following shall apply:
   - Handling of the stainless steel material with mild steel tools.
   - Grinding shall be performed with discs and abrasive cloths impregnated with artificial resin or rubber. Traces of the grinding shall be pickled.
   - After the mechanical cleaning the seams in the stainless steel structures shall be pickled with suitable pastes.

11.3.2 Valves

11.3.2.1 General

1. All valves shall be designed to the minimum working pressure of PN 10. Flanges for valves shall comply with EN 1092-2:1997 for cast iron flanges, or equivalent.

2. Unless otherwise specified, all valves shall be anti - clockwise opening and operated by hand wheel for up to 300 mm, above 300 mm geared actuators shall be used. The maximum effort required to be applied at the circumference of the hand wheel to operate the valves against the maximum unbalanced head shall not exceed 200 Nm.

3. Unless detailed otherwise all hand wheels shall have the words “open” and “close” in English with arrows indicating the direction of rotation cast on. All hand wheels shall be of a solid cast type.

4. Valves of all types shall be capable of withstanding corrosion in the ambient conditions and any parts manufactured from a material which is not itself corrosion-resistant must be protected.

5. Works tests will not normally be witnessed except where so specified or required by the Engineer. A certificate from manufacturer's for shop testing shall be provided for the approval of the Engineer.

11.3.2.2 Gate valves

Gate Valves shall be resilient seated with smooth straight through bore. Body and bonnet shall be of cast iron with non-rising stem of stainless steel spindle. The wedge shall be of ductile iron, inside and outside fully rubberised with vulcanised elastomer, the wedge guide of wear resistant plastic with high gliding features both suitable for potable water.

11.3.2.3 Butterfly Valves

1. The butterfly valves shall be manufactured according to the ISO 5752, or equivalent. The seepage free shut-off pressure difference of the valve shall be 10 bar against atmospheric pressure.

2. The body shall be made of cast iron and rubber lined. The disc shall be of cast iron and the shaft of stainless steel. Removal and replacement of seals without removing the valve shaft shall be possible.

11.3.2.4 Actuators

1. Actuators shall be suitable for the medium, temperature and pressure of the system into which they are being fitted.

2. Settings and emergency operation shall be possible with the use of handwheel. By operating the hand/auto lever the motor drive is connected and the manual drive shall automatically be disconnected. During electric operation the hand wheel shall not rotate.
3. Actuators shall be adjusted at the manufacturer's works to ensure that they provide the correct fully open position and fully closed position. Mechanical adjustable stops shall be provided to prevent overtravel of the valve in the open and closed positions. The operating torque at the hand wheel level shall be less than 150 Nm.

4. Electrically operated valves shall incorporate an actuator providing sufficient force to fully open and fully close the valve against the maximum system differential pressure.

5. The gearing of the actuators shall be either of the positive lock worm gearing type, or of the travelling nut type. The electrical actuator must be equipped with electromechanical brake.

6. The enclosure of the actuator shall be minimum IP 55 including the cable glands.

7. The actuator shall be provided with:
   - a motor according to requirements stated in the Electrical Specification
   - an integral reversing contactor starter
   - terminals for connecting all external wiring
   - built-in motor protection with anti-condensation heater
   - selector switch for local-off-remote control
   - an integral switch or pushbuttons for open-stop-close
   - a potential free contact indication open-close position
   - adjustable limit switches for electric control
   - an option for stepless control with 4 to 20 mA signal.

11.3.2.5 Pressure Gauges

1. Gauges shall be provided having mounting arrangements, scale ranges, designation and alarm contacts as required. Gauges shall be of the Borden tube type with isolating diaphragm, brass case with flanged neck and stainless steel bezels. They shall have removable backplate to facilitate inspection and adjustment. Diameter of dial shall not be less than 100 mm. The dial shall be calibrated in kPa. Pressure range shall not exceed system working pressure more than 1.5 times.

2. Each gauge shall be fitted with a stainless steel isolating cock.

3. Pump delivery pressure gauges shall be mounted direct on to the pressure tapping in the delivery mains and be corrected to show actual pressure at the delivery flange of the pump.

11.3.2.6 Flexible Couplings

1. Axially restraining flexible couplings shall be provided at least where shown on the Detailed Design Drawings. Each joint shall be complete with all associated fittings and shall be installed in accordance with the manufacturers instructions.

2. Max. allowable pipe movement in couplings shall be about 10 mm and shall be achieved by deformation of the sealing ring, not by sliding action of the ring on the pipe.

11.3.3 Testing

11.3.3.1 General

1. During and after installation the Contractor shall take all reasonable measures, including the provision of plugs where appropriate, to prevent ingress of debris into pipework systems. Before testing of a pipework system commences the Contractor shall ensure that it is clean and contains no obstructions.

2. All pipework systems shall be tested by the Contractor for watertightness and stability.

3. The Contractor shall provide all necessary plant and equipment, including pressure gauges, struts and thrust blocks, as may be necessary for effectively testing the pipelines to the specified pressures, and shall be responsible for the supply and disposal of all water as set out in the Contract.

4. Should any inspection be unsatisfactory or any test fail, the Contractor shall at his own expense re-execute defective work following which cleaning and testing will be repeated.

5. Before applying the test pressure, all air shall be expelled from the pipe. After all the air has been expelled, all cocks shall be closed and the test pressure applied as specified above. The line shall be filled slowly to prevent possible water hammer.

6. The specific method of testing, i.e. from pump pedestal, discharge pipe or valve chamber overpumping connection, shall be agreed with the Engineer prior to the commencement of the test.

7. See also section 7.5

11.4 HOISTING EQUIPMENT

1. The hoists and cranes shall be manually operated (unless otherwise specified in the particular specifications) for travelling, traversing and hoisting by endless steel chains.

2. All chains shall be of electrically welded steel, heat treated, polished and accurate to pitch.

3. Chain hoist shall consist of frame, casing, reduction gear and flanged load sleeve with precision roller bearings, load and operation chain, overload limiter, mechanical brake and safety hook lock.

4. Overhead bridge travelling cranes shall consist of manually operated hoist, travelling and traversing rails, stoppers, and all necessary components such as fixing bolts and the like for proper and efficient operation of the crane.

5. All members of a crane shall have a minimum safety factor of 5 based on ultimate strength of materials. Maximum deflection of the bridge shall be 1/800 of the span with given rated load. The Contractor shall ensure all civil works line and level tolerances are within the limits set by the crane manufacturer.

6. All hoisting equipment shall comply with the regulations governing manufacture in the country of origin and a certificate and license shall be provided by the Contractor to demonstrate compliance with this requirement.

11.5 SURGE PROTECTION SYSTEM

11.5.1 Operation Principle

1. The air chambers have a certain pressurised initial volume of air which pushes water into the pipeline during negative pressure transients and dampens the positive pressure transients. The pressure transients are developed after sudden changes in the flow rate. Generally most dangerous situation is developed after a power failure.

2. The system shall be provided with water level automatics in order to maintain continuous readiness to protect the system against excessive pressure transients (surges).

11.5.2 Applicable Standards

The applicable standards for the pressure vessels are the following:

- EN 286-2 European Standard; Simple unfired pressure vessels to contain air or nitrogen
- BS 5500
- ISO 2604 Steel products for pressure purposes
- ISO 6303 Pressure vessel steels not included in ISO 2604

11.5.3 Ratings

The pressure vessels and auxiliaries shall be designed for 10 bar overpressure and for 0,5 bar below atmospheric pressure (vacuum). Stiffeners can be used if necessary.

11.5.4 Materials

1. Material can be carbon steel according to applicable standards for pressure vessels or stainless steel.

2. Carbon steel vessels shall be protected against corrosion internally and externally by painting according to painting instructions of this specification, 2 component epoxy, total dry film thickness (DFT) not less 250 μm.

11.6 SURFACE PROTECTION

11.6.1 General

1. The climate and corrosive ambient conditions of the Site shall be considered when selecting the paint systems.

2. The surface preparation requirements shall be based on DIN EN ISO 12944, or equivalent and also on the paint manufacturer's requirements and the Engineer’s instructions.

3. Equipment not to be painted are stainless steel tanks, vessels, piping, etc. and piping to be insulated.

4. All items that require surface protection shall be delivered to Site with at least workshop, factory, manufacture’s etc. applied undercoat and topcoats leaving only the final colour painting to be applied at Site.

5. The paint materials selected for the paint systems can only be changed on the written order by the Employer.

6. All gauges, surfaces of bearings, open pipes, pumps, electric motors, etc. that are not to receive surface protection shall be protected during painting operations.

7. The steel structures which will be embedded in concrete shall be painted for 50 mm of the length inserted into the concrete during pouring.

8. Every coat in a paint system shall be a different colour to facilitate measuring the coat thickness. Safety colours shall be according to the Moldovan regulations.

9. Finish or top colours for all items except items Site manufactured ones shall be in manufacturer's standard colours and the items delivered to Site in these colours. Finish or top colours of Site fabricated items will be as advised.

10. Un-insulated steel and cast iron pipes shall be coated with anti-corrosive paint, colour complying with flowing substance.

11.6.2 Paint Materials and Storing

1. Paint materials are delivered to the Site in manufacturer's packages.

2. The paint materials shall be stored in a well ventilated room all according to the paint manufacturer's requirements.

11.6.3 Steel Surfaces

Pre-cleaning shall be carried out before rust removal and painting. After pre-cleaning the steel surfaces should be blasted DIN EN ISO 12944, or equivalent.

11.6.4 Painting

1. DIN EN ISO 12944 or other equivalent national or international standards shall apply.

2. Airless painting methods shall be used. Painting will only be permitted in weather conditions that meet the paint manufacturer's requirements.

3. Shop primers and washes shall be used according to the paint manufacturer's requirements.

11.6.5 Transportation and Handling of Painted Structures

1. All painted surfaces must be allowed to dry long enough before the structures are transported. Textile slings, rubber or plastic covered wire ropes or hoisting straps should be used for lifting. If bare wire ropes or chains are used, a protective padding shall be inserted between the painted surface and the lifting device.

2. During storing of the painted structures a protective padding should be used between the painted surfaces.

3. Damaged areas shall be repaired to reinstate the original paint system.

12 GENERAL ELECTRICAL SPECIFICATION

12.1 PREAMBLE

This General Specification is intended to indicate the minimum standard of design, workmanship and the materials acceptable for electrical works and instrumentation.

12.2 STANDARDS, RULES AND REGULATIONS

1. Unless otherwise specified standards to be followed in the works are the regulations of the European Committee for Electrotechnical Standardization (CENELEC) or International Electrotechnical Commission (IEC) and the materials to be used shall fulfil the requirements of the testing programme and approval given by any Inspectorate Institute following the rules published by CEE (International Commission on rules for the approval of Electric Equipment) provided they are not against the Governing Law. These regulations and standards shall hereinafter be referred to as "the rules and regulations".

2. All equipment to be used shall be suitable for the humid ambient conditions.

3. All components shall be clearly and indelibly marked with reference numbers of the standards with which they comply, or that shall be supplied separately.

4. Wherever the Technical Specifications call for materials, workmanship, arrangements, construction etc. of a better quality than is required by the rules and regulations, the Technical Specifications shall prevail.

12.3 PERMITS

The Contractor shall obtain all permits related to electrical work, arrange for all official electrical inspections covering his work and pay the related fees and charges. The Contractor shall give all the notices that are required by the authorities having jurisdiction over his work. The attention of the Tenderers is drawn to the Moldovan regulation requiring licensing of firms carrying out electrical installation.

12.4 ELECTRICAL DRAWINGS

12.4.1 Electrical Drawings

1. The shop drawings to be prepared by the Contractor will hereinafter be referred to as the "Contractor's drawings". These Contractor's drawings shall include all the electrical drawings called for in this Technical Specification.

2. A complete set of Contractor's drawings shall be submitted by the Contractor to the Engineer for approval.

3. Contractor's drawings shall be such quality that all works can be carried out without additional design by the Contractor at Site.

4. Contractor's drawings shall indicate the code numbers of the equipment etc. and shall clearly show the features and details applicable to the equipment etc. being supplied.

5. Manufacturers' catalogue or manual pages or drawings applicable to an entire family or range of equipment etc. will not be accepted as Contractor's drawings unless they are clearly marked up to show the pertinent data for the particular equipment and the like. Manufacturers' catalogues or O&M manual pages or drawings may however be used to supplement information on the Contractor's drawings.

6. If a device is available with optional features, shop drawings shall clearly show the options which will be provided.

12.5 CO-ORDINATION WITH LOCAL ELECTRICAL NETWORK COMPANY

It shall be the Contractor's responsibility to conform with the local Electrical Network Company's requirements and servicing details such as service point installation of the transformers, primary switchgear and metering devices, limitations for motor starters and power factor correction and the like.

12.6 ELECTRIC DISTRIBUTION SYSTEM

12.6.1 High Voltage (10 kV) Power System

1. The Contractor shall follow in the design, supply and installation the Moldovan Regulation on Installation of the Electrical Equipment

2. The Employer will hand over the high voltage system including the high voltage and transformer rooms to the local electric authorities upon the pre-commissioning.

3. The Contractor shall submit all his working drawings for the high voltage system via the Employer for the approval of the local electric authorities.

12.6.2 Low Voltage (0.4 kV) Distribution System

1. The low voltage (LV) 0.4 kV distribution system is based on 3-phase 4-wire network with earthed neutral. Nominal voltage is 380/220 VAC and frequency 50 Hz.

2. Power distribution shall be carried out by cables having a common shield.

3. All power supply to any electrical equipment shall be wired via distribution boards and constructed according to the Technical Specification.

4. The power supply system shall be constructed so that any circuit or equipment having a nominal voltage shall be isolated from the mains by opening one disconnector in the distribution board.

12.7 EARTHING

1. The earthing system shall be follow the principles shown on the Detailed Design Drawings. The technical requirement is that the resistance measured in any point between neutral (N) and earth (PE) shall not exceed value R_E 4.0 Ω and if it is exceeded the Contractor shall install necessary number of grounding electrodes to meet the requirement.

2. All electrical equipment having a metal or otherwise conductive enclosure or by any means having a terminal for that purpose shall be grounded.

12.8 ILLUMINATION LEVELS

All places in the Works where constant work is carried out shall be illuminated. In general Table 12-1 shall be used in the selection of lighting fittings.

Table 12-1: Illumination levels in various areas

Area description	Illumination level in Lux (lumen/m^2)
Outdoors in general	20 to 40
Pumping stations	200 to 300
Control rooms	500 to 750
Corridors	100 to 200

Office rooms	300 to 500

12.9 AREA CLASSIFICATION AND ENCLOSURES

The minimum IP-class needed for enclosures shown in Table 12-2 shall be followed.

Table 12-2: **Area and equipment minimum IP-class for enclosures**

Enclosure description	Construction	Main feature of protection degree	Most common use location
Ordinary	IP 20	Accidental touching of voltage carrying parts rendered impossible	Dry place with no dust
Drip-proof	IP 22	Live parts protected in working positions against dripping water	Humid places, outdoors, under roof eaves
Splashproof	IP 34	Live parts protected from the outside against water splashes from any direction	Humid places, wet places, places with danger of fire
Jetproof	IP 55	Live parts from the outside against water sprayed from any direction	Wet location, places with corrosive material
Watertight	IP 67	Live parts protected against ingress of liquid	Wet location, places with corrosive materials
Immersion Tight	IP 68	Protected against the effects of immersion	Temporary location under water

12.10 MATERIALS AND EQUIPMENT

12.10.1 General

1. All materials and equipment furnished under this Contract shall be as specified in every respect and shall be constructed and finished in a workmanlike manner. Materials shall be suitable for the service intended. Equipment shall be modern in design and new and unused except as required by tests.

2. All equipment shall be fitted with safety devices.

3. Notwithstanding technical information submitted with his Tender, the Contractor shall submit the following information for any or all proposed materials and products to be supplied:

- Name and address of manufacturer,
- Trade name, model and catalogue number,
- Performance, descriptive and test data,
- Manufacturer's installation or application instructions

12.10.2 Material Approval

The material shall be approved by the Engineer as required. Materials and equipment on which approval agencies or other authorities regularly place labels of approval shall bear such labels.

12.10.3 Factory Inspection And Test For Equipment

All electrical equipment shall be factory inspected and tested. No witness tests will be required.

12.11 REQUIREMENTS FOR SITE EQUIPMENT

12.11.1 Motors

1. All motors shall be constructed and selected with an adequate rating to drive the load at specified capacity.

2. Insulating grade shall be class F ("hottest spot" temperature 155 ^{0}C).

3. Ratings shall be for continuous running duty, class S1.

4. Motors shall generally be of the squirrel cage induction type arranged and rated for full voltage direct-on-line starting. If the motor speed is controlled by frequency converter the motor shall be constructed accordingly.

5. Motor cabling shall be made by using copper cables to terminal marked U, V and W indicating the direction of rotation of the motor which shall also be marked on the enclosure of the motor.

6. The motor mains electrical supply connections enclosure shall be IP 54 minimum.

7. The voltage drop shall be limited to less than 15 % during the starting period.

12.11.2 Power Factor Correction Capacitor

1. The automatic capacitor bank shall be a complete unit and be suitable for existing nominal electricity network. It shall be of maintenance free construction and with integrated contactors controlled by a regulator.

2. Nominal voltage and frequency shall be 380 V and 50 Hz respectively.

3. The enclosure shall be min. IP 40.

4. The ambient temperature range shall be -5 through +55 ^{o}C.

12.11.3 Socket Outlets

1. All socket outlets shall be of commercial grade quality having outlet numbers. Sockets having separate earth terminal pins shall be constructed in such a way that when any portable electric machine is connected to the socket by a suitable plug, earthing for the machine is ensured.

2. Sockets other than indoor shall be of the weatherproof type and shall have spring-loaded, gazetted, hinged covers.

3. Single and three phase sockets shall be rated I_N = 16 A unless shown otherwise on the Detailed Design Drawings.

4. The rotation direction for three phase sockets shall be checked before put in to use.

5. The body of the socket outlets shall be PVC wherever possible.

12.11.4 Light Switches

Light switches shall be of commercial-grade quality having a rating to suit the circuit load. All switches shall be splash proof. The body of the socket outlets shall be PVC wherever possible.

12.11.5 Motor Safety Switches

Each motor shall be provided with motor safety switch provided with a contact which shall be wired into the control circuit to prevent the motor starter being energised when the safety disconnect is turned to the "OFF" position. These switches shall be capable of being lockable in the "OFF" position with padlocks. Switch enclosures shall be metal or PVC and positioned next to the respective motor.

12.11.6 Junction Boxes

Junction boxes shall be made of PVC or aluminium and be large enough for connecting all incoming cables. The enclosure shall be minimum IP 34.

12.11.7 Light Fixtures and Lamps

1. The light fixtures shall be factory made and be suitable to be installed in the intended place.

2. All lamps shall be of the bright white colour or equal which combines well with daylight. Factory tested usage time and output lumens shall be presented before installation for review by the Engineer.

3. All light fixtures with fluorescent and discharge lamps shall fulfil the minimum overall power factor value 0.95. The power factor correction capacitors shall be factory assembled in the light fixtures.

4. The design temperature range of light fixtures shall be -5 ... +55 ºC.

5. Only lamps which can be purchased locally will be accepted.

12.11.8 Emergency Light Fixtures

The emergency light fixtures shall be portable, factory made torch type including battery and charger. It shall plug into a socket outlet and in case of power failure it shall switch on automatically. The battery shall be rated for 2 hours uninterrupted use.

12.12 CONTROL CIRCUIT PRINCIPLES

1. Control circuits shall be kept simple but reliable.

2. Any safety shutdown shall require manual acknowledgement and reset, unless otherwise specified.

3. Control circuits shall be designed in general for 220 V AC or 24 V DC inside the boards and panels. Other voltages are allowed to be used but effects and changes to other equipment and systems shall be assessed and all related costs associated with using another voltage shall be borne by the Contractor.

4. All motors shall be started and stopped manually or automatically by using switches, push buttons or automatic operation via SCADA system. Each motor circuit shall include a switch which will enable manual or automatic operation. This switch shall not by-pass the motor safety switch.

5. Each motor starter circuit shall have its own control fuse.

6. Switches shall be provided in each room for lighting fixtures in that room.

7. Rooms with more than one door shall be furnished with a lighting switch at each door. Unless otherwise shown on the Detailed Design Drawings, outdoor of buildings lights shall be controlled by a switch located inside the building adjacent to the main door used for personnel access.

8. Outdoor area lighting shall be controlled only from one place.

12.13 LOW VOLTAGE CABLES AND CONDUCTORS

12.13.1 0.4 kV Power Cables

1. The 0.4 kV cables shall fulfil all the requirements determined by the environment in which they are to be installed and as set out in the Specification. They shall be manufactured to meet the requirements of an internationally recognised cable specification.

2. Cables shall be delivered to Site with the manufacturer's seals, labels or other proof of origin attached.

3. Conductors shall be of copper. Only if the connection to the equipment sets limits for the use of copper, aluminium may be used but each case shall be approved separately by the Engineer. The colour of each conductor shall be clearly marked as follows and shall not be connected for any other purpose:
   - earthing yellow/green
   - neutral blue

4. Insulation material for cables and cores shall be PVC.

5. The outside markings of the sheath of the cables shall state:
   - manufacturer's name
   - type mark
   - number of conductors
   - cross sectional area
   - rated voltage
   - continuous metric marking

6. The permissible temperature of the conductors shall, in short circuit, be minimum 160 ^{0}C for not more than 1 second.

12.13.2 Instrument Cables

1. Instrumentation cabling shall provide protection against magnetic and electrostatic interference by using twisted shielded cable and steel armour. Where the cable will be installed in magnetic conduit, a non-magnetic cable or sheath may be used.

2. Shield cable shall have stranded, twisted pair copper conductors. Cables shall have individual pair shielding, an overall shield and an overall PVC jacket. Shields shall be foil type with a drain wire for each shield. Cable armour shall be interlocking steel type where it has to be magnetic, or a continuous aluminium sheath where magnetic armour is not required.

12.13.3 0.4 kV Underground Cables

0.4 kV underground cables shall fulfil the technical requirements for power and instrument cables but these shall be provided protection against mechanical damages by using steel armour.

12.13.4 Conductors

Conductors shall be copper, and unless otherwise specified and shall be insulated with thermoplastic rubber or cross linked polyethylene insulation with a conductor temperature rating of at least 70 ^{o}C. Conductors shall be stranded. Except for shielded instrumentation cables, conductors shall be minimum 1.5 mm^2.

12.13.5 Marking

1. All cables, conductors and wires shall be marked with reliable and replaceable plastic marker tied around the both ends of the cable. Cable marking shall have the following information:
   - number of cables corresponding to design

- number of cores and cross-section
- code of start and end point

2. After a cable has been installed through the cable gland inside an equipment and the sheath has been removed, each core shall be marked by the number of the terminal to be connected.

3. If not otherwise identified, wires connected to terminal block shall be marked with the terminal block designation.

4. Control conductors identified on the Detailed Design Drawings with wire numbers shall be marked correspondingly. In case cable consists of factory numbered conductors, those shall be used and those markings shall shown on the As-Built-Drawings.

12.14 CABLE INSTALLATION

12.14.1 General

1. All cables shall be installed to a high standard of neatness with respect to visible outlook of the final result and the arrangement and alignment with other apparatus and equipment. Every cable shall be run vertically, horizontally or parallel to adjacent walls, beams or other structural parts.

2. No cable shall be drawn into any raceway until all work of any nature that may cause injury to the cable or its insulation have been completed. During cable pulling, the conductors shall be fed carefully into the raceway to prevent twisting, kinking, or looping.

3. Where cables and conduit have to pass through floors and walls, the Contractor shall core or drill the necessary holes. Cables shall always be inserted in conduit and conduit always grouted in position.

4. Where it is not practicable to locate the cables underground, they shall be mounted on the interior surface of a building and/ or structure using surface-mounted cables and conduit as described above. Except as approved by the Engineer, no wiring shall be installed exposed on the outside of a building.

5. Cables serving terminal boards shall be neatly dressed into them and secured with nylon cable ties.

6. Cables shall form a loop before connecting to terminals to permit reconnections.

7. Cables shall be fixed with sufficient fittings to carry all mechanical loads caused by the cable weight.

8. Cables running in straight cable routes shall not lace and when fixed parallel shall not crossing each other as far as possible. The cables shall not be bent to a radius less than the manufacturer's recommended radius.

9. Cables between different equipment shall be continuous without any connections. Where connections are required they shall be approved by the Engineer.

10. In an environment where mechanical damages to cables are likely, the cables shall be protected. Without exception this shall be done in places where cables pass through floors, walls or run on the surface individually less than 1.2m from the finished floor or ground level. Protection shall be arranged by using rigid or flexible steel pipe minimum 20 mm diameter and at least 20% larger than the diameter of the cable to be installed in it. In case three or more cables run parallel on the finished surface a combined rigid steel sheet cover can be used. The protection pipes shall be painted the same colour as the structure behind the pipes.

12.14.2 Channels

Cables laid directly in to the cable channel shall be installed following the methods stated in 'General' chapter above as far as those rules are acceptable.

12.14.3 Conduits

Cables shall be pulled into conduits and lacing of them shall be avoided. Cable pulling string or auxiliary wires shall be used. In principle one cable per one conduit is recommended.

12.14.4 Trenches

1. Cable trench shall be at least 800 mm deep. The trenches shall be excavated as specified in the Particular Specification. The trench bottom shall be covered with fine sand (grain size maximum 2 mm) in a layer 100 mm thick. After laying the cables parallel with the distance between adjacent ones being not less than the diameter of the larger cable, the cables shall be totally covered with the same sand as is under the cables. A precast concrete cover shall be placed with its bottom 100 mm above the cable and be sized as follows:

- shape half round, 120 mm diameter
- thickness 30 mm
- length of one cover 500 mm

2. A warning tape shall be installed to indicate and warn about the underground cables. The concrete cover shall be covered with a 50 mm layer of fine sand. After this work the trench shall be filled with selected excavated material if not otherwise specified elsewhere.

3. Arrangement of cables in trench shall be such that no free air space shall be left around the cables.

4. The backfilling and reinstatement of the trench above the cover slab shall be carried out in accordance with the Particular Specification.

12.14.5 Cable Trays

Cables installed on vertical tray sections shall be fastened every 0.3m with cable clamps designed for such purpose. Cables installed on horizontal tray sections shall be tied every 1.0m with nylon cable ties. If airspace between cables installed on a tray is inadequate, the current carrying capacity of the cables shall be re-rated as required by the necessary rules and regulations.

12.14.6 Surface Installation

Where cables are run individually they shall be supported by cleats fixed directly to the concrete or brickwork. Cleats shall be spaced so as to avoid sagging of cables and shall in any case be not more than 0.3m between centres. When more than one row of cables following a single route cleats shall be fixed with backstraps.

12.14.7 Cables on Steelwork

Structural steelwork shall not be drilled for cable fixing. If needed a metal conduit shall be fixed along the steelwork for the cable as a raceway. Individual clamps shall not be used for cable.

12.15 CABLE TERMINATION

1. Each cable penetrating any equipment enclosure shall be provided with a gland to ensure the original degree of protection specified and shall ensure that any mechanical traction occurs on the protective sheath of the cable and not the terminals.

2. All electrical equipment shall be provided with adequate numbers of terminals and numbered by the recommendation published by CENELEC (Comite Europeen de Normalisation Electrotechnique) for each core of the cable and shall be marked by the number to be connected.

3. Lacing of conductors shall not be permitted. Cables shall form a loop before connecting to terminals to permit reconnections.
4. Stranded control conductors terminating at devices having binding head screws shall be fitted with insulated, compression-type solder free lugs. Compression fittings shall be made only with the tool appropriate for use with the size and type of lug used.

5. Conductors ≤ 10 mm^2 may be spliced or tapped with twist-on connectors and conductors ≥ 16 mm^2 shall be sliced or tapped using compression connectors.

12.16 CABLE PROTECTION

1. The wires and circuit breakers shall be selected to fulfil the requirements of **Table 12-3**.

Table 12-3: Cable Protection

Legend:
1. Cross section of wire, mm^2 Cu
2. Minimum allowed continuous current for wire
3. Maximum allowed nominal current for circuit breaker (short circuit and overload protection)
4. Maximum allowed nominal current for circuit breaker combined with protective switch for a motor (overload protection)

1.	2.	3.	4.		1.	2.	3.	4.
1.5	14	10	25		35	93	80	200
2.5	20	16	35		50	116	100	250
4	25	20	50		70	146	125	315
6	32	25	63		95	146	125	400
10	41	35	80		120	185	160	500
16	58	50	125		150	232	200	630
25	73	63	160		185	292	250	800

2. The cable manufacturer shall state the minimum temperature which is allowed for the conductors in normal use. The minimum requirement is 70 ^{0}C.

3. All cables shall contain a separate grounding conductor where required. Three-phase cables shall contain a full-capacity neutral conductor ≤ 16 mm^2 and bigger size may contain a reduced-capacity neutral.

12.17 CABLE RACEWAYS

12.17.1 Conduit Materials

1. Conduit in buildings and structures shall be rigid aluminium. Rigid PVC shall be used in corrosive areas and for underground installations where needed.

2. Conduit for instrumentation wiring, where magnetic shielding is to be provided, shall be rigid galvanised steel, except for corrosion-prone areas where rigid PVC conduit in conjunction with armoured cable shielding shall be used.

12.17.2 Conduit Installation

1. Conduit systems shall be cleaned to remove all moisture and foreign substances before pulling in the cables.

2. Conduits shall be supported with a proprietary non-corrosive fastening system.

3. Empty conduits shall be provided with an insulated 1.5 mm^2 copper pull wire.

4. Surface-run conduits shall be installed after to the painting of surface on which it is installed.

5. Conduit bends, sweeps, offsets and the like shall be made only where necessitated by structural or mechanical requirements.

6. Metal conduit bends bigger then 25 mm nominal size shall be either factory supplied or made on an appropriate bending machine.

7. Groups of conduits traversing the same route shall have their bends and offsets in the same plane and these bends and offsets shall have a common centre of curvature with a varying radius to present a neat appearance.

8. PVC conduit bends, sweeps, offsets and the like shall be made with factory-fabricated fitting for sizes larger than 50 mm diameter.

9. Cut ends of conduits shall be reamed with a pipe reamer to remove all burrs. Threaded male end rigid steel conduit shall be painted with a coating of zinc chromate before connecting to female ends of fittings, couplings and the like.

10. If required to prevent cable damage, flexible conduit shall be used to connect conduit to motors, solenoid valves, pressure switches and the like. The length of flexible conduit to be used for such connections shall be minimised.

11. Exposed conduit runs shall be parallel or perpendicular to the building or structures and shall be supported at the intervals not more than 1 m.

12. Couplings for rigid-type metal conduit shall be threaded.

13. PVC conduit couplings shall be threadless type. PVC fittings, couplings and conduit shall be of the same manufacture.

12.17.3 Cable Trays

1. The cable rack system shall be constructed by using only factory made parts and they shall be manufactured by the same company to ensure compatibility and neatness with each other.

2. They shall be made of profiled aluminium with standard widths of 150, 200, 300 and 500 mm. The number of cables installed in a single tray shall be such that a cable weight of 100 kg/m is not exceeded, otherwise two or more racks shall be used. Support distances shall not exceed 3.0 m.

3. Manufactured fittings shall be used such as y-pieces, tees, crosses and vertical and horizontal elbow pieces for changes in direction.

12.18 WORKMANSHIP

12.18.1 Safety Features

1. All electrical Works shall be undertaken by professional and qualified electricians only.

2. The Works installed shall not be hazardous or dangerous to any personnel working or having access to the Site.

3. Adequate warning notices shall be installed in those areas where unintentional contact with electrically live parts is possible. Such notices shall be plastic and have black lettering engraved on red background in both Moldovan and English.

12.18.2 Precautions During Construction

All conduits and boxes shall be capped or closed when electrical work is not actually in progress. A manufactured PVC cap shall be used. Boards, control units, switch gear, and other electrical equipment shall be properly protected against the entrance of dust, dirt and moisture and protected against mechanical damage during installation. Damage to electrical equipment including painted surfaces caused by failure of the Contractor to properly protect the equipment shall be promptly and properly repaired by the Contractor to a condition equal to or better than the original condition.

12.18.3 Cleaning

The interior of all enclosures, boxes, wiring areas and the like shall be cleaned of all dust, dirt and the like and all water and moisture removed. All fastening screw holes provided in boxes and enclosures shall have fastening screws installed.

12.18.4 Switches, Socket Outlets and Boards

1. Socket outlets, switches, junction box and the like shall be mounted in an accessible locations. Unless otherwise shown on the Detailed Design Drawings, the following devices shall be mounted at the distance stated from the finished floor level to the device centre line:

- lighting switches 1.35 m
- motor safety switches 1.35 m
- distribution boards (top of trim) 1.80 m
- socket outlets 1.00 m

2. Surface-mounted outlets, junction and switch boxes shall be rigidly secured to buildings, structures and the like. Powder-activated anchors may be used provided the manufacturer's recommendations with regard to size, penetration, and explosive's charge is strictly followed. Surface-mounted boxes shall be installed past to painting to buildings, structures and the like. Where lighting fixtures are hung from surface-mounted boxes, these boxes shall be supported independently. Conduits serving the box shall be securely fastened within 200 mm of each side of the box.

3. The space around the recessed outlet, switch, junction boxes and the like serving weatherproof devices shall be carefully sealed to prevent moisture or dirt from entering the building or structure.

4. Conduits entering boxes shall have their openings effectively sealed to prevent dust and dirt entering.

12.18.5 Unused Openings

Boxes and boards shall have only those openings necessary to accommodate conduits or cables at the time of installation. Unused taps in conduits, fittings, and boxes shall be plugged with conduit plugs. Unused opening in sheet steel boards or boxes shall be plugged with press-in plugs.

12.19 SITE TEST

12.19.1 General

1. In addition to other tests set out in this Specification, these general conditions shall be met.

2. The tests shall be carried out so that wherever possible each result obtained should be capable of being checked from two independent reference sources.

3. On completion of the separate parts of the work the Contractor shall carry out full scale Site tests in the presence of the Engineer on all sections of the work.

4. Provision of skilled labour, supervision, apparatus and instruments required for carrying out the tests efficiently will be the responsibility of the Contractor and made at his expense. The accuracy of the instruments shall be demonstrated if required.

5. Each completed system within the installation shall be tested as a whole under operating conditions to ensure that each component functions correctly in conjunction with the rest of the system.

6. The Contractor shall carry out all calibration and tests necessary to ensure that his work and all equipment, materials, and components are in satisfactory physical condition and perform the intended function and operations. Adjustments required to make the system operate in the manner intended shall be made at no extra cost.

7. Prior to requesting the final inspection, the Contractor shall submit to the Engineer completed test data sheets. These sheets shall be filled out after adjustment of all protective devices.

8. The following data shall be listed and completed for each test:
- Equipment code and description
- Full nameplate data
- Description of testing procedure
- Technical result of test
- Date of testing
- Personnel taking part in the test
- Notice and description of failures
- List of test equipment

12.19.2 Tests During Installation

1. During installation the Contractor shall make regular tests to ensure that satisfactory installation is being achieved consistent with the requirements of the Contract.

2. The testing shall be carried out in the presence of the Engineer.

3. Minutes of each test shall be made and signed and any faults and/ or defects shall be recorded.

4. The Contractor shall provide all necessary facilities for the testing and the Engineer shall be allowed to use any instrument or testing apparatus that he may consider necessary to carry out the tests.

12.19.3 Testing Equipment

1. The Contractor shall give evidence of the accuracy of any testing device used by him if required by the Engineer. All such apparatus used during the test shall be calibrated not more than 12 months before the actual testing date.

2. At least but not limited to, the following devices shall be made available by the Contractor:
   - transmitter 4 to 20 mA
   - insulation tester (megger)
   - multimeter (V-A-Ω)
   - rotation direction indicator
   - illumination tester (Lux)

12.20 INSPECTION OF ELECTRICAL WORK

12.20.1 General

1. Prior to requesting the final inspections, the Contractor shall ensure that all electrical systems which have an effect on that part to be inspected are completed, tested and ready for use with all equipment operating satisfactorily.

2. Approval of any work by the representative of the Local Electrical Network Company. (inspector) will not be regarded as reason for omitting any work shown on the Detailed Design Drawings or specified herein, unless the inspector decides and presents in written form, that the work so shown or specified is in violation of the Moldovan electrical rules and regulations.

12.20.2 Certificate of Inspection

The Contractor shall submit to the Engineer, prior to requesting the final inspection, the Certificate of Inspection signed by the authorised representative of the Local Electrical Network Company.

12.21 DISTRIBUTION BOARD AND PANEL DEVICES

12.21.1 General

1. All devices in the same category shall be from the same manufacturer in order to minimise the number of spare parts.

2. The boards and panels shall be constructed from factory made standard size steel plate (minimum 1.5 mm thick) cubicles, which together with a steel framework shall form a robust structure for cables and equipment. The surface treatment shall be made by epoxy powder painting. Colour to be manufacturer's standard colour.

3. The internal wiring shall be identified with reliable markers having the same information as the point to be connected to. All equipment shall be clearly marked following the codes shown on the Detailed Design Drawings. Terminal blocks used for different voltages shall be clearly and reliable separated.

4. The following Drawings shall be submitted for the Engineer's approval before manufacturing:
   - General arrangement drawings
   - Layout of internal parts

12.21.2 Low Voltage Main Switchgear

1. Enclosure protection min. IP 34. In each cubicle there shall be separated spaces for apparatus and busbars.

2. The switchgear construction shall be tested for the rates set by any apparatus or equipment connected. The following information shall be included in panel labels:
   1) Manufacturer and the type of construction
   2) U_N (V), I_N (A), f_N (Hz), I_{th} (kA), I_{dyn} (kA), IP

3. The insulation test shall be carried out at 2,500 V for 1 minute.

4. A facility shall be provided to allow a portable earthing device to be attached by means of an insulating rod.

5. The final lay-out design of the switchgear shall be carried out by the Contractor but the following arrangement shall be followed:
   - each cubicle shall have direct access with cable or wire from a separate cable duct except for the main feeder cubicle where power supply cables may penetrate direct from below
   - each circuit breaker and other items of equipment logistically belonging in one group shall be in their own cubicle and on the door shall be clearly marked the purpose of the group
   - power cables shall be connected direct to the apparatus cubicles through the plate between them

6. Every auxiliary contact from any component shall be wired to terminals whether it is in use or not. Each terminal block shall be clearly marked from the end point in a way that no other terminal strip has the same “address”.

7. Doors shall be provided with a rubber gasket, fixed locks with handles and hinges to enable doors to opening at least 120 ^{o}.

8. The construction shall ensure high operational reliability and personnel safety.

9. The power distribution inside the switchgear shall be made with copper busbars and connection from them to the equipment can be done either by using busbars or individual wires.

12.21.3 Distribution Boards

1. Boards shall be circuit-breaker and line protection breaker types, surface-mounted and shall have a hinged door with concealed hinges and a combination lock and latch. Two (2) keys shall be provided with each board.

2. Board shall be identified by an engraved non-corrosive metallic nameplate. Degree of protection shall be minimum IP 20 indoor and IP 54 outdoor.

12.21.4 Contactors

1. Contactors shall be reliable and rated for the loads shown on the Detailed Design Drawings and shall have simultaneous action for all contacts. Wires shall be possible to be connected with screws to terminals. Coil and contact blocks shall be replaceable and the electrical endurance shall be not less than 10 million cycles.

2. Elapsed time meter and running status light shall be connected through a motor starter auxiliary contact.

12.21.5 Thermal Relays

1. Thermal relay shall provide overall protection for motor against overload and phase failure with the contactor. It shall be compensated in such way that the disconnect time is not depending on outside area temperature.

2. Thermal relay shall be connected to main circuit.

12.21.6 Relays

Relay shall be reliable and rated for the loads shown on the Detailed Design Drawings and shall have simultaneous action for all contacts. Wires shall be possible to be connected with screws to terminals. Electrical endurance shall not be less than 10 million cycles.

12.21.7 Time Relays

Time relay can be either mechanical or electronic type constructed to provide either on or off delay function for range demanded.

12.21.8 Running Time Meters

Running time meter shall consist of a mechanical display and be panel mounting type and fulfil the requirements as follows:

- input 220 V AC/50 Hz;
- 8digits; and
- hour and minute display.

12.21.9 Totalisers

1. Totalizer shall consist mechanical display and be panel mounting type and fulfil the requirements as follows:
   - input signal 24 V DC, 25 ms (1 pulse);
   - 8 digits; and
   - non-resetable.

2. The scale of the pulse converted to display shall follow the measuring device output range, which could be for example 1 pulse = 100 m^3.

12.21.10 Selector/ Operating Switches

1. Selector and operating switch shall be of sturdy modular construction comprising a number of similar switching elements operated by a single shaft and combined cam to ensure simultaneous operation of the contacts shown on the Detailed Design Drawings.

2. The switch shall operate at angles of 0^0 - 30^0 - 45^0 - 60^0 - 90^0.

3. A suitable engraved position indicator shall be provided to clearly show the selected position of the switch.

12.21.11 Push Buttons

1. Push buttons shall be square, minimum size 20 x 20 mm, provided with a lens engraved with the text shown on the Detailed Design Drawings and have electrical endurance of not less than 0.3 million cycles. The colour of the lens shall be:
   1) GREEN for start, reset, test and open; and
   2) RED for stop and close.

2. The push buttons shall fulfil the following requirements:
   - U_N = 220V AC, I_N = 10A;
   - number of contact as designed;
   - operating by pressing;
   - impulse function; and
   - position indicating plate (engraved).

3. Luminous push button may be used having an integral lamp arrangement.

12.21.12 Current Transformers

Current transformers shall be a compact structure with primary and secondary windings enclosed in an insulating box.

12.21.13 Current Transducers

Current transducer shall be a compact structure enclosed in an insulating box.

12.21.14 Indicator Lights

Indicator light shall be round and minimum 20 mm diameter provided with lens engraved with the text or figures shown on the Detailed Design Drawings and a nominal voltage according to the source of power supply. The colour of the lens shall be:

- Green for run and open
- Red for alarm and close

12.21.15 Indication Displays

1. Indication displays shall be of same manufacturer as far is possible. The display shall be panel mounting type and shape and provided with a scale as shown on the Detailed Design Drawings.

2. Displays having operating contacts for alarm etc. shall have built-in relays with auxiliary power supply 220V AC. Relays shall have one potential free contact for each operation. Operating points shall be adjustable with screwdriver. Accuracy shall be ± 1.5 % of full scale.

12.21.16 Locks

1. Where a lock is specified or shown it shall be of a cylinder type and provided with key. Where a lock is provided for a particular group of items (e.g. a cabinet) key shall be interchangeable.

2. A master key shall be provided for groups of essential locks. Keys shall be clearly and permanently marked in such way that they are easy to be identified.

3. All keys shall be handed over in one metal key box to be fixed on wall as directed.

12.21.17 Alarm Bells

Alarm bells shall operate at 220 V AC/50Hz and have a sound level of minimum 100 dB when energised.

12.22 ELECTRICITY MEASURING INDICATORS

12.22.1 General

1. All electrical measuring indicators shall be of the direct reading flush panel mounted type, accuracy class 0.5 of full scale deflection and shall be unaffected by temperature changes.

2. Each indicator shall have a zero adjustment knob (screw) situated in such a way that adjustment can be made without removing the cover.

3. All equipment shall be from the same manufacturer. Ranges shall be selected to show 50 to 75 % of full scale deflection.

12.22.2 Ammeters

1. Ammeters shall be of moving iron, spring controlled type and shall be capable of withstanding overload under fault conditions.

2. Each ammeter shall be provided with separate peak indicator recording the full load and shall be of the reset type.

3. Input current shall be 0 to 5 A when connected with current transformer.

4. Motor phase current shall be measured with the motor operating at normal load. The Engineer shall be notified if the measured current exceeds the motor nameplate full-load current, or if phase current of polyphase motors differ by more than 10 %.

12.22.3 Voltmeters

Voltmeters shall be moving iron spring controlled type and equipped with suitable resistors.

12.22.4 kWh and kVA Meters.

The meters shall be suitable for operation with three phase and current input (0 to 5 A) four wire with 50 Hz input unbalanced load. The meters shall be one counter, non-resetable type with accuracy ± 0.5 %.

12.23 MEASUREMENT CIRCUITS

1. Systems shall be provided as required with voltage stabilisers to ensure that proper voltages exist between each phase and neutral and between phases.

2. Maximum error in any measurement signal is 2 % from the real value. Standard 4 to 20 mA current output/input signal shall be used for measurements.

3. 220 V AC voltage for control or indication shall be used for elapsed hour counter, on/off, open/close and run/stop

4. Standard 24 V DC/25 ms pulse output/input signal shall be used for totalizer.

12.24 MEASURING INSTRUMENTATION

12.24.1 General

1. All measurement instruments belonging to same sub-category shall be from one manufacturer.

2. All instruments shall be of range and size specified in the Particular Specification or shown on the Detailed Design Drawings and suitable for the chemical properties to be measured (e.g. temperature, conductivity, etc.).

3. Instruments having remote display or a calculation function shall also record same values and be readable from the instrument locally.

4. Accuracy ± 1 % of full scale with transmission distance of minimum 1 km.

5. Input voltage shall be 220 V AC and if the measuring equipment needs a different operation voltage level a transformer shall be supplied as a combined unit together with the measuring device.

12.24.2 Electro Magnetic Flowmeters

1. Electro magnetic flow meter shall operate on a magnetic field basis having no mechanical sensor head.

2. Meter shall consist of a combined sensor and transmitter to convert input data to analogue output 4 to 20 mA. Flow meter shall be equipped with device which shall send output signal to a totalizer with pulse height 24 V DC and length 25 milliseconds equivalent to measured amount.

3. The arrangement of flow meter measuring system shall be done in such way that total un-interfered transfer distance shall be maximum 200 m (e.g. built-in amplifier).

4. The meter shall be not resetable type after installation. Enclosure shall be minimum IP 68.

12.24.3 Pressure Transmitters

1. Pressure transmitters shall consist combined sensors and transmitter to convert input data to analogue output 4 to 20 mA.

2. Mounting shall be in the horizontal position. Enclosure shall be minimum IP 65.

12.24.4 Level Meters

1. Level meter shall consist on combined sensors and transmitter to convert input data to analogue output 4 to 20 mA.

2. Mounting shall be in the horizontal position. Enclosure shall be minimum IP 65.

12.25 MEASURING CONTROLS

12.25.1 Pressure Switches

1. Pressure switch shall be that type suitable to be installed by means of devices for the location shown on the Detailed Design Drawings.

2. The minimum and maximum pressures shall be possible to be adjusted and the contact shall operate so that when pressure is reached maximum contact opens, and when minimum pressure reached contact closes. Connection accuracy shall be minimum 0.2 bar.

12.25.2 Level Switches

1. Level switches shall be that type suitable to be installed by means of devices in the positions shown on the Detailed Design Drawings.

2. Level switches installed in open tanks shall be floating type provided with the facility to allow adjustment of the low and high levels and shall consist of two independently operating potential free contacts indicating both positions. Installation shall be from the top of tanks.

3. Level switches installed in covered tanks shall be the floating type mounted horizontally. Switches shall consist of one potential free contact indicating position.

12.26 BOARDS, PANELS AND GENERAL PRINCIPLE FOR PUMPING

12.26.1 General information

The general principle for pump operation and control is that the pumps shall be started or stopped manually from the Control Board pushbuttons when selected for “Local” control.

The selector switches shall be located on Control Board. Control Board shall be installed and located in the pumping room close to pumps.

All alarm and position lights shall be provided with engraved text. Text shall be in Romanian language. Alarms should be duplicated by alarm bell sound.

12.26.2 Boards and Panels

The board for pumping station shall be built from factory made zinc-phosphate standard size steel plate (minimum 1,5 mm thick) cubicles, which together with steel framework shall form a robust structure for cables and equipment. The surface treatment shall be epoxy powder painting. Color is to be the manufacturer's standard color.

Number of starts in 24 hours shall be suited to operation conditions, min. 2 times per hour, and all equipment used for construction of boards shall give possibility for this frequency of starts for sustained periods without any form for damage of equipment.

The internal wiring shall be identified with reliable markers having the same information as the point to be connected to the drawings. All equipment shall be clearly marked following the codes on the Drawings. Terminal blocks used for different voltages shall be clearly and reliable separated.

12.27 CABLES

The minimum size of conductors used shall be 0,75 square mm for control circuits wiring and 1,5 square mm for power circuits.

Power cables shall be grades for 600-1000 Volt for Low Voltage (LV) application for installation outside booster pumping stations shall be AXPK 4G95 1kV or AXPK 4G16 1 kV .

The following types of cables shall be used inside pumping stations:

- Cables for general power distribution within buildings, and cables underground, shall be copper cored PVC armoured cables, complying with IEC-standard.
- Cables run in conduits and pipe systems and shall be copper cored PVC insulated cables, complying with IEC-standard.
- Cables for motor installations shall be copper cored PVC armoured cables with screen, complying with IEC-standard.
- Cables for instrumentation and PLC input/output signals shall be twisted pair copper cored PVC armoured signal cables with screen (shielded), complying with IEC-standard.

Cables, except those laid in ground, shall run in horizontal cable troughs or in ducts and shall be firmly supported and fixed.

Single runs of PVC armored cables shall be supported by use of PVC cable clips. Multi-cable runs of PVC armoured cables shall be fixed into heavy gauge galvanised steel cable trays and supporting steel work.

Non-armoured PVC cables shall be installed in conduits or plastic pipes.

Cables and cable cores shall be identified at both ends by means of sleeve bands like Partex PK bearing the cable/core reference number, which shall relate to the reference number shown on the drawings. Where multiple cables are laid in troughs, ducts, clipped on ladder over long runs through several rooms in buildings, or laid in the ground closely together, intermediate markings to identify specific cables shall be applied.

Where cables are installed in ducts, the cables shall be identified with the cable reference number within each cable draw chamber.

In the cables the individual conductors must be identifiable either by colour or conductor number.

Color codes for cables shall be as follows unless otherwise is agreed with the Engineer before the cable works are started:

Earth: Green/Yellow

Neutral: Blue

12.28 LOW VOLTAGE SWITCHBOARD

Switchboards must be made with 10% expansion capacity.

Surface treatment: A very high corrosion resistance is desired. The frames shall be of 2,5 mm steel. Side plates and front plates shall be of 2,0 mm steel.

Switchboards must be divided into cubicles. Door structures and hinging shall be designed to ensure that doors do not deflect, drop or distort due to their own weight and/or the weight of mounted equipment on the doors.

There must be shielding plates between all components (MCB's, contactors, relays, etc.) and their connection terminals.

The switchboard must be ventilated so that the interior temperature in the switchboards does not exceed 40 °C under normal conditions.

Each part of the switchboard shall be fitted with an anti-condensation heater with an adjustable thermostat. The heaters shall be rated to maintain the interior temperature 5° above the air temperature outside the switchboard.

The total switchboard shall perform a total selectivity at maximum and minimum short-circuit currents.

The Switchboard must be fitted with DIN rail (except for main feeders). Switchboards must be equipped with a section for cable trunking for at least every two modules with switchboard equipment.

All wires/cores for any automatic system as well as for the PLC-system shall be terminated to separate terminal blocks. Terminal blocks must contain 10% available extra terminals. Terminal blocks to PLC must be of segregation type.

All electrical switchboards shall be fitted with a separate Protective Earth (PE) bus-bar (fitted in the full length of the bottom of the switchboard and the full height of each cable trunking section).

The main switchboard shall be divided into relevant sections and with separate section switches according to this dividing.

A clear physical separation shall always be kept so that electrical installations belonging to the building are always separated from installations belonging to the process. Minimum enclosure in switchboards between the different types of installation is IP 2X.

Short-circuit protection, overload protection and other thermal protection shall be based on MCCB's (Moulded Case Circuit Breakers) and MCB's (Miniature Circuit Breaker).

At each switchboard a surge arrester shall be installed according to the actual earthing system to protect against lightning and other electromagnetic influences.

The switchboard shall as far as possible be built as a non-fuse installation.

In general, the Switchboards will be installed inside pumping station control room. Switchboard shall include at least the following devices:

- Selector /Operating Switches
- Motor control Remote – 0 – Local - Auto
- Push Buttons (Green for start, reset and open; Red for stop and close
- Motor control "Start", "Stop" "Emergency Stop"
- Voltage monitoring device
- mA- meters for monitoring motor's current in one phase
- Indicator for monitoring pressure

- Indicator for monitoring flow rate (if necessary)
- Indicator for monitoring water level in reservoirs (if necessary)
- Alarm Bells, sound level of minimum 100dB when energized. Reset button
- Graphical display
- PLC or other equipment necessary for pumping station operation and pumps work monitoring (if necessary)
- Extra space for future communication system

12.28.1 Short circuit calculations

The Contractor shall calculate the short circuit level for the switchboard. For the entire power installation a compensation according to the demands of the local authorities shall be calculated, however, not less than Cos phi = 0.9.

The switchboard is to be built-up and equipped in accordance with IEC standard as well as the demands of local authorities to short circuit protection.

The following information shall be included in panel labels:

- Manufacture and the type of construction
- Un (V), In (A), fn (Hz), Ith (kA), Idyn (kA), IP

The insulation test shall be carried out at 2 500 V for 1 minute

The final lay-out design of the Switchboard shall be made by the Contractor and agreed with Engineer. Following minimum requirements described below:

- each circuit breaker and other items of equipment shall be logistically in one group in their own cubicle and on the door shall be clearly marked the purpose of the group.
- power cables shall be connected directly to the apparatus cubicles through the gaskets
- doors shall be provided with a rubber gaskets, fixed lock either handles and hinges to enable doors to opening at least 120 °.
- the construction shall ensure high operating reliability and personnel safety, The Switchboard shall be free standing with rigid base on the floor.
- the power distribution inside the Switchboard shall be made with copper busbars.
- the Switchboard will be supplied from the existing 10/0.4 kV substation

12.28.2 Packing and care of Switchboard

The switchboard shall be delivered to site totally enclosed in protective packaging, reasonably proofed against the entry of dust and rainwater during unloading and against the entry of dust prior to installation. Provision shall be made for lifting and handling the protective packaging in position.

The space available for storage on site and for maneuvering the switchboard into its installation position shall be taken into account in designing and, if necessary, sub-dividing it for delivery. Account shall also be taken of the need to remove or temporarily reposition any existing control equipment from the building while the new switchboard is stored here.

If, after the switchboard is unwrapped, any dust generating operations arise, the switchboard shall be completely sheathed in polythene sheet to the Engineer satisfaction. It shall remain protected until dust-free conditions are restored to the Engineer's satisfaction

12.29 FREQUENCY CONVERTER

Frequency converter shall be micro processor based, fully configurable and fitted with an internal multilingual alphanumeric control panel with keypad display for user interface for monitoring, adjusting parameters, manual control and configuration of the converter. Frequency converter shall have an extensive library of pre-programmed application macros to allow rapid configuration of its in and outputs.

Voltage	400 V
Enclosure class	IP 55, self cooling

Frequency converter shall include following components:

- Low voltage air circuit breaker
- Semiconductor fuses
- Current transformer 4-20mA transducer and A-meter in one phase
- V-meter
- Ventilation unit
- Auxiliary relays

12.30 SOFT STARTER

Softstarter with electronic overload relay shall include the following components:

- low voltage air circuit breaker
- bypass contactor;
- semiconductor fuses;
- running time meter;
- terminator relays or PT100 monitoring;
- auxiliary relays;
- current transformer, 4-20 mA transducer and A-meter in one phase;
- ventilation unit;

12.31 GENERAL REQUIREMENTS FOR PLC. PROPERTIES OF PLC SOFTWARE

During normal operation all pumps shall be controlled automatically by the PLC system installed in the Switchboard.

It shall be possible to switch each pump (with on/off) individually between local mode (control from the Switchboard) and automatic mode (control from the PLC). The choice between local and automatic mode shall be carried out locally at the switchboard respectively at the frequency converter. The choice of mode for a pump shall be communicated to the PLC by a binary signal (the signal contact shall be closed when the pump is in automatic mode). Local is mode only to be used for testing purposes.

Each pump motor (both on/off controlled motors) shall be monitored by a binary signal, normally closed contact, to the PLC. The signal shall be activated by a hardware error in the motor.

If automatic mode has been chosen for a motor, and if the above-mentioned fault signal is not active, then the motor shall be automatically controlled from the PLC. Manual control of a motor from the operation panel is not required.

If one or more motors becomes unavailable for the automatic control, because of a fault or because of switching into local mode, then the automatic control shall continue to function in a suitable way for the other motors that remain available for automatic control.

The booster pumping stations and borehole pumps shall be able to operate in a fully automatic mode and in fully or partly manual mode.

It shall be possible to control the automatically controllable components (the components that can be controlled by a program, for example a pump or a sectioning valve at the three levels A, B and C:

The software in the PLCs that takes care of the process control and monitoring shall preferably be based on the IEC 1131-3 standard. Graphic programming should be possible.

The PLC programs shall to the largest possible extent be composed of standardised modules that can be individually tested and documented.

The variables that correspond to the standardised components (for example sectioning valves) shall be organised in standardised structures that correspond with the standardised program modules that carry out the functions for the individual components. These program modules shall be compatible with the corresponding functionalities of a future SCADA system (for example symbols for display and commands, alarm presentation, and data logging). The same applies to the data structures for the standardised control functions (for example analogue regulation).

Functions for Process Components

The following sections specify general requirements. The Contractor shall design the data structures and program modules so that these requirements are fulfilled in the best possible way.

12.31.1 Analogue Measurements

The signal level for analogue measurements shall be 4-20 mA as a standard.

The raw value from the A/D converter shall be converted to an internal representation in the process station with technical units and sign, if relevant. The conversion shall in most cases take place by linear operations, offset and scaling, but it shall also be possible to apply non-linear operations, for example square root extraction.

If the signal falls below 4 mA or rises above 20 mA, the measurement shall be regarded as being invalid, and an alarm shall be generated. The state “Invalid” shall be shown on the display, for example by a different colour. An invalid signal cannot be used in automatic functions, in analogy to a passivated signal (see above).

12.31.2 Monitoring of Transition Time

If the PLC issues a command for switching a process component from one discrete state to another, it shall monitor, on the basis of feedback signals that the state of the component changes according to the command within a predefined time, the transition time. This applies for example to sectioning valves (open/close) and pumps (start/stop).

If the state of the component does not change within the defined transition time, an alarm shall be generated in the PLC.

For each component type a default transition time shall be defined. It must be possible to change this time later, by a simple procedure, without recompiling the program.

Monitoring of the transition time is not required for commands that cause the change of an analogue state, for example the degree of opening of a regulating valve or the rpm of a pump with speed regulation.

12.31.3 Monitoring of Operating Hours and Number of Starts

For all rotating machines (for example pumps), which are controlled by a PLC, the operating hours and the number of starts shall be monitored, preferably in the process station.

The operating hours shall be displayed and recorded. For each component it shall also be possible to define upper limits for the operating hours and the number of starts from a future SCADA system. When such a limit is exceeded, an alarm shall be generated.

It shall be possible for an authorised operator to change, and especially to reset, the recorded operating hours and number of starts.

12.31.4 Sequence Control

A PLC shall be able to carry out automatic sequence control. An automatic sequence consists of a number of steps that are executed in a predetermined sequence. It can for example be the sequence for starting a pump and running it into parallel operation with the other pumps of the well-field or booster pumping station.

Each step of the sequence represents a switching action. When a step becomes active, one or more commands are given, and the execution of these commands is monitored by logical criteria that are based on feedback signals from the process. When all criteria for a step have been fulfilled, the next step of the sequence is activated, either at once or after a predefined delay time.

For each step a run time is defined. If not all criteria have been fulfilled at the end of this time, the sequence stops and an alarm is generated.