IJMAA – ODOR CONTROL SYSTEM

JEBB JENNINE SOLID WASTE TREATMENT FACILITY

TENDER DOCUMENTS

General Technical Specifications
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1 GENERAL TECHNICAL REQUIREMENTS

1.1 SCOPE OF WORK

The scope of works of the present contract comprises the construction an odor control and treatment unit pertaining to the existing Jebb Jennine solid waste treatment facility. Indeed, one of the major challenges towards the social and environmental acceptance of the facility is the waste gas produced due to degradation of organic waste in the facility’s composting plant, which needs to be extracted and treated.

As such, in order to ensure the environmental sustainability and social acceptability of the facility’s operations, the present project aims to construct, install, test and commission an odor control system for the facility in Jebb Jennine.

The system is composed of a biofilter odor control system working on the basis of biofiltration, equipped with a pre-scourber to humidify the inlet fouled air and in provision for peak ammonia concentrations; complete including all associated civil, electrical and mechanical works and including the installation of air extraction fans (centrifugal fans to extract the air from the facility composting plant, and axial fans to push air from the sorting hangar to the composting hangar; with their associated air extraction and collection systems) and other associated amenities as described elsewhere in these Tender Documents.

The project site is located in the Bekaa region of Lebanon, namely the Jebb Jennine solid waste treatment facility located in the village of Jebb Jennine, which has recently been commissioned for the Union of Municipalities of Bouhayra.

1.2 PROVISIONS OF SURVEYING INSTRUMENTS

The Contractor shall prior to commencement of the work provide for the exclusive use of the Supervisor and for the whole duration of the works two (2) complete sets of total station surveying equipment comprising:

- 1 no. automatic levels;
- 1 no. theodolite reading to 20 seconds of arc;
- 1 no. total station consisting of a theodolite reading to 1 seconds of arc, electronic distance measurement apparatus (EDM) complete with data logger and tripod;
- 4 Meters staff;
- 50 Meter steel tape;
- 30 Meter liner tape;
- Tripods;
- Ranging rods;
- Surveying pins;
- Field books;
- Marking Materials;
- Torch.

Such total stations shall be new, of modern type, accurate, in first class condition and shall be insured and maintained and kept safe by the Contractor to the satisfaction of the Supervisor, and shall remain his property.

The Contractor shall provide all necessary facilities, all necessary additional instruments, appliances, labour and chainmen, etc. which the Supervisor may require for checking the setting out of the works.

1.3 CONTRACTOR’S STAFF FOR SUPERINTENDENCE

The minimum number and qualifications of the Contractor’s team for the superintendence of the works shall be as listed in Volume 1 of the Tender documents “Instruction to Tenderers”, but this shall not relieve the Contractor of his responsibility to provide sufficient number of personnel of the required skill to superintend the works.

The Engineers shall be members of the Lebanese Order of Architects and Engineers (not applicable for foreign European Engineers)

The superintendence team stated above shall be capable of reading and speaking fluent English as well as Arabic or French, and must have the written approval of the Supervisor who shall have the authority to withdraw his approval at any time. If such approval shall be withdrawn by the Supervisor, the Contractor shall, after receiving a written notice, remove immediately from the site of the works whoever has been disapproved of, be it his Representative on the site or any of his Engineers or technical assistants, and shall replace him within the time stated by the Supervisor with a substitute approved by the Supervisor.

The Contractor shall advise the Supervisor in writing in advance, of any proposed change in the Contractors staff, and shall obtain the written approval of the Supervisor before putting any such change into effect.

1.4 ELECTRICITY AND WATER FOR WORKS

The Contractor shall make his own arrangements for, and bear all costs for the supply of any electricity and water that he may be required for and in connection with the works. He shall maintain, alter and/or supply lines as may be required in accordance with local regulations and to the satisfaction of the authorities and the Supervisor. All temporary services shall be removed on completion of the works, and the Contractor shall make good all ground and areas disturbed, to the approval of the Supervisor.

The Contracting Authority will not be responsible for any breakdown in supplies, limits of supplies, or load shedding, and the Contractor shall arrange for any emergency supply etc. that may be required by him. In the event the Contractor uses his own installations for the temporary supply of electricity he shall install. All necessary overload cutouts and fuses between the temporary services shall be removed on completion of the works, and the Contractor shall make good all ground and areas disturbed, to the approval of the Supervisor.

The Contracting Authority will not be responsible for any breakdown in supplies, limits of supplies, or load shedding, and the Contractor shall arrange for any emergency supply, etc. that may be required by him. In the event the Contractor uses his own installations for the
temporary supply of electricity. He shall install all necessary overload cutouts and fuses between the temporary wiring and the main incoming supply in order to safeguard other users of the public supply all in accordance with the instructions of the Contracting Authority.

1.5 TELEPHONES

The Contractor shall make any required arrangements and shall bear all costs for the supply and use of telephones on Site, and for the removal on completion. The Contractor shall make good all ground and areas disturbed to the approval of the Supervisor.

1.6 SITE ACCOMMODATION

The Contractor shall provide and maintain all temporary Site offices, etc. required for the execution of the works.

Offices for accommodation of the Contractor’s Representative and staff shall be open at all reasonable hours to receive notices or other communications served upon the Contractor.

These offices shall be provided with telephones.

All temporary buildings shall be situated in approved locations.

One fully furnished office shall be reserved for the use of the Contracting Authority and the Supervisor.

It shall be the Contractor’s responsibility to make arrangements for, and bear all costs associated with the acquisition and use of such areas.

It shall be the Contractor’s responsibility to make arrangements to keep the Site clear of obstructions from whatever cause for the duration of the Contract.

All pre-fabrication of material prior to incorporation in the Works shall be carried out in workshops or approved areas away from the actual place of work to avoid unnecessary congestion and nuisance.

Sanitary facilities for the use of persons employed on the Works shall be provided and maintained by the Contractor to the extent, and in such manner, and at such places as approved by the Supervisor and the concerned authority. The Contractor shall make all arrangements for the proper discharge of sewage, and drainage from / or in connection with the Works and shall maintain the same to the satisfaction of the Supervisor and the concerned authority as long as may be required.

1.7 SAMPLING FIELD TESTING

Sampling and testing for soils pipes, steel and concrete as called for in the General Specifications, shall be performed in an independent approved testing laboratory in accordance with the latest tests specified therein and at the Contractor’s expense for the whole period of execution of the works.

However, the Contractor shall provide all apparatus and equipment, and shall bear all expenses for approved skilled technicians to perform in-situ testing such as, but no limited to:

- Density of soil in place by the sand-Cone method, ASTM D 1556-74
- Slump of Portland cement concrete, ASTM C 143-74
- Concrete test specimens, making and curing in the laboratory, ASTM C 192-76
The Contractor shall at all times, when requested by the Supervisor, order all additional apparatus, materials and spare parts required to perform the tests and shall provide and maintain all such materials, and replace all broken apparatus for the whole duration of the job.

The Contractor shall obtain the approval of the Supervisor for the program of tests, number and location of equipment or material to be tested. The program of testing shall be in accordance with recognized West European Standards or American Standards for the manufacturing and supply of equipment of material.

The Contractor shall bear all expenses for sampling and delivering samples for testing at the independent testing laboratory.

1.8 INSPECTION AND TESTING DURING MANUFACTURE

Materials, pipes, equipment or any part thereof, and workmanship may be inspected and tested by the Supervisor during all stages of manufacture and assembly at the manufacturer’s or the supplier’s work.

The Contractor shall submit a 3 week written notice to the Supervisor to allow him or his representative to be present to witness all examinations inspections and tests.

For all inspections and tests, the Contractor shall engage a third party testing authority, such as LLYODS or equivalent, and shall pay all expenses incidental to such inspections performed by the third party inspector. The Contractor shall obtain approval of the Supervisor for the program of tests, number and location of equipment or material to be tested.

The Contractor shall submit for the Supervisor’s review and approval, and inspections and tests schedule detailing all tests intended to be conducted at manufacturer’s works from the procurement phase of raw materials to the finished product. The inspections and tests schedule shall indicate the proposed location and date of test.

The Contractor shall supply any shop or detailed drawing that may be requested by the Supervisor during inspection and testing.

Materials, fabrication, assemblies that do not meet the requirements of the Contract Documents shall be rejected, revised, replaced and / or retested, whichever applies, until the final product meets all the requirements of the Contract Documents. All work performed in order to satisfy these conditions shall be the sole responsibility of the Contractor. Review or inspection by the Supervisor of his representative shall not constitute acceptance of the work.

All tests shall be in accordance with the relevant approved B.S. or ASTM standards unless otherwise specified or requested by the Supervisor.

1.9 TEST CERTIFICATES BY INTERNATIONAL INSPECTION OFFICE

The Contractor shall submit to the Supervisor, test certificates issued by and internationally recognized inspection office, approved by the Supervisor, certifying that all supplied equipment, materials, construction, duty and functions are in agreement with the requirement of these Specifications and accepted Standards.
1.10 STANDARDS

Where standards, codes of practice, and specifications issued by any of the organization hereinafter referred to the following abbreviations are used in the Contract Documents they shall have the meaning set forth opposite each:

AASHTO  American association of State Highway and Transport Officials
ACI       American Concrete Institute
AFMBA     Anti-Friction Bearing Manufactures Association
AGA       American Gas Association
AGMA      American Gear Manufacturer's Association
AIEE      American Institute of Electrical Engineers (Institute of Electrical and (IEEE) Electronics Engineers, Inc)
AISC      American Institute of Steel Construction
AMCA      Air Moving and Conditioning Association
ANSI      American National Standards Institute
API       American Petroleum Institute
ASCE      American Society of Civil Engineers
ASHRAE    American Society of Heating, Refrigeration and Air Conditioning Engineers

ASME      American Society for Testing & Materials
AWWA      American Water Works Association
BS        British Standard Specification
BSPT      British Standard Pipe Thread
DIN       Deutshes Institut für Normung (German Institute for Standardization)
EN        EURONORM
IEC       International Electrotechnical Commission
ISO       International Organization for Standardization
NBS       National Bureau of Standards
NEC       National Electrical Code; latest Edition
NEMA      National Electrical Manufactures Association
SMCNA     Sheet Metal and Air Conditioning Contractors National Association, Inc.
NPT       National Pipe thread
USS Gage  United States Standards Gage
The reference to standard pertains to the latest editions. Copies of the applicable standards must be submitted to the Supervisor.

Wherever particular to standards are not specifically mentioned in the documents, the Contractor shall use American, British or other Standards acceptable to the Supervisor, provided that standard’s not in English shall be submitted in certified translation.

1.11 PERIODIC REPORTS

The Contractor must present to the Supervisor monthly summary reports showing the following:

- Labour force working during that period;
- Quantity and quality of materials and equipment used during that period;
- Quantity of work executed;
- Graph showing the relation between the executed portions of the works and the corresponding portions in the work program.

The Contractor shallrove to the Supervisor upon his request, the correctness of the above mentioned reports without having the right to use such documents to support a claim for any extra payment or compensation whatsoever in regard or in relation to such report. The Contractor shall, in addition, when called for by the Supervisor, produce and/or sign daily and weekly reports as required in support of proper documentation of the progress and standing of the Works.

1.12 PROGRESS MEETINGS

During the course of the Works, and at the demand of the Supervisor, progress meetings shall be held regularly once every two weeks of when deemed necessary, in order to review the progress of the Works and insure that full compliance with the various sequences of the Contract are maintained. Minutes of such meetings will be recorder. Copies will be distributed to all parties concerned and full effect shall be given to all instructions contained therein.

Every two weeks, in advance of such meetings, The Contractor shall submit to the Supervisor details in writing of that portion of the works he proposes to construct during the coming two weeks with details of the plant and methods which be proposes to employ. These proposals shall be discussed and approved at the meeting. Action shall be taken by the Contractor to implement them immediately thereafter.

1.13 PHOTOGRAPHS

Once every month and as directed by the Supervisor, the Contractor shall, at his expense, furnish the Supervisor with digital color photographs with a soft copy.

1.14 PLANT AND EQUIPMENT

The Contractor shall submit, with his tender, a detailed list of plant and equipment which he undertakes to provide as minimum required on site to carry out the works. This list shall be as complete as possible, and shall include the type of plant and equipment type, manufacturer, model identification number, year of manufacture and time required at the site.
The Contractor shall bring to the Site all listed items, and in no case, thereafter, shall the Contractor remove from the site item of plant and equipment, or potions thereof, without the prior written consent of the Supervisor.

All plant and equipment necessary for the construction of any type or section of the works must be on site and inspected and approved by the Supervisor prior to the commencement of that particular type or section of the Works. Any plant, equipment or portion thereof, which becomes worm or defective, shall be immediately repaired or replaced to the satisfaction of the Supervisor.

The Contractor shall submit original catalogues specific to the requirements of all the proposed equipment complying with the Specifications at the time of submitting his tender. The catalogues shall be in English.

The Contracting Authority reserves the right to visit the place or places of manufacture of all plant, equipment and materials for the purpose of inspection and testing. The Contractors shall arrange for all reasonable tests and demonstrations to be performed, or other evidence to be provided, to satisfy the Supervisor of the quality of the items being inspected.

1.15 SUPPORTING WORKS
The Contractor shall provide all labour, materials, scaffolds, coverings equipment tools, implements, and accessories required to carry out the specified Works and shown on the Drawings to the full satisfaction of the Supervisor.

1.16 INCIDENTALS
The Contractor shall supply and install all the incidentals and sundry component necessary for the complete execution of the Works, and for the proper operation of each installation. All such items shall be of the same standard of materials as the equipment associated with, and shall constitute no extra cost to the Contracting Authority.

1.17 COORDINATION
The Contractor shall be responsible for coordinating the work of the electromechanical services with that of the other trades and prevent damage to work of other trades already completed, and at the same time protect the electromechanical works from damage during the execution to the other trades.

1.18 SUBMITTALS
The Contractor shall submit with his tender an outline bar chart programme of work and brief details of major works and number of working crews he proposes to use.

The Contractor shall submit a bar line programme within four weeks of the commencement Date of the Contract for the Supervisor’s review and approval. The programme shall be updated monthly from the current information available.

The Contractor shall also submit details of the construction plant and labour force which he proposes to employ and shall broadly describe his proposed construction method and shall include a comprehensive work programme for his order procedure of work.

The details of the construction plant shall include, the make type, capacity or rating, and the number of units. Details of the labour force shall include senior staff, trade of specialist categories indicating the proportion of local labour which the Contractor expects to employ,
and shall show the variation in staff and labour levels and their distribution throughout the
duration of the Contract consistent with the programme.

The Contractor shall adhere to the approved programme and if any delay occurs, he shall
immediately prepare a revised programme and submit it to the Supervisor for approval. The
approval of the revised programme will not absolve the Contractor from any penalties set forth
beyond the period of the Contract.

In preparing all programme and methods of work, the Contractor shall take into account the
following requirements:

a) The Contractor shall ensure that the progress of the works is in accordance with
the approved programme(s);

b) It shall be the responsibility of the Contractor to obtain all necessary permissions to
proceed with the works, and to comply with all laws and regulations.

c) The Contractor’s attention is brought to the presence of other Contractors working
in the vicinity on other construction and pipe laying contract. The Contractor shall
programme and carry out the Works accordingly.

d) The Mobilization Period, which shall be used for setting up site offices and
organizations of key members of staff, shall not exceed 60 calendar days from the
date of notice to proceed and shall from part of the Period of Completion.

e) Upon expiration of the Mobilization Period, the Contract shall be expected to have
completed or be able to produce evidence of being well advanced in the
procurement of all plant, labour, and materials necessary for the execution of the
works and have completed construction of the site establishment, including all
offices and site facilities, such as storage yards, fabrications shops, and site
laboratory.

f) In the event mobilization is not completed within the specified period, then no
Advance Payment Certificate will be issued until such time as mobilization has been
completed in the Supervisor’s opinion.

g) The Contractor shall allow in his programme and tender for the following;

- The Contractor may have to work in more than one location on site.
  These work locations shall be subject to the approval of the Supervisor.
  The Contractor shall identify these work locations on his working
  programme.

- The Contractor may have to work out of sequence due to an interruption
  of his work and come back to complete this work or will have to change
  his programmed work location. The Contractor shall not claim any
  additional time or cost for out of sequence work.

Notwithstanding item 1.14, and as soon as possible after the date of signing the Contract, and
within 90 calendar days thereof, the Contractor shall submit for approval a final and complete
set of submittals, incorporating all the Supervisor’s comments, and including all information,
data, catalogues and samples (samples to be clearly marked) to illustrate all the materials and
equipment intended to be used. Within 30 days from the date of receiving the detailed
information, the Supervisor shall communicate his approval or rejection. The Contractor shall, upon rejection of any of the materials or equipment proposed, submit within 30 calendar days of such rejection alternative offers within 30 calendar days from the date of receiving the alternative offers the Supervisor shall communicate his approval/ rejection.

No orders for equipment or materials shall be placed by the Contractor before obtaining the written approval of the Supervisor. Only approved materials shall be employed in the Works. Materials or equipment installed without prior approval shall be removed and replaced by approved ones at the expense of the Contractor.

Samples of pipes, cables, conduits, wires, switches, meters, accessories, valves, jointing, compounds, tapes, gauges, strainer, welding, electrodes, welding flux, paints and all other complementary and small items used in the job shall be submitted by the Contractor as specified herein-above. These samples shall be correctly labeled and shall be kept in a locked room under the control of the Supervisor. Samples shall not be used in the installation.

Only manufacture’s performance data and certified factory drawings giving full information pertinent to the adequacy of the submitted equipment shall be for approval.

Submittals shall be made in a manner to ensure complete information regarding what is being offered and in a manner that facilitates easy filing and ready access to all date, throughout the contract period.

Where data and certified drawings or other required information regarding what is not available until after orders have been placed, the Supervisor may give provisional approval until all requested information and drawings are supplied for his approval. It is the Contractor’s responsibility to ensure that all necessary information is supplied to the Supervisor in accordance with the progress of the Works.

Should the Supervisor give provisional approval, of an order, due to lack of complete information and should the missing information not eventually meet with his approval, the Supervisor will not be held responsible for any delays or extra expenses incurred.

The Contractor, shall in this case, shall bear all direct and indirect expenses related to the unproved order and shall re-submit for materials or equipment to obtain approval.

1.19 COMPLEMENTARY ITEMS

The Contractor shall also submit to the Supervisor, for his approval, all accessories and parts necessary for the construction, whether specified or not.

1.20 CONTRACT DRAWINGS AND SPECIFICATIONS

The Contract Drawings and specifications provided to the Contractor with the Contracting Authority’s Detailed Design shall be considered as basis of the work to be done and of the arrangement desired. The Contractor shall be responsible for detailed execution based on these drawings. The Contractor may only execute his works based on drawings marked clearly by the note “Approved for Execution” by the Supervisor.

The Drawings and specifications are complementary and any material equipment or work called for by any, shall be furnished as if called for by all.
Should any conflict occur between the Drawings and the Specifications, the Supervisor shall interpret them and determine the manner or item with which the works shall be carried out. If any deviation from the Specifications is deemed necessary by the Contractor for the proper design and safe execution of the works, detail of such deviation, and the reasons thereof, shall be submitted, as soon as practicable, to the Supervisor for approval. No such deviations shall be made without the prior written approval of the Supervisor.

The drawings of the Contracting Authority’s detailed design show the general arrangement and layout of the works and are binding. However the drawings are no workshop drawings and thus do not purpose to indicate all details. Such details have to be added by the Contractor within his workshop design once the final makes have been approved by the Supervisor. The Contractor shall not claim for any additional costs there from such action. In the case where several tolerances are indicated, the Contractor shall apply the most stringent tolerance.

1.21 WORKING AND DETAILED DRAWINGS

1.21.1 GENERAL

The Contractor shall submit for approval three copies of prints of workshop drawings for each part he intends to work on. Drawings shall be prepared to an approved format the maximum size shall be A1.

These drawings shall be submitted early enough to get the approval 30 calendar days prior to any installation or construction work, but not before submitting and getting the approval of the Supervisor for the equipment and other items shown on the drawings, or items necessary for the installations, as mentioned herein before.

The Contractor shall provide for at least 30 calendar days to get such an approval, besides the time needed for corrections and modifications, without delaying the progress of the work, and affecting the 30 calendar days period mentioned above, prior to the construction. This should be coordinated to conform to the general programme and schedule of work for all trades.

These drawings shall be supplemented by the manufacturers recommendations and drawings, and shall show in particular the exact details depending on the respective makes.

Workshop drawings shall be based on the Contracting Authority’s detailed design drawings and mainly include but not be limited to the following details:

- Location of anchors, guide support, equipment, layout of expansion joints, etc…

The plans shall be supplemented with the necessary sections at appropriate scale and installation levels.

The Contractor shall be responsible for the coordination of the different services together with the civil works on said drawings.

- Installation details for each piece of equipment to scale not less than 1/20 showing all relative weights, accessories, service connections and sizes, anti-vibration isolators, etc. and all other information needed for checking the installation.

- Construction details for all supports, anchors, guides, expansion joints and loops functioning for each piece of equipment, switchboards and the completion of the works.
- Schematics showing typical connections and ancillaries needed for the good functioning for each piece of equipment, switchboards and the completion of the works.
- Builder’s works necessary for the installation, without thereby implying any limitation, shall include the following:
  - All builder’s works in connection with fixing of equipment, supports, brackets, etc.
  - Cutting or forming all opening, mortises, chases, etc. in floors, walls and ceilings required for the Electro-mechanical installation.
  - Painting details for all exposed steel work in connection with supports for pipes, cables, conduits and equipment as specified.
  - All earth rock excavation, backfill concrete and all kinds of civil works

All above builder’s work to be carried out to the entire satisfaction of the Supervisor.

The Contractor shall show on said drawings any modifications or addition needed to suit the equipment to be installed, for the approval of the Supervisor.

All work done before obtaining the Supervisor’s approval shall be at the Contractor’s responsibility. The Supervisor in this case shall have the right to impose any alterations he may find necessary.

If after the approval of the drawing, it is found that any of said drawings does not conform to the conditions of contract, or the details do not conform with the original plans which were used as basis for the design, all changes in characteristics or materials involved due to these circumstances shall be done by the Contractor at no extra cost.

1.21.2 DISCREPANCIES AND OMISSIONS

The Contractor shall be responsible for any discrepancies, errors, or omissions in the workshop drawings and other particulars supplied by him whether such drawings and particulars have been approved by the Supervisor or not.

If anything necessary to the proper installation of operation of the Works omitted from the drawings and specifications, or if indicated incorrectly, the Contractor shall immediately call the attention of the Supervisor to this omission or inaccuracy, before work drawings are prepared. Should the Contractor fail to do so, he shall be held responsible and shall make good at his own expense such errors or omissions in any damages caused by such errors or omissions.

1.21.3 INTERFERENCE AND ERRONEOUS LOCATIONS

The Locations of electrical and mechanical equipment, devices, pipes, cables, conduits, valves, gates and similar items shall be properly coordinated between the Supervisor and the Contractor to avoid interference with other trades.

The Contractor shall be responsible for obtaining all necessary field measurement and information pertaining to such work or to other trades related or affecting such work.

In case of interference with other or erroneous location with respect to equipment or structures, the Contractor shall furnish all labour and materials necessary to execute and complete the work in an approved manner.
1.21.4 ACCESSIBILITY

Accessibility shall be maintained to systems and parts thereof requiring servicing and/or adjustment after installation. If the Contractor thinks that such accessibility is not given within the Contracting Authority’s detailed design he has to note it to the Supervisor’s attention and coordinate together with the Supervisor for providing proper access.

1.22 AS-BUILT DRAWINGS

The Contractor’s attention is directed to his obligations under the Contract to submit as-built drawings for all work executed by him. Such drawings shall include:

- Layout drawings for all structures;
- Layout drawings for all pipelines including all sizes and types of pipe and location of all manholes and chambers;
- Layout drawings for the complete electrical and mechanical installation showing the actual routing of cables conduits, wires, pipes, ducts. Etc. together with the exact size, type and location of valves, air outlets, socket outlet, switches, supports, anchors etc. Cable and pipes shall be properly labeled on drawings as per their respective labeling.
- Exact equipment installation detail all accessories fully defined.

The preliminary reception of works will not take place unless three copies and one original of these drawings have been submitted by the Contractor and approved by the Supervisor.

1.23 TRAFFIC REQUIREMENTS

Where temporary, partials road closures, road diversions or construction detours are required, the Contractor shall:

- Execute the work at time when the traffic is least congested. If, in the opinion of the Supervisor, the work may result in unacceptable inconvenience to traffic, the work shall be carried out during the night time.
- Carry out his various activities at such time and in such a manner that no disturbance is caused to the public.

- Provide safe pathways not less than 1.20 wide for pedestrians and traffic lanes not less than 3.5 m wide for vehicles, and controls traffic by means of traffic signals.
- Provide, in all cases, fencing, signs, light signals, floodlights, and watchmen to ensure that no mishaps will befall the public or properties as a result of the works.
- Reinstate to original condition and make good without delay.

1.24 UTILITIES

1.24.1 DEFINITIONS

"Utilities" shall mean services ranging from the water, gas and oil supply networks, electrical and telephone networks, poles, pylons, lighting columns and traffic signals, storm water drainage and sewerage networks as well as roads, gardens, squares, trees, and other public or private services.
1.24.2 SERVICES COORDINATION

The Contractor shall notify all ministries and authorities where services might be affected by the Works regarding his programme. He shall also submit every two weeks details of the work contemplated for execution in order to enable the service authority to inspect, and/or to indicate their services on the site, and/or take any measure deemed necessary.

The Contractor shall curtail his activities in areas where the services are being relocated by others until the relocation work is complete.

The Contractor must ensure that he pays all fees and obtains any work or excavation permit from the service authority necessary to allow him to carry out construction works in the vicinity of existing services.

1.24.3 PROTECTION OF EXISTING STRUCTURES AND UTILITIES

The Contractor shall refer to and comply with the current regulations and specifications of the service authorities before commencing any works adjacent to existing structures, buildings and other utilities. This requirement will not relieve the Contractor of responsibility for taking every precaution to avoid damage to these structures, buildings and other utilities, and he shall be held solely responsible for the cost of repair of all damages to these structures, buildings and other utilities, and he shall be held solely responsible for the cost of repair of all damages and other liability claims in accordance with the conditions of Contract and the Specification.

1.25 PUBLIC SAFETY AND CONVENIENCE

The Contractor shall not deposit the earth obtained from excavation, and/or store, or deploy equipment, necessary tools and plant, in locations that will affect the safety of the public, public services, or properties, and/or in such a way that impedes traffic, or pedestrians, and any other works, or public authorities, or private concerns.

The Contractor shall backfill promptly all trenches and openings to the standards required by the Supervisor and as specified in these Specifications.

The Contractor will be held responsible for the sufficiency of his safety measures and shall be liable for keeping the Works safe at all times.

1.26 DISPOSAL OF DEBRIS

The Contractor shall keep the construction site neat and clean to the satisfaction of the Supervisor by daily removal of unwanted material arising from demolished pipes and manholes, sewer cleaning, excavations, rubbish, temporary installations, and daily cleaning to remove wind blown and other debris. All debris shall be removed from the site to a public disposal location approved by the Supervisor. The disposal location may be at my distance from the project site, and may be changed by the Supervisor during the time of construction material at the approved location. The Contractor shall allow for this in his rates.

The Contractor shall keep the site free from insect and rodent infestation, and shall control offensive odors so as not to affect the environment. The Contractor shall ascertain, and comply with all requirement of the appropriate authorities for his sanitary precautions.

Upon final completion of the works, the Contractor shall clear away and remove from the site all remaining construction plant, surplus materials, rubbish, and temporary works of every kind, and leave the whole of the site clean to the satisfaction of the Supervisor.
1.27 TEMPORARY FENCING

Unless otherwise directed by the Supervisor, all open excavations and other hazardous areas shall be totally enclosed from all sides by temporary fencing.

In all cases, details and locations of the temporary fencing proposed by the Contractor shall be submitted to the Supervisor for approval prior to installation. The Contractor shall not commence any works until the associated temporary fencing is erected and the installation has been approved by the Supervisor.

Damaged sections of temporary fencing shall be repaired or replaced promptly to maintain all times the standard of fencing and installations as initially approved. Temporary fencing shall not be removed from any location without the prior written approval of the Supervisor. The name of the Contract and Contractor shall be affixed at regular intervals on these temporary fences.

Unless otherwise agreed with the Supervisor, temporary fencing for urban areas shall have a minimum overall height of 2.0 m manufactured in section from chain link fence or other approved material. The Supervisor shall direct which areas of the Site shall be considered as urban areas for the purposes of temporary fencing. The Supervisor’s decision shall be final.

In non-urban areas the style of fencing shall be determined by the locations of open excavation or hazardous area, its proximity to public through fares and the anticipated time for which the fencing must remain.

1.28 FAILURE OF THE CONTRACTOR TO COMPLY

Should the Contractor fail to comply with one or more of the requirement of clauses 1.26, 1.27 and 1.28 or the requirement of section 16 of these Specifications, he will be given written notification by the Supervisor of the default and shall commence execution of the work required to comply with the requirements of these Clauses, within 24 hours of receipt by him of such written notification.

Should the Contractor fail to commence execution of such works within the required time, the Supervisor may suspend all work on the Contract. The Contracting Authority may execute (or have executed by others) the work directed by the previously issued written notification and deduct all costs incurred from amount due, or becoming due to the Contractor, and/or shall recover the said amount as a debt due for payment by the Contractor. The suspension of work shall not relieve the Contractor of his responsibility to complete the contract on time nor will he be entitled to any additional compensation or an extension of Time for Completion because of this suspension. The suspension of all work on the project shall automatically be rescinded on completion of the notified works to the satisfaction of the Supervisor.

1.29 PREVENTION OF NOISE AND VIBRATION

Every care should be taken to minimize noise and vibration. The Contractor must carefully check the construction detail, the noise and vibration characteristics of the equipment and devices supplied by him to ensure that no objectionable effects will be produced in the occupied areas.

Any additional or changes in the structure necessary to ensure compliance with the noise and vibration requirement should be clearly stated in the submittals and shown on the working drawings.
Any vibration isolators, isolating bases, flexible connections, silencers or other acoustic treatment of anti-vibration precautions necessary should be included in the rates for the equipment.

Equipment intended for use at night near inhabited areas shall not exceed 60 Decibels at a distance of 5 meters from the inhabited area.

1.30 PROTECTION OF STREETS AND SIDEWALKS

The Contractor shall protect streets and sidewalks and shall repair damage caused by construction activity. The Contractor shall comply with local rules and regulations in connection with the use of streets.

The Contractor shall protect all private roads and walkways and shall maintain them during the course of the work. He shall repair all damages caused by him during construction.

1.31 LIGHTING AND POWER

The Contractor shall provide temporary lighting and power lines for the Works. The Contractor shall also be responsible for payment of all other fees and charges for providing temporary mains to the site.

1.32 EXISTING SERVICES

The Contractor is to include for all temporary works to maintain and protect existing power, lighting, water and telephone services while the Works are being executed. Temporary shutdown of the services shall only be made with the prior approval of the Supervisor and the owner of the services.

The Contractor is required to allow for the protection and maintenance of all pipes, ducts and cables met in excavations, for keeping all ditches, gullies and channels clear and unobstructed, and for making good any damage caused to public or private roads, paths, kerbs and drains, and to pay all costs and charges incurred.

1.33 MARKING AND LABELLING

1.33.1 GENERAL

The Contractor shall provide and fix identification labels and warning signs on/or at close proximity to each item of equipment and instrument. Unless otherwise specified, the labels and signs shall be of brass and shall be of minimum size 8cmx4cm, or as approved by the Supervisor.

Labels on equipment shall indicate the function and duty of such equipment and shall be engraved in English.

Any equipment which requires periodic lubrication, greasing, or other maintenance shall be similarly labeled with the appropriate directions including the grade of oil or grease to be used.

1.33.2 LABELS AND INSTRUCTION PLATES

A brass name plate shall be attached to each item of equipment in a conspicuous place. The following information shall be plainly marked in English on the name plate:

- Name of manufacturer and address
- Serial and Model Numbers
- Manufacturing Date
- Major ratings (speed, capacity, horsepower etc.)
- Temperature, pressure, voltage, current frequency or other limitations
- Any other information the manufacturer may consider necessary or is stipulated in the relevant standards specified in this document
- Distribution board and electric cable runs shall be labeled

1.34 SAFEGUARD TO EQUIPMENT
It shall be the Contractor’s responsibility to safeguard by means of temporary or permanent support, or otherwise, all cables, pipes and equipment and other materials and equipment which would be liable to suffer damage if such precautionary measures were not taken.

Temporary and permanent safeguards shall be to the approval of the Supervisor.

1.35 SAFEGUARD TO PERSONNEL
All “Live” parts of electrical equipment shall be protected in such a way as to adequately safeguard from injury all personal working on or in the vicinity of the equipment. Wherever possible, all protective guards shall be supplied by the equipment manufacture. In addition, all precautionary means must be taken to safeguard all personnel against hazards.

1.36 PROTECTION OF INSTALLATIONS
The Contractor shall keep all pipes, sanitary fixtures and other equipment or instruments clean of dirt, debris and other obstruction until testing and/or acceptance.

1.37 DEFECTIVE OF DAMAGED EQUIPMENT
Every care should be taken by the Contractor to safeguard materials and equipment against damage during loading, unloading, storing, installation or after installation.

Equipment or material found defective during storage, installation, or test, shall be replaced by the Contractor and at his expense in a manner approved by the Supervisor’s Representative.

1.38 GUARANTEE
The Contractor shall guarantee in writing to the Supervisor that all electromechanical works installed by him shall be free from any defect in workmanship and materials, and that all equipment will withstand variations in temperature, load and atmospheric conditions which arise under working conditions without undue distortion, deterioration or setting up of undue stresses and strains in any part of such magnitude as to offset the strength and suitability of the various parts. It shall also be guaranteed that all equipment have, or will perform according to the capacities and characteristics indicated on the drawings and specifications, and that if during a period of one year from date of the certificate of completion and acceptance of his work, any such defects in workmanship, materials or performance appear, he will promptly remedy them to the satisfaction of the Contracting Authority. All costs involved in carrying out his works shall be at the Contractor’s expense.
1.39 TEST ON SAMPLES
The Contractor shall submit all necessary samples for testing or inspections as may be requested by the Supervisor. Tests shall be carried out in a laboratory approved by the Supervisor and the Contractor shall allow for the cost of such tests in his unit prices.

1.40 TESTS WORK & TEST CERTIFICATES
Unless the approval of equipment is based on performance data presented in certified standard manufacturer’s catalogues, tests at manufacturer’s works will be required and a test certificate should be issued to ensure compliance of the equipment with the requirement of the specifications and the approved shop drawings.

Tests work shall be conducted by an international test and inception authority appointed by the Contracting Authority.
Test certificates shall be submitted to the Supervisor in due time before shipment.

1.41 TESTS ON COMPLETION
Upon completion of the Electro-mechanical works, the Contractor shall run complete performance tests on each system to establish compliance with the Contract requirement. The details of such test are outlined under the respective sections.

The Contractor must give the Supervisor three calendar days written notice, of his intention to carry out any tests. On completion of satisfactory tests, the Supervisor will give written approval.

These tests shall be carried out on site after the completion of a part or whole of each piece of equipment or system, and prior to any provisional acceptance or the work.

The Contractor shall submit to the Supervisor, prior to the commencement of the tests, six copies of the complete test procedure. The procedure method and point of measurement, as well as the method of calculations, shall be approved by the Supervisor before any test is carried out. Six copies of the test result shall be furnished to the Supervisor for his approval.

The Contract shall supply skilled and all necessary instruments to carry out any test of any kind on a piece of equipment, apparatus, part of system, or on a complete system, if the Supervisor requests such a test for determining specified or guaranteed data.

Any damage resulting from the tests shall be repaired and/or damaged material replaced, at no extra cost, all to satisfaction of the Supervisor.

In the event of any repair or any adjustment having to be made, other than normal running adjustments, the tests shall be void and shall be recommenced after the adjustment or repairs have been completed.

All testing, balancing and final adjustment shall be in accordance with the provisions of the Contract requirements.

1.42 SPARE PARTS
As per recommendation and the approval of Supervisor, the Contractor shall provide under his Contract all spare parts and other consumables sufficient for serving and maintaining the whole works for a five years period of operation. If any of the spare parts are used for the purpose of
correcting defects arising during the period of maintenance as called for in the Conditions of the Contract, then such spare parts shall be immediately replaced by the Contractor as at his own expense.

All spare parts shall be interchangeable with the corresponding parts of the installation. The quality of square parts shall not be inferior to that of the originally installed. Spare parts shall be adequately protected and packed in suitable containers to withstand storage under site conditions and shall be handed over with a detailed list of the spare parts.

1.43 INSTRUCTION MANUAL
The Contractor shall furnish, in triplicate, in booklet form an instruction manual containing the minimum following information:

Brief description of each system, its services and basic operating features.
Manufacturer’s mechanical equipment parts, list of all functional components of the systems. The list shall give system No., Unit No., Manufacturer's Model No., and Manufacturer’s Drawings No.
Step by step operating instructions for each system including preparation for starting, shutdown and draining.
Maintenance instructions for each type of equipment.
Manufacturer’s literature, describing each piece of equipment listed in the equipment schedules, control diagrams and wiring of all controllers, starters, panels and switchboards.
As installed control diagrams by the control manufacturer of all systems with description of sequence of operation for each system.
Possible breakdown and repairs for each type of equipment.
The Contractor shall furnish all the foregoing to the Supervisor for his review as to the fulfillment of the specified requirements.

1.44 CLIMATIC CONDITIONS
All equipment is to be tested to ensure that it is suitable for the conditions prevailing on site, which are stated below.

Due consideration should also be given to local rises of temperature in unventilated areas, areas exposed to the sun and areas that will have increased temperatures due to emission of heat from equipment.

All equipment and materials to be continuously rated and derated in an approved manner for the ambient temperatures in which they will be installed. Particular care should be taken to ensure that any plastic components exposed to the sun, are suitable for high temperatures involved.

Summer-Max shade Temperature 35° C with 28° C W.B.
Relative humidity up to 80%
Winter – Min. temperature -5°C
Sun-Temperature-Max. sun Temperature 60°C
The above conditions are not design conditions but max and min temperature likely to be normally encountered. Design conditions and other temperature rating for equipment are given under specific section. All equipment should however be suitable for the maximum and minimum temperatures.

1.45 LANGUAGES

All documents submitted for approval shall be in English.

1.46 BEFORE AND AFTER PHOTOGRAPHS

Before starting construction operations on any section of the works, the Contractor will take sufficient record photographs of the whole area that will be disturbed from different angles and aspects so as to illustrate and record the condition of the section before starting the works. The photos taken will be as directed and agreed by the Supervisor.

1.47 PROJECT SIGNS

The Contractor shall provide and erect sign boards of an acceptable overall size with the name of the Contracting Authority, the project, the Consultant and the Contractor clearly printed in a manner, design and position in accordance with the attached CDR Sign Board Specification and as approved by the Supervisor’s Representative.
1 EARTHWORKS

2.1 GENERAL

The Contractor shall carry out all necessary excavations for trenches, structures etc… to the required lines and grades and in any types of soil and ground of whatever nature may be. He shall backfill and compact such excavations in layers to the extent specified, and shall dispose of unsuitable and surplus material to approved dumping areas.

The Contractor shall furnish and place all sheeting, bracing and supports, execute all cofferdaming, pumping and draining and shall render the bottom of the excavations from and dry until acceptable in all respects.

Excavations shall be carried out to the dimensions shown on the approved drawings, and in such manner as will give suitable room for building the structures or laying and joining the pipework.

All excavations, except as otherwise specified or permitted, shall be in the open, and shall be carried out in such portions at one time as the Supervisor may direct, in order to avoid inconvenience to the public and maintain safety of operation.

Excavations, dewatering sheeting and bracing shall be carried out in such a manner as to eliminate all possibilities of undermining or disturbing existing services, foundations of existing structures of work previously executed under this contract.

The soil conditions met during the foundation works especially in the formation level are to be checked by the Contractor's soil Engineer, recorded and compared with previous known or investigated results. If essential differences occur, which could be detrimental to the structures, the Contractor has to inform the Supervisor, and to propose further measures. Foundations works in such areas are to be continued only after approval of such measures by the Supervisor.

If there is any doubt the soil quality, or if discrepancies appear with regard to the previous decisions or investigation by the Supervisor, then additional measures are to be taken after consulting the Supervisor (e.g additional excavation and lean concrete fill).

Immediately before concreting any footing, the Contractor has to verify the specified soil conditions below the foundation level.

Soil testing shall be carried out in accordance with BS 1377.

For soil improvement works, i.e excavations of special foundation (except replacement method), only special Contractors (or subContractors) are acceptable, subject to providing proof of experience in successful execution of such works in the form of a detailed description and references.

During excavation, as far as possible, top soil and other types of excavated materials shall be kept separate for appropriate use or disposal. Every care shall be taken to avoid unnecessary damage to trees.
2.2 **NATURE OF EXCAVATION**

The Contractor has to visit the site, satisfy himself as to the nature of the ground and sub-soil to be excavated, and make himself conversant with the local conditions to be encountered during the execution of the Contract.

Any claims arising from want of knowledge in this respect shall not be entertained.

2.3 **EXCAVATION IN RESTRICTED AREAS**

In conformity with the drawings, or as necessitated by site conditions, or directed by the Supervisor, the Contractor shall in general carry out excavations, in restricted areas and close to existing structures and utilities, by hand, in order to safeguard such structures and utilities from any damage whatsoever. The Contractor shall make good at his own cost any damage caused by him to these existing structures and utilises.

2.4 **TRIAL EXCAVATIONS**

Prior to any excavation, the Contractor shall carry out trial trench and pit excavations to such extent, as required, in order to locate the expose existing buried services and utilities, or reveal ground conditions etc... The prior approval of the Supervisor shall be obtained for such excavations.

Unless otherwise approved, trial excavations shall be carried out by hand and in a manner to ensure that damage to existing utilities are avoided.

The Contractor shall submit to the Supervisor, for his approval, a written report and sketch drawings of the data obtained from trial excavations carried out at every location. No backfilling of such excavations shall be made prior to the approval of the Supervisor.

2.5 **SHEETING AND BRACING**

The Contractor shall furnish, put in place, and maintain such sheeting bracing etc. as may be necessary to support the sides of the excavation and to prevent any movement of earth which could in any way diminish the width of the excavation to less than that necessary for proper construction, or could otherwise injure or delay the work, or endanger work people, adjacent services or structures. If the Supervisor is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the expense of the Contractor.

Wherever the excavations for trenches or structures are inshore, under water, and/or greater than three (3) meters below ground level, the Contractor shall present to the Supervisor for his approval, construction drawings indicating methods of executing sheeting, bracing strutting, or other suitable support etc... excavating and dewatering and all other pertinent details relating to pipe laying, execution of concrete box culverts and all other concrete structures.

Wherever possible, sheeting shall be driven ahead of the excavation to avoid loss of material from behind the sheeting. If it is necessary to excavate below the sheeting, care shall be taken to avoid trimming behind the face along which the sheeting will be driven. Care shall be taken to prevent voids outside of the sheeting, but, if voids occur, they shall be filled immediately with sand, and compacted.

The Contractor shall leave in place to be embedded in the backfill, or concrete, all sheeting, bracing, etc... as indicated on the approved drawings to be so left in place or as may be
ordered by the Supervisor. He also shall leave in place any and all other sheeting, bracing etc, which the Supervisor may direct him in writing to leave in place, at any time during the progress of the work, for the purpose of preventing injury to structures or property.

All sheeting and bracing not to be left in place shall be carefully removed in such manner as not to endanger the construction or other structures. All voids left or caused by the withdrawal of sheeting shall be backfilled immediately with approved material and compacted by ramming with tools especially adapted to that purpose, by watering or by other means as may be directed.

2.6 STOCKPILING EXCAVATED MATERIAL

The stockpiling of excavated material in or adjacent to the work areas will not be permitted. The Contractor must allow for immediately loading and transporting all suitable excavated material to be used for select backfill to an approval off-site storage area to avoid any nuisance to persons or properly. Unsuitable excavated material shall be immediately disposed of at an approved disposal location at any distance from the job site. The Contractor shall transport this suitable material back to site for backfilling of trenches as soon as backfilling operations starts. The Contractor shall allow for this double handling in his unit rates.

Excavated select material shall be stockpiled in approved storage areas to avoid obstructing entrances, sidewalks driveways, hydrants, manholes, and any other service, and in a manner not to cause any obstruction to traffic. The Contractor shall ensure that stockpiled excavated material does not obstruct pedestrian or driver visibility at road crossing or junctions.

Should the Contractor consider that there is sufficient space at the main site to store part of the selected excavated materials, then he should apply to the Supervisor for permission to utilise the space for temporary stockpiling.

The Supervisor shall not be obliged to grant permission, and no stockpiling shall take place without such written permission.

Any damage resulting from Contractor's failure to comply shall be rectified at the Contractor's own expense, all as directed by the Supervisor.

2.7 EXCAVATION IN POOR SOIL

The Contractor shall report in writing to the Supervisor any unsuitable or weak ground material which may be found below the indicated excavation levels before executing any trimming of the excavation, pipe laying, concreting, or other work.

Where the bottom of the excavation at subgrade is found to be unstable or to include ashes, cinders, any type of refuse, vegetable or other organic materials, stones, or large pieces and fragments of material that, in judgment of the Supervisor, should be removed, the Contractor shall excavate and remove such unsuitable material to the width and depth ordered by the Supervisor. The level shall be made up by backfilling with approved material in layers not exceeding 150mm compacted thickness. The layers shall be placed in accordance with AASHTO T 180 to 95% compaction, tamping by hand, and as directed by the Supervisor to provide a uniform and continuous bearing and support for the pipe. The trench bottom shall be finished by means of hands tools.

All group of soil classified in accordance with ASTM D 2487 types, CL, OL, MH, CH, OH and PT shall be deemed unsuitable material.
2.8 KEEPING EXCAVATIONS FROM WATER

2.8.1 GENERAL
To ensure proper conditions at all times during construction, the Contractor shall provide and maintain ample means and devices (including spare units kept ready for immediate use in case of breakdown) with which to intercept and/or remove promptly and dispose properly of all water entering trenches and other excavations. Such excavations shall be kept dry until the structures, pipes, and appurtenances to be built therein have been completed to such extent that they will not be floated or otherwise damaged.

All water pumped or drained from the work shall be disposed of in a suitable manner without undue interference with other work, damage to pavements, of the surfaces, or property. Suitable temporary pipes, flumes, or channels shall be provided for water that may flow, along or across the site of the work. No such water into be disposed of into the existing sewer systems of the city.

2.8.2 TEMPORARY SUBDRAINS
Temporary subdrains, if used, shall be laid in trenches, beneath the grade of the structure. Trenches shall be of suitable dimensions to provide room for the chosen side of subdrain and its surrounding gravel.

Subdrain pipe shall be acceptable vitrified clay or concrete pipe of standard thickness. Sewer pipe of the quality known as "second" will be acceptable.

Subdrains, if used, shall be laid at an approved distance below the bottom of the normal excavation and with open joints wrapped in cheesecloth, and entirely surrounded by graded gravel, or crushed stone to prevent the admission of sand or other soil into the subdrains. The distance between the bottom of the pipe or structure and the top of the bell of the subdrain and the pipe or structure shall be filled with screened gravel, or-crushed stone, which shall be rammed, if necessary, and left with a surface suitable for laying the pipe or building the structures.

Unless otherwise directed by the Supervisor all temporary drains and subdrains shall be finally sealed with concrete at intervals to the Supervisor’s satisfaction, and all temporary ditches, sumps, wells, etc., shall be refilled, all surfaces reinstated and all damage made good as specified or directed.

2.8.3 DEWATERING SYSTEM
The Contractor shall provide, operate and maintain satisfactory and adequate system of pumps, well points, wells, sumps, pipework, drains, intercepting ditches, cut-off drains subdrains, other dewatering equipment, or other dewatering techniques, and all things necessary to keep surface water out of the excavations and to remove from excavations surface water, sub-soil water or water from any other sources and to maintain the water table below bottoms of excavation in order that the construction can be carried out in the dry.

The soil profile encountered during drilling of the dewatering wells has to be recorded by the Contractor.

For the wells, or drains, filtration measures shall be adopted, which prevent extraction of soil particles out of the subsoil through the filter into the well. On the other hand, the filter material
has to be permeable enough so that a sufficient amount of water can be pumped out for ground water lowering purposes.

For ground water lowering systems which lower the ground water level more than 3m or in the case of high sensitivity of the structure towards over flooding, a second independent stand by power supply is to be installed.

Spare pumps, material and installations for additional wells are to be provided on a scale of 20 to 50% of the number of the installed wells.

The ground water lowering effect is to be checked by piezometers in unfavorable positions (e.g. in the middle of the structure pit) before starting the excavation.

Prior to dewatering operations, the Contractor shall submit to the Supervisor for review detailed procedures and means intended for such dewatering operations.

For major water lowering systems, a design report, together with the calculated water volume to be pumped, has to be handed over to the Supervisor for approval before work commences.

2.8.4 FLOODING

The Contractor shall take all precautions, to any extent necessary, to avoid flooding of the excavations either as a result of failure of the dewatering system or of marine flooding, in order to ensure that excavation and backfilling, pipework, structures and appurtenances are constructed and completed to such extent, that such will not be damaged, floated, or subjected to uplift forces which may endanger, or, on any way affect their safety. Any damage arising from such flooding shall be made good at the Contractor's expense.

2.9 EXCAVATION IN ROCK

Rock excavation shall include but not be limited to, all volcanic, alluvial and residual boulders having a volume of 0.50 cubic meters or more, or any other unaltered and unweathered firm and rigid igneous, metamorphic and sedimentary rocks or cemented conglomerates which cannot be removed by normal excavator's tools and equipment and which require drilling, blasting, wedging, sädling, baring or braking up with power operated tools or other special means for their removal.

Rock, boulders, stones, etc…, shall be removed to provide a clearance of at least 15cm below and to the sides of all pipes, valves, fittings, etc…

Where pipeline pass from rock to softer strata, the trench shall be excavated to an extra depth of 50 cm, where the rock ends and this extra depth shall be reduced successively in a straight line along a leveling stretch of about three (3) meters to the depth stated above and then backfilled with approved compacted material to the prescribed levels.

Blasting by explosives shall not be permitted.

The Contractor shall not be entitled to any additional payment for excavation in rock.

2.10 EXCAVATION FOR TRENCHES

2.10.1 GENERAL

The Contractor shall erect all forms and racing, and make ready all excavations for trenches necessary to install all sanitary sewage lines and box culverts and other conduits that may be
required for this Contract, to the lines and grades shown on the approved drawings and/or as directed by the Supervisor.

Where pipe is to be embedded in sand, gravel or concrete cradle, the trench may be excavated by machinery to, just below the designated grade, provided that the material remaining at the bottom of the trench is not disturbed. Where pipe is to be laid directly on trench bottom, the excavation by machinery shall be stopped just above the designated grade and the bottom of trenches in earth shall be cut, trimmed and finished by means of hand tools to form a flat or shaped bottom, true to grade, so that the pipe will have a uniform continuous bearing on firm and undisturbed material between joints. If rock is encountered at the designated subgrade, the Contractor shall carry excavations depending on the pipe diameter fifteen (15) cm to twenty-five (25) cm below such a subgrade and backfill with approved sand fill or other approved specified material which shall be compacted.

During excavation, material suitable for backfilling shall be piled at sufficient distance from the sides of the trench to avoid overloading and prevent cave in. All excavated material not required, or unsuitable for backfilling, shall be removed and carted away to an approved dumping area.

Grading shall be done as necessary to prevent surface water or rainwater from flowing into trenches, and any water which may accumulate therein shall be removed immediately. Trenches shall be dry during the whole period until backfilling is completed and approved.

2.10.2 DEPTH OF TRENCH

Trenches shall be excavated to such depths as will permit the pipe to be laid at the elevations, slopes, or depths of cover indicated on the approved drawings, and at uniform slopes between indicated elevations.

The depth of any trench shall be taken to mean the depth from the natural ground surfaces to the invert of the pipe, where correctly laid, except where the natural ground surface will be lowered by the trench shall be paid under another item in which case the depth of the trench shall be measured from the ground surface as lowered in accordance with that item.

Where rock excavation is encountered the trench shall be excavated to such extra depth as is called for under the Clause headed "excavation in rock".

2.10.3 WIDTH OF TRENCH

Pipe trenches shall be made as narrow as practicable and shall be not be widened by scraping or loosening materials from the sides. Every effort shall be made to keep the sides of the trenches form and undisturbed until backfilling has been completed and consolidated.

Trenches shall be excavated with approximately vertical sides between the elevation of the centers of the pipes and an elevation of 30cm above the top of the pipe. At this elevation, the minimum width of trench for single pipe trenches and box culverts shall be as follows:

**SINGLE PIPE TRENCHES**

<table>
<thead>
<tr>
<th>Nominal size Diameter</th>
<th>Width of Trench</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Width of Culvert (mm)</td>
<td>Width of Trench (mm)</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>3000 x 2000</td>
<td>5800</td>
</tr>
</tbody>
</table>

For each additional pipe in the same trench, the external diameter of the additional pipe + 15 cm + width of trench shall form the minimum width of multiple pipe trench.

Trenches shall be of such extra width, when required, as will permit the convenient placing of timber supports, sheeting and handling of specials.

If during excavation the width of the trench becomes greater than the above mentioned values, the Contractor may be requested to change the bedding details as per the Supervisor’s instructions.

The Contractor shall be responsible for the safety of all his trench excavations. All excavated pit sides, trench walls, or slopes shall be stable and established with respect to all current international safety standards.

### 2.10.4 TRENCH EXCAVATION IN FILL

If pipe is to be laid in embankments or other recently filled material, the material shall first be placed to the top of the fill or to a height of at least 30cm above the top of the pipe, whichever is the lesser. Particular care shall be taken to ensure maximum consolidation of material under the pipe location. The pipe trench shall be excavated as though in undisturbed material.
2.10.5 TRENCH BRIDGING
The Contractor shall, at his own expense, provide suitable and safe bridges and other crossings where required for the accommodation of travel, and to provide access to private property during construction, and shall remove such said structures thereafter.

2.11 EXCAVATION FOR FOUNDATIONS AND SUB-STRUCTURES
Excavation for foundations and sub-structures shall be carried out to the lines and grades shown on the approved drawings. The excavation shall be of sufficient dimensions to permit construction of forms and bracing for foundations and sub-structures, and installation of waterproof materials or any other trade as called for.

The elevation of the bottom of foundations as shown on the approved drawings shall be considered as approximate and indicative only. The Supervisor shall order in writing any change in dimension or elevations of foundations as may be deemed necessary to ensure a firm foundation of uniform density.

After each section of excavation is completed, the Contractor shall notify the Supervisor to that effect, and no concrete blinding course for foundations shall be poured until the Supervisor has approved the excavation and the character of the foundation material.

The method of excavation shall take into consideration existing and adjacent structures and utilities, and shall be submitted to the Supervisor for approval prior to any excavation.

Any excavated material unsuitable for fill or backfill shall be carted away and deposited in an approved dumping area.

2.12 SETTLEMENT AND EXPANSION JOINTS
Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature differential settlement, etc, do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joints width, which is to be at least 2 cm, is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc).

2.13 FOUNDATION AT DIFFERENT DEPTHS
Foundations at different levels should be based beyond a load spread angle of 30° (against the horizontal). Otherwise, the load influence (e.g. earth pressure) of the higher level structures on the lower ones must be taken into consideration.

2.14 SAFETY AGAINST UPLIFT
For all of the structures extending into the groundwater, safety against uplift has to be guaranteed during all execution stages, especially when groundwater lowering is terminated.

2.15 SHALLOW FOUNDATIONS
In this clause, shallow foundations are described where the footings rest on the natural bearing soil.
The excavation for foundations can be done by machines, if the underground is not disturbed by this procedure. In every case, the last 20cm above the foundation level are to be excavated by hand.

2.16 REPLACEMENT

If unsuitable soils are encountered below the foundation level or basement floor, they are to be replaced by suitable layerwise compacted material down to the bearing soil.

2.17 DEEP VIBRATORY TECHNIQUES

2.17.1 GENERAL

Loose granular soils in the natural or existing state unsuitable for foundation purposes can be improved by deep vibratory techniques. The thickness of such layers may be up to 30m deep and are suitable below the groundwater table.

Hence two procedures can be differentiated:

- Vibro-compaction is employed for densification of granular non-cohesive soils, up to a certain silt content where sand is added to replace the soil volume "lost" during the compaction procedure, due to the decreasing of the void ratio of the granular soils.

- Vibro-replacement (or stone column method) is used. The equipment used for this process is the same as that for vibro-compaction.

Other methods such as vibro-flotation may be acceptable subject to the approval of the Supervisor.

2.17.2 MINIMUM REQUIREMENTS

All layers between foundation level and bearing soil are to be compacted to a relative density of at least 80%, and prepared for an admissible soil pressure of at least 250kN/m². The modulus of deformation shall be not less than \( E_s = 50 \text{ MN/m}^2 \) down to 3m below the foundation level, \( E_s = 70 \text{ MN/m}^2 \) down to 5m below the foundation level and \( E_s = 100 \text{ MN/m}^2 \) beyond 5m below the foundation level.

For areas where these requirements and those mentioned below cannot be achieved by vibro-compaction, the vibro-replacement method is to be employed.

The final foundation level is to be covered with at least 50cm crushed stone or gravel fill and compacted to 80% relative with a 10t vibrating roller (at least two layers performing 6 passes).

The soils below foundation level are to be improved by vibro compaction / replacement such that requirements of the structure above are covered, i.e. the permissible total settlements and differential settlements are not exceeded and a sufficient bearing capacity / permissible soil pressure is obtained.

2.17.3 QUALITY ASSURANCE

Before starting the compaction works, the Contractor has to prove by tests whether he is able to improve the underground to the above requirements. The test program and vibro pattern is to be proposed by the Contractor and to be approved by the Supervisor, and shall contain a trial compaction, dutch cone tests (before and after the treatment), and big scale load tests comprising at least 4 compaction points covered by a concrete footing.
All test results shall be compiled in test reports, where values obtained are compared with requested values.

A method statement and quality control programme shall be prepared by the Contractor and approved by the Supervisor prior to start of vibro works. The method statement shall contain at least the above requirements and information about the following:

- Description of large scale load test including load steps waiting time.
- Data recording of probe number and depth, date and time of execution, installation time for every probe, gravel consumption, power consumption versus time or depth (automatically recorded) etc.

2.18 PILING

2.18.1 GENERAL

a) Work included

The work include the furnishing of all labor, materials and equipment, and the performing of all work required for test piles, pile load tests and working piles (including logs and reports) at the site of the project, in accordance with conditions at site and the drawings. This, especially applies to under ground installations about which the Contractor has to collect sufficient information (e.g. by digging) in order to avoid any damage of these.

b) Submittals

The following papers shall be submitted to the Supervisor for approval:

- Reference concerning pile foundations carried out by the Contractor.
- The type of piles assigned for this project shall be described by the Contractor in details as well as the equipment for installation.

c) Quality assurance

All work executed shall comply with, but not limited to, state of the art, applicable codes and the following standards:

- BS 5930 Code of practice for site investigation
- BS 031 Code of practice for earthwork
- BS 8004 Code of practice for foundations
- BS CP 2012 Code of practice for foundation for machinery
- BS 5573 Code of practice for safety precautions in the construction of large diameter boreholes for piling and other purpose
• Recommendations No. 17 of Buildings Research Establishment Digest: Concrete in sulphate-bearing soils and groundwater.

Concreting reinforcement and steelwork shall be executed in accordance with the corresponding clauses of this specification.

The work described in this clause shall be done by a Contractor experienced in piling techniques. He shall prove employment of adequate equipment as well as competent personnel, i.e., a foreman for every pile crew, who shall always be present during the works, as well as professional Engineer, well experienced in piling works, for supervision.

Prior to the installation of working piles, pile load tests are to be performed in order to determine bearing capacity and settlement behavior. The test piles shall correspond in all respects to the working piles and the actual conditions (groundwater conditions, type of pile, material and dimension, embedment depth and manner of installation). The worst and most unfavourable underground conditions of the piled area have to be included.

The soil conditions are to be investigated in the immediate vicinity of each test pile and soil density to be determined (e.g. sounding). This is to be done by performance of a borehole if no sufficient soil data (e.g. by samples) are obtained during pile installation.

The number of the load tests is fixed as follows:

* Up to 20 working piles: 1 test
* Up to 60 working piles: 2 tests
* More than 60 piles: 3 tests

The number of these tests shall be increased by the Supervisor, if results are not conclusive, or above requirements are not met.

After pile performance and execution of the above test the bearing capacity and settlement behaviour shall be checked by the following quality control load tests:

* Up to 60 piles: 1 test
* Up to 120 piles: 2 tests
* More than 120 piles: 3 tests
* More than 500 piles: 5 tests

The piles to be tested are chosen by the Supervisor based on driving data and above integrity tests. In case of any doubt on pile quality and if tests fail, additional tests are required by the Supervisor.

d) Group effect

For the determination of the bearing capacity and settlement behaviour of piles the influence of group action (especially for tension piles, uplift safety of soil body is to be considered) and also negative skin friction shall be taken into account.
2.18.2 PRODUCTS

Design fabrication and installation of working piles are under the full responsibility of the Contractor, governed by the standards mentioned in item "quality assurance" and approved by the Supervisor. If a pile is rejected by the Supervisor, e.g. for reasons of bad execution, the Contractor has to replace it by others in the vicinity of the rejected pile, on instruction of the Supervisor and at no expense for the Contracting Authority - Supervisor.

2.18.3 EXECUTION

A suitable pile type and manner of installation shall be chosen in order to penetrate all kinds of obstructions to piling, which may occur in the subsoil.

During piling works the elevation of the bearing horizon as well as the groundwater level shall be verified (e.g. by soundings or standard penetration tests inside the casing).

After installation, the piles shall be without damage and correctly placed in accordance with the approved drawings (tolerance ± 5cm at top and less than 2% deviation of the pile tip).

a) Driven piles

When selecting piles, the properties of the strata through which they are to be driven shall be taken into account. Piles shall be driven by equipment of adequate capacity. The Contractor may choose his own method within the scope of the mentioned conditions.

The pile-driver shall be such construction that the piles can be driven with the necessary safety and care, and where required, can be satisfactorily guided.

When required depth of driving can be achieved only with accompanying damage to piles, the piles may be pre-bored or jetted into the underground, but only with the approval of the Supervisor.

The spacing between piles must be sufficiently large so that there is no risk of the compacting or displacing effect having any adverse effect upon adjacent piles or structures. Driven piles oriented in the same direction shall have a minimum center to center spacing of:

\[ e = 3 a_{\text{max}} \]  

(Where \( a_{\text{max}} \) = maximum side dimension or diameter of pile shaft or pile foot)

The clear distance should however be not less than 1.0 m.

For all piles, driving data are to be recorded.

Reinforced driven concrete piles shall be so designed that bending moments or other stresses occurring when pile is transported, lifted, or driven can be resisted without notable crack formation.

b) Bored piles

A suitable type of drilling equipment shall be provided in order to penetrate obstacles (e.g. boulder) which may be met during the execution of the piles.

Generally, drilling operations shall be carried out in such a way as to avoid any disturbance of the soil. A temporary casing shall be installed to the full depth of the

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the borehole (except in stable rocks). The bottom of the casing shall always be kept sufficiently below the excavated borehole bottom, in order to prevent inflow or loosening of the adjacent soil.

When drilling below the groundwater table, inside the casing shall always be maintained above the natural groundwater level by at least 1.5 e.g. water has to be added accordingly. Therefore the groundwater level at time of boring must be known. If necessary, special observation wells shall be drilled.

Just before reinforcing and start of concreting, the pile foot is to be cleaned out so that no disturbed, loose or weak soil remains below the pile tip.

For concreting, an efficient tremie technique shall be used especially if groundwater is present. The concrete column shall not be interrupted and the reinforcement not be lifted up. The concrete column shall always be 1 m above the bottom of the casing during withdrawal of the casing (to avoid penetration of soil into the pile shaft) and the tremie pipe end has to be covered by at least 1.0m concrete.

The reinforcement shall be carried down to the full length of the piles.

Abandoned boreholes are to be carefully backfilled with lean concrete.

The Contractor shall notify the Supervisor for inspection and further decisions, of any difficulties occurring during piling which affect pile quality adversely.

c) Testing piles, pile load tests procedure

Compression and tensile load tests shall be carried out according to international standards. Compression, as well as tensile, load tests may be carried out on one pile, the compression test being carried out first.

d) Load arrangement

The load shall be applied in such a way that it acts as precisely as possible along the longitudinal axis of the pile, does not vary during the test, and cannot tilt.

e) Measurements

All measuring instruments and loading devices shall be newly calibrated and if necessary adjusted before the tests are begun. The instruments shall be adjusted to the measuring range excepted. The accuracy for load measurements is 1% of maximum load to be measured by a separate cell and for dial gauge it is 2/100mm.

2.19 SHEET PILING

2.19.1 GENERAL

For sheet pile works, in general, the same requirements are valid as for piling, especially if sheet piles are used as bearing members.

a) Work included

The work includes the furnishing of all labor, materials, equipment, and the performing of all work required for sheet piling, in accordance with conditions at the site and the drawings.
Internationally recognized safety regulations are to be applied especially in relation to sheet pile support (anchors, struts).

b) Submittals

Drawings, calculations and driving records of sheet piles for excavations deeper than 3.5 m are to be submitted by the Contractor to the Supervisor approval. For permanent structures, this applies in every case.

Concerning the stability of sheet piled structures, the following requirements are to be met and demonstrated by the Contractor's calculations:

- Sufficient driving depth to ensure static stability,
- Safety against shear failure,
- Stability of the anchorage against failure in the deep slip line,
- Safety against extracting of anchors,
- Safety against hydraulic failure or piling and erosion,
- Water-tightness of the sheet pile wall.

c) Quality assurance

The Contractor shall prove the employment of adequate equipment as well as competent and experienced personnel.

For standards to be used see item “Piling” above.

2.19.2 EXECUTION

When selecting a certain type of sheet pile, the local subsoil conditions shall be taken into consideration so that the necessary depth can be reached without damage.

Driven sheet piles initially used for temporary works, may become later part of the permanent structure, only if no disadvantage to the permanent structure will result. Such a measure is to be decided upon the Supervisor. The stability of the temporary works must be demonstrated (calculation, detailed drawings, etc).

The method of extractions shall be such that the structure, adjacent buildings, services or other installations are not damaged, and soil is not extracted.

The Contractor shall provide the Supervisor with information on drawings, and when required, also by local identification of indicating sheet piles or anchors which cannot be removed, or can only be partially removed.

2.20 EXCAVATION NEAR EXISTING UTILITY LINES AND SERVICES

The Contractor’s attention is brought to the fact that there exist along the project line all kinds of utilities and services.

The Contractor shall be responsible for establishing the exact position of all utility lines and services liable to interfere with the new construction, prior to carrying out construction in the vicinity.

The Contracting Authority accepts no responsibility for the reliability, completeness or the available information, and the Contractor shall carry out as directed, trial holes or trial trenches to locate such existing services and any other buried indications.
As the excavation approaches pipes, conduits or other underground structures, digging by machinery shall be discontinued and the excavation shall be done by means of hand tools, as directed. Such manual excavation when incidental to normal excavation shall be deemed to be included in the Contractor’s rates and prices for normal excavation.

2.21 DIVERSION AND REPLACEMENT OF EXISTING SERVICES AND STRUCTURES

A part from clarifying and locating positions to prevent damage to existing services, the security is to clarify those services which might conflict with the permanent works.

Where service connections are encountered that conflict with the permanent works, their diversions will be agreed upon in detail with the Supervisor. All work, in connection with removal and relocation, shall be carried out by the Contractor under the supervision of the Supervisor and/or the concerned utility authority. Alternatively, the concerned authority, should it prefer to, may carry out the work itself, in which case the Contractor, will afford all reasonable assistance and access during the undertaking of the work.

All relocation work shall be designed by the Contractor in conjunction with the utility authority and shall comply in all respects with their current regulations and specifications. The Contractor must allow for the preparation of all shop drawings and for obtaining approvals for the designs from concerned authorities.

For each case of main conflict of existing services with the permanent works, the Contractor shall inform the Supervisor, in writing, and prepare, for his approval, entirely at his own expense, suitable scale drawings on his proposed diversion or amendment to the design.

In addition to the scrutiny referred to above, the Contractor shall take all reasonable precautions to prevent damage to existing buried main services and connections to buildings. Any damage shall be repaired at the Contractor’s expense.

In removing existing pipes or other structures, the Contractor shall use care to avoid damage to materials.

The structures to which the provisions of this clause shall apply include utility lines and cables and other structures which, in the opinion of the Supervisor, will impede progress to such an extent that satisfactory construction cannot proceed until they have been changed in location, removed (to be later restored), or replaced. When fences are within the Contractor’s operating location, he shall remove and, unless otherwise specified, later restore them to at least as good a condition as that in which they were found, immediately before the work was begun, all without additional compensation. The restoration of fences shall be done as promptly as possible and not left until the end of the construction period.

2.22 SHOP DRAWINGS

Prior to commencing construction and subsequent to the Contractor’s determination of the location of the existing utilities lines, the Contractor shall prepare and submit to the Supervisor for his review shop drawings complete with the description of the procedure, materials and related date of the Contractor’s proposed method of protection for said utility lines. Review and comments by the Supervisor shall in no way relieve the Contractor of the full responsibility for all protection and precautions required during the works.
2.23 NOTICE OF INTENT
The Contractor shall file a Notice of Intent with the service authorities, who have services at the site or works in progress at the site, at least two weeks before he desires to carry out any work near, above, or under their services. He shall submit a detailed programme for each area in which shall be commenced and the anticipated date of commencement, in addition to a report, signed by the Supervisor, the service authority Engineer, and the Contractor confirming the Notice of Intent.

2.24 PROTECTION OF EXISTING STRUCTURES AND UTILITIES
The Contractor shall be responsible for the care and protection of all existing utilities or other facilities, buildings and structures which may be encountered in or near of work. Temporary supports, adequate protection and maintenance of all underground and surface utilities encountered in the progress of the work shall be furnished by the Contractor at his expense and under the direction of the Supervisor and the service authority. Any structures that have been disturbed shall be restored immediately.

The Contractor shall be responsible for bracing and supports of structures, utilities and services to prevent settlement, displacement or damage to same.

The Contractor shall remove and cap abandoned utilities in accordance with service authority direction and as directly by the Supervisor. The method of capping the lines shall conform to the requirements of the utility or service authority.

2.25 MAINTAINING UTILITIES IS OPERATION
The Contractor shall ensure that gas, electrical, water, sewer house connections, and telephone services shall not be interrupted during the course of this project. This may require the establishment of temporary service connections including sewer and water house connections until the works are complete and all reinstatement of utilities are made.

2.26 BREAKING UP ROAD PAVEMENTS
The Contractor shall remove only as mush of any road pavement as is necessary for the execution of the work. Where in the opinion of the Supervisor, it is necessary to prevent damage to the adjoining road surface and parking areas, the Contractor shall use appropriate pneumatic tools. Where pavement is removed in large pieces, it shall be disposed of before proceeding with excavations.

2.27 CARE AND RESTORATION OF ROAD PAVEMENTS AND STRUCTURES
On paved surfaces the Contractor will not use or operate tractors, bulldozers, or other power-operated equipment of which the treads of wheels are so shaped as to cut or otherwise injure such surfaces.

All pavements which have been damaged by the Contractor’s operations shall be restored to a condition at least equal to that in which they were found immediately before work had begun. Suitable materials and methods shall be used for such restoration.

2.28 USE OF SURPLUS MATERIALS
All excavated materials shall be removed from the site either to approved off-site storage areas or approved dumping sites as approved or directed by the Supervisor. Surplus excavated materials suitable for backfill shall be used to backfill excavations or to replace materials
unsuitable for use as backfill. If shall be used as appropriate to make or widen fills for paved areas and embankments, flatten side slopes, fill depressions and low areas on site, or around and under structures and the like, or shall be neatly deposited for other purposes, all as directed or approved.

All surplus, approved excavated material shall be used for backfilling and filling the site of work up to the prescribe levels of the foundation course of paved areas, and below the sand fill, on the previous hard core under ground slabs, whichever is specified.

Surplus excavated materials not needed, as specified above, shall be hauled away and dumped by the Contractor, at his expense, at appropriate locations, and in accordance with arrangements made by him.

### 2.29 PREPARATION AND INSPECTION OF EXCAVATIONS

Bottoms of excavations shall be leveled, well rammed and consolidated before laying of pipes, placing concrete foundations etc…, all to approval of the Supervisor.

If excavations are carried out below the levels indicated or prescribed, the resulting void shall be backfilled at the Contractor's expense with thoroughly compacted, selected fill, if the excavation is for a pipeline, or with concrete, if the excavation is for a masonry or concrete structure, all too the satisfaction of the Supervisor.

### 2.30 FILLING AND BACKFILLING

#### 2.30.1 Generalities

In general, and unless other material is specified, material used for filling trenches and excavations around structures shall be suitable material, of granular type gradation.

If needed, the Contractor shall procedure suitable additional material from outside sources, such as borrow pits, conforming to the specifications herein below:

- Fill material from borrow pits shall be granular type material and shall pass a three (3) inch U.S Standard Sieve and shall be non-plastic. The amount passing No. 200 U.S Standard Sieve shall not exceed fifteen percent (12%).
- Wherever a percentage of compaction for backfill is indicated or specified, it shall be the percent of maximum density at optimum moisture content as determined by Method D of ASTM D 1557 latest editions, Standard Methods of Test for Moisture-Density Relations of Soils Using 10 lb. Hammer and 18 in. Drop. If the percentage of compaction is not indicated, it shall be understood to be 95%.
- Filling and backfilling shall start only after preparation and inspection of trench excavations and testing of the structure to be backfilled has been performed, and approval by the Supervisor has been secured.
- Backfill shall not be placed against, or on, any structure until such structure has attained the strength to safely support the loads to which it will be subjected. Unequal soil pressures shall be avoided by depositing the backfill evenly around the structure. For walls with fill on both sides, the difference in the level of backfill shall not be such as to endanger the safety of the walls.
2.30.2 Filling and Backfilling

PART 1 GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Backfilling building perimeter to subgrade elevations.
   2. Backfilling site structures to subgrade elevations.
   3. Fill under slabs-on-grade.
   4. Fill under paving.
   5. Fill for over-excavation.
   6. Various fill works required

1.2 REFERENCES (Equivalent Equal Acceptable)
A. American Association of State Highway and Transportation Officials:

B. ASTM International:
   1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN/m³).
   2. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
   3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN/m³).
   4. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
   5. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
   7. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

1.3 SUBMITTALS
A. Submittal Procedures: Refer to requirements for submittals.

B. Product Data:
   1. Refer to requirements for submittals of data sheets and testing requirements.

C. Samples: Submit, in air-tight containers, 4.5 kg sample of each type of fill to testing laboratory.

D. Materials Source: Submit name of imported fill materials suppliers.

E. Manufacturer's Certificate: Certify that Products meet or exceed specified requirements.
PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Structural Fill: Conforming to the standards of the Municipality or Ministry of Public Works; excavated and reused material or imported borrow materials from approved pits outside the site; selected, graded and free of clay, silt, roots, rocks, debris, large weeds and foreign matter.

B. Agricultural Top Soil for Landscaping: Fertile capable of sustaining vigorous plant growth.

PART 3 EXECUTION

3.1 EXAMINATION

A. Administrative Requirements: Refer to requirements

B. Verify subdrainage, dampproofing, or waterproofing installation has been inspected.

C. Verify underground tanks are anchored to their own foundations to avoid flotation after backfilling.

D. Verify structural ability of unsupported walls to support loads imposed by fill.

3.2 PREPARATION

A. Compact subgrade to density requirements for subsequent backfill materials.

B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with structural fill and compact to density equal to or greater than requirements for subsequent fill material.

C. Scarify subgrade surface to depth indicated on drawings.

D. Proof roll to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

3.3 BACKFILLING

A. Backfill areas to contours and elevations with unfrozen materials.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy subgrade surfaces.

C. Place geotextile fabric over fill prior to placing next lift of fill (if and as applicable)

D. Place fill material in equal continuous layers not exceeding 200 mm thick and compact.

E. Employ placement method that does not disturb or damage other work.
F. Maintain optimum moisture content of backfill materials to attain required compaction density.

G. Backfill against supported foundations.

H. Backfill simultaneously on each side of unsupported foundations until supports are in place.

I. Slope grade away from building minimum 50 mm in 3 m, unless noted otherwise.

J. Make gradual grade changes. Blend slope into level areas.

K. Remove surplus backfill materials from site.

L. Leave fill material stockpile areas free of excess fill materials.

3.4 TOLERANCES

A. General: Finished excavation and fill for Permanent Works shall be to the lines, levels, and profiles shown on the Contract Drawings with the tolerances specified herein.

B. Tolerances for Fill (except fill for road embankment):
   1. General Fill ± 100mm.
   2. Fill to be covered with concrete in foundations or linings, or drainage or filter layers of artificial or selected natural materials, or any layer of other material: +0mm, -75mm.
   3. The surface tolerance requirements:
      a. Tolerances along the top edge of any slope steeper than 1 vertical to 30 horizontal shall not vary by more than 10% of the specified slope inclination at any point on the slope.
      b. Slopes steeper than 1 vertical to 30 horizontal shall not vary by more than 10% of the specified slope inclination at any point on the slope.

C. Tolerances for Road Excavation and Road Embankment Fill:
   1. No point on excavation slopes shall vary from the plane of the design slope by more than 100mm measured at right angles to the slope except for excavation in rock where no point shall vary by more than 500mm.
   2. In no case shall any portion of the excavation slope encroach on the roadbed.
   3. No point on the completed embankment slope within 1.0 meter below shoulder grade shall vary from the plane of the design slope by more than 100 mm measured at right angles to the slope. Slopes more than 1.0 meter below shoulder grade shall not vary from than 200 mm measured at right angles to the slope.
   4. No point on the completed median and side slopes which are on 1 vertical to 6 horizontal or flatter slopes, whether in excavation or embankment, shall vary from the plane of the design slope by more
than 60 mm measured at right angles to the slope. Flow lines within medians shall be graded to drain and shall not vary more than 30 mm from the required grade line.

D. Quality Requirements: Tolerances: subject to the approval of the Supervisor

3.5 SETTLEMENT PERIOD

A. Where a settlement period is shown on the Contract Drawings or otherwise specified, the permanent fill shall be constructed to full height and to the order limits shown or specified and shall remain in place for the required settlement period before commencing construction of foundations or placing other layers of materials on the fill surface.

B. Where a settlement period for a surcharged permanent fill is shown on the Contract Drawings or otherwise specified, the surcharge fill shall be constructed to the height and to the limits shown or specified. The surcharge fill shall remain in place until the end of the settlement period shown or specified.

3.6 DUST CONTROL

A. The contractor shall use all means necessary to control dust on and near the Work and on and near all borrow areas.

B. Thoroughly moisten all surfaces as required to prevent dust being a nuisance or a hazard to the public and affect the performance of other work on the site.

3.7 FIELD QUALITY CONTROL

A. Quality Requirements: Testing and inspection services – Execution and testing Requirements: refer to corresponding sections

B. Perform laboratory material tests in accordance with ASTM D1557, ASTM D698, and/or AASHTO T180.

C. Perform in place compaction tests in accordance with the following:

D. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

E. Frequency of Tests: At the discretion of the Supervisor.

F. Proof roll compacted fill surfaces under slabs-on-grade, and paving.

3.8 PROTECTION OF FINISHED WORK

A. Refer to corresponding sections.

B. Reshape and re-compact fills subjected to vehicular traffic.

3.9 SCHEDULE

A. Compact uniformly to minimum 95 % of maximum density.
2.31 BACKFILL PIPE TRENCHES

The nature of the backfill materials will govern both their acceptability and the methods best suited for their placement and compaction in pipe trenches. The materials and the methods shall both be subject to the approval and direction of the Supervisor.

Unless otherwise specified to have concrete encasement, pipes shall be embedded in sand, and cement, selected granular material or crushed aggregate to the depth and dimension shown on the approved drawings.

After compaction and approval of the bedding, the remaining backfilling of trenches shall be carried out in layers of fifteen (15) cm compacted thickness, using only that suitable fill material which was removed in the course of excavating the trench, or imported from outside subject to the following restrictions:

a) Backfilling material shall include no stone or rock fragment larger than 30mm in greatest dimension, as to endanger the pipeline when dropped into the trench.

b) Where required and/or directed by the Supervisor, a timber grillage shall be used to break the fall of material dropped from a height of more than 1.50 meters.

c) Pieces of bituminous pavement shall be excluded from the backfill unless their use is expressly permitted, in which case they shall be broken up as directed.

As soon as practicable after the pipe have been laid and the joints have acquired a suitable degree of hardness, if applicable, or the structures have been built and are structurally adequate to support the loads, including construction loads to which they will be subjected, the backfilling shall be carried out. Under no circumstances shall water be permitted to rise in unbackfilled trenches after the pipe has been placed.

Trenches shall not be backfilled at pipe joints until after that section of the pipeline has successfully passed any specified tests required.

The zone around the pipe shall be backfilled with the materials and to the limits as indicated on the approved drawings. Selected fill, or screened gravel, if used, shall be thoroughly compacted by careful hand tamping in layers 15 cm in depth up each side.

The remainder of the trench above and around the pipe puddling, shall be compacted by water-jetting, puddling, or tamping, as directed or approved. Water-jetting or puddling shall be used wherever the material does not contain so much clay or loam as to delay or prevent satisfactory drying.

If the backfill is to be compacted by water-jetting, the material shall be placed in uniform layers not exceeding fifteen (15) cm depth. Before the succeeding layer is placed, each layer shall be thoroughly saturated throughout its full depth and at frequent intervals across and along the trench until all slumping ceases. To accomplish this, the Contractor shall furnish one or more jet pipes, each of sufficient length to reach the specified depth, and of sufficient diameter (not less than 4cm), to supply an adequate flow of water to compact the material. The jet pipe shall be equipped with a quick-acting valve, and be supplied through a fire hose from a hydrant or a pump having adequate pressure and capacity.

If the backfill is to be compacted by puddling, the material shall be deposited in water of sufficient depth so the material will be submerged when in place. Dams or dikes constructed
in the trench to hold the water used for puddling shall be permitted in soils which are preponderantly clayey.

If the material is unsuitable for water-jetting or puddling, compacting shall be accomplished by tamping. The materials shall be deposited and spread in uniform, parallel layers not exceeding a thickness of 15cm before compaction. Before the next layer is placed, each layer shall be tamped, as required, so as to obtain a thoroughly compacted mass. If necessary, the Contractor shall furnish and use an adequate number of power driven tampers, each weighing at least 10kg for this purpose. Care shall be taken that the material close to the bank, as well as in all other portions of the trench, is thoroughly compacted. If necessary to ensure proper compaction by tamping, shall be done when the material is too wet whether from rain or too great an application of water. In this case the work shall be suspended until the previously placed and new materials have dried out sufficiently to permit proper compacting, or such other precautions shall be taken as may be necessary to obtain proper compaction.

Whatever method of compacting backfill is used, care shall be taken that stones and lumps are not nested and that all voids between stones are completely filled with fine material. The Contractor shall, as part of the work done under the items involving earth excavation and rock excavation as appropriate, furnish and place all other necessary backfill material.

All voids left by the removal of sheeting shall be completely backfilled with suitable materials and thoroughly compacted.

When required, excavated material, which is acceptable to the Supervisor for use in the pavement sub-bas course, shall be placed at the top of the backfill to such depths as may be specified elsewhere, or as directed.

Follow manufacture’s recommendation for backfilling around GRP pipes and concrete pipes, strict adherence to the manufacture’s instructions for laying and backfilling, under, around, and above the pipe shall be adhered to, and as approved by the Supervisor.

2.32 FILL AND BACKFILL UNDER STRUCTURES

Unless otherwise indicated or specified, all fill and backfill under structures shall be compacted, well graded screened graved having a maximum size of 5 cm. The gravel shall consist of clean, hard, and durable particles of fragments, free from dirt, vegetable, or other objectionable matter, and free from an excess of soft, thin, elongated, laminated or disintegrated pieces. Crushed rock of suitable size and grading may be used instead of screened gravel. The specifications which follow shall apply whichever material is used.

The fill and backfill materials shall be spread in layers of uniform thickness not exceeding fifteen (15) cm, and then shall be thoroughly compacted by means of a suitable vibrator or mechanical tamper to attain the specified percentage of compaction specified in this section.

2.33 BACKFILLING AROUND STRUCTURES

The Contractor shall not place backfill against, or on, structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking or other damage. As soon as practicable after the structures are structurally adequate and other necessary work has been done, (such as block wall building for waterproofing protection) special leakage tests, if required, shall be carried out in one operation until its completion. The best of the excavated materials shall be used on
backfilling within 50 cm of the structure. Unequal soil pressure shall be avoided by depositing the material evenly around the structure.

Backfilling shall be carefully compacted by tamping in layers not exceeding 15 cm or by water-jetting or puddling as directly by the Supervisor.

Walls with fill on both sides shall have the fill constructed, such that the difference in the top elevation of the fill on the two sides does not exceed 60cm at any time.

2.34 RETAINING WALL DRAIN

The Contractor shall install wall drains as necessary. The Contractor shall obtain the approval of the Supervisor regarding the design and type of drains to be used before construction. The drains can be of porous concrete, polyvinyl chloride or similar material approved by the Supervisor.

2.34.1 POROUS CONCRETE DRAINS

Technical specifications of pipe:

- Section Circular
- Internal diameter 200mm
- Length each erection 0.75 m
- Wall thickness 40 mm
- Average weight 56 kg/m
- Material porous concrete prepared with hard limestone aggregate with CPA 210/325 cement with spigot and socket ends for jointing

The bottom half of the pipe shall be rendered waterproof by dipping in concrete slurry or hot bitumen.

2.34.2 PLASTIC DRAINS

Type PVC (polyvinyl chloride) with perforation on upper half of pipe

- Nominal diameter 150 mm
- Length of each section 5 m
- Wall thickness 2-3 mm
- Joint Solvent Weld

All drain pipes shall be inspected for defects at the time of installation.
3 CONCRETE WORKS

3.1 GENERAL

No material shall be used in the Works until prior approval for its use has been given by the Supervisor; neither shall any change in the nature, quality, kind, type, source of supply or manufacture be made without the Supervisor's approval.

Names of manufacturers and test certificates for materials not supplied by the Contracting Authority shall be supplied as soon as possible to the Supervisor.

The cost of providing samples and the cost of carrying out tests required by this specification (except as otherwise provided in the Conditions of Contract) together with the cost of supplying equipment for sampling and site testing shall be borne by the Contractor.

During the progress of the Works, consignment notes for materials not supplied by the Contracting Authority shall be supplied to the Supervisor giving details of each consignment.

3.2 CONCRETE

3.2.1 REQUIREMENTS

The mix proportions shall be selected to ensure that the workability of the fresh concrete is suitable for the conditions of handling and placing, having regard to the structural element being constructed, the disposition of reinforcement, and taking full account of the environment to which it will be subjected.

The concrete shall be of the class indicated in the Bill of Quantities and as shown on the drawings, and shall have the following requirements:

<table>
<thead>
<tr>
<th>CLASSES OF CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>AA</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>B bis</td>
</tr>
<tr>
<td>C</td>
</tr>
</tbody>
</table>

* Maximum water per sack of cement shall include free moisture and liquid admixtures.
The seven days compressive strength shall not be less than seventy five (75) percent of the required twenty eight days strengths.

**Class AA**
Concrete shall be used as shown on the Drawings, in the Particular Technical Specifications and as directed by the Supervisor.

**Class A**
Concrete shall be used for all reinforced concrete in not very aggressive conditions, not otherwise specified or noted on the Drawings, and as directed by the Supervisor.

**Class B**
Concrete shall be used for non-reinforced ordinary plain concrete, wherever medium strength is required, including blinding concrete under foundations for structures and cyclopean concrete fill, or otherwise specified or noted on the Drawings, and as directed by the Supervisor.

**Class B bis**
Concrete shall be used for non-reinforced ordinary plain concrete, wherever lower medium strength is required, including blinding concrete under foundations for structures and cyclopean concrete fill, or otherwise specified or noted on the Drawings, and as directed by the Supervisor.

**Class C**
Concrete shall be used wherever low-strength concrete is required, and elsewhere indicated on the Drawings or directed by the Supervisor.

### 3.2.2 STRENGTH
The characteristic strength of concrete means that value of the 28 day cube strength below which 5% of all possible test results would be expected to fall.

The relationship between grade of the concrete and its characteristic strength shall be as given in BS 5328. The grade of concrete to be used in particular locations shall be as given in Table 3.1.

<table>
<thead>
<tr>
<th>Location</th>
<th>Maximum Aggregate Size (mm)</th>
<th>Coarse Aggregate Size</th>
<th>Grade of Concrete (BS 5328)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinding Concrete:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- General Structures</td>
<td>20 or 40</td>
<td></td>
<td>C15P</td>
</tr>
<tr>
<td>- Liquid Structures</td>
<td>20</td>
<td></td>
<td>C20P</td>
</tr>
<tr>
<td>Blinding Concrete:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sulphate Condition</td>
<td>20</td>
<td></td>
<td>C25P</td>
</tr>
<tr>
<td>Substructure thickness less than 400 mm</td>
<td>20</td>
<td></td>
<td>C25D</td>
</tr>
</tbody>
</table>
Substructures, Walls and Slabs more than 400 mm | 20 | C25D
---|---|---
Superstructures normal concrete | 20 | C25D
Liquid retaining structures | 20 | C35A
Fine Concrete | 10 | C25D
Precast Concrete | 10 or 20 | C30D

In the above table suffix P means a prescribed mix, D means a designed mix and A means a design mix complying with the requirements of BS 8007.

### 3.2.3 MIXES

(a) **Designed Mixes**

Proportions shall be determined in accordance with the "Design of Normal Concrete Mixes" published by the United Kingdom Department of The Environment and obtainable from: Building Research Establishment and Bookshop, Garston, Watford WD2 7JR, ENGLAND; or other approved methods, which comply with the requirements set out in this Specification.

For the purpose of determining the design mean strength of the concrete, a margin shall be added to the characteristic strength for the particular grade of concrete. This design margin shall be assessed on the degree of control reasonably to be expected in the manufacture of the concrete and shall not be less than 7.5N/mm² nor less than 1.64 times the standard deviation. Until such time as the standard deviation has been assessed the margin shall be not less than 15N/mm².

Details of the designed mixes shall be forwarded immediately to the Supervisor for his approval.

(b) **Prescribed Mixes**

Proportions for the several grades of concrete shall conform to the requirements of Tables 3.2 and 3.3.

(c) **Chloride Content**

The total chloride content of the concrete mix shall comply with the requirements of BS 8110: Part 1: Section 6.
Table 3.2  Mass of Dry Aggregate to be Used with 100 kg of Cement

<table>
<thead>
<tr>
<th>Grade of Concrete</th>
<th>Nominal maximum size of aggregate (mm)</th>
<th>40</th>
<th>20</th>
<th>14</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Workability</td>
<td>Med</td>
<td>Hig</td>
<td>Med</td>
<td>Hig</td>
</tr>
<tr>
<td></td>
<td>Range for standard sample</td>
<td>50-100</td>
<td>80-170</td>
<td>25-75</td>
<td>65-135</td>
</tr>
<tr>
<td></td>
<td>Range for sample taken in accordance with 9.2 (mm)</td>
<td>40-110</td>
<td>70-180</td>
<td>15-85</td>
<td>55-145</td>
</tr>
<tr>
<td></td>
<td>Total Aggregate</td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
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<tr>
<td>C7.5P</td>
<td></td>
<td>1080</td>
<td>920</td>
<td>900</td>
<td>780</td>
</tr>
<tr>
<td>C10P</td>
<td></td>
<td>900</td>
<td>800</td>
<td>770</td>
<td>690</td>
</tr>
<tr>
<td>C15P</td>
<td></td>
<td>790</td>
<td>690</td>
<td>680</td>
<td>580</td>
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<tr>
<td>C20P</td>
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<td>530</td>
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<tr>
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<td>510</td>
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<td>460</td>
</tr>
<tr>
<td>C30P</td>
<td></td>
<td>510</td>
<td>460</td>
<td>460</td>
<td>400</td>
</tr>
</tbody>
</table>

Table 3.3  Percentage by Mass of Fine Aggregate to Total Aggregate

<table>
<thead>
<tr>
<th>Grade of Concrete</th>
<th>Nominal maximum size of aggregate (mm)</th>
<th>40</th>
<th>20</th>
<th>14</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Workability</td>
<td>Med</td>
<td>Hig</td>
<td>Med</td>
<td>Hig</td>
</tr>
<tr>
<td>C7.5P</td>
<td></td>
<td>30-45</td>
<td>35-50</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C10P</td>
<td></td>
<td>30-45</td>
<td>35-50</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>C15P</td>
<td>C20P</td>
<td>C25P</td>
<td>C30P</td>
<td></td>
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<td>-----</td>
<td>------</td>
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<td>------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Grading zone 1</td>
<td>35</td>
<td>40</td>
<td>40</td>
<td>45</td>
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<td></td>
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<td>50</td>
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<td>2</td>
<td>30</td>
<td>35</td>
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<td>40</td>
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<td>40</td>
<td>45</td>
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<td>40</td>
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</tbody>
</table>

Notes on the use of Tables 3.2 and 3.3:

Note 1: The proportions given in the tables will normally provide concrete of the strength in N/mm² indicated by the grade except where poor control is allied with the use of poor materials.

Note 2: For grades C7.5P, C10P and C15P, a range of fine-aggregate percentages is given; the lower percentage is applicable to finer materials such as zone 4 sand and the higher percentage to coarser materials such as zone 1 sand.

Note 3: For all grades, small adjustments in the percentage of fine aggregate may be required depending on the properties of the particular aggregates being used.

Note 4: For grades C20P, C25P and C30P, and where high workability is required, it is advisable to check that the percentage of fine aggregate stated will produce satisfactory concrete if the grading of the fine aggregate approaches the coarser limits of zone 1 or the finer limits of zone 4.

Note 5: N/A = not applicable

3.2.4 QUALITY CONTROL

Compliance with the specified characteristic strength shall be based on tests on cubes at an age of 28 days. Sampling and testing of concrete shall comply with BS 1881. For major structures the frequency of sampling shall be initially three samples taken each day for five days of concreting and thereafter at a frequency of one sample per 10m of concrete but not less than one sample for each day’s concreting.

For minor structures the frequency of sampling shall be one sample per 20m³ but not less than one sample for each day’s concreting. For mass concrete works and concrete works at pipeline appurtenances sampling shall be at on average of one sample per 50 m³.

A minimum of 3 test cubes shall be made from each sample.

Where materials are of an unfamiliar grading or type, or where directed by the Supervisor, compression tests shall be carried out at 7 days and adjustments made in advance of the main control methods outlined above.
Cube test results will be examined individually in 10 consecutive sets of four and the standard deviation and mean strength of each set calculated. The concrete mix proportions will only be acceptable if all of the following requirements are complied with:

(i) Not more than two results in 40 are less than the characteristic crushing strength.

(ii) No value of the average for any set of four results is less than the characteristic strength plus one-half of the design margin.

(iii) When 40 results have been obtained and the mean strength and standard deviation are calculated, the mean strength minus 1.64 times the standard deviation shall be greater than the characteristic strength.

Where the results do not conform to the above requirements the following action shall be taken:

- Adjustments to the mix shall be made to obtain the strength required.
- In the case where any result is less than 80% of the characteristic strength the structural implications shall be considered and action taken as ordered by the Supervisor.

For those Prescribed Mixes required to be tested, requirements (i) and (ii) only will be applicable.

### 3.2.5 PRODUCTION

Aggregates and cement shall be proportioned by weigh-batching. Subject to the prior approval of the Supervisor volume-batching may be used for small sections of work, but volume batching of cement will in no case be accepted. The Contractor may, however, so proportion the mix that each batch shall use a whole bag or bags of cement, the weight of which is known precisely. All gauge boxes shall be accurate and due allowance shall be made for bulking of the aggregates in assessing the correct volume to be used.

The aggregates and the cement shall be thoroughly mixed in a clean mechanical mixer for a period of time agreed with the Supervisor and the water added on the basis of the approved design.

The amount of water added shall conform to the requirements of Clause 3.2.1.

Batch mixing machines shall comply with the requirements of BS 1305. They shall be provided in such numbers and of such capacity as to ensure a continuous supply of freshly mixed concrete at all times during construction.

Continuous mixing machines shall be used only with the written permission of the Supervisor.

### 3.2.6 READY MIXED CONCRETE

Unless otherwise stated the relevant clauses of BS 1926 shall apply.

Ready mixed concrete shall only be used with the prior approval of the Supervisor. The Contractor shall not be relieved of his obligation to provide concrete to the standard laid down in this Specification by virtue of any approval given for the use of concrete supplied by others, and the Supervisor reserves the right to withdraw his approval at any time consequent on any
deterioration in the quality of the Concrete, or unsatisfactory delivery or any other reason he considered detrimental to the Works.

Ready mixed concrete manufactured off the site shall be transported in a revolving drum and shall be continuously agitated until it is used in the work unless otherwise approved. The time interval between adding water to the drum and placing shall not exceed 90 minutes.

3.2.7 CEMENT

Cement shall comply with one of the following sub-Clauses (i) to (iv) below:

(i) BS 12 (Ordinary and rapid-hardening Portland cement).

(ii) BS 146 (Portland-blastfurnace cement).

(iii) BS 4027 (Sulphate resisting Portland cement).

(iv) BS 6588 (Portland pulverised-fuel ash cement) provided that sub-Clause (vii) below is complied with.

Cement used for structures in contact with wastewater shall be Sulphate Resisting Portland Cement in accordance with BS 4027.

Cement shall be fresh when delivered to Site and the consignments shall be used in the order of their delivery. The Contractor shall mark the date of delivery on each consignment and each consignment shall be stored separately and in such manner as to be easily accessible and identifiable.

Cement in bags or other containers shall be intact at the time of mixing.

Cement bags shall be stored in a waterproof building and be placed on dry boards above the floor to prevent deterioration or contamination from any cause.

Bulk cement may be used provided it is stored in an approved container.

Cement of different types shall be kept separate in storage and shall not be mixed together.

3.2.8 AGGREGATES

Fine and coarse aggregates shall be as defined by and be of the quality and nature required by BS 882 and BS 1201 whichever is applicable. In addition they shall be chemically inert to alkali reaction.

Prior to acceptance of an aggregate as inert to alkali reaction the report of a qualified geologist, appointed by the Contractor, on the suitability or otherwise of the aggregate shall be obtained. The Supervisor may require that samples be taken from boreholes.

Aggregates shall conform to the requirements of the "Acceptance Standards" of Table 3.8. The flakiness index of coarse aggregate in accordance with BS 812 shall not exceed 35%.
The Contractor shall ensure that the nature and gradings of aggregates remain reasonably consistent, and shall, if necessary, stockpile and include different gradings to ensure that the overall grading remains constant for each section of the work.

Dust or flour resulting from crushing the aggregate shall not be allowed to contaminate the stockpiles. When, in the opinion of the Supervisor such contamination has taken place it shall be removed by an approved means or the aggregate shall be rejected.

The aggregates of various sizes shall be kept separate and away from all possible contamination, and shall be stored on a hard-standing area or in bins and provided with proper drainage at the base of the stockpiles.

Except where aggregates have been otherwise specified the grading of aggregates shall be as follows:

(a) **Coarse Aggregate:**

(i) 10 mm max. size, graded, for all "fine" concrete.

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

(iii) 40 mm max. size, graded, for all reinforced concrete walls and slabs in excess of 400 mm thick.

(b) **Fine Aggregate:**

(i) Where aggregates conforming to Zones 2 or 3 of BS 882 are available they shall be used.

(ii) For Prescribed Mixes, Zones 1, 2, or 3 aggregates only shall be used.

### 3.2.9 WATER

Water, for use in concrete and in concreting operations shall be of potable quality. Where required by the Supervisor it shall be tested in accordance with BS 3148 and if necessary shall be treated to assure compliance therewith.

Water for washing and curing shall be such that it will impair neither the strength of the finished concrete nor its appearance.

### 3.2.10 ADMIXTURES

Before approval for the use of a proprietary admixture is given the Contractor will be required to satisfy the Supervisor as to its suitability for the work and its compatibility with the cement it is intended to complement and for the intended use of structure. Admixtures that contain chlorine shall not be used for potable water retaining structures.

### 3.3 REINFORCEMENT

#### 3.3.1 STEEL

Reinforcement shall be:

a) Plain round mild steel or High Yield steel bars conforming to BS 4449;
b) Cold worked steel bars conforming to BS 4461; or

c) Fabric reinforcement made of cold drawn high tensile bars conforming to BS 4483.

The Contractor shall obtain from his suppliers certificates of the mechanical and physical properties of the reinforcement and shall submit them to the Supervisor for approval, except where reinforcement has been supplied by the Contracting Authority. The frequency of sampling and the method of quality control shall be in accordance with Table 4 and Clause 20 respectively of these British Standards. All high yield and cold worked bars (except in welded fabric reinforcement) shall be deformed bars complying with Classification Type T2 for bond strength in accordance with BS 4449.

3.3.2 STORAGE

Reinforcement shall be stored on Site under cover and supported clear of the ground and in such manner as to make identification easy. Supports shall be such that distortion of the steel is avoided and contamination and corrosion prevented.

3.3.3 BENDING AND FIXING

The Contractor shall prepare detailed reinforcement drawings and bending schedules which shall comply with the typical details and drawings and schedules provided by the Supervisor. The Contractor shall provide on Site facilities for cutting and bending reinforcement whether he is ordering his reinforcement bent or not and shall ensure that a token amount of straight bar is available on Site for bending as and when directed by the Supervisor.

Prior to cutting and bending reinforcement the Contractor shall check the drawing and schedules.

Any discrepancy or inaccuracy found in the Drawings shall be notified to the Supervisor immediately.

Reinforcement shall be wire brushed and cleaned, before and/or after it is placed in position.

The bars shall be cold bent in strict accordance with the Drawings and the Contractor shall be responsible for the accuracy of the bending. Bending dimensions shall be worked to the tolerances indicated in BS 4466 and BS 8110 table 3.26. Bars which are outside the limits of the foregoing tolerances shall be replaced by new bars, or, may be straightened and rebent cold subject to the Supervisor’s prior approval.

After bending, reinforcement shall be securely bundled and labeled with weather-proof tags or shall be marked with other approved signs by which it can readily be identified.

The reinforcement shall be fixed in accordance with the Drawings to give the required cover, spacing and position. Suitable precautions shall be taken by the Contractor to prevent any displacement of reinforcement during the placing and compaction of concrete. The Contractor shall provide adequate templates, stools or other supports. Precast concrete support blocks for reinforcement shall be manufactured from Grade C30D “fine” concrete to ensure the correct cover thickness. They shall be well cured before use and carefully stored on Site to avoid
contamination. Plastic and metal supports and chairs, may be used, subject to the Supervisor's prior approval.

Where the lap length is not detailed, a lap of not less than 40 diameters of the smaller bar shall be provided for Mild Steel bars and not less than 50 diameters for High Yield bars.

All intersections of bars in walls and slabs and all connections between binders or links and main bars in columns or beams shall be tied with soft iron wire ties or with fixing clips, wire ties or fixing clips shall not project into the specified cover.

Welding of reinforcement at intersections or for the joining of bars is prohibited.

Where galvanised reinforcement is used any damage suffered by galvanising shall be made good by the application of an approved galvanising formulation, before concrete placing is commenced.

3.3.4 COUPLERS

Couplers for reinforcement shall be either Standard Swaged Splices or Type II Alpha Couplers manufactured by CCL Systems Limited, Cabco House, Ewell Road, Surbiton, Surrey England, KT9 7AH, UK., or similar approved. Where bars of different diameters are to be joined a CCL Reducer Sleeve or similar shall be used.

Couplers shall be suitable for the type and size of reinforcing bars and shall be capable of developing 115% of the characteristic strength of the smaller of the reinforcing bars being joined in both tension and compression. Couplers shall be installed in accordance with the manufacturer's recommendations. Square twisted reinforcing bars shall not be used with couplers.

3.4 FORMWORK

3.4.1 REQUIREMENTS

The term "formwork" shall be taken to include centering, formwork, shuttering, bracing and all necessary supports.

When instructed by the Supervisor the Contractor shall submit formwork drawings and calculations to the Supervisor in advance of the concreting.

Formwork shall be of such accuracy, strength and rigidity as to carry the weight and pressure from the concrete to be placed on or against it, together with all constructional, wind or other loads likely to be imparted to it, without producing deformation of the finished concrete in excess of the specified tolerances.

Formwork shall be sufficiently tight, without plugging, to prevent loss of grout during the vibration of the concrete. When required by the Supervisor joints between formwork facing boards shall be sealed with foam rubber, sealing strips or other approved material.

Faces of formwork shall be clean, free from projecting nails, adhering grout and other imperfections or defects. Formwork shall be treated with approved mould oil before positioning. The Contractor shall prevent reinforcement or steelwork from being contaminated by the oil.

Formwork, which as a result of prolonged use or general deterioration or is otherwise in the opinion of the Supervisor unsuitable, shall not be used.
Through-bolts or ties will not be permitted in liquid-retaining structures. The Contractor shall use only such bolts or ties as are capable of being removed in whole or in part so that no part remaining embedded in the concrete shall be nearer the surface of the concrete than the specified thickness of cover to the reinforcement.

Beam soffits shall be erected with an upward camber of 5 mm for each 3 metres of span, or as directed by the Supervisor.

Top formwork shall be counterweighted or otherwise anchored against flotation.

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.

On all external arises of the concrete 25 mm chamfers shall be formed.

Any openings provided in formwork for inspection and for cleaning-out shall be formed so that they can conveniently closed before the placing of concrete.

All props shall be supported on adequate sole plates and shall not bear directly on or against concrete. They shall be capable of being released gently and without shock to the formwork. No appliance for supporting the formwork shall be built into the permanent structure without the Supervisor's prior approval. Props for upper level support shall be placed directly over those at lower levels; Props shall only bear upon work sufficiently mature to carry the load.

Formwork shall be such as to allow for its removal without damaging the concrete, and in the case of suspended floors, for the removal of the beam sides and slab soffits without disturbing the beam-bottom boards and their props.

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

Where timber is used for formwork it shall be properly cured, free from warp, straight, clean and free from loose knots.

Where metal forms are used for formwork they shall be of the type strengthened by intermediate ribs or cross bracing.

Moving formwork may be used where in the opinion of the Supervisor it is appropriate.

3.4.2 SAWN FORMWORK

Sawn formwork shall be properly designed and constructed of closely-jointed sawn boards sheet metal or other approved material. It shall produce a standard of finish free from substantial voids, honeycombing or other large blemishes. There shall be no loss of grout.

3.4.3 WROUGHT FORMWORK

All exposed concrete shall be formed by wrought formwork.

Wrought formwork shall produce a high standard of finish with a hard smooth surface with true clean arises. Only minor surface blemishes shall be permitted. The face in contact with the concrete shall consist, framed plywood or metal panels or other approved material. Joints between boards and/or panels shall be arranged in a uniform pattern.
3.4.4 SPECIAL WROUGHT FORMWORK

Special wrought formwork shall provide the highest standard of finish where the face of the finished concrete is to form a particular feature. The face in contact with the concrete shall consist of large smooth sheets, unless otherwise specified, arranged in an approved uniform pattern, with joints coinciding with possible architectural features, sills, window heads, or changes in direction or surface. Accurate alignment of all joints shall be maintained. Wrought boarding and standard steel panels shall not be used unless specially faced.

3.4.5 TOLERANCES

Unless otherwise indicated, the tolerances of the finished concrete with respect to the dimensions shown on the approved drawings shall not exceed the limits set out in Table 3.4.

Table 3.4 Tolerances of Dimensions for Finished Concrete

<table>
<thead>
<tr>
<th>Items</th>
<th>Tolerances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall dimensions and levels</td>
<td>± 5</td>
</tr>
<tr>
<td>Column sizes</td>
<td>± 5</td>
</tr>
<tr>
<td>Beam sizes</td>
<td>± 5</td>
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<tr>
<td>Wall sizes</td>
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<tr>
<td>Vertical lines out of plumb</td>
<td>5 mm ± 5 in every 15 m height</td>
</tr>
</tbody>
</table>

The dimensions of the finished concrete shall be not less than those shown on the approved drawings.

3.4.6 STRIKING AND REMOVAL

The following recommendations are given as a minimum requirement for striking formwork:

Table 3.5 Striking of Formwork

<table>
<thead>
<tr>
<th>Item</th>
<th>Sulphate Resisting and Ordinary Portland Cement Normal Weather (16°C and above) Days</th>
<th>Rapid Hardening Cement Normal Weather (16°C and above Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Sides, Walls, Columns</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Slabs (props left under)</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Beam soffits (props left under)</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Removal of props to slabs</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Removal of props to beams</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Shafts and tunnels</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
The above striking times are for normal conditions; the period shall be extended if:

a) The span of the structural member under consideration exceeds 6 metres for beams and 3 metres for slabs an additional period of one day for each 500 mm of additional span shall be allowed;

b) The dead load of the structural member under consideration forms a large proportion of the total design load;

c) Constructional loads coming on to the structural member under consideration are being placed soon after the concreting operations and these loads form a large proportion of the total design load;

d) The setting of the concrete has been retarded for any reasons;

e) The temperature falls below 8°C an additional period of half a day shall be added for each day on which the temperature falls below 8°C and on additional one day for each day on which the temperature falls below 30°C;

f) Any combination of the above or other considerations which would call for the striking times to be extended.

Design information relevant to the above shall be obtained by the Contractor from the Supervisor.

3.5 CONCRETING

3.5.1 REQUIREMENTS

The finished concrete shall be dense, durable, impervious to the ingress of water, free from cracks and honeycombing, and resistant to wear and mild chemical attack.

3.5.2 TRANSPORTING

Concrete shall be transported to the place of final deposit by approved means.

Barrows, spades and other equipment used in the process of transporting concrete shall be thoroughly cleaned before each day's work or after a long interruption and they shall be free from hardened concrete.

Concrete shall be transported as soon as possible after mixing, by methods which will prevent the segregation, loss or contamination of the ingredients.

Bridging for traffic over reinforcement shall be provided so that the reinforcement is not distorted, damaged or displaced.

Where approval is obtained for concrete to be conveyed by chutes, these shall have a slope (not exceeding 1 vertical to 2 horizontal) such as to ensure a continuous flow of concrete. Additional water shall not be introduced to assist the flow. If deposition is to be intermittent the chute shall be arranged to discharge into a storage hopper. In no case will a clear fall of more than 1 m be permitted at the discharge end of the chute.
Where approval is obtained for pumping the concrete, the pump manufacturer's recommendations as approved by the Supervisor shall be followed. The pumps used shall be of adequate capacity and power to ensure delivery of a continuous supply.

Wherever transport of concrete is interrupted for any period of over half an hour the chutes, pumps, pipes and any other means of distribution shall be thoroughly flushed out and cleaned. These shall also be flushed out immediately prior to resumption of concreting and shall be kept free from hardened concrete. All washwater used shall be discharged outside the formwork and clear of any freshly placed concrete.

### 3.5.3 PLACING AND COMPACTION

No concrete shall be placed until the Contractor has obtained approval from the Supervisor. When the Contractor intends to place concrete he shall inform the Supervisor in sufficient time to enable his inspection. The Contractor shall provide all facilities for such inspection.

Concrete shall be placed within 30 minutes of mixing, to uniform level, in layers not exceeding 500 mm deep in such manner as to avoid segregation. Each layer shall be compacted by means of approved vibrators to form a dense material free from honeycombing and other blemishes.

If internal vibrators are used, they shall be withdrawn immediately water or a thin film of mortar begins to appear on the surface of the concrete. Withdrawal shall be carried out slowly to avoid the formation of voids.

If external vibrators are used, the formwork shall be designed for external vibration and shall be strong enough to withstand the forces of vibration.

Temporary or permanent stoppages of work shall be made only against stop ends. Unless otherwise specified, before placing new concrete against concrete which has already hardened, the face of the older concrete shall be prepared by the removal of any laitance and loose aggregate, and shall be cleaned by a jet of compressed air.

### 3.5.4 CONCRETING IN DEEP LIFTS

Where concrete is to be placed in lifts greater than 2.5 m high it shall be placed by suitable tremie pipes.

### 3.5.5 HOT WEATHER CONCRETING (FOR TEMPERATURES ABOVE 20 DEGREES CENTIGRADE)

Concreting shall not be permitted if its temperature at 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 wholly or in part as instructed by the Supervisor:

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

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

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

(iv) Rapid-hardening cement shall not be used;
(v) 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 directed by the Supervisor.

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. To maintain the water/cement ratio within permissible limits, an approved water-reducing agent shall be included in the mix.

The maximum water/cement ratios may be increased with the Supervisor's permission by 0.05 (or 2.5 litres/50 kg of cement) during mixing, but on no account shall water be added to concrete once it has left the mixer.

In order to reduce premature drying of the concrete during transporting and placing, all chutes, formwork and reinforcement shall be cooled by watering when possible, or shall otherwise be protected from the direct rays of the sun. Any water so used shall be removed by jetting with compressed air before placing the concrete.

As soon as possible after concreting, the formwork shall be stripped and the surface of the concrete shall be treated.

Where drying winds are encountered, wind shields shall be positioned as necessary to protect exposed surfaces of the curing concrete.

### 3.5.6 WET WEATHER CONCRETING

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.

During showery weather, the Contractor shall ensure that work can be concluded at short notice by the provision of stop ends. On no account shall work be terminated before each section, between one stop end and another, is complete. Adequate covering shall be provided to protect newly placed concrete from the rain.

### 3.5.7 HOLES, CAVITIES AND FIXINGS

Holes shall be accurately marked and boxed-out for before concreting operations commence, no holes shall be formed after the concrete has set.

Where bars, if placed to specified spacing would foul holes of size less than 250 mm x 250 mm, the full length of the bar shall be moved to one side unless otherwise indicated on the approved drawings. For holes exceeding 250 mm x 250 mm, the bars shall be cut on site and lapped with additional equivalent bars.

Wherever possible, the Contractor shall build in all pipework, ironwork, and steelwork which passes through walls and floors. The pipework, ironwork, and steelwork shall first be thoroughly cleaned and freed from any deleterious matter. Every care shall be taken to ensure that it is thoroughly encased in concrete.

Bolts, hooks and other fixings shall be embedded in concrete, or holes shall be drilled and fitted with threaded expanding anchors to receive the bolts. The Contractor shall ensure that bolts, hooks, and fixings are accurately positioned. Holding down bolts for machinery shall be set to template.
Where brick or stonework is to form a facing to the concrete or where the end of a brick or stone wall butts against a concrete face, galvanized metal ties of approved manufacture to BS 1243 shall be incorporated.

3.5.8 PROTECTION AND CURING

Newly placed concrete shall be protected by approved means from rain, drying winds, sun.

No traffic or constructional loads shall be permitted on newly placed concrete until it has hardened sufficiently to take such traffic or load.

Curing methods shall ensure that cracking, distortion and efflorescence are minimised.

Concrete shall be cured using methods approved by the Supervisor. The method of curing shall prevent loss of moisture from the concrete. Immediately after compaction and for 7 days thereafter concrete shall be protected against harmful effects of weather, including rain, rapid temperature changes and from drying out.

The curing time shall be the number of days given in Table 4.7 unless the average temperature of the concrete during the required number of days falls below 10°C in which case the period of curing shall be extended until the maturity of the concrete reaches the value given in the table.

Curing shall be carried out using either of the following basic methods, or any other method agreed with the Supervisor. Methods involving the use of dampened hessian coverings shall not be used. The method adopted for any particular situation shall be agreed with the Supervisor.

a. Membrane Applied by Spray

   Liquid membrane compounds shall be applied to moist concrete surfaces as follows:

   (i) Unformed Surfaces

      The compound shall be applied immediately after the free water has left the surface.

   (ii) Formed Surfaces

      The compound shall be applied immediately after removing the forms. If there is appreciable drying, the surface shall be mist sprayed with water to produce a uniformly damp appearance before the compound is applied.

   The method and rate of application shall be in accordance with the compound manufacturer's instructions as approved by the Supervisor.

   If rain falls on the newly coated surface before the film has dried sufficiently to resist damage, or if the film is damaged in any other manner, a new coat of compound shall be applied to the affected area. The membrane shall be maintained effective for the specified curing time.

   Compound applied to construction joint surfaces, or to other surfaces to which concrete is to be bonded, shall be removed prior to placing the fresh concrete.

b. Polythene Sheeting

   The concrete surfaces shall be covered with white polythene sheeting as follows:
(i) **Unformed Surfaces**

The sheeting shall be laid over the surface as soon as possible without marking the surface, and not until initial stiffening has taken place.

(ii) **Formed Surfaces**

The surfaces shall be covered immediately after the removal of the forms.

The sheeting may be in contact with the concrete or made into portable shelters on light weight frames. In both cases, the sheeting shall be jointed and sealed against the concrete surfaces to prevent Wind blowing between the sheeting and the concrete.

**C. Other Curing Methods**

Other methods of curing may be agreed with the Supervisor.

**Table 3.6 Normal Curing Methods**

<table>
<thead>
<tr>
<th>Conditions under which concrete is maturing</th>
<th>Number of Days (Where the average temperatures of the concrete exceeds 10°C during the whole of the period)</th>
<th>Equivalent Maturity (°C hours - calculated as the age of the concrete in hours multiplied by the number of °C by which the average temperature of the concrete exceeds - 10°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot weather or drying winds</td>
<td>Type IV 7 Type I or Type V 4 Type III 2</td>
<td>Type IV 3500 Type I or Type V 2000 Type III 1000</td>
</tr>
<tr>
<td>Conditions not covered above</td>
<td>Type IV 4 Type I or Type V 2 Type III 1</td>
<td>Type IV 2000 Type I or Type V 1000 Type III 500</td>
</tr>
<tr>
<td>Where: Type IV - Low Heat Portland Cement</td>
<td>Type I - Ordinary Portland Cement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type V - Sulphate-Resisting Portland Cement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type III - Rapid hardening Portland Cement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot Weather - Temperature over 16°C</td>
<td></td>
</tr>
</tbody>
</table>

Where the thickness of concrete placed exceeds 1.5 m, the Contractor shall submit for the Supervisor's approval proposals to ensure that, during the curing period:

a) the rate of rise of temperature in the concrete does not exceed 15°C per hour for the first 3 hours;

b) thereafter the rate of rise and fall of temperature in the concrete does not exceed 35°C per hour;
c) the maximum temperature in the concrete does not exceed 700°C; and

d) the maximum difference in temperature between the core and the surface of the concrete does not exceed 20°C.

The proposals shall include consideration of:

(a) concrete mix design;

(b) temperature of mix at time of placing;

(c) method of curing.

Where required by the Supervisor, the Contractor shall carry out temperature measurements in the concrete. The method and procedure of temperature measurement shall be agreed with the Supervisor.

3.6 JOINTS

3.6.1 CONSTRUCTION JOINTS

Construction joints shall be formed either on horizontal or vertical planes and located in the work to suit working stresses. They shall be so located and the quantity of work placed at any time shall be so limited in size and shape as to minimize shrinkable and temperature effects.

All reinforcing steel and fabric shall be continued across construction joints. Keys and inclined dowels shall be provided as directed by the Supervisor. Longitudinal keys at least forty (40)mm deep shall be provided in all joints in the walls and between walls and slabs or footing. The surface of the concrete at all joints shall be straight and be thoroughly cleaned and all laitance removed.

3.6.2 EXPANSION JOINTS

In no case shall the reinforcement or other embedded metal items be run continuous through an expansion joint unless where required sleeves are provided as approved by the Supervisor.

Expansion joints shall be filled with joint filler strips, cut back and pointed with joint sealer.

Expansion joints and construction joints where exposed to water pressure, shall unless otherwise instructed by the Supervisor, be coupled with approved waterstops and all ensure complete water tightness.

3.6.3 WATERSTOP

Waterstop shall be manufactured of rubber or PVC (polyvinylchloride) and shall be of the type and size as directed by the Supervisor. Site joints shall be made in accordance with the manufacturer's instructions as approved by the Supervisor. All intersections and junctions shall be obtained prefabricated from the approved manufacturer. For water retaining structures the Contractor shall submit waterstop fabrication drawings to the Supervisor prior to fabrication.

Plasticized PVC waterstops shall comply with the relevant provisions of Wls No. 4-31-02.

Rubber waterstops shall have the following properties when tested in accordance with the relevant Part of BS 903:
Rubber waterstops shall be suitable for storage, handling, installation and service within a temperature range of 0°C to +40°C.

All waterstop and jointing materials which are not required for immediate use shall be stored at all times in a cool damp place.

Waterstop shall be located and maintained accurately in position. Details of the propose method of fixing shall be submitted to the Supervisor for approval. On no account shall waterstop be secured by nails or by any other means involving puncture of or damage to the waterstop material unless purpose made nailing flanges are incorporated in the design of the waterstop.

### 3.6.4 JOINT FILLER

Joint filler for joints in structures to retain aqueous liquids shall be self expanding cork, natural bonded cork, resin bonded cork, or other material as detailed on the approved drawings. Joint filler shall be cut and trimmed accurately to suit the joint profile and shall be maintained accurately in position by means of an approved adhesive. Self expanding cork filler shall consist of cork granules bound together with an insoluble synthetic resin. Cork filler shall have maximum water absorption of 0.3% by volume when tested in accordance with ASTM D3595. The load required to compress the filler to 50% of its original thickness shall not exceed 1.5 N/mm² for self expanding cork (moist), 0.6 N/mm² for resin bonded cork and 0.90 N/mm² for natural bonded cork. Recovery after compression test shall exceed 90%.

Joint filler in non water retaining concrete structures shall be non-extruded bitumen impregnated fibreboard.

### 3.6.5 JOINT SEALANTS

Joint sealing compounds shall be impermeable ductile materials of a type suitable for the conditions of exposure in which they are to be placed, and capable of providing a durable, flexible and watertight seal by adhesion to the concrete throughout the range of joint movement.

Hot poured joint sealants shall comply with BS 2499, Ordinary Type AI sealant.

Cold poured polymer-based joint sealants shall comply with BS 5212: Part 1, Normal Type N sealant.

Two-part polysulphide-based sealants shall comply with the relevant provisions of BS 4254. Pouring Grade shall be applied to horizontal upward-facing joints and Gun Grade to joints of any other aspect or inclination. Other two-part polymer-based sealants of Gun or Trowel Grade shall comply with the physical and test requirements of BS 4254.

Silicone based building sealants shall comply with the relevant provisions of BS 5889.
Primers for use with joint sealants shall be compatible with, and, obtained from the same manufacturers as, the adjacent sealant. Primers shall have no harmful effects on concrete.

Sealants and primers which will be in contact with water to be used for potable supply shall not impart to water taste, colour, or any effect known to be harmful to health, and shall be resistant to bacterial growth.

Sealants and primers which will be in contact with sewage or sewage sludge shall be resistant to biodegradation.

3.6.6 SLIP MEMBRANE

The slip membrane shall be not less than 1.5 mm thick and shall be a plastic perforated strip with low coefficient of friction specifically manufactured for use as a separating membrane in sliding joints between concrete surfaces. Each joint shall comprise two layers of the membrane.

The concrete surface to which the slip membrane is to be fixed shall be finished with a steel float to provide a smooth true surface free from dust and loose particles.

3.7 FINISHES

3.7.1 FINISHES - GENERAL

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

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

3.7.2 SURFACE FINISHES

(a) Wood float finishes shall be formed by smooth floating the accurately levelled and screeded 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.

(b) Mechanical and Manual Steel trowel finishes shall be formed while the concrete is still wet by means of a steel trowel applied to an accurately levelled and screeded surface.

(c) Screeded finishes shall be formed by levelling and screeding the concrete to produce a uniform, plain or ridged surface as specified.

(d) Bush-hammered or pattern-worked finishes.

When exposed aggregate is to be the surface texture, the Contractor shall ensure that a uniform distribution of the coarse aggregate takes place at the face. The formwork shall be removed as soon as possible from the face to be treated; the surface shall be thoroughly wetted and wire brushed, and bush-hammered or pattern-worked as and when instructed. Surface retarders shall be used only when permitted by the Supervisor.

Bush-hammering or pattern-working shall not be relied upon to obscure any defects in the concrete face which arise from formwork imperfections.
3.7.3 MAKING GOOD

Honeycombed or damaged surfaces of concrete, which in the opinion of the Supervisor, 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 formwork as follows:

1:1.5 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 surface of uniform colour is finally presented.

3.8 DEFECTS

3.8.1 REMOVAL AND REPLACEMENT OF UNSATISFACTORY CONCRETE

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

- (a) the concrete does not conform to the Specification, or
- (b) deleterious materials or materials which are likely to produce harmful effects have been included in the concrete, or
- (c) the honeycombed or damaged surfaces are too extensive, or
- (d) the finished concrete sizes are not in accordance with the Drawings within permissible tolerances, or
- (e) the setting-out is incorrect, or
- (f) the steel cover has not been maintained, or
- (g) the protection, including curing, of the concrete during the construction was inadequate, resulting in damage, or
- (h) the work of making good or other remedial measures the Supervisor may indicate are not carried out to his satisfaction, or
- (i) undue deformation of or damage to the works has taken place due to inadequate formwork, or to premature traffic or to excessive loading, or
- (j) any combination of the above points has taken place resulting in unsatisfactory work.

3.8.2 LOADING TESTS

The Supervisor may permit that a loading test be made on the works or any part thereof for one or more of the following reasons:

- (a) failure of "Site Cubes" to attain the strength requirements;
- (b) premature removal of formwork;
- (c) overloading of structure during construction;
- (d) improper compaction and/or curing of concrete;
(e) any other circumstances attributable to alleged negligence on the part of the Contractor, which, in the opinion of the Supervisor, may result in a structure being of less than the required strength;

Loading test shall be carried out in accordance with the requirements of BS 8110.

If the results of the test are not satisfactory, the Supervisor will direct that the part of the work concerned be taken down or removed and reconstructed to comply with the Specification, or that such other remedial measures as he may think fit be taken to make the work acceptable.

The Supervisor may instruct the Contractor to take out cylindrical core specimens from the structures concerned and have them tested. The cutting equipment and the method of doing the work shall be to the Supervisor's approval. The specimens shall be dealt with in accordance with BS 1881. Prior to testing, the specimens shall be available for examination by the Supervisor.

3.9 SAMPLING AND TESTING

The Contractor shall provide on the Site equipment, staff and labour for carrying out the sampling and testing, and he shall carry out any or all of these tests at such times and with such frequency as may be requested by the Supervisor.

All equipment shall be calibrated and checked from time to time as the Supervisor may require.

The Contractor shall provide all samples required by the Supervisor. Those samples to be tested in an off site laboratory shall be carefully forwarded by the Contractor to an approved laboratory. Results of laboratory and site tests shall be kept on site and copies of all test reports shall be forwarded in duplicate to the Supervisor.

Frequency of tests and the number of samples required will be governed by the results of the previous tests, the quality of the materials revealed during the tests, and the uniformity of that quality. Should it become evident that the quality of concrete is deteriorating the Supervisor may require additional samples to be taken and test cubes to be made and tested to determine the cause.

3.10 SPECIAL CONCRETE

3.10.1 CYCLOPEAN CONCRETE

The boulders used for the cyclopean concrete should have a maximum dimension of 20 cm. Each boulder should be perfectly and entirely coated with concrete and the distance between two adjacent boulders or between a boulder and the formwork should not be less than 5 cm. The necessary precautions should be taken to prevent the accumulation of the aggregates at the concrete surface.

If, at the striking of the formwork, honeycombs of aggregates are identified in the concrete, the Supervisor reserves the right to require the demolition and the rectification, at the Contractor's expenses, of the portions of the works judged by the Supervisor as defective.

The cyclopean concrete should necessarily be cast in formworks.

However, for concrete with sulphate resistance is required, the cyclopean concrete shall consist of 70% concrete class C 25 D (SRPC) and 30% of gravel and boulders.

The aggregates and boulders should be of very good quality, hard, with a high strength, etc.
3.10.2 NO-FINES CONCRETE
No-fines concrete for use in subsoil drainage shall consist of a 1:8 cement/aggregate mix by volume. Aggregate shall be 20 mm to 10 mm graded with no more than 5% passing the 10 mm sieve. Only sufficient water shall be added to ensure complete coating of the aggregate. One half of this water shall be placed into the mixer first, after which the aggregate and cement shall be admitted. After partial mixing the balance of the water shall be added until a consistency of mix is achieved.

Preliminary tests shall be carried out on site to prove the suitability of the finished concrete, and adjustments made to the proportions and or grading as may be required by the Supervisor.

3.10.3 AIR-ENTRAINED CONCRETE
Concrete for roads, and those structures where specified, shall include an approved air-entraining agent capable of producing a 5% air-entrainment with a tolerance of 0.5%. The mix shall be purposely designed, having regard for the nature of grading of the aggregates and air-entraining agent being used.

Preference shall be given to the use of air-entraining agents which can be administered in fixed calibrated amounts through a dependable mechanical dispenser or sachet, and which are added to the mixing water.

Frequent air meter tests shall be carried out and the consistency of the air-entrainment maintained to the above tolerances by adjustments in the mix, as may be necessary.

3.10.4 CONCRETE IN BENCHING
Concreting for benching in manholes, pumping stations and works structures shall consist of Grade C25P concrete unless otherwise specified. It shall be placed with low workability to the approximate shape required and, while still green, shall be finished with not less than 50 mm of Grade C25P concrete to a steel trowelled finish and to the contours indicated on the approved drawings.

3.10.5 PNEUMATICALLY APPLIED MORTAR (GUNITE)
(a) Requirements
The pneumatic application of mortar shall be carried out only by Contractors experienced in this type of work and who are in possession of proper plant and equipment. Nozzlemen employed on the works shall be skilled operators.

The finished product shall be dense, of even texture and colour, and to the requirements of strength, tolerance and finish set out in this Specification.

(b) Strength
After curing, the mortar shall be capable of producing cored samples with a 28-day characteristic strength of not less than 27.5N/mm².

(c) Materials
Sand, cement and water shall comply with the requirements of this Specification except that the sand shall conform to the grading of Zone 2 of BS 882.

(d) Proportions
The mix shall be not weaker than one part of cement to four parts of sand by volume, having regard to the adjustments for bulking of the sand.

(e) Operation
Air and water pressures shall be such as to permit the proper application of the mortar, and shall be determined with reference to hose lengths and nozzle diameter.

Rebound, recovered, cleaned and uncontaminated with extraneous matter, may be re-used but not for water-retaining structures. It shall be regarded as an equivalent volume of sand which shall not exceed 20 per cent of the total sand requirement.

Rebound which has lodged in the formwork or between reinforcement shall be removed by compressed air.

Reinforcement shall be completely embedded in the mortar by the proper direction of the nozzle and the mortar shall be applied as a steady and uninterrupted flow from the nozzle.

Mortar application shall be discontinued at any section of the work where sagging of the mortar is in evidence.

(f) Joints
Joints shall be formed by sloping the surface to a thin edge. Before applying new mortar, the surface shall be thoroughly wetted. Laitance shall be removed by the initial discharge of fresh mortar.

(g) Tolerances
The thickness of applied mortar shall be not less than the dimensions specified nor greater than 10 mm over those dimensions, unless otherwise permitted.

(h) Protection and Curing
Shall be carried out in accordance with the requirements of the Specification.

(i) Finishes
Unless otherwise specified all surfaces shall be brought to a granular textured finish by means of a wooden float.

(j) Cold Weather Work
No application of mortar shall be made against frozen surfaces nor when the air temperature is below 5°C.

(k) Making Good
Any defective work shall be cut out immediately and made good with fresh mortar pneumatically applied.
3.10.6 PUMPED CONCRETE
Where pumping of concrete is permitted to be used no relaxation of the requirements of this Specification will be permitted. Particular attention shall be paid to the proper grading of aggregates to prevent bleeding and/or segregation during the pumping operations. The inclusion of water-reducing additives or other materials, including flyash, to improve the flow characteristics of the concrete will only be permitted where it can be shown that they do not adversely affect the concrete either in the plastic phase or in the finished work.

3.11 PRECAST CONCRETE UNITS
3.11.1 REQUIREMENTS
Precast concrete units, unless otherwise stated, shall be manufactured true to dimension and shape, with true arises and with perfectly smooth exposed faces free from surface blemishes, air holes, crazing and other defects, whether developed before or after building-in. They shall comply with the appropriate British Standard. The requirements of Table 4.1 shall be adhered to on all occasions units are supplied by others, the Contractor shall ensure the Supplier satisfied the requirements of the specification.

3.11.2 KERBS
Approved air-entraining agents may be permitted to be used providing that approved adjustments are made to the mix with regard to water and fine aggregate proportions.

3.11.3 PAVING SLABS
Paving slabs shall conform to BS 368 and shall be 50 mm thick unless otherwise specified.

3.11.4 OTHER BLOCKS
Blocks used for building work shall conform to BS 6073: Part 1: 1981.

3.12 SITE BOOKS AND STANDARDS
3.12.1 INSTRUCTIONS TO BE RECORDED
The Contractor shall provide and keep permanently on the Site a numbered triplicate book wherein the Contractor shall record all instructions relating to concrete work issued by the Supervisor. One copy of every entry therein shall be sent to the Supervisor on the same day as the entry is made.

3.12.2 SITE DIARY
The Contractor shall provide and keep permanently on the Site a continuous entry diary wherein he shall record details of formwork, construction, placing of reinforcement, concreting and curing operations, striking of formwork, making good and daily temperature and weather conditions. This diary shall always be available for inspection by the Supervisor.
Table 3.7  Sampling, Testing and Acceptance Standards

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4 PIPES AND PIPELAYING

4.1 GENERAL

4.1.1 SCOPE OF WORK
The Contractor shall furnish, install and test the pipes and fittings as herein specified and according to the instructions in writing of the Supervisor.

Prior to shipment from factory, pipes shall be tested at the place of manufacture, and the Contractor shall submit to the Supervisor for each consignment or shipment an authenticated certificate to indicate that the pipes and fittings have been tested by the manufacturer and found to comply with these specifications.

4.1.2 RELATED CODES AND STANDARDS
Any Standard mentioned in the bill of quantities prevails to this section

- Deutsches Institut für Normung (DIN)
- EORONORM (EN)
- International Organisation for Standardization (ISO)
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)

Refer to Section 1 - General Technical Requirements for other Codes and Standards

4.1.3 QUALITY ASSURANCE
Manufacturers shall be regularly engaged in the manufacture of products specified, and who have been in satisfactory use, in similar for not less than 10 years.

4.1.4 SUBMITTALS
The Contractor shall submit manufacturer's product data and equipment installation instructions, together with detailed shop drawings showing in accurate scale, installation details and space relationship.

4.1.5 MATERIALS

a) PE-HD pipes

- **PE 80 Wastewater pressure pipes**
  Pipe for laying in sand bed / noble split coarsest grain 11 mm or gravel 16/32 mm. Verbindungstechnik Heizelementstumpfschweißen oder Heizwendelschweißen.

- **PE 100 Wastewater pressure pipes**
  Pipe for laying in sand bed / noble split coarsest grain 11 mm or gravel 16/32 mm. Verbindungstechnik Heizelementstumpfschweißen oder Heizwendelschweißen.
Relevant Norms

- DIN 8074/75 “Pipes from Polyethylen Dimensions, General Quality Requirements, Testings“
- DIN EN 12201 „Plastic Pipe Systems for Water Supply, Drainage Pipelines And Wastewater Pressure Pipes“
- DIN EN 1610 „Laying and Testing of Wastewater Pipes and Channels“
- DVGW W 400-2 „Technical Regulation of Water Distribution Facilities (TRWV) – Construction and Testing“
- DVS 2207 „Welding of thermoplastic resin“
- PAS 1075 „Pipes from Polyethylene for Alternative Laying Technique – technical Requirements und Testing“
- DWA-A 127 „Static Calculation of Wastewater Channels and Pipelines“
- DIN EN 10204 „Kinds of Test Certifications“

General Requirements for Storage and Processing:

During storage it is to be emphasize in avoiding any kind of permanent deformations or damages. Pipe stackings should not exceed a height of 1,5 m. Impact loading are to be avoided. Damaged Pipes or Fittings are to be removed from the site. This applies also for pipes that show gaugings of more than 10% of the wall thickness due to transport. It will only be accepted that the pipe laying and installation works are sub-contracted to pipeline construction companies having staff at their disposal which is professionally educated according to European Water Frame Work Directive respectively German WHG § 19. The connection pipes by welding is to be executed by plastic welders, certificated according to DVS 2212 Part 1. The welding by means of butt-welding with heating elements and sleeve welding with incorporated heating elements is to be executed according to DVS 2207 Part 1 „Welding of thermoplastic resin; Welding of Pipes and Fittings with heating elements and Panels of PE-HD“. The data of the procedure of welding are to be recorded and handed over to the Contracting Authority after finalization of the welding works. The burial is to be executed according to DIN EN 1610 „Laying and Testing of Wastewater Pipes and Channels“. The structural analysis of buried pressure pipes for wastewater is to be executed according to the DWA Regulation A 127 „Static Calculation of Wastewater Channels and Pipelines.

For pipe laying, instalation and pressure testing above ground oberirdische Verlegung, Montage und Druckprüfung the requirements of the regulation DVS 2210 „Industrial Pipes of Thermoplastic Resin – Projecting and Execution of Pipesystems above Ground“ are to be followed.

b) Ductile iron pipe
Flanged pipe work shall conform to BS 4772 and ISO 2531 with flanges to BS 4504 – Table 16.

Ductile iron fittings and specials shall comply with the relevant British Standards. Non-standard castings shall be avoided. Ductile iron pipes shall be lined internally in accordance with the requirements of this specification.

Flanged joints shall be made with 3 mm thick, full face, rubber gaskets.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe supports, shall be included in the tender, and any excavation, building in or reinstatement shall be carried by the Contractor.

All pipe work, valves and fittings shall be to a class in excess of the maximum pressure they will attain in service including any surge pressures, with a factor of safety of at least 1.5 times these pressures.

Pipe work shall not be supported by the items of machinery. Duck foot bends and other pipe supports shall be used to prevent loads being transmitted to machinery.

The pipe work installation shall be so arranged to allow case of dismantling and removal of pump and major items of equipment.

A flange adapter shall be included in the suction and delivery pipe work of all pumps for easy dismantling and provision made for a flexible joint arrangement adjacent to structures. The adapter on the pump delivery shall be upstream of its respective reflux valve.

The ends of pipes for use with flange adapters and couplings shall be faced square and sized to the tolerances required by the manufacturer of the coupling.

All lose flanges shall be secured to fixed flanges by suitable tie-bolts.

Where the coating of the pipes is damaged the surface shall be cleaned and dried and the Contractor shall paint the damaged area with a minimum of three coats of approval paint and to the full thickness of the original coating, all in accordance with the requirements of this specification.

Flanged adapters and unions shall be supplied and fitted in the pipe work runs wherever necessary to permit the simple disconnection of flanges, without the need to spring long runs to remove valves, equipment, etc, and where joining to external pipe work.

c) Glass reinforced plastic pipes and fittings (GRP)

GRP pipes and fittings shall be as specified under clause 4.4 of this Section of the specification.

d) Reinforced concrete pipes with PVC liner

Reinforced concrete pipes with PVC liner shall be as specified under clauses 4.5 and 4.6 of this Section of the specifications.
4.1.6 WORKMANSHIP

a) Jointing pipes

If not specified within the Bill of Quantities the Contractor shall submit to the Supervisor the type of jointing he proposes for the various types of pipes.

Pipes shall be jointed in accordance with the manufacturer's instructions and the directions given by the Supervisor respectively specified in the Bill of Quantities. The Contractor shall adopt all measures as may be directed or approved by the Supervisor to ensure that every newly laid pipe is concentric with the previously laid pipe to which it is jointed.

All joints must remain absolutely watertight and shall withstand the pressure and tightness tests specified as the case may be. Any joint showing cracks, loss or sweating, shall be remade and again tested until a satisfactory result is obtained.

All costs for jointing and for remaking of unsatisfactory joints shall be included in the items for the complete pipeline.

The Contractor shall insure that the portions of the pipe which will come into contact with the jointing material are perfectly clean and dry.

The jointing materials shall withstand, without any alteration or modification for a period of at least the same as that the barrel of the pipe, all stresses and stains to which they may be subjected as well as all chemical or physical attack from sewage or ground water as might be expected, and the Supervisor reserves himself the right to demand a guarantee of the manufacturer of jointing material.

The joints shall be to the latest average standards utilized by the pipe manufacturer and approved by the Supervisor.

Cement mortar joints or similar joints shall in no case be accepted.

All costs for jointing and remaking of unsatisfactory joints shall be included in the items for the complete pipeline.

b) Laying pipes

i. General

Each type of pipe or joint, immediately before being laid, shall be carefully brushed out, and tested for soundness, and any pipe or joint which shows any sign of being defective, shall be rejected.

The Contractor shall adopt such measures as may be approved by the Supervisor to ensure that every newly laid pipe is concentric with the previously laid pipe with which it joints.

Unless otherwise approved by the Supervisor, pipes shall be laid in an upstream direction and the sockets of spigot and socket shall point upstream.
Before commencing the laying operation, the Contractor shall ensure that the portions of the pipe which will come into contact with the jointing materials are perfectly clean.

Each pipe shall be laid accurately to line, level and gradient so that, except where otherwise provided, the finished pipe line shall be in a straight line both in horizontal and vertical planes.

ii. Inspection before installation

All pipes shall be carefully inspected and examined for cracks, damage at joints, and any defects, immediately before installation in final position.

iii. Pipe laying and jointing

The pipes shall be laid and jointed immediately following excavation. The pipes shall be laid at the level and gradient as specified on the detailed design drawings approved by the Supervisor. The pipes shall be aligned carefully both in line and level. Except where the pipe is to have a concrete bed or surround, supports shall not be placed under the pipe. The bedding shall be shaped and scooped out at pipe joints to ensure the pipe rests only on the barrel of the pipe and not on any widening at the joints. Joints shall be free from dirt and grease.

The Contractor has to exercise extreme care in making joints, including constructed to manholes, and other appurtenances to ensure that no leakage whatsoever occurs from the joints.

The Contractor shall ensure that all pipes and structures, when laid as constructed, are secured against floating by backfilling or by some other approved means.

The Contractor must obtain the fullest possible information on the variations in water table and water level fluctuation that may affect the works and shall carry out having due regard to this information.

No "y" connections to laterals shall be made. All connections shall be made directly to the manholes or to the shafts of the box culverts. When such direct connections are not possible, a solution shall be proposed by the Contractor for the Supervisor’s approval.

No pipe shall be laid when climatic conditions, in the opinion of the Supervisor, are unsuitable.

c) Backfilling

All backfilling within roadways and footpath limits, tiled areas, underneath, around, and over concrete structures shall be compacted to a minimum of 95% of AASHTO Ti80 density. Backfilling all other areas shall be compacted to a minimum 90% of AASHTO Ti80 density. All compaction shall be done in layers not exceeding
150mm in thickness and fill shall be brought up simultaneously on all sides of the excavation.

Excavations shall be backfilled with suitable material without unnecessary delay, but not until pipes and manholes, and other construction details have been tested and accepted by the Supervisor. Necessary precautions shall be taken during backfilling to ensure that pipes, manholes, and other structures are not damaged. Any spaces left by the withdrawal of timbering shall be properly filled and compacted immediately.

Trenches for pipes shall be backfilled to a depth of 300mm above the top of the pipe by hand. Above the 300mm, approved mechanical means shall be used for compaction. The Contractor shall use special care in placing this portion of the backfill so as to avoid damaging or moving the pipe. The backfill material shall be placed in 30mm layers and compacted.

Backfilling should not start before 24 hours after placing any concrete. Heavy compactors and any traffic loading should not be allowed before 72 hours after placing any concrete.

d) Select backfill

Selected fill shall consist of approved granular material obtained from the excavation, borrow pits or elsewhere as necessary and shall exclude stones larger than 38 mm in size. The material shall be capable of being compacted to a solid mass and achieve a 95% Compaction Proctor Test.

Selected fill material shall comply with group "GW, GP, GM, BC, SW, SM, SP, SL, in compliance with ASTM D 2487.

Selected fill material shall not contain ashes, cinder, refuse, rubbish, organic material, or the like. All select material used for backfilling shall be placed in layers not exceeding 150 mm and compacted as per Section “Earthworks”, of the specifications. Excavated local material may be used if satisfactory, subject to the approval of the Supervisor.

e) Pipe bedding

i. Sand bedding and surround – Type I (selected granular material):

   While preparing bedding on natural bed, care shall be taken to ensure that pipes do not get supported on pointed objects. Cut holes in trench bottoms for sockets/couplings and lay pipes resting uniformly on their barrels and adjusting to exact line and level. Hard packing under pipes shall not be used.

   Shall fill to 300 mm minimum above crown of pipe shall be natural well graded sand having hard, strong, durable angular particles. It shall be clean and free from extraneous materials, clay balls, organic matter or other detrimental material. The amount of fines passing sieve No 200 shall not exceed 15 percent.

ii. Sand cement bedding and surround – Type 2:
Sand cement bedding and surround for GRP pipes shall be as per sand bedding and surround except that material shall be a mixture of sand cement (200 Kg cement to 1 cubic meter of sand).

iii. Crushed aggregate bed – Type 3:

Granular material for bed type 3 shall be composed of 14mm maximum size material gravel, crushed gravel, or crushed rock, free from dirt, clay, roots, organic, and other deleterious material mixed with sufficient sand to fill the voids, about 30% to 35% by volume. Lay and compact to the specified thickness over the full width of the trench. Scoop out suitable holes for the sockets and coupling and lay pipes. Adjust to exact line and level.

After testing and acceptance by the Supervisor, backfill with a protective cushion of selected sand fill compacted by hand in layers not exceeding 150mm to a level not less than 300mm above crown of pipe.

iv. Pipe bedding in rock excavation – Type 4:

Sand fill in rock excavation shall be 300mm minimum above the crown.

v. Crushed aggregate bed and surround – Type 5:

Granular material for bed type 5 shall be as described for granular bed type 3. Scoop out suitable holes for the sockets and couplings and lays pipes, digging slightly into bed to the shape of barrel so that pipe barrels have uniform support along their full length. Adjust to exact line and level. After testing and acceptance by the Supervisor, lay and hand compact further granular material simultaneously and uniformly up both sides and over pipe to a level not less than 300 mm above crown of pipe. Geotextile lining shall be installed where crown of pipe is under water table or as directed by Supervisor.

vi. Concrete bed – Type 6:

Pipe shall be laid on a concrete bed, concrete shall be class A.

Trench shall be excavated up to proposed concrete bed bottom level. Pipe shall be laid in the trench on designed slope and alignment and supported on precast concrete. Each pipe segment shall have a minimum of two such supports near the joints. Concrete shall be laid up to the desired bedding shape. Care shall be taken not to disturb the pipe alignment while laying and compacting the concrete underneath the pipe.

vii. Concrete encasement – Type 7:

Where the superimposed loads on the pipe due to backfill loads and /or traffic loads are so high that the desired bedding factor cannot be achieved by any type of bedding, the pipes shall be surrounded by concrete.

Excavation of the trench shall be done up to the purposed bottom of concrete encasement. Pipes shall be laid and jointed on the designed grade and alignment having precast concrete supports underneath, minimum of two supports for each pipe piece. Concrete shall be laid in a minimum of two layers to avoid buoyancy of pipes in concrete. The first layer of concrete shall cover the pipe up to the DN/4. Second layer may be laid after 24 hours so that the first layer has hardened adequately and developed a proper bond with the
bottom of the pipe to prevent it from floating when the second layer of concrete is laid and compacted.

Flexibility of the pipeline shall be maintained by providing polystyrene or styropore, or similar flexible boards on the joint. Utmost care shall be taken to keep the trench completely free from ground water until the concrete has hardened sufficiently.

For other pipe material it shall be based on the structural calculations for backfill and traffic loads likely to come over the pipe. All cases shall be referred to the Supervisor for approval.

On passing onto sand embedment at each end of a concrete embedment or at each face of a concrete structure, a short pipe of length equal to 2 to 2.5 times the nominal pipe diameter shall be provided having a fully flexible joint at each end. The nearer joint shall be not more than 300 mm from the concrete face.

f) Geotextile fabric:

Geotextile fabric shall be provided and installed when directed by the Supervisor. The geotextile shall be a previous sheet of nonwoven polyester, polyethylene, nylon, or polypropylene filaments, and formed into a uniform pattern. The geotextile shall have the following minimum properties when measured in accordance with the reference standards:

<table>
<thead>
<tr>
<th>Test</th>
<th>Minimum</th>
<th>ASTM standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab tensile strength</td>
<td>58 kg</td>
<td>D 1682</td>
</tr>
<tr>
<td>Trapezoidal tear</td>
<td>32 kg</td>
<td>D 2263</td>
</tr>
<tr>
<td>Mullen burst</td>
<td>0.83 N/mm²</td>
<td>D 751</td>
</tr>
</tbody>
</table>

The Geotextile shall be finished so that the filaments will retain their relative position with respect to each other. The edges of woven fabric shall be finished to prevent the outer material from pulling away from the fabric. Provide manufacturer’s certificates of compliance attesting that the Geotextile meets the requirements of these specifications. Provide mill certificates stating the length and width of fabric contained on each roll.

Prevent exposure of geotextile to light until needed for construction geotextile laying and subsequent covering with succeeding layers of trench backfill shall proceed in such a manner as to limit exposure to light for a maximum of 24 hours.

The surface to receive the geotextile shall be smooth, free from obstructions, depressions, and sharp objects. Lay geotextile so as to minimize the number of joints and seams. Lay geotextile loosely, but without creases. Provide at least 2 feet of overlap at the joints. The geotextile shall extend up the sides of the trench to at least feet above the top of pipe.

Do not operate machinery directly on the geotextile. When placing material over joints, place in the direction from the overlaying geotextile to the underlying
geotextile. Prevent puncture, tear, or displacement of geotextile and prevent from
damage. Replace torn areas and holes by placing an overlay of Geotextile having
dimensions at least 2 feet greater than the tear or hole.

g) Unstable subsurface conditions:
Where soil is completely unstable and large settlements in the pipeline are
expected, and where deemed necessary, special arrangements as listed below
should be made after proper site investigation and structural calculations.

- Improvement of mechanical properties of the soil
- Replacement of soil by other soil or concrete
- Pile foundations
- Reinforced concrete slab foundation

Where such conditions occur, a report shall be submitted to the Supervisor, along
with all the site data and Contractor's proposals for approval.

Where hard rock occurs in the bed just before or after compressible soft bed, it is
desirable to provide a flexible joint at the junction of two materials to allow rotation
of pipes pieces without damage in case of settlement of the soft bed. In the case
of pipeline laid under the slope of an embankment, any longitudinal tensile or
bedding stress occurring in the pipe shall be taken into account.

4.1.7 TESTING SEWERS AND MANHOLES

All sewer pipe lines shall be tested before being backfilled. The lines shall be tested in lengths
between manholes or such shorter lengths as the Supervisor may approve, in all cases the
tests shall be applied in the presence and to the satisfaction of the Supervisor.

The testing of pipelines will normally be carried out after the placing of the embedment to the
lower 120 degrees of the pipe and before the remainder of the backfill.

Every pipeline subjected to a test shall comply with the following conditions:

- The pipeline and all concrete shall be perfectly clean and dry the joints uncovered;
- The level of the ground water in the trench shall be maintained as low as possible and
  in every case below 30cm from the pipe invert or more depending on the type of
  bedding;
- No form work for additional concrete shall have been erected.

Air smoke or water shall be used to test the pipelines, as detailed for each of pipes, but the
Supervisor reserves the right to direct the Contractor to test any particular length by any of the
specified methods, where circumstances in his opinion so require, and the Contractor shall
comply with such directions and shall make no charge for so doing.

a. Air or smoke tests
   Air or smoke tests shall be performed in accordance with ASTM C 828.

b. Water tests
Water tests shall be performed in accordance with the detailed requirements specified elsewhere in this section for each type of pipe.

c. Post-construction CCTV inspection

Prior to the issue of the completion certificate required by the Supervisor, the Contractor shall carry out a CCTV survey in accordance with section 20 of these specifications. The line shall be clean and free from any visible defects and leakage at joints. The Contractor shall remedy any defects at his own expense.

If the Supervisor should suspect that a pipeline has been damaged during concreting or backfilling or subsequently he may order the Contractor to retest the suspected length by one of the approved methods. Should the retest indicate that the line is no longer capable of withstanding the prescribed test, the Contractor shall forthwith search for and repair the damage and retest the pipe line until a satisfactory test is obtained, and all costs incurred, including those of the retest, shall be borne by the Contractor.

Should it be found on completion of any particular section of the work that there is a rate of infiltration into the sewage system in that section in excess of 1 liter per hour per meter of internal diameter per linear meter of pipe, the Contractor shall at his own expense search for, isolate, repair and reset the defective lengths of pipe all to the satisfaction of the Supervisor.

All manholes must be constructed a water tight condition and the Contractor shall make his own arrangements for ensuring that all manholes are so constructed. In general, manholes will be inspected visually and will be tested. Should it become apparent in the light of experience, that the Contractor's methods are proving inadequate, and that a proportion of manholes are being constructed in a non-watertight condition, the Supervisor reserves the right to direct the Contractor to test the manholes in subsequent construction before backfilling the surrounding excavations, in order that any necessary works or repair may be carried out, at the Contractor's expense and in accordance with such directions as the Supervisor may issue.

The Contractor shall at his own expense provide ample expanding stoppers for each diameter of pipe to be laid, together with such upstand tubes, U-tubes, pumps and all other required testing apparatus of the Supervisor.

The costs of supplying water and subsequently disposing of it in an approved manner shall be borne by the Contractor. Ground water may be used for testing pipelines. The Contractor shall be responsible for adequately strutting or stoppers when pipelines are subjected to a water test, and shall take adequate precautions to ensure against any stopper or strutting being carried into a downstream pipe when the water is released.

4.1.8 THRUST BLOCKS AND PIPE ANCHORAGE

Thrust blocks pipe anchorage shall be constructed on all pressure mains at each change of direction and wherever a toe junction or blank end is constructed. Thrust blocks shall be constructed of class "B" concrete.

4.1.9 PUDDLE FLANGES

Unless otherwise specified, all pipes passing concrete walls or other similar structures shall incorporate a puddle flange. Such flanges shall be of the same dimensions as flanges for the size and class of pipe to which they are attached.
4.1.10 PROTECTION OF PIPELINES AND STRUCTURES FROM CORROSION

The following pipelines and structures shall be protected from corrosion in the following manner.

a) Pipelines and structures incorporating ferrous metals:

All pipelines and other structures incorporating ferrous metals which are laid in direct contact with the ground and (or) with sewage or sludge shall, unless otherwise directed by the Supervisor, be protected from corrosion by painting with three coats of bituminous paint, and each coat shall be protected with a layer of approved glass fiber. The requirements concerning the coating of cast iron and ductile iron pipes are as specified in the ISO specifications for such pipes, and the pipes shall be protected externally by the application of polyethylene sleeving.

b) Concrete pipelines and box culverts:

Concrete pipelines and box culverts with the associated sewer manholes shall be protected internally by the application of a PVC lining in order to protect the concrete from possible corrosive attack.

The type of attack is that normally known as "sulphide attack" and is mainly due to the formation of sulphuric acid on the surface of the concrete.

The PVC sheet shall be cast integrally with the pipe, box culverts and sewer manholes during manufacture and construction. The sheet shall have a minimum thickness of 1.65 mm and shall incorporate keys or ribs at a minimum spacing of 17.5 N/mm. The ribs may run circumferentially or longitudinally, but if the latter, shall have 10 mm gaps at 2.5 meters centers to provide relief of back pressure to the invert section. The PVC lining will cover 300' (83%) of the internal sewer circumference (unless otherwise stated), the gap being located at the invert. In sewer box culverts and manholes, the lining shall cover the entire internal surfaces.

The PVC lining to be used shall be obtained from an approved manufacturer, the composition of the material being specially designed for use in foul sewers carrying waste at a temperature up to 40° C. The lining shall be impermeable to sewage gases and liquids and shall not promote bacterial or fungus growth. The lining shall be capable of repair at any time during the life of the pipe and manhole. All joints between individual sheets or sections of the lining shall be continuously heat-welded by the use of welding strips of same type materials as the liner.

All work for, and in connection with the installation of the lining in the concrete pipes, box culverts and manholes, the field scaling and welding of joints and testing of the lining shall be done in strict conformity with all applicable specifications, instructions and recommendations of the lining manufacturer. Samples taken from the sheets, joints or weld strips shall be tested to determine material properties. The lining shall be spark tested to a minimum of 10,000 volts prior to dispatch from the factory, and any flaws rectified. The Supervisor
may require other tests to be carried out to determine the suitability of proposed lining. All costs incurred for carrying out the tests shall be included in the Contractor's rates for the lining.

4.1.11 OPENING IN WORKS UNDER CONSTRUCTION

Wherever possible, all pipes passing through walls and floors shall be built in as the work proceeds.

All holes or opening for pipes or other things passing through walls, floors or other permanent work, shall be neatly and accurately cut or formed and any work disturbed shall be made good at the Contractor's expense and to the approval of the Supervisor.

All bolt holes or other openings required for securing machinery or plant shall be carefully formed in the exact position required. The Contractor shall be responsible for obtaining from the various manufacturers, exact details of all holes and securing bolts required, and shall be responsible for all boxing-out and subsequently grouting-in or, where this procedure is deemed necessary by the Supervisor for obtaining templates and subsequent building in of bolts etc., all at the Contractor's expense. The position of all holes shall be checked by the Supervisor before concreting or grouting is commenced.

All bolt holes in exposed positions and near the edge of concrete structures shall be sealed.

4.1.12 TREATMENT OF IRONWORK AND STEELWORK

All cast iron work and spun iron pipes, except where otherwise specified or ordered by the Supervisor, shall be dipped hot in approved bituminous solution, and thoroughly coated therewith immediately following manufacture.

With the exception of reinforcing steel, and unless otherwise specified or directed by the Supervisor, all steel and wrought iron work shall be galvanized by pickling in dilute hydrochloric acid, staved and dipped in pure virgin speller, and washed and brushed all to the satisfaction of the Supervisor.

The galvanizing shall be evenly covered and, the additional weight there of after dipping shall be not less than 610 gm per m² of surface galvanized. In particular bolt holes shall be cut to pre-plating limits and the unit galvanized after cutting.

All edges shall be clean and all surfaces shall be bright.

The Contractor shall include in his prices for cast iron, wrought iron and steelwork, the costs of coating or galvanizing as specified above.

4.1.13 PAINTING OF IRON WORK AND STEELWORK

All ironwork and steelwork used in the contract shall be thoroughly freed from rust, scale, grease and other deleterious matter and shall be painted with three coats of approved paint to an approved color.

All painting shall be carried out in accordance with the manufacturer's printed instructions unless otherwise varied by the Supervisor. Iron and steelwork in contact with water or sewage must be painted with a high grade chlorinated rubber paint of approved manufacture.
4.1.14 WELDS
No welding shall be carried out without the express permission of the Supervisor in writing unless such work is specified in the contract documents.

4.1.15 WORKS TO BE WATERTIGHT AND TESTING OF WORKS
The whole of the works and connections to the works shall be constructed in a watertight condition and shall be so maintained for the period of the contract. Should any leakage or weeping take place in any part of the works, the defects shall be rectified by the Contractor at his own expense, and should the Supervisor consider it necessary, any part of the works shall be tested with water to ensure that they have been so constructed and maintain. All weirs shall be tested with water to ensure that they have been accurately constructed to level.

4.1.16 WORKS TO BE LEFT PERFECT
The whole of the works shall be handed over at the expiration of the period of maintenance, in a thoroughly sound, substantially clean, trim and watertight condition.

4.1.17 CLEARING UP
On completion of the work, the Contractor shall at his own expense forthwith remove all plant, timber, waste and surplus and other materials and leave this site in a clean and tidy condition.

4.2 MANHOLES

4.2.1 GENERAL
The Contractor shall furnish all plant, labor, equipment, appliances, materials and tools, and perform all operations necessary for the construction of manholes, in accordance with the specifications and instruction of the Supervisor.

4.2.2 MATERIALS
a) Concrete components
Concrete components such as cement, aggregates, water, reinforcement, formwork, testing etc…., for all types of concrete, shall be as specified in section 3, “concrete works”.

b) Pipes and pipe fittings
Pipes and fittings shall be as specified under “pipes and pipelaying” of the present section.

c) Step irons
Step iron for manholes shall be grey cast iron, similar to “Kassardjian” ref. No. 2301 or approval equal.

d) Manholes covers and frames
Manhole cover and frames shall be of cast iron, similar to “Kassardjian” Ref. No. 2132, approximate weight 260 KGs, or approval equal.

e) Leveling bricks
Leveling bricks used for adjusting the height of cast iron covers to road levels shall be of a concrete class A as specified under “Concrete works”. Bricks shall be radial or tapered in Shape 20cm long and 5cm thick, cast at least three weeks before use and properly cured. Any cracked or defective bricks shall be rejected.

The Contractor shall submit samples of all types of cast iron frames and covers, mud collection buckets, and step irons for approval by the Supervisor before placing orders or importation to the site.

4.2.3 WORKMANSHIP

Manholes shall be constructed of Class “AA” reinforced concrete, dimensions and shapes shown on the drawings.

Benching to the manholes shall be in class B concrete. “U” channels shall be formed with bottoms flush with the inside surfaces of pipes and the sides of the channels shall extend to the full height of the largest pipe and then sloped black at a minimum fall of ten percent. The benching and channels shall have a smooth steel trowelled finish. The finished diameter of channels shall be as the diameter of incoming and outgoing pipes. Branch channels shall be formed in the same manner as the main channels and streamlined.

Step iron shall be installed and fixed to walls in an approved manner. The uppermost step iron shall be fixed at a distance of 60cm from the underside of the cover slab, and the others at 30cm centers in a vertical line allowing for a distance of 15 cm, on either side of the vertical line unless otherwise or directed.

Manholes frames and covers shall be placed immediately after the construction of the manhole or structure. The frame shall be fixed in position and embedded in concrete or in non-shrink mortar as directed or approved. Covers shall be greased on the surfaces in contact with frames.

Where pipes are built into manhole walls, the pipes shall be set accurately to the required line and elevation and the joints between pipes and walls shall be completely watertight.

4.2.4 PROTECTION OF EXTERIOR CONCRETE SURFACE

The exterior surfaces of all manholes and structures above the water table shall be given three coats of an approved tar compound.

The Contractor shall produce documentary evidence that the tar compound proposed to be used is suitable for the intend purpose and has been successfully used in similar installations. Surfaces to be protected shall be dry and thoroughly cleaned from dust and loose material. Projections shall be removed and all defects shall be adequately repaired and made good before the application of the compound. The tar compound shall be applied in accordance with the manufacturer’s instructions and recommendations and as directed or approved by the Supervisor.

Manholes and structures below the water table shall be waterproofed in accordance with Section 13 of this specification.
4.3 PIPELINE CONSTRUCTION BY TRENCHES TECHNIQUES

4.3.1 GENERAL

Two methods of trenches techniques (boring techniques with jacked in place steel casing and micro-tunneling) are specified and described herein below. For large size pipe diameter the Contractor may propose tunneling techniques by jacking of pipes or pipe and tunnel shield and should submit details for approval of the Supervisor.

The Contractor may use boring techniques with steel casings as specified or otherwise use micro-tunneling techniques as specified and with no steel casing requirements.

The extent of construction of sewer pipelines by micro-tunneling techniques along roads or in any other areas shall be as directed by the Supervisor.

These locations will be determined after review of the soil investigation results which will be done by the Contractor, and the submittal by the Contractor of his system of boring and micro-tunneling systems. Both boring techniques and micro-tunnelling techniques shall be submitted to the Supervisor for approval.

The Contractor shall obtain all necessary approvals from the concerned authorities and submit them to the Supervisor before commencing any work. Prior to starting construction, all required labor, materials, and equipment shall be made available on site. Notify all concerned authorities and the Supervisor at least 72 hours in advance of commencing work.

The Contractor shall be deemed to be experienced in this type of work and shall follow all safety procedures required in performance of pipe jacking/thrust boring works. All precautions shall be taken to protect the infrastructure, existing utilities, and structures from settlement or damage, and all safety precautions shall be implemented to protect the workmen undertaking these operations.

The success or failure of any tunneling procedure shall be solely the responsibility of the Contractor. Approval of the Supervisor shall not relieve the Contractor from all obligations and requirements of this section.

The Contractor’s design shall include for any de-watering systems and any soil supporting system to prevent any adjacent ground from loss of fines, shrinkage, settlements, etc. during construction.

The Contractor shall limit the settlements arising from the construction work to the minimum level that shall ensure the safety of the structures nearby, the utilities and the road system. However in no case shall settlements exceed the following limits:

1. In ground or road or roadway along the centerline of pipe: 2mm
2. At front face of adjacent structure: 15mm
3. Other critical places near buildings, as approved by the Supervisor.

The Contractor shall take all necessary safety to protect all utilities and structures and to ensure that no damage shall occur to construction operations.

The Contractor shall include in his tender submittal, complete material standard and specifications for his proposed piping system and shall also indicate where such pipe has been used before in similar conditions.
The Contractor shall survey all structures adjacent to the tunneling centerline and to a minimum distance of three times the depth of the pipe invert being laid. The Contractor shall also take photographs of all structures before commencing the tunneling operations. This survey shall include levels on the structures and the roadways.

The Contractor shall carry complete and comprehensive soil investigation program along the route of the proposed lines to be constructed by trenches techniques. The Contractor shall hire a competent geotechnical firm to design, and operate a monitoring program for soil observation to include:

- Settlement anchors
- Observation wells
- Horizontal and vertical alignment
- Surface settlement points
- Others as determined by site investigation and as instructed by the Supervisor.

The Contractor shall carry out all monitoring work during the construction operation and until deemed satisfactory and instructed to stop by the Supervisor.

4.3.2 PIPELINE CONSTRUCTION BY BORING TECHNIQUES WITH STEEL CASING

a) General

The Contractor shall undertake the laying of the sewer line by boring techniques with jacked in place steel casing which is capable of installing sewer pipes of different materials in any soil and under the water table prevalent in the area.

The Contractor shall abide by all requirements of the relevant clauses of the specifications. The Contractor shall submit complete detailed shop drawings for approval of the Supervisor to include, but not be limited, to the following:

i. Prior to commencing construction, the Contractor shall submit detailed shop drawings for utilities locations as obtained from slit trenches, protection existing structures and utilities, all as specified.

ii. Complete detailed shop drawings for the driving pits, jacking operation, soil investigation results, pipe design, pipe joints designs, receiving pits, and all relevant information for approval of the Supervisor.

The Contractor shall abide by all notices of intent for the various Ministries and concerned authorities and shall obtain the necessary approvals and submit same for the Supervisor.

b) Materials

i. Sewer pipe

Sewer pipe shall be of the sizes approved by the Supervisor and shall be especially designed for tunneling to withstand jacking pressures. Pipe shall be manufactured with mechanical compression joints resistant to corrosion and shall withstand all external loads including hydrostatic water pressure, earth pressure, and traffic loads as per AASHTO H20-S16 truck loading at the appropriate environmental conditions. Sewer pipes shall be as follows:
For non man entry pipes smaller than Ø 800mm, composite pipe of reinforced concrete pressure pipe with GRP liner with minimum STIS 5000 N/m² specially designed for tunneling and jacking. The alternative pipe material shall be submitted to the Supervisor for approval.

For pipe size Ø 900mm and larger, reinforced concrete pressure pipe with PVC liner shall be used. The pipes shall be suitable for tunneling and jacking and the pipe and pipe joints shall be designed to withstand all the tunneling and jacking forces and all loads as required above and as approved by the Supervisor. The pipes and pipe lining shall meet the minimum requirements as specified for the reinforced concrete pressure pipes in these specifications.

ii. **Jacking pits**

The jacking pits shall be watertight, and designed to be capable of sustaining the reaction loads from the jacking operations, earth loads and traffic loads, and shall be approved by the Supervisor.

iii. **Casing**

Jacked-in place casing for bored under-crossings shall be smooth steel pipe conforming to AWWA C200, or equal fabricated in sections for welded field joints. Casing pipe shall be coated inside and outside with two coats of cold applied coal tar epoxy or equal, and approved protective coatings applied in accordance with the manufacturer’s recommendations. Fields joints shall be full circumference welded butt joints. Casing pipe diameter shall be as required having 12mm minimum wall thickness. The Contractor shall be responsible for selecting a wall thickness and diameter consistent with his operation.

The casing diameter shall be sized for vitrified clay pipe or any approved alternative pipe as applicable. The inner diameter of the casing shall be at least 100mm greater than the maximum outside diameter of the pipe socket or pipe and skids.

Casings shall be equipped with nipples at the spring line and crown at 3-m centers for pressure grouting. The grout nipple spacing is the minimum acceptable and the Contractor shall be responsible for providing sufficient numbers and locations of ground nipples to satisfactory perform the grouting.

- **Grout**
  
  Grout for pressure grouting outside jacked casing pipe shall be 1 part sulphate resisting cement and 3 parts sand, by volume.

- **Casing seal**
  
  Casing seals shall be synthetic rubber pull-on seals with stainless steel grade 316L bands and shall be in one piece.

- **Pipe skids**
  
  Pipes skids shall be of a design appropriate to the pipe laying method adopted. Bands shall be not less than 12mm wide by 0.5mm thick type 304 stainless steel.

- **Casing sand**
Casing sand shall be fine clean sand and shall conform to the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve size</th>
<th>Percent passing by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>318 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>95 – 100</td>
</tr>
<tr>
<td>No. 10</td>
<td>80 – 100</td>
</tr>
<tr>
<td>No. 40</td>
<td>10 – 70</td>
</tr>
<tr>
<td>No. 100</td>
<td>0 – 25</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 – 5</td>
</tr>
</tbody>
</table>

c) Workmanship
   i. General
      Prior to the start of the work, submit satisfactory evidence to the Supervisor that all requirements called for by the concerned authorities have been complied with. All proposed construction methods and materials for the under-crossing shall be approved by the Supervisor and concerned authorities prior to the crossing operation, and no construction shall be started until written approval to proceed from the concerned authorities has been submitted to the Supervisor.

   ii. Steel casing installation
      Install steel casing by jacking and boring from within the steel casing. Methods of tunnel excavation, whether by a tunnel boring machine or hand digging, shall be at the Contractor’s option, subject to, the review of the Supervisor. The Contractor shall control settlement of the ground surface, adjacent structures, and buried utilities through an appropriate control of activities such as excavation, jacking, and dewatering. Should any settlement above the tunnel or at any location occur, the Supervisor may require modification of the method or sequence of work. In event of further settlement at any location occur, the Supervisor may require a shutdown of the work to make appropriate changes in the construction operation. Changes required to keep settlement within acceptable limits and to prevent movement and/or damage to existing structures shall be made solely at the Contractor’s expense.

   iii. Grouting void outside casing
      In cased crossing, fill void space between ground and casing completely with lean grout. After the casing has been jacked or tunneled into position, pressure grout through the grout holes provided to fill all voids outside the pipe. Start grouting at the spring line hole at one end and pump grout until grout appears at crown, then start grouting through the opposite spring line hole until grout appears at hole in the crown. Next grout the hole at the crown until grout appears in the next set of holes along the pipe. Plug the holes at the starting point and move to the next set of holes and repeat grouting sequence until full length of jacked or tunnelled pipe has been grouted.

   iv. Cased sewer pipe
Install skids on all pipes in accordance with the manufacturer’s recommendations.

After installation, sewer pipeline shall be tested in accordance with the appropriate clauses of this section.

v. Placing fill in casing

Fill the annular space between the casing and the pipe completely with sand. Accomplish sand filling by using a gunite machine for blowing, or other approved equipment.

Dispose of excess excavated material as approved by the Supervisor.

vi. Placing seals at ends of casing

After the pipeline has been tested and approved, place casing seals in strict accordance with the manufacturer’s recommendations.

vii. Manhole construction

The Contractor shall remove or abandon jacking pits, backfill to the required invert and prepare location to be able to build as specified for each type.

4.3.3 PIPELINE CONSTRUCTION BY MICRO TUNNELING

a) General

The Contractor shall undertake the laying of the sewer line by micro-tunneling system which is capable of installing sewer pipes of different materials in any type of soil and under the water table prevalent in area. The micro-tunneling system used shall be of the proven in the market and shall have been successfully used for the installation of similar pipe diameters under similar conditions. The micro-tunneling systems shall be capable of installing water tight sewers with special type of joints at uniform slopes. The micro-tunneling systems shall be safe to operate near existing structures, foundations, road surfaces or utilities. The micro-tunneling systems shall be suitable for use in inhabited areas and shall comply with requirements and provisions of BS 5228 for noise control and other requirements of these specifications or as directed by the Supervisor.

The Contractor shall submit complete and detailed shop drawings for approval of the Supervisor to include but not limited to the following:

- Prior to commencing the construction, the Contractor shall submit detailed shop drawings for utilities locations as directed from slit trenches, protection of existing structures and utilities all as specified.
- Complete and detailed shop drawings from the driving pits, jacking operation, soil investigation results, pipe design, pipe joints designs, receiving pits, and all relevant information for the approval of the Supervisor.

The Contractor shall abide by all notifications of intent for the various Ministries and concerned authorities and shall obtain the necessary approvals and submit same for the Supervisor.

b) Materials

i. Sewer pipes
Sewer pipes shall be of the same materials stated in Clause 3.2.2 of this Section.

ii. Jacking pits

The jacking pits shall be watertight and designed to be capable of sustaining the reaction loads from the jacking operations, earth loads and traffic, and shall be approved by the Supervisor.

c) Workmanship

The micro-tunneling system shall be able to install pipes of internal diameter ranging between 200 mm and 1800 mm. The system shall be able to install at least a stretch of pipeline of more than 60 meters in length. The individual pipe lengths to be between one and two meters in length. The jacking pit length or diameter shall be restricted to the minimum size needed to drive a certain stretch of pipe.

The micro-tunneling system shall be able to work in varying ground conditions ranging from stiff clays, sand/silt, stiff, gatch, under at least a head of 6 meters of water. The micro-tunneling system shall be fitted with slurry type pumps for excavation removal where this is deemed necessary to allow work under water table conditions. The micro-tunneling system shall be able to deal with “cobbles” of at least 200 mm in size. The Contractor shall undertake extensive soil investigations for each stretch of sewer to be. Installed and familiarize himself with the ground conditions before undertaking any micro-tunneling work.

The micro-tunneling system shall be capable of installation of the pipe lines in continuous operation from the jacking pits. The pipes shall be able to withstand all the jacking forces imposed on them as well as the load arising from the overburden and traffic loading. If necessary, facilities for lubricating the external surface of the pipeline shall be provide to minimize the jacking forces. Also facilities of grouting around the pipe shall be provided. The micro-tunneling system shall at least ensure an average rate of installation of not less than 10 meters per working shift. The micro-tunneling systems shall be capable of installing pipelines to a maximum deviation from the line and level of 25 mm. the micro-tunneling system steering shall be by hydraulic jacking mechanism acting in conjunction with a laser/target or other such control system. It shall also be fitted with an automatic steering control by means of microprocessor system with line and level prediction capability.

After installation, sewer pipe shall be tested in accordance with the appropriate clauses of this section.

4.3.4 MANHOLE CONSTRUCTION

The Contractor shall remove or abandon jacking pits, backfill the pits to the required invert and prepare location to be able to build the manhole as specified.

4.3.5 CONTRACTOR’S RESPONSIBILITY

The Contractor shall be fully responsible for settlement or deterioration of the roadway pavement until the maintenance certificate is issued by the Contracting Authority.
4.4 GLASS REINFORCED PLASTIC (GRP) PIPE AND FITTINGS

4.4.1 GENERAL

This section covers the specifications for glass reinforced plastic (GRP) pipe and fittings.

GRP pipes shall meet the requirements of the most recent edition of ASTM D 3262 together with the requirements specified here in. GRP pipes and fittings shall be purchased locally provided they conform to these specifications.

If any pipes cannot be obtained locally then it shall be the Contractor's responsibility to obtain such pipes from other sources capable of satisfying the specifications. The Contractor shall be entitled to claim additional payment or extension of time due to any delays in supplying pipes due to circumstances that occurred beyond the Contractor's control.

The Contractor shall also be responsible for securing the required quantities at the proper time for the work.

The Contractor shall also supply to the Supervisor, manufacturers signed certificates stating that the pipes comply in all respects with the provisions of these specifications and giving the results of all specified tests.

GRP pipes and fittings shall generally comply with these specifications but consideration will be given to minor deviations to suit different manufacturing processes provided the performance of the pipes and fittings is not impaired. Pipes shall be manufactured by any approved filament winding process and shall conform to the requirements of ASTM D 3262.

The Supervisor may ask the Contractor to conduct all the tests in his presence or may appoint a representative to supervise and witness all the tests on the premises of the manufacturer.

Other methods for manufacturing of GRP pipes may be proposed but such methods will be subject to the approval of the Supervisor. Any alternative method of manufacture shall comply with recognized international standards and shall meet the requirements of the specifications. The pipe design, thickness stiffness etc. shall be subject to the approval of the Supervisor and the pipe material shall have an established world wide track record for use in similar conditions.

4.4.2 MATERIALS

a) Appearance

The internal surface of all pipes and fittings shall be smooth, hard, durable and free from all tack, protruding fibers, voids, pits, bubbles, crack, blisters, and foreign matter.

The external surface of all pipes and fittings shall be a fiberglass surface mat impregnated with polyester resin and shall be commercially free of resin runs, dry areas, dirt, and black marks.

Prior to the commencement of manufacture, the Contractor shall obtain the Supervisor's approval to minimum acceptable standards of surface finish (both internal and external) based on actual pipe samples and photographs.

The resin reinforcement and aggregates, when combined as composite structure, shall produce pipes and fittings that satisfy the performance requirements of these specifications.

b) Design requirements
All pipes and joints shall be designed for a minimum working life of 50 years.

Pipelines may run beneath roads and be subjected to maximum loading conditions; therefore, design shall be for the worst surcharge conditions and loading applicable in Lebanon.

The pipe shall be designed to withstand the internal environmental conditions specified below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH value</td>
<td>1 to 9</td>
</tr>
<tr>
<td>BOD</td>
<td>up to 1000 mg/l</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>up to 1000 mg/l</td>
</tr>
<tr>
<td>Chloride</td>
<td>1500 mg/l</td>
</tr>
<tr>
<td>Free NH3</td>
<td>150 m/l</td>
</tr>
<tr>
<td>Sulphate</td>
<td>1000 M2A</td>
</tr>
<tr>
<td>Temperature</td>
<td>5 to 50°C</td>
</tr>
<tr>
<td>Prevailing temperature throughout sewage</td>
<td>Medium is 30° C</td>
</tr>
<tr>
<td>Sewage dissolved H2S</td>
<td>Up to 20 mg/l</td>
</tr>
<tr>
<td>H2 gas concentration</td>
<td>Up to 2000 mg/l</td>
</tr>
</tbody>
</table>

c) **Resins**

Details of all resins to be used in the manufacture shall be provided and shall include all properties listed in the table herein. All curing agents, flexibilisers and additives shall also be as listed.

The resin system adopted shall be that most to the internal and external environmental conditions. Type of resin to be used shall have been tested in accordance with ASTM C 581 and full test results and reports shall be submitted for the approval of the Supervisor. The laminate funned from the liner resin shall be tested in brine. Both tests shall be carried out 40° C ± 2°C.
### Resin properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Liquid resin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid value</td>
<td>BS 2782 - BS 3532</td>
<td>mg KOIYG</td>
</tr>
<tr>
<td>Viscosity at 25 deg C</td>
<td>BS 188 – BS 3532</td>
<td>m Pas</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>BS 3532</td>
<td></td>
</tr>
<tr>
<td>Volatiles content</td>
<td>BS 3532 - BS 2782</td>
<td></td>
</tr>
<tr>
<td>Refractive index</td>
<td>ASTM D1045</td>
<td></td>
</tr>
<tr>
<td><strong>Cured Resin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat distortion temperature</td>
<td>BS 3532 Appendix A</td>
<td>°C</td>
</tr>
<tr>
<td>Glass transition temperature</td>
<td>Differential thermal analysis</td>
<td>°C</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>BS 2782</td>
<td>MN/m²</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>BS 2782 - BS 3532</td>
<td>MN/m²</td>
</tr>
<tr>
<td>Ultimate elongation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Basin resin</td>
<td>BS 2782</td>
<td>%</td>
</tr>
<tr>
<td>b. If flexibilised</td>
<td>BS 2782</td>
<td>%</td>
</tr>
<tr>
<td>Barcol hardness</td>
<td>BS 4549 Appendix A</td>
<td></td>
</tr>
<tr>
<td>Water absorption</td>
<td>BS 2782 - BS 3532</td>
<td>mg</td>
</tr>
</tbody>
</table>

Information supplied on cured resin shall include details of the cure system employed, which shall be the same as that proposed for manufacture of pipes and fittings.

d) **Fiber reinforcement**

With the exception of a veil on the inside face of the pipe, all fiber reinforcements used shall be of ECR type glass and shall comply with the appropriate standard listed below and shall have a surface treatment compatible with the resin.

- BS 3691 Glass fiber roving for the reinforcement of polyester and of epoxy resin system
- BS 3496 E Glass fiber chopped strand mat for the polyester resin systems
BS 3396  Woven glass fiber fabrics for plastic reinforcement

BS 3749  Woven roving fabrics of glass fiber of the reinforcement of polyester resin systems. If a veil is used on the inside face of the pipe, this shall be “C” glass fiber.

e) Aggregates and fillers
Details of all aggregates and filler used in manufacture of composite pipes and fittings shall be submitted together with details of the distribution and amounts of such materials in the laminate(s). Silica sand shall be a minimum of 95% pure silica. A sieve analysis and particle gradation curve shall be provided for each aggregate to be used. The maximum percentage by weight of all aggregates and fillers in the laminate(s) shall not exceed 50%.
No pigment shall be added to any resin used.

f) Liner
All pipes and fittings shall have a suitably reinforced resin rich liner to give high corrosion, impact, and abrasion resistance. The thickness of this liner shall be determined by the pipe manufacturer, but shall not be less than 1 ½ mm. No aggregate or fillers shall be included in the liner.

The liner shall consist of two layers, a surface layer and a barrier layer. The surface layer shall be a minimum of 1mm thick with a minimum of 90% Venylester resin. Any reinforcement in this layer shall be of C type glass or approved suitable synthetic material. The barrier layer shall have 70% to 80% Venylester resin with ECR glass reinforcement.

g) Structural design
Pipes and fittings shall be designed to the standards for the ground conditions to be encountered. All pipes and fittings shall have a minimum stiffness of 500 N/m² to accommodate handling and transportation stresses unless specified otherwise.

Pipe shall have an initial ultimate resistance, to longitudinal tensile force per unit of circumference, of not less than the following:

<table>
<thead>
<tr>
<th>Diameters</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to including DN 600</td>
<td>150 N/mm²</td>
</tr>
<tr>
<td>Greater than DN 600 up to and</td>
<td>200 N/mm²</td>
</tr>
<tr>
<td>including DN 1200</td>
<td></td>
</tr>
<tr>
<td>Greater than DN 1200 up to and</td>
<td>250 N/mm²</td>
</tr>
<tr>
<td>including DN 2400</td>
<td></td>
</tr>
</tbody>
</table>
h) **Sizes and tolerances**

i) **Diameter**

The diameter of the pipe shall be designated by the nominal internal diameter. The manufacturing tolerance of internal diameter shall be:

- ± 1.5mm for pipes up to and including 150mm
- ± 3.0 mm for pipes over 150 mm up to & including 600mm
- ± 1/2 % for pipes over 600mm

All deviations from roundness, with the exception of pipe deformation due to its own weight, shall be contained within the tolerances. Deviations in diameter of spigot and sockets shall be kept to the absolute minimum and shall be such that the seal at the joints is not affected.

ii) **Length**

Pipes shall generally not exceed 12m in effective length. The permitted tolerance on the effective length shall be ± 25mm. The deviation from straightness of the bore of the pipe shall not exceed 0.3% for pipes up to 5m effective length and 15 mm pipe having and effective length greater than 5m.

Where it is found necessary to cut or turn down a pipe to form a joint, the exposed surfaces shall be fully sealed with a continuous coating of fully cured resin.

iii) **Wall thickness**

At no position shall the wall thickness of gravity sewer pipes and fittings be less than as specified in the following table:
### Walls thickness requirements of G.R.P Pipes

**Minimum wall thickness (mm)**

<table>
<thead>
<tr>
<th>Nominal Diameter (mm)</th>
<th>For stiffness factor 5000 N/mm²</th>
<th>For stiffness factor 1000 N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>As recommended by the pipe manufacturer and to the approval of the Supervisor</td>
<td>As recommended by the pipe manufacturer and to the approval of the Supervisor</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1800</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: stiffness factor “F” shall be calculated as follows:*

\[
F = \frac{E I}{d^3}
\]

*Where,*

- \( E \) = Flexural modulus of elasticity of pipe material in circumferential direction.
- \( I = \frac{S^3}{12} \)
- \( S \) = Wall thickness (m)
- \( d \) = Mean pipe diameter (m)

For depths of cover over the pipe less than 4.0 meters, GRP pipe stiffness shall be minimum 5000 N/mm².
For depth of cover over the pipe more than 4.0 meters, pipe stiffness shall be minimum 10000 sites.

i) **Fittings**

All fittings and collars such as bends, tees, junctions, and reducers shall be equal to, or superior, in performance to pipes of the same classification. Fittings shall be made as swept or one piece moldings but mitred construction will be an acceptable alternative, subject to the approval of the Supervisor. The use of metals for any part of these fittings will not be permitted. However, the Supervisor may allow the use of fittings of other materials which are commonly used in the construction of sanitary sewers, provided that the design of fittings and pipes are mutually compatible. The tolerance from the stated value on the angle of change of direction of the bend, tee, or junction shall be ± 1 degree for pipes up to and including 600mm internal diameter and ± 0.50 degree for pipes of larger diameters. The tolerance on the effective length of fittings quoted by the Contractor shall be ± 5 mm taken from the point of intersection of the fittings or ± 10mm on a straight fitting.

j) **Joints and gaskets**

Joints shall be of the collar incorporation rubber rings. All joins shall be capable of withstanding the various tests specified for the appropriate class of pipe and shall withstand a deflection of not less than 1 ½ degrees in any direction while maintaining the specified test pressures.

Minimum requirements for the rubber rings shall be as specified in BS 2494. Gaskets shall be of a thickness and design to provide watertight joints. The joints shall be qualified before installation with full testing according to ASTM D 416 1. At least one test shall be carried out for each diameter. The Contractor shall ensure that the joint gaskets and joint ring are suitable for use in the prevailing climatic soil, ground water and sewage conditions.

All rubber rings shall be of the type that can pass an acid ageing test as directed by the Supervisor without any noticeable deterioration in the mechanical or chemical properties of the materials used.

Flanged pipes shall incorporate an annular gasket at the joints. The gaskets shall cover the full face of the flanging and shall have holes cut in them corresponding to the bolt holes in the flanges. Alternative forms of gasket may be used, subject to the approval of the Supervisor. Flanges shall be drilled to BS 4504, metric units, Type NP16.

k) **Testing**

i) **Raw materials**

1. **Resins**

All deliveries of resin shall be checked for consistency by viscosity reactivity, and refractive indices. Resins deviating from these specifications shall not be used.

2. **Glass**
All deliveries of glass shall be checked for consistency by dry strength and chemical resistance to 1.0 N sulfuric acid. Pipes shall only be manufactured from batches of glass exhibiting similar strength and chemical resistant properties. Should these properties change due to variations in suppliers, the pipes produced from this glass shall be tested in accordance with the strain corrosion test as if they were different diameter or class. The Supervisor may accept test reports of ECR glass as supplied by the manufacturer, and testing of pipe factory glass may be dispensed with.

3. **Sand or aggregate**

All deliveries of sand or aggregate shall be checked for consistency of grading, moisture content, and purity.

ii) **Fabricated pipes**

1. **Strain corrosion test**

Control testing shall be carried out during the manufacture of pipes in accordance with section 6.3 of ASTM D 3262 using the specified test solution. Control tests shall be carried out for each diameter and class of pipe.

In the event regression curves are not available or any changes to the pipe wall and laminate build-up, and/or the properties of the raw materials at any time during the manufacture of the pipes, two complete sets of corrosion tests (including a regression curve) shall be carried out in accordance with ASTM D 3681. One set shall use a 10% WIW solution of sulphuric acid maintained at a temperature of 25°C ± 1°C. The other set shall use a 5% WIW solution of sulphuric acid maintained at a temperature of 23°C.

Strain corrosion tests shall be run on a minimum of 6 samples from each lot of pipe diameter to ensure that they fall above the regression curve valves defined by the manufacturer.

2. **Hydraulic test in factory**

All pipes shall be subjected to an internal hydraulic pressure test at the manufacturer’s plant prior to delivery. The test shall be applied to a pressure equal to two times the working pressure or 6 bars of water head whichever is higher. The test pressure shall be applied for a minimum period of 5 minutes without signs of leakage.

All fittings shall be subject to an internal low pressure test at the manufacturer’s plant prior to delivery. The pressure test shall be carried out at 0.1 bar and shall be applied for a minimum period of 5 minutes without signs of leakage or distress. Fittings of metric construction shall be manufactured from pipe which has successfully passed the tests defined above.

3. **Stiffness**
A minimum of one pipe in every 30 pipes, one per shift, or one per production run, whichever is less, shall be tested for stiffness in accordance with ASTM D 2412 (ESM1) “Test for External Loading Properties of Plastic Pipe by Parallel Plate Loading”. A minimum of one pipe for each size shall be tested.

4. **Longitudinal tensile strength**

For pipes with internal diameters of 600mm and less, a minimum of one pipe in every 1000 pipes manufactured shall undergo a beam test in accordance with ASTM D 3262, section 8. A minimum of one pipe for each size shall be tested.

5. **Curing / hardness test**

All manufactured pipes shall be subjected to both a Barcol Hardness Test in accordance with BS 4549, part 1, appendix A, and a commercial acetone test. Both tests shall be carried out on internal and external pipe surfaces.

6. **Loss on ignition**

A minimum of one pipe for every 30 pipes, one per shift, one per production run, whichever is less, shall be tested in accordance with ASTM D 2584. From each test pipe, two samples shall be taken for test. One sample shall comprise the complete laminate including the liner. The second sample shall comprise the laminate without the liner and shall be split off at the interface between the liner and structural wall.

7. **Quality control and test records**

Quality control testing shall include thorough checks of all materials to ensure that they comply with the relevant standards and requirements of the specifications. All pipes and fittings shall also be subject to a complete visual inspection before shipment. Records of all tests and inspections shall be maintained by the manufacturer and six copies of all test certificates shall be forwarded to the Supervisor.

In addition, the Contractor shall submit all necessary data and manufacturer’s specifications of the GRP pipes and joints, including details of raw materials, pipe design, manufacturing process, laying instructions, and all other relevant information required by the Supervisor.

8. **Test failure**

In the event of a pipe failing the strain corrosion test, two more tests shall be performed: one on a pipe from the previous fives pipes, and one on a pipe from following five pipes, if any of these two pipes fails, all pipes of that diameter and class which have been manufactured shall be rejected and shall be replaced entirely at the Contractor’s expense.

Pipe failing any other test shall be rejected and an additional ten pipes shall then be tested. Five of these pipes shall have been sequentially produced immediately prior to the failed pipe and five immediately
following. If anyone of these ten pipes fails, every pipe shall be tested. Only pipes passing the tests will be accepted.

All pipes and fittings will be subjected to a visual inspection by the Supervisor after offloading at site. All pipes and fittings that have been damaged during delivery shall be repaired and/or replaced by the Contractor and the pipe shall be subject to a further hydraulic test to be carried out by the Contractor as specified herein. Such making good and hydraulic testing at site shall be entirely at the Contractor's expense.

9. Marking and identification

All pipes, including cut lengthy and fittings, shall be indelibly marked prior to delivery, in the order given below with:

1. The manufacturer's name, initials, or identification mark;
2. The nominal internal diameter in mm;
3. The classification i.e. pressure stiffness (to avoid confusion, pipe rated at 2.5 or 12.5 bars shall be marked 2½ or 12½ and not 2.5 or 12.5);
4. The date of manufacture;
5. A suitable stamp to indicate that the pipe have satisfactory passed the required inspection and hydraulic tests at the manufacturer's plant;

These markings may be arranged either in one line or in several lines provided that the order is preserved.

10. Third party inspection

All tests shall be supervised and certified by a third party inspection agency approved by the Supervisor. All costs for the inspection agency shall be borne by the Contractor and shall be included in the cost of the pipe.

All pipes shall be visually inspected on site prior to installation. The pipes shall be free of defects such as delaminating, air bubbles, protruding or exposed fibers, cracks, air holes, surfaces, non-impregnated with resin which can affect, due to their extent, the rigidity and usefulness of the pipe.

The surface of the pipe joints shall be free of all defects and surface irregularities that can affect their integrity. All repairs executed on site shall be agreed to by the Supervisor and conducted by qualified personnel from the pipe manufacturer.

4.4.3 WORKMANSHIP

a) Loading, unloading and transportation of pipes

GRP pipes are made of delicate elastic materials and, therefore, require special care in loading, unloading and other handling. Nylon lifting strings shall be used for loading and unloading of pipes. Pipes shall not overhang trucks or trailers while being
transported, and shall be securely tied. Avoid sudden drops or motion while loading and unloading.

b) **Storing pipes, fittings and accessories**

Pipes shall be stored on flat ground having no stones or debris to prevent any damage to the pipe barrel. It is advantageous to store pipes on timber pieces to facilitate placement and removal of lifting strings. Storage of pipes in heights over 2m shall be avoided. All pipes shall be properly secured to prevent rolling in high winds.

Rubber ring gaskets shall be stored in the shade in the original packing. The store shall be air-conditioned during summer. Gaskets shall be protected from exposure to greases, oils, solvents or any other petroleum derivatives or chemicals.

Gasket lubricant shall be carefully stored to avoid damage to the container. Partially used buckets shall be properly sealed to prevent contamination. If the lubricant is contaminated by any foreign substance it shall be abandoned.

c) **Laying of pipes**

GRP pipes shall be laid and bedded in a granular material, send cement mixture, crushed aggregate or concrete encasement as required by the Supervisor, based on the manufacturer’s recommendations for the type of load and soil encountered, except where concrete protection is required. The granular material shall extend from not less than 150mm beneath the pipes to 300mm above the crown of the pipes, as approved by the Supervisor. Subsequent backfilling of the pipe trench shall be as specified in section 2, Excavation.

All materials and methods employed for the embedment of flexible pipes shall be to the approval of both the pipe manufacturer and the Supervisor.

The deflections of every pipe at the spigot, mid-point, and socket shall be checked after the laying of each pipe length.

Case A- After the pipe surround materials has been placed and compacted to 300mm above the pipe crown.

Case B- On completion of all backfill material up to final ground level but before the dewatering is removed.

Case C- Immediately prior to the issue of a completion certificate.

Pipes exhibiting any negative vertical deflection in Case A, and/or pipes exhibiting a deflection in excess of the initial deflection stated in the pipe design under Case B, shall be exposed and the surround replaced and re-compacted. Should any deflection exceed the long-term deflection stated in the pipe design by more than 30% that pipe shall be removed from site and not incorporated in the permanent works.

Pipes exhibiting a deflection in excess of the long-term deflection in Case C, shall be exposed and the surround replaced and recompacted. Should the deflection exceed the long-term deflection by more than 30% the pipe shall be rejected as specified above.

All pipes exposed for recompaction and those replaced shall be subject to the same three deflection checks specified above.
- Initial deflection in Case A shall not exceed 1%;
- Initial deflection in Case B shall not exceed 2%;
- Long-term deflection in Case C shall not exceed 2.5%.

GRP pipe shall not be used where native soil bedding is classified as soft or very loose soil as per ASTM MH, CH, OL and OH (OR ATV type 4).

For soil classification of group 3 and above, GRP pipes can be used and the manufacturer shall submit pipe laying calculations as per ASTM D 3839.

The Contractor shall provide suitable mechanized devices for gauging the deflections to the approval of the Supervisor. Pipes 800mm and larger only may be inspected visually. The gauging devices shall become the property of the Contracting Authority at the end of the Contract.

Any special instructions, including use of specialized tools by the manufacturer of pipes and pipe joints for the laying, field cutting, and turning pipes, shall be adhered to strictly and shall be deemed to be part of the specifications unless contrary instructions are issued in writing by the Supervisor.

Properly fitted temporary rubber stoppers shall be provided and constantly used to close the ends of all uncompleted pipe lines. The stoppers shall only be removed when pipe laying and jointing starts again from that end.

When a pipe passes through a wall and is encased in concrete, such as a connection to a manhole, a socket shall be fixed while casting the structure, and the layout of the pipeline shall include a joint within one to two pipe diameters of the connection as directed by the Supervisor.

All points where pipes are built into concrete walls or floors, great care shall be taken to ensure that the joints are made good. Short pieces shall be installed as follows:

Max: smaller of 2 m or 2 nominal diameters
Min: smaller of 1 m or 1 nominal diameter

Any cut end of GRP pipe in these or other locations shall be properly sealed with resin.

If hard rock is encountered under the pipe, a flexible joint shall be provided at the starting point as well as on the ending point of the section with hard rock. Such joints shall reduce shearing of the pipe at the interface of the hard and soft bedding material and possible differential settlement between the two materials.

When it is essential to surround the GRP pipes in concrete, care shall be taken to avoid buoyancy of the pipe in the concrete and also deformation due to excessive hydraulic pressure of the concrete while it is still in fluid state. To achieve this, it is essential to pour the concrete in small layers not exceeding 30cm and each successive layer laid only after the previous layer has solidified. To facilitate proper concrete pouring beneath the pipes, precast concrete supports to keep the pipe in position and to avoid buoyancy while pouring the concrete. Such straps shall be tied securely to the base and shall be used at spans of about 4m.
In addition to the above, the Contractor shall follow the manufacturer's instructions for laying and handing GRP pipes all abnormal site conditions, the manufacturer's recommendation shall be followed strictly.

d) **Prevention of migration of backfill material**

Where there is a likelihood that backfill material may flow into the voids of surrounding soil due to fluctuations in the ground water table, the Contractor shall use a suitable filter fabric to surround the backfill within the pipes zone completely with overlaps as recommended by the manufacturer. The filter fabric shall have a minimum design life of 50 years.

In all cases, the Supervisor shall direct and approve the use of filter fabric to surround the backfill in pipe zone.

e) **Wall thickness**

The wall thickness shall be measured for each pipe before the pipes are lowered into the trench and shall not be less than as specified.

f) **Field hydraulic test**

Prior to acceptance all the pipes laid at the site shall be tested at a pressure of 0.8 kg/cm² minimum to ascertain the workability of the joints. This test shall continue regularly and shall follow the pipe laying closely so that any corrections or replacements can be done prior to backfilling and without delay.

Before filling the pipe with water for testing, it shall be ensured that all thrust blocks and backfilling above the pipe to depth equal to the pipe diameter, but leaving joints exposed for inspection, have been completed. Pipe shall be filled slowly with potable water allowing air to escape through vents specially fixed for this purpose. A pressure gauge shall be fixed at the highest point in the line. The pressure gauge shall be calibrated, and a calibration certificate shall be issued by the approved calibration company. Test shall usually commence after one hour of filling the pipe, or as directed by the Supervisor.

Pressure in the line shall be increased gradually to prevent any damage to the pipeline. Water shall be added at 10-minute intervals to maintain specified test pressure. If water so added during 30 minutes does not exceed 0.1 liter/hr/mm diameter of pipe for a pipe length of 100 m, and also if there are no visible leakage of water, the test shall be considered successful and completed.

If a section of pipe does not pass the test, leakage points shall be marked and all water drained after repairing defective joints, the pipe shall be tested again as specified above. If leakage is noticed, the pipe shall be removed and replaced with an approved piece of pipe, all at the Contractor's expense.

No brackish/sea water shall be used for testing of the pipe line.
4.5 REINFORCED CONCRETE PIPE

4.5.1 GENERAL

This section covers the specifications of reinforced concrete pipe which shall be used for sewer pipelines.

The Contractor shall submit the required test data and the proposed layout of the piping, pipe lengths, segment weights, joints details, and all items pertinent to the work, to the Supervisor for review prior to delivery of such item to the project site.

The Contractor shall provide the Supervisor with a certificate of compliance that the pipe and concrete mix conforms, in all respects to the specifications and other non-conflicting requirements of the referenced ASTM specifications.

4.5.2 MATERIALS

a) Pipe

Reinforced concrete pipe shall be manufactured for pressure of 15 meters of head in accordance with ASTM C 361 standards. The wall thickness and the D-load strength classification shall meet as a minimum the ASTM C 76 requirements for, wall B or C, class IV.

All pipes shall be lined in accordance with Clause 4.21 PVC Sheet Liner. The lining shall be applied on the top 300 degrees of the inside of the pipe.

Pipes shall be manufactured by wet, cast in stationary vertical forms with the concrete compacted by high-frequency vibration.

The following additional requirements shall be met:

- Portland cement shall be sulphate-resisting Type V conforming to ASTM C 150;
- The minimum cement content shall not be less than 335 Kg per cubic meter;
- The water/cement ratio shall not exceed 0.49;
- Elliptical reinforcing is not permitted;
- The area of the outer circular reinforcing cage shall not be less than 75 percent of the inner cage;
- Curing shall conform to the requirements of AWWA C 302.

All pipes shall have circular reinforcement steel. Each piece of pipe shall be clearly identified as to class and date of manufacture.

Pipe sections shall be made in nominal lengths of at least 2.5 meters except where shorter lengths are required to meet special conditions. Shorter lengths shall be used only where shown or accepted.

i) Method of manufacture

The pipe shall be manufactured using the vertically cast method. The transportation and placing of concrete shall be by methods that shall prevent the separation of the concrete materials and the displacement of reinforcement.
steel in the forms. When placing the concrete in the forms, the concrete shall be vibrated with external mechanical vibrators in an approved manner so as to prevent “honeycombing” of exposed finished surfaces.

The whole process of casting, curing and striking shall be such that the tee-lock extensions of the PVC liner shall be fully embedded in dense concrete of the tee-locks sufficient strength at the time of striking, to ensure that the tee-locks will not pull out of the concrete.

ii) Curing

1) General

The Contractor's manufacturing plant, or the plant of this pipe supplier, shall provide adequate steam plant, piping, enclosures, and other facilities for curing the pipe. The enclosures shall be such that the temperature and humidity can be controlled to keep the pipe surfaces moist at all time and the temperature maintained continuously between limits described below.

2) Pipe shall be subjected to any one of the methods of curing described in AWWA C 302 and hereinafter, or to any other method or combination of methods approved by the Supervisor that will give satisfactory results and without damaging the PVC sheet liner. The pipe shall be cured for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less. Crushing (compressive) tests shall be performed on test cylinders or cured pipe cylinder utilizing test methods in compliance with ASTM C 497 M.

c) Accelerate curing (alternative method)

The pipe shall be placed in a curing facility, otherwise covered by a suitable enclosure that shall allow proper circulation of moist air or steam. Until the initial set of the concrete occurs, the ambient temperature within the enclosure shall not be less than 15°C and shall not be raised above 38°C by the introduction of heat. After a delay period of one to four hours, the temperature shall be increased at a rate not to exceed 22° C per hour, and thereafter maintained at a temperature between 32°C and 66°C.

d) Water curing

Water curing shall begin as soon as the concrete has set sufficiently to prevent damage to the exposed concrete surfaces. The total cure, consisting of the water cure and the ambient air cure, shall be sufficient to produce the concrete strength required.

e) Combination curing

Curing of pipe may consist of any combination of accelerated curing and water curing.

iii) Forms

a) General
The forms for the pipe shall be of steel made with bat joints throughout, and the surfaces of the forms adjacent to the pipe walls shall be smooth and true. (all forms shall be sufficiently tight with suitable gaskets provided at all form joints to prevent leakage of mortar. The forms shall be braced and sufficiently stiff to withstand, without detrimental deformation, all operations incidental to the placement, and compaction of concrete within the form. The form and end rings shall be so constructed that the pipewhen manufactured shall have circular and cylindrical inner surfaces and so, that they may be stripped from the pipe without damage to the pipe or its surfaces.

Forms shall be cleaned and oiled at the start of each day of continuous production. Defective forms and end rings shall be discarded or adequately repaired to the satisfaction of the Supervisor.

b) Pipe joints

The reinforced concrete pressure pipe shall have a flared bell and spigot joint, or flush bell design with confined rubber gasket in conformance with ASTM C-361. The bell and spigot gasket joint mating length shall provide allowance for the maximum possible joint deflection, pre-set joint opening to allow for joint deflection, joint creep, and safety allowances to ensure positive gasket sealing during joint movement.

The Contractor shall submit details of the pipe and joints for review by the Supervisor prior to manufacture.

c) Gaskets

Gaskets shall be subjected to a field test by the Supervisor. Twenty percent of all rubber gaskets delivered to the job shall be bent a minimum of 180 degrees and a maximum of 270 degrees around a bar the same diameter as the gasket. The test section of the gasket shall be at the point where the ends of the greater are jointed together. Each lot delivered to the job shall be tested. If any of the tested gasket joints separate during the test, the entire lot will be rejected and new gaskets supplied and tested as specified.

Furnish a certified statement from the manufacturer of the gaskets, setting forth the basic polymer used in the gaskets, and results of the tests of the physical properties of the compound. Gaskets shall be shipped in containers with identification of the batch from which the gaskets were fabricated. Lubricant for joints shall be fit to the environmental conditions of Lebanon as detailed elsewhere in these specifications. After immersion of samples in a solution of 10% (WIW) sulphuric acid for 112 days at 40°C, all specified tests in ASTM 31 M for the physical properties shall be performed and the loss in properties shall be as follows:

- Flexural strength < 10%
- Tensile strength < 10%
- Shore durometer hardness < 5%
- Change in weight < 2.5%

Gaskets stock shall comply with ASTM C 361 M and shall be a synthetic rubber compound in which the elastomer is neoprene, exclusively. Said compound shall contain not less than 50% by volume of neoprene and shall contain no factice, reclaimed rubber or any deleterious substances. The stock shall be extruded or molded and cured in such a manner that any cross-section shall be dense, homogeneous and free from porosity, blisters, pitting and other imperfections. The stock shall be extruded or molded with smooth surfaces to the specified size within a tolerance of ± 6 percent on any dimension, measured at any cross section.

d) Joint lubricant

Furnish joint lubricant with the pipe. Furnish the amount and type recommended by the pipe manufacturer. The lubricant shall be a water soluble, non-toxic, vegetable soap compound conforming to United States Pharmacopoeia No P39.

e) Feeler gauge

Furnish sufficient feeler gauges of the proper size, type, and shape for use by the installation Contractor and Supervisor's representative to check the rubber gasket joints.

f) Material test and inspection

The Supervisor and his representatives shall have access to all phases of the work, and the manufacturer shall provide proper facilities for access and inspection. Material, fabricated parts, and pipes which are discovered to be defective, or which do not conform to the requirements of these specifications, will be subject to rejection at any time prior to final acceptance of the pipe.

Acceptance of all reinforced concrete pipe, manufactured according to these specifications, shall be on the basis of external load-bearing tests, material tests, concrete compressive strength tests, joint performance and permeability tests, and inspection of manufactured pipe for dimensional conformance and freedom of defects and imperfections.

Each length of pipe shall be subject to inspection and approval at the factory, 4 point of delivery, or any site of work. Samples of pipes to be load-bearing tested, or cored, shall be selected at random by the Supervisor. Tests on pipe and cores shall be made all at the manufacturers plant.

When the specimens tested conform to the requirements of these specifications, all pipe represented by such specimens shall be considered acceptable based on the parameters measured. Copies of test reports shall be submitted to the Supervisor before the pipe is delivered to the monogram under the supervision of the Supervisor prior to shipment to the project site.

In the event that any of the test specimens fail to meet these specifications, all pipe represented by such tests shall be subject to
rejection. The Contractor may furnish two additional test specimens from the same lot for each specimen that failed and the pipe may be considered acceptable if all these additional specimens meet the requirements, of the applicable standards.

The number of pipe sections to be tested shall be the maximum recommended under the appropriate ASTM specifications. Where the ASTM specifications do not indicate the number of pipe that may be tested, test shall be run 0.5 percent of the total number of pieces, to be represented by the test. In no case, than shall less two pipe sections be tested for each class and size manufactured.

For pipe testing purpose, a lot shall be defined as all pipe of the same diameter and class, manufactured by the same process in one plant over a period not to exceed one week. Pipe which has been rejected by the Supervisor shall be marked with a permanent marking and shall not be delivered to the project.

1. Load bearing tests
   Test specimens in the amount stated in the applicable ASTM specifications shall be furnished and tested at the Contractor's expenses.
   
The load-bearing capabilities of each size and class of pipe shall be verified by tests as prescribed by the appropriate ASTM specifications and following additional requirements. The Supervisor shall be notified in advance of external load crushing testing so that he may approve the schedule and observe the testing.
   
Pipe lot load bearing testing of reinforced concrete sewer pipe, manufactured in with ASTM C 76M, shall be by a three-edge bearing load test.
   
Gravity sewer shall be tested with the PVC lining installed and with the unlined quadrant centered at the bottom of the pipe. All gravity sewer pipe tested shall be at the applicable 0.30 mm D-load crack in accordance with ASTM C 497 M. The Supervisor reserves the right to direct that loading be continued to the ultimate strength of the pipe.
   
Pipe that has been loaded beyond the formation of the 0.30 mm crack shall not be used in the work.
   
The cost of the pipe tested to ultimate strength will be borne by the Contractor.

2. Core tests
   Two cores shall be drilled from the pipe wall of each load bearing test pipe to determine compliance with the specifications. Cores shall be taken and tested in accordance with ASTM C 497.
3. **Cylinder test**

At least 7 test cylinders for compressive strength shall be cast from each day concreting. Where more than 40 cubic meters of concrete are cast in a day, set of seven test cylinders shall be cast from each 40 cubic meters of such concrete placed that day. The rate of cylinder casting may be varied by the Supervisor to establish or confirm control levels. Three cylinders shall be tested at age 7 days and three at age 28 days. The remaining cylinder shall be tested when directed by the Supervisor.

The cylinder shall be cured in the same manner as the pipe which they represent.

An additional 9 cylinders shall be cast on each of 2 separate days during the casting operation as directed by the Supervisor. The cylinders shall be tested in groups of three at 28 days, 3 months and 12 months, to give an indication strength time characteristics. These cylinders, after initial curing, shall be stored under site conditions.

4. **Hydraulic tests**

Hydraulic tests of pipe manufactured under this section shall be made in accordance with section 10.4 of ASTM C 361M for pipe and joints, for a test pressure of 15 meters of head. In addition to the hydrostatic test on rubber gasket joints specified in section 10.42 of ASTM C 361 M, pipe joints shall be tested under the same conditions of hydrostatic pressure, with the joints deflected to create a position 38 mm wider than the assembled position on the side of the outside perimeter, with no water leakage.

Provide manufacturer's certificate of compliance for rubber gaskets provided in accordance with section 10.5 of ASTM C 361 M.

5. **Dimension tolerance**

Each pipe shall be dimensionally checked prior to delivery of the pipe to the job site. Pipe shall be subject to rejection for failure to conform to the following dimensional tolerances:

a. The internal diameter shall not vary more than ± 6 mm from the specified size.

b. The squareness of the pipes ends shall be determined by taking diagonal measurements from the face of the spigot to the shoulder of the bell at the 114 points on the circumference of the pipe. The maximum variation between measurements shall be limited to 10 mm.

c. The roundness shall be determined by taking diameter measurements at 1 ¼ points across the inside of the bell, outside of the spigot, and inside of the pipe barrel.
Maximum variation between measurements shall be 2mm at the joint and 6mm in the pipe barrel.

Pipes shall be subject to rejection for failure to conform to any requirements of the specifications or any of the following:

a. Chips, fractures, cracks, or irregularities in the pipe joint and gasket bearing area.

b. Spalls, fractures, cracks or irregularities in the thrust bearing area of pipe to be jacked. Minor repairs will be permitted if they are of a quality at least equivalent to that of a new pipe.

c. Chips, fractures, or air pockets on the interior of the pipe exceeding 5cm in length, 2cm width, and 1cm in depth.

d. Defects that indicate improper proportioning, mixing and molding.

g) Pipe coating

The external surface of the pipe shall be coated with coal tar epoxy as specified here in below. The dry film thickness of the coating shall not be less than 650 microns.

The coal tar epoxy shall be solvent free, 100% solids, durable, abrasion resistant and especially designed for production line application on moist surfaces. The coating shall be of two components heated separately, from 49 to 66 degrees C, and using in-line static mixing, allowing the use of the fast reacting resin and cure materials, for rapid production line processing of the pipe being coated.

h) Marking

The following markings shall be stamped on each pipe delivered to site:

- Factory Name
- Reference Standard
- Design Pressure
- Class and Wall Type
- Inspection Agency

### 4.5.3 WORKMANSHIP

a. Distributing materials

Distributing materials on the job no faster than 5 days supply in advance of pipe laying except as approved by the Supervisor. Store materials in a manner that will not be hazard to traffic or to public in general, will not obstruct access to adjacent property, and will not obstruct other Contractor's working in the area.
b. Handling and transportation

During loading, transportation, unloading, storage, and laying, every precaution shall be taken to prevent damage to the pipe, linings and coatings. Trucks, trailers or railway cars used for transporting coated pipe shall be provided with bolsters between each layer of pipe curved to fit the outside of the pipe. Pipe ends shall be tightly closed with a plastic wrap. The plastic wrap shall consist of at least a 10 mil sheet polyethylene plastic, and shall remain on the pipe until the time of installation.

Lifting of pipe during unloading shall be done using two slings placed at the quarter points of the pipe sections. Pipe may be lifted into the trench using one sling near the center of the pipe, provided the pipe is guided to prevent uncontrolled swinging and no damage will result to the pipe or harm to the workmen. The slings shall bear uniformly against the pipe. When not being handling, the pipe shall be supported on timber cradles or on properly prepared ground, graded to eliminate all rock points, and to provide uniform support along the full length. Any unit of pipe that, in the opinion of the Supervisor, is damaged beyond repair shall be removed from the site of work and replaced with another unit.

Heavy canvas, or nylon slings of suitable strength shall be used for lifting and supporting materials, do not use chains or cables.

Pipes and fittings shall not be stored on rocks or gravel, or other hard material which might damage the pipe, lining or coating. No pipe shall be allowed to rest on the bell end section. This shall include storage areas and along the pipe trench.

c. Rubber gasket storage

Store all rubber gaskets in an air conditioned place and do not expose to the direct rays of the sun. Gaskets shall be stored separate from oil, fuel, petroleum, or solvents.

d. Pipe preparation and handling

Each pipe fitting shall be carefully inspected before being installed. The interior lining and exterior protective coating shall be inspected, and all damaged areas patched in the field with material equal to the original. Any pipe or coating system which, in the opinion of the Supervisor, is damaged beyond repair shall not be used and shall be promptly removed from the site. Clean ends of pipe thoroughly. Remove foreign matter and dirt from inside of pipe and keep clean during and after installation.

Use proper implements, tools, and facilities for the safe and proper protection of the pipe. Carefully handle pipe in such a manner as to avoid any physical damage to the pipe. Do not drop or dump pipe into trenches under any circumstances.

e. Excavation and earthwork

Unless otherwise directed, for trench excavation and earthwork, comply with specified requirements of Section 3 "Excavation", and for setting out, comply with specified requirements elsewhere in this Section.

f. Preparing pipe for trench

Inspect each pipe and fitting before the pipe and/or fitting is lowered into the trench.
Damaged portions of coating or lining shall be cleaned and repaired by experienced personnel, so that the protective coating or lining is equal to the original. Manufacturer's recommendations for repairs shall be followed.

g. Laying pipe
   i) Installation
      All pipes, fittings and appurtenances shall be installed in accordance with the manufacturer's instructions and these specifications.
   ii) Laying procedure
      All pipe shall be prepared as herein before specified, and shall be laid on the prepared pipe bedding and bedded to ensure uniform bearing. No pipe shall be laid in water, or when, in the opinion of the Supervisor, trench conditions are unsuitable. Joints shall be made as specified for the respective types.

      Necessary precautions shall be required to prevent excavated or other foreign material from entering the pipe during the laying operation. At all times, when laying operations are not in progress, at the close of the day's work, or whenever the workmen are absent from the job, close and block the open of the last laid section of the pipe with a watertight plug to prevent entry or foreign material or creep of the gasket joints. End closure shall be sufficient to prevent trench water from entering. Keep water out of trench.

      Where the pipe is connected to concrete structures, or manholes, connection shall be made as the details shown on drawings.

   iii) Joining pipe
      Assemble joint in accordance with manufacturer's instructions, and called for by the specifications. As the next section of pipe is ready for laying, clean the bell of the previously laid pipe of all foreign material and apply a thin film of the specified lubricant to the entire surface of the bell ring. At the same time, lubricate the gasket and install in the spigot groove. The gasket tension shall be uniform around the groove before placing the pipe in the trench. Lower the pipe section to be laid into the trench until it is approximately in the line with the previously laid pipe section and the spigot is centered in the bell. Then force the pipe home and secure to proper alignment and grade with the specified pipe zone material, well tamped. The gasket position shall be checked with a feeler gauge, furnished by the pipe manufacturer, to ensure proper seating.

      Prevent foreign material from entering the pipe while it is being placed in the trench. Remove all foreign material from the pipe or joint ring before the next pipe is placed, if the pipe laying crew cannot put the pipe into trench and in place without getting earth into the pipe, the Supervisor may require that snugly fitted, tightly woven canvas bags be placed over each end before lowering the pipe. The bags shall be left in place until the connection is to be made to the adjacent pipe. During laying operation keep debris, tools, clothing, or other material out of the pipe.

      Take all precautions necessary to prevent the uplift or floating of the line prior to the completion of the backfilling operations.
Follow pipe laying operations closely with backfilling of the trenches with sufficient material prevent the pipe from moving. Place backfill carefully, and simultaneously, on both sides of the pipe to avoid displacement of the pipe and damage to the joints and coating.

Unless otherwise directed, lay pipe with bell end facing in the direction of the laying.

h. Backfilling

Backfilling shall be in conformance with Section 2 of these specifications, in addition to other requirements mentioned herein below.

Particular attention must be given to the area of the pipe zone from the flow line to the centerline of the pipe to ensure that firm support is obtained to prevent any lateral movement of the pipe during the final backfilling of the pipes zone.

Where it is approved by the Supervisor to deflect pipe from a straight line, either in the vertical or horizontal plane, do not exceed 75 percent of the amount of the deflection recommended by the pipe or coupling manufacturer and approved by the Supervisor.

i. Time interval before filling pipe

The Contractor shall not fill the pipe with water until joint protection materials have cured.

j. Testing

Testing pipelines shall be performed as per Clauses 4.17 and 4.5 of this section and as specified here in below:

The part of the pipeline under test shall be filled with water to give an effective minimum interval water pressure of 7 m at the highest point and a maximum of 10 m at the lowest point. The pipe test section may be filled 24 hours prior to time of ex-filtration testing, if desired, to permit nominal absorption into the pipe walls to take place. Then the pressure of 7 m head of water shall be maintained for 10 minutes and water added shall be measured. If water consumption in 10 minutes does not exceed one liter per hour per linear meter of pipe per meter of nominal internal diameter of pipe and, if there are no visible leakage through joints, the pipeline shall be passed.

4.6 PVC SHEET LINER

4.6.1 GENERAL

a. Scope of work

These specifications cover the supply and installation of a PVC sheet liner in reinforced concrete pipes, manholes and other structures to effectively protect the exposed concrete surface from corrosion. To accomplish this, the liner must be continuous and free of pinholes, both across the joints and in the liner itself, and that any joint welding and sealing be equally as effective as the liner.

All work for and in connection with the installation of the lining in concrete pipe, manholes and other structures and the field sealing, and welding of joints shall be done in strict
conformity with all applicable specifications, instructions and recommendations of the lining manufacturer.

The manufacturer of the lining shall furnish an affidavit to the successful use of its material as a lining for sewer pipes, manholes and other sewage related structures for a minimum period of 15 years in sewage conditions recognized as corrosive or otherwise detrimental to concrete.

The PVC liner shall withstand the prevalent condition in the sewer system, and the Contractor shall design his lining to withstand these conditions for the design life span of the pipe, namely 50 years.

The lining, and pipe manufacturers shall, both, be aware that the sewer pipes are generally laid under the water table. In this respect, the Contractor shall submit, for approval to the Supervisor, the pipe and lining manufacturer's recommendations for the design of the liner thickness and structural capability, as well as the design of the liner system whereby to insure that the PVC liner can withstand and such hydrostatic forces that will arise from the water table conditions, and the methods to release this water where necessary.

b. Submittals

The Contractor shall submit for the Supervisor's approval but shall not be limited to the followings:

- Shop drawings
- Sample 30cm x 30cm
- Adhesive product and application procedures
- Manufacturer's Certificate of Compliance
- Manufacturer’s catalogue information and installation instructions

c. Manufacturer's qualification

The manufacturer of PVC liner shall have a proven record of fifteen (15) years of successful full-scale operational experience with the installation of its liner in sanitary sewers. The manufacturer shall certify in writing to the Contractor and Supervisor that he has the required record of successful operational experience, and he shall furnish the Contractor and the Supervisor with a list of references showing locations, pipes sizes, pipe lengths and pipe materials lined with his product.

d. Manufacturer's technical representative

The manufacturer of the PVC liner shall furnish the services of an experienced technical representative during the production of at least the initial (5) percent of the PVC lined pipe furnished for this project, and for training the Contractor's personnel in the field of welding the liner. The technical representative shall instruct the pipe manufacturer's personnel in the installation technique of the liner, and shall ensure that the liner is installed in accordance with the manufacturer's recommendations. He shall report any installation problems to the Contractor, which in turn he will inform the Supervisor.

4.6.2 MATERIAL

a. General
PVC liner sheet, joint corner and weld strips shall be manufactured from a high molecular weight polyvinyl chloride resin combined with plasticizers, pigment and other necessary ingredients to make a permanently flexible material suitable for use as protective liner in pipe or other structures. Polyvinyl chloride resin shall constitute not less than 99 percent by weight of the resin used in the formulation. Copolymer resins will not be permitted.

At any time during manufacturing or prior to the final acceptance of the work, the Supervisor may sample specimens taken from sheets, strips of welded joints for testing. Changes in formulation will be permitted only after prior notice is given to the Supervisor, and the manufacturer demonstrates that the new PVC liner will meet or exceed all requirements specified here in for chemical resistance and physical properties.

b. Properties

PVC liner sheets including locking extensions, all joint, corner, and welding strips, shall be free of cracks, cleavages, or other defects adversely affecting the protective characteristics of the material. The Supervisor may authorize the repair of such defects by an approved method.

Except at shop welds, all PVC liner sheets, joint, corner and weld strips shall have the following properties when tested at 25° C ± 3°C.
c. Details and dimension
   i) Thickness of material

   The minimum thickness of sheet and strip shall be as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet, integral locking extensions</td>
<td>1.65 mm</td>
</tr>
<tr>
<td>Joint strip</td>
<td>1.90 mm</td>
</tr>
<tr>
<td>Weld strip</td>
<td>2.40 mm</td>
</tr>
</tbody>
</table>

   ii) Material

   Sheets of liner used for pipe shall be sized to provide the coverage as specified. Joint strips shall not be less than 100 mm ± 6 mm in width. Welding strips shall not be less than 25 mm ± 3 mm in width. All welding strips shall have edges beveled at time of manufacture.

   iii) Locking extensions

   All liner to be embedded in concrete shall have integral locking extensions.

   Locking extension shall, be of the same material as the liner, shall be integrally moulded or extruded with the sheets, and shall have as approved cross section with a minimum height of 9.5 mm, and a minimum web thickness of 2mm. The locking extensions shall be such that when embedded in concrete, the liner will be held embedded in concrete, and will be held permanently in place.

   Locking extension shall be parallel or perpendicular to axis of pipe as recommended by the manufacturer and approved by the Supervisor. Where locking

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**Properties**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Initial</th>
<th>After exposure for 112 days in chemical solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength</td>
<td>154 kg/cm²</td>
<td>147 kg/cm²</td>
</tr>
<tr>
<td>Elongation at break</td>
<td>200% min</td>
<td>200% min</td>
</tr>
<tr>
<td>Shore durometer</td>
<td>Within 1 sec 50-60</td>
<td>± 5 (with respect to initial test result)</td>
</tr>
<tr>
<td>Type D</td>
<td>10 sec 35 – 550</td>
<td></td>
</tr>
<tr>
<td>Weight change</td>
<td>± 1.5%</td>
<td></td>
</tr>
<tr>
<td>Tear strength</td>
<td>80 Nmm min</td>
<td></td>
</tr>
</tbody>
</table>
extensions are parallel to axis of pipe, they shall be continuous except where interrupted for joint flaps or bonding to the forms.

d. Tests

i) General

Samples taken from sheets, joints, or weld strips shall be tested to determine material properties. Determination of tensile strength and elongation shall be in accordance with ASTM D 412 using Die B. Determination of identification hardness shall be in accordance with ASTM D 2240 using a type D durometer, except that a single thickness of material will be used. Determination of change of weight and indentation hardness shall be made on 25 x 75mm specimens. Thickness of specimens shall be the thickness of the sheet or strip.

The lining shall have good impact, resistance, shall be flexible, and shall have an elongation sufficient to bridge up to 8mm settling cracks, which may occur in the pipe or in the joint after installation, without damage to the lining.

ii) Measurement of initial physical properties

The initial values for tensile strength, weight, elongation, and identification hardness shall be determined prior to chemical resistance tests.

iii) Chemical resistance tests

The physical properties of the specimens shall be determined after exposure to chemical solutions. Test specimen shall be conditioned to constant weight at 43.3° C before and after submersion in the following solutions for a period of 112 days at 25°C ± D° C.

<table>
<thead>
<tr>
<th>Chemical solutions</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphuric acid</td>
<td>20%**</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>5%</td>
</tr>
<tr>
<td>Ammonium acid</td>
<td>5%</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>1%</td>
</tr>
<tr>
<td>Ferric acid</td>
<td>1%</td>
</tr>
<tr>
<td>Soap</td>
<td>0.1%</td>
</tr>
<tr>
<td>Detergent (linear alkyl benzyl sulfonate of LAS)</td>
<td>0.1%</td>
</tr>
<tr>
<td>Bacteriological test at 25°C ± 3°C</td>
<td>BOD not less than 770 ppm</td>
</tr>
</tbody>
</table>

** Volumetric percentages of concentrated reagents of C.P grade.

At 28 days intervals, specimens shall be removed from each chemical solution and inspected. If any specimen fails to meet the requirements specified before completion at the 112 days, the material will be subject to rejection.

iv) Pull test for locking extension
Liner locking extensions embedded in concrete shall withstand a test pull of at least 17.5 N/mm, applied perpendicularly to the concrete surface for a period of one minute, without rupture of the locking extensions or withdrawal from embedment. The test shall be made at a temperature between 21°C to 27°C inclusive.

v) Shop welded joint

Shop welding used to fuse individual sections of liner together shall be at least equal to the minimum requirements of the liner for thickness, corrosion resistance, and impermeability. Welds shall show no cracks or separations and shall be tested for tensile strength. Tensile strength measured across the welded joint, in accordance with ASTM D 412 using Die B shall be at least 13.8 MPa. Test temperature shall be 25 deg C ± 3°C, and the measured minimum width and thickness of the reduced section shall be used.

vi) Spark test

All liner shall be shop tested for holes with a park tester set to provide from 15,000 to 20,000 volts. Sheets having holes shall be satisfactorily repaired in the shop prior to shipment from the manufacturer's plant.

4.6.3 WORKMANSHIP

a. General

The installation of all PVC liner pipes, manholes and other structures shall be done in accordance with these specifications.

Liner shall be applied and secured to the forms, inspected and approved by the Supervisor prior to the placement of reinforcing steel. Forms in contact with PVC liner need not to be oiled.

The manufacturer shall provide a minimum of three months on site welding training for the Contractor's personnel. The Contractor shall have all welding performed by personnel approved by the manufacturer and the Supervisor.
b. Placing liner

The circumferential coverage in pipe shall be the top 300 degrees.

All liner installed in pipe shall be positioned so that the locking extensions are parallel or perpendicular to the axis of the pipe as per manufacturer recommendations and as per the approval of the Supervisor. At manhole entrance, the last segment shall have a transverse direction to stop instruction of water from manhole behind liner if locking extensions are parallel to the axis of the pipe.

Liner shall be set flush with the inner edge of the socket end of a pipe section and shall extended either to the spigot end or beyond the spigot end, as required for the type of liner joint to be made with the adjoining pipe. All liner shall be factory installed for precast pipes.

At all pipe joints, the space between ends of locking extensions, measured longitudinally shall not exceed 100 mm.

c. Security of liner in place

Liner shall be held snugly in place against inner forms. For pipes and similar circular sections, light steel banding straps or other approved means may be used.

Concrete shall be performed from flowing around the edges of sheets at joint by welding a weld trip over the back of the joint.

d. Weep channels

If the locking extensions are placed longitudinally then weep channels shall be provided as specified herein.

At each pipe joint a gap not less than 50 mm or greater than 100 mm shall be left in all locking extensions to provide a transverse weep channel. If locking extensions are removed to provide a weep channel at joints, the base of the extension left on the sheet shall not be less than 0.8 mm.

Intermediate weep channels shall be provided as necessary to maintain a maximum spacing of 2.5m.

As a part of the work of installing liner, outlets of weep channels shall be cleared of obstructions which would keep them from functioning.
e. Concreting operations

Concrete placed against liner shall be carefully vibrated to avoid damage to the liner and to produce dense concrete securely anchoring the locking extensions into the concrete. Vibrators shall be used particularly along the lower terminal edge of the liner.

f. Removing form

In removing forms, care shall be taken to protect liner from damage. Sharp instruments shall not be used to pry forms from lined surfaces.

Following completion of form removal, liner in pipe shall be cleaned for inspection. Repairs to the liner shall be completed to the satisfaction of the Supervisor.

Bandings straps used in securing liner to forms at pipe shall be removed within the limits of the unlined invert, and voids left in the invert at the edge of the liner shall be filled with cement mortar or other material approved by the Supervisor.

g. Field jointing of liner

No field joint shall be made in liner until the lined pipe has been backfilled. Liner at joints shall be free of all mortar and other foreign material and shall be clean and dry before joints are made.

Hot joint compound shall not be brought in contact with liner.

No coating of any kind shall be applied over any joint, corner, or welding strip.

Field joints in liner pipe shall be one of the following types:

- Type P1 joint shall consist of at least 100mm joint strip, centered over the pipe joint and secured along each edge to adjacent liner by means of a 25 mm welding strip.

- Type P2 joint shall be made with an integral joint flap with locking extensions removed, extending 100mm ± 6mm beyond the spigot end of the pipe. The flap shall overlap and be welded to the lining of the adjacent pipe section with a 25mm weld trip. Care shall be taken to protect the flap from damage. Avoid excessive tension and distortion in bending the flap during pipe laying.

Any flap which has been bent back, and held, shall be allowed to return to its original shape and flatness well in advance of making the liner joint.
h. Installation of welding strips

Welding strips shall be fusion welded to joint strips and liner by qualified welders using only methods and techniques approved by the liner manufacturer. The welding operation of any joint shall be continuous until that joint has been completed.

Adequate ventilation shall be maintained in confined spaces during welding operations.

Welding strip shall be centered over the cleaned surfaces to be joined and fused across its entire width. Incomplete fusion, charred, or blistered welds will be rejected.

Hot air welding guns shall provide clean effluent air at constant pressure to the surface to be joined within a temperature range between 260°C and 315°C unless otherwise specified by the manufacturer and approved by the Supervisor.

i. Protection and repair of PVC liner

All necessary measures and precautions shall be taken to prevent damage to liner from equipment and materials used in, or taken through the work. Any damage to installed liner shall be repaired by the Contractor in accordance with the requirements set forth herein for the repair of liner.

All nail and tie holes and all out, torn and seriously abraded areas in the liner shall be patched. Patches made entirely with welding strip shall be fused to the liner over the entire patch. The use of this method is limited to patches which can be made with a single welding strip. The use of parallel, overlapping, or adjoining welding strips will be not permitted. Larger patches may consist of smooth liner over the damaged area, with edges covered with welding strips fused to the patch and to liner adjoining the damaged area. The size of a single patch of the latter type shall be limited only as to its width, which shall not exceed 100mm.

Whenever liner is not properly anchored to concrete, or whenever patches larger than those permitted above are necessary, the repair of liner and the restoration of anchorage shall be done by the Contractor as directed by the Supervisor.

After repairs have been made, defective welds will be reinspected and tested and pipes having badly damaged lines shall be rejected.

j. Field test

Upon completion of the installation of the PVC linings, the surface of the liner shall be cleaned to permit visual inspection, and spark testing by the Contractor in the presence of the Supervisor using a spark type detector capable of providing from 15,000 to 20,000 volts, or as recommended, and approved the Supervisor. The Contractor shall furnish the spark tester and shall be fully knowledgeable in its use. All areas of liner failing to meet the field test shall be properly repaired and retested.

All welds shall be physically tested by a non destructive probing method; all patches over holes, or repairs to the liner wherever damage has occurred shall be accomplished in accordance with these specifications.

Each transverse welding strip extends to a lower edge of the liner shall be tested. The welding strips shall extend at least 50mm below the liner to provide a tab. A 46N pull will be applied to each tab. The force will be applied normal to the face of the structure by means of a spring balance. Liner adjoining the welding strip will be held against the
concrete during application of the force. The 46N pull will be maintained, if a weld failure develops, until no further separation occurs. Defective welds will be rested after repairs have been made. Tabs shall be trimmed away neatly by the Contractor after the welding strip has passed inspection. Inspection shall be made within 2 days after joint has been completed in order to prevent tearing the projecting weld strip, and consequent damage to the liner from equipment and materials used in or taken through, the work.
5 PLUMBING, DRAINAGE AND DOMESTIC MECHANICAL WORKS

5.1 SCOPE OF WORK

The Contractor shall furnish all labour, materials, equipment, tools appurtenances, services, and temporary work to provide and complete the drainage and plumbing services for building all in perfect working order. This work shall include but not limited to the following:

- Cold and hot water services;
- Sanitary fixtures and fittings;
- Soil, waste and vent systems to discharge waste from the above fixtures and other equipment and to provide drainage from floor drains and waters storage systems into and including main drainage (drains and interconnecting manholes) leading to the overflow and inlet structures;
- Testing of all piping systems, equipment with controls and other devices to demonstrable that the entire installation is in perfect working order;
- Builders work: as required.

All equipment and materials shall be brand new bearing stamped rating, as required and must be approved by the Supervisor prior to their use.

The foregoing sub-paragraphs are not intended to itemize all works required by this section of the Specifications and are only for the purpose of routing the extent of work for the guidance of Tenders.

All Electrical works shall conform the requirements of the Electrical Specifications.

5.2 BUILDER'S WORK INCLUDED

The following builder's work, without thereby implying any limitation, shall be considered as part of this section:

a) All builder's work in connection with fixing of supports, brackets, and clips as required;

b) Cutting or forming all openings, mortices, chases, etc., in floors, walls, and ceilings required for the installation and making good after;

c) Painting all steelwork in connection with supports for pipe and equipment exposed to the elements with two coats of an approved rust preventive paint.

All builder's work to be carried out to the entire satisfaction of the Supervisor.

5.3 DISINFECTION OF WATER PIPING

The Contractor shall disinfect water piping and storage tanks before it is placed in service. He shall furnish all equipment and materials necessary to do the work of disinfecting, and shall perform the work in accordance with the procedure outlined in the AWWA Standard for Disinfecting Water Mains, Designation C601-latest editions.

The dosage shall be such as to produce a chlorine residual of not less than 10ppm after a contact period of not less than 24hours. After treatment, the piping shall be flushed with clean water until the residual chlorine content does not exceed 0.2ppm.
5.4 TESTING

5.4.1 GENERAL
Test shall be done according to a predetermined program and shall not commence before the approval of the Supervisor’s Representative.

Pressure tests for piping shall be at least 1½ times the operating pressure but not less than 3 Kg/sq.cm. Test pressure shall be read at the highest point of the building.

Discharge test of pipes fixtures and installations shall be at full load.

The Supervisor reserves the right to request any additional tests not enumerated here but judged necessary by him.

All systems shall be thoroughly cleaned both externally and internally before performing any tests.

All tests shall be made before systems are painted, covered or enclosed in building construction whenever conditions permit. When so directed by the Supervisor’s Representative, systems shall be tested in sections.

When all pressure tests of piping and all normal working pressure tests have been performed on all fittings and appliances a discharge test shall be carried out for each group of fixtures at the normal operating pressure and temperature.

Where any evidence of stoppage is detected in piping, equipment, etc. the Contractor shall disconnect, clear, repair and reconnect all obstructed piping, equipment and fixtures at his expense.
5.4.2 TESTING PROCEDURE

- **Drainage System:** After completion of the installation related to each stack for each floor, the connection opening and the lower end of the stack shall be plugged and filled with clean water for a height of at least three (3) meters above the tested joint, and the lines inspected for any visible leaks. The water must remain without any drop of level for at least eight (8) hours and any such drop will mean improper and defective installation.

  The Contractor may perform the test after the complete installation of the sanitary piping, but in this case tee connections shall be introduced on the stack at each floor intervals in order to make it easy to plug the stack for testing purposes. The branch shall be fitted with a cleanout plug which shall not be measured for payment.

- **Cold and hot water pipes and all pipes, other than drainage piping,** shall be tested for the whole building before installation of sanitary fixtures or equipment. All pipes shall be vented and plugged then subjected to pressure of 3Kg/sq.cm. at roof level.

  The pressure shall be maintained in the piping system for at least eight (8) hours without any further pumping. Any drop in pressure shall mean defective installation.

- **Flow Test:** After all hydraulic tests on pipes as mentioned above are completed and approved, the Contractor shall test the sanitary fixtures and other equipment connected to the pipes at full load temperature and pressure, and following the instructions of the Supervisor’s Representative.

  The Contractor shall provide all facilities and necessary instruments for testing and shall make good any defects at his own expense to the entire satisfaction of the Supervisor’s Representative.

5.5 PIPES, FITTING & ACCESSORIES

5.5.1 PIPE MATERIAL

Pipe materials shall be in accordance with the requirements set under the respective standards.

5.5.2 PIPE JOINTING

a) **Threaded Joints**

  Threaded joints on all pipes shall be made tight with oil and graphite or an approved compound especially for the purpose. An approved jointing tape may also be used. All joints compounds shall be delivered to site in the original manufacturer’s container. Hemp shall in no way be accepted for the pipe jointing.

b) **Flanged Joints**

  Flanges may be used to join pipes where indicated in Table A. In this case flanges shall be of the same class as the pipes and fittings and shall have faces perpendicular to the adjoining pipe. All matching flanges to equipment shall be drilled either on site or at factory to match the equipment flanges. Rubber gaskets shall be used for cold water piping and asbestos or klingerite gaskets shall be used for hot water piping. Thickness of gaskets shall not be less than 1.5mm.
Flanges may be welded to pipes except for galvanized pipes in which case flanges may be threaded to the pipe.

c) **Bell and Spigot Joints**

UPVC bell and spigot type shall be assembled by means of rubber rings or solvent cement, as approved by the Supervisor. Jointing of a group of fittings could be made as an assembly before being positioned in final place. Pipe hangers, supports and holders shall be provided in all places requiring such fixing, and shall be of a design adopted for the rest of plumbing works and in locations approved by the Supervisor’s Representative. Rubber rings shall comply with ASTM D 1869. Solvent cement shall comply with ASTM D 2564.

Provision shall be made in all soil and waste piping for accessible cleanouts at every abrupt change in direction.

### 5.5.3 ACCESSORIES

All accessories shall be of the same standard of pipes on which these are fitted and shall be threaded, flanged, welded or brazed according to the type of pipe, its diameter, and the location where the pipes are to be installed. Accessories of buried pipes shall be supplied by the same pipe manufacture.

### 5.6 PIPE HANGERS & SUPPORTS

Pipe hangers and support shall be made of standard sections of steel. The type and design of the hangers and support, and method of fixation to walls and/or ceilings shall be presented to the Supervisor for approval before installation. In all cases where hangers, brackets, etc., are supported on concrete care shall be taken to not to damage any water proofing installation, if any.

### 5.7 PIPE CONTACT SHOES

All insulated pipes, resting on supports, hangers, or on racks inside the buildings, shall be equipped with contact shoes at the point of support. The contact shoes shall be of the semi-cylindrical construction and be filled with insulation material.

### 5.8 PIPE SLEEVES

Sleeves shall be of galvanized steel pipes of approved weight, sufficiently large to avoid restriction of expansion of pipes, but not larger than necessary for the purpose. The sleeves shall be provided where pipes pass through roofs, floors, walls, partitions or similar construction. Sleeves shall be of adequate size to permit space for insulation. Sleeves passing through walls, partitions, and ceiling shall terminate flush with the finished wall, or ceiling surface. Sleeves passing through floors shall extend 50mm above finished floor.

Sleeves, in external walls below ground, or in walls to have liquid on one or both sides, shall have a 5 cm annular find of 3mm thick plate welded, with a continuous weld, completely around the sleeve at about mid-length. Sleeves shall be galvanized after the fins are attached. In addition, the space between the sleeves and pipe covering shall be caulked with approved plastic and waterproofing suitable for the temperature of the pipes.
5.9 PIPE INSULATION

Insulation to hot water pipe-work shall be formed from sections of fire resisting glass wool insulation material with a conductivity of not more than 0.28 Btu/hr/inch/sq./ºF. Domestic hot water pipes embedded in walls shall be insulated with fibre glass blankets wrapped around the pipes and protected with canvas wrapping and two coats of bituminous paint.

Insulation material shall not be applied before the pipes are installed, tested and painted. Pipes shall be insulated up to fixed equipment.
5.10 PROTECTION OF UNDERGROUND PIPES

All pipes buried underground outside the building shall be covered by selected clean sand fill and shall be buried at a minimum cover depth of 80 cm, or as approved by the Supervisor.

All pipes with a depth less than 80 cm and for road crossings shall be protected by a concrete encasement.

5.11 VALVES

5.11.1 TYPES AND CLASS

All valves shall be designed for packing under pressure with valve opened or closed. All gate valves shall have a clear waterway equal to the nominal diameter if the valve and shall open counter clockwise by means of non rising stems. Valves with threaded ends shall have joints in accordance with the BS pipe threads. Flanged valves shall have bolt holes to match the equipment to which they are connected.

Gate valves up to 50mm, inclusive, shall conform to BS 1952 CLASS 125 or equivalent.

Gate valve of 65mm, and over, shall conform to BS 5150, PN 10 or equivalent.

Check valves up to 50mm, inclusive, shall be all bronze screwed, swing type conforming to BS 1953, PN 10 or equivalent.

Check valves 65mm, and over, shall be iron body flanged, bronze moulded, swing type, conforming to BS 5153, PN 10 or equivalent.

Float valves shall be of bronze construction actuated by means of a bronze lever arm and float. Each valve shall be equipped with a gate valve having the same diameter.

5.11.2 USE OF VALVES

Gates valves shall be used for shut off and sectioning purposes. Values shall be installed in each principal branching of hot and cold water, heating services.

Valves shall also be installed on each branching supplying bathrooms, or to isolate each group of sanitary fixtures or equipment as requested by the Supervisor.
5.12 VENT CAPS
Vent caps shall be of plastic construction, and design approved by the Supervisor. Caps shall be provided with slots and mosquito wire screen and shall have a minimum size equal to the vent pipe size.

5.13 FLOOR DRAINS
Floor drains shall be constructed of “P” or “S” traps with the same material, and of the same size and standard of pipe accommodated, and provided at the end with an adapter and threaded plug. Cover plates and frames shall be as indicated on the Drawings “P” or “S” drain shall be of cast iron.

5.14 CLEANOUTS (FLOOR TYPE)
Cleanouts shall be formed of standard fittings such as “Y” or 45° bends, and shall be of the same material, standard characters and full size of pipe accommodate, and provided at the end with an adapter and threaded plug. Channels shall be of cast iron.

5.15 SUPPLY CONNECTIONS TO UNITS
The service connection to any unit shall be equipped with a cut off valve, and solid or flexible connections which shall be kept well plugged until it is connected to the unit.

5.16 GENERAL INSTALLATION REQUIREMENTS
5.16.1 LOCATION OF PIPES
Generally all pipes running under floor tiles shall be wrapped with self-adhesive PVC tape, and embedded in cement and sand mortar (1:4); care shall be taken to insure that no line is added to the mortar mix. In addition, hot water pipework shall be insulated with sections of fire resisting glass wool as specified above, before pipes are embedded in the cement and sand mortar. Pipes embedded in walls shall also be wrapped with a self-adhesive PVC tape and insulated as required.

All steel pipes buried in ground shall be protected against corrosion by tape wrapping after applying protective painting. Tape wrapping shall be achieved by means of a self-adhesive PVC tape applied with the necessary overlap in accordance with the manufacturer’s instructions.

All waste pipes running in the ground floor slabs under the buildings shall be fully embedded and surrounded with Class B concrete. The Supervisor shall inspect and approve trenches for the said piping before any pipe or concrete is laid. The drains shall be jointed to manholes and junction boxes in a water-tight manner satisfying perfect running condition. Then invert of the incoming drain pipe shall be at least 0.10 meter higher than the invert of manhole.

Floor drains shall be installed in the openings provided for them in the concrete slab.
The pass of piping shall reduce to minimum the loss space and save height.
Valves shall be grouped together as close as possible.
All waste drains shall be located under the floor, unless otherwise indicated. Only where it is deemed necessary by the Supervisor, waste pipes shall run in the slab where a minimum of slab breaking shall be permitted.

All soil and vent pipes shall extend above the highest point of roof and shall be equipped with a vent head and caps as specified. The projecting pipe above roof slab shall be provided with sleeves, such sleeve shall extend at least 0.30 meter above the finished surface and rendered waterproof as detailed in “Roofing and Waterproofing”.

5.16.2 COMMON CONDITIONS FOR PIPE ASSEMBLY

Before installation, all pipes shall be cleaned of all foreign and matter and shall be reamed smooth after cutting, and all trenches cleaned up.

Pipes shall be spaced to permit their installation and insulation if any.

Pipes shall be carefully cut hacksaw of by special pipe cutting machine. Pipe edges shall be cleaned and smoothed before threading.

Threading shall be done for the total length of joint or accessory and shall be done with a reliable threading machine, cutting tapered threads.

Concealed pipes shall be installed in such a way as to permit their maintenance and inspection. Pipes shall be installed true to plumb, to the directions indicated on the Drawings, and parallel to building lines with a minimum slope of 2% for horizontal stretches needed for venting and draining.

Open ends of pipe shall be plugged until use by means of flanges and blind flanges, or threaded plugs.

Valves, control instruments and accessories shall have a minimum number of access openings.

Hangers and supports shall be grouped together for all pipes running in the same area.

Details for pipe hangers, supports, guides, shoes shall be presented to the Supervisor for approval before installation.

5.17 SANITARY FIXTURES AND FITTINGS

5.17.1 GENERAL

The sanitary fixtures and fittings shall be of the models indicated here below and shall be supplied and installed complete with all necessary related accessories for proper installation and functioning. The manufacturers catalogue numbers mentioned here below are only to indicate the shape, size and materials to be offered. However, the Contractor may offer any equal model or make, subject to the approval of the Supervisor.

All apparent parts of the fittings shall be of chrome plated brass unless otherwise mentioned.

5.17.2 LAVATORY BASINS

Lavatory basins shall be of white color vitreous china (560 x 405) mm for all fixing. They shall be supplied complete with:

- Pop-up drain adapter
- Brilliant handles
- Concealed handles
- Bottle trap similar to Grohe 28920
- ½ inch angle valves similar to Grohe 22938

Mirrors shall be (450 x 450) mm complete with fixing accessories and humidity-resistance protection on the back.

5.17.3 EUROPEAN WATER CLOSETS (EWC)

European water closets shall be vitreous china siphonic action complete with:
- Pan with bottom outlet
- 11 liters cistern with valveless fittings with siphon, sealing gasket and bolts for securing cistern to basin
- Heavy plastic seat and cover of matching color
- Floor fixing flanges and gasket
- Fixing screws
- Isolating valve

5.17.4 URINALS

Urinals shall be vitreous wall hung wash out type complete with:
- Wall hangers
- 1 ¼ inch outlet gratings
- Divisions, with concealed wall hangers and screws
- Automatic flushing cistern with siphon, drip tap and wall hanger
- Stainless steel flush pipes with spreaders and clips
- Traps 1 ¼ inch
- Fixing screws

5.17.5 SHOWER TRAYS

Shower tray shall be of white color in ceramic glazed fireclay, (760 x 760) mm, complete with:
- ½ inch 3-way concealed diverter
- ¾ inch wall outlet adjustable flange
- Adjustable cast showerhead 65 mm diameter with ball joint bent
- Shower curtain and rod with all accessories to be approved by the Supervisor
5.17.6 SINK
Sink shall be single bowl of stainless construction 500 x 500 mm and as approved by the Supervisor. The unit shall have outlets including all drainage accessories and cupboard, complete with ½ inch swivel clock identical to Grohe type 30402 metal handle with blue marking.

5.17.7 TOILET PAPER HOLDER
Toilet paper holder shall be of vitreous china construction and recessed.

5.17.8 SOAP AND BRUSH TRAY
Soap and brush tray shall be of vitreous china construction size 305 x 150 mm and of the recessed type.

5.17.9 POLYETHYLENE WATER TANKS
Water tanks for storing domestic water supply, of heavy duty Polyethylene, shall be installed and connected properly with float valves, drain pipes and other accessories and support, as follows:

- One 2 m³ tank capacity for the main administration and technical buildings
- One ½ m³ tank capacity for the Guard House
- Any additional water tanks required for other buildings if needed.

Tanks shall be obtained from a reputable local manufacturer and shall be installed where and as approved by the Supervisor.

5.17.10 WATER HEATERS
Water heaters shall be electric, thermal storage pressure type manufactured by a reputable manufacturer. The unit shall generally consist of a cylindrical inner container constructed of cold rolled copper sheet, tinned internally, with all seams overlapped and brazed. The outer casing shall be made of high grade sheet steel, rust proof with two coats of anti-rust paint, inside and outside, and finished in white baked on hard wearing enamel. Space between inner and outer container shall padded with efficient thermal lagging.

The immersion heater shall be constructed from nickel chromium resistance wire in a mineral filling, the whole being encased in a copper tube and sealed against moisture. An adjustable automatic thermostat 20 ampere rating, minimum rating for temperature regulation from 32 - 85°C, shall be provided for the unit. Heaters shall be suitable for the single or three phases, 220V or 380V, 50 cycles.

5.17.11 ROBE HOOK
Robe hook shall be of the semi-recessed vitreous china construction.
5.17.12 **METHOD OF INSTALLATION**

Installation of sanitary fittings shall proceed in a manner to suit the schedule of finishes and at a time set forth by the Supervisor to avoid interference with other trades.

Before any attempt is made to install fittings, all plugged pipe openings shall be left open and branches tested for proper discharges tested for proper discharge of water.

The installation of any fitting in place shall be in a manner imposed by its design and according to manufacturers’ recommendations, and shall be worked out in the best accepted practice, and left in perfect water-tight connections and surroundings. The Contractor shall submit a copy of the installation requirements to the Supervisor for approval before installations.

The Contractor shall install all sanitary fittings at the exact locations to the satisfaction of the Supervisor.

The works on sanitary fittings installation shall include the installation of all accessories related to each fixture intended function. Flexible connections and all necessary items to connect pipe ends provided, especially for the unit connection, shall me made of chrome plated brass tube and valve. All fittings installed on walls shall be provided with escutcheons.

The Contractor shall take precautions to protect the fittings and the fitting openings against damage and/or entrance of trash until completion of work. All open drains, W.C. bends, lavatories, sinks, vents and other fittings shall be capped or plugged to keep all debits out. All fittings shall be cleaned of labels, paint, dripping and dirt and shall be completely polished before acceptance.

### 5.18 PIPE MATERIAL

<table>
<thead>
<tr>
<th>Fluid Conveyed</th>
<th>Pipes Inside Building</th>
<th>Pipes Outside Buildings Burried in Trenches</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drinking Water, and Domestic Cold and hot Water</strong></td>
<td>Seamless Galvanized Steel Pipe to BS 1387 Medium Grade or equal</td>
<td>Threaded [Same as inside but with PVC Tape Wrapping] [Same as inside but with PVC Tape Wrapping]</td>
</tr>
<tr>
<td><strong>Fuel Oil piping</strong></td>
<td>Black seamless Steel Pipe to BS 1387 Medium Grade or equal</td>
<td>Threaded up to 2” Flanged 2½” and over [Same as inside but with PVC Tape Wrapping] [Same as inside but with PVC Tape Wrapping]</td>
</tr>
<tr>
<td><strong>Drain Lines &amp; Vent</strong></td>
<td>UPVC to ASTM D 3034</td>
<td>Bell and Spigot Ruller Rings or [Same as inside] [Same as inside]</td>
</tr>
</tbody>
</table>
6 BLOCKWORK

6.1 SCOPE OF WORK

The Contractor shall furnish all necessary materials and construct all blockwork required under this Contract as herein specified.

6.2 MATERIALS

Cement and water shall be as described in "Concrete Work". Lime shall be hydrated lime complying with BS 890 Class B to be soaked in water for not less than 16 hours before use.

Sand shall be clean and sharp, free from salt, loam and organic matter. It shall comply with BS 1199 and 1200 as appropriate.

6.3 CONCRETE BLOCKS

Generally blocks shall be of an approved local manufacture made with cement and sand in approved vibrated pressure machines. The sand to be used for blocks shall be chemically and structurally stable and comply with the table of grading given hereunder.

<table>
<thead>
<tr>
<th>B.S test Sieve No</th>
<th>Sizes</th>
<th>Sand for Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>microns</td>
</tr>
<tr>
<td>-</td>
<td>4.76</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>2.40</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>1.20</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>-</td>
<td>600</td>
</tr>
<tr>
<td>52</td>
<td>-</td>
<td>300</td>
</tr>
<tr>
<td>100</td>
<td>-</td>
<td>150</td>
</tr>
</tbody>
</table>

Note: the above figures represent the limits of percentage (by weight) passing sieves of the sizes mentioned.

The following mixing table shall be strictly adhered to in all cases:

<table>
<thead>
<tr>
<th>B.S test Sieve No</th>
<th>Sizes</th>
<th>Sand for Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>microns</td>
</tr>
<tr>
<td>-</td>
<td>4.76</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>2.40</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>1.20</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>-</td>
<td>600</td>
</tr>
<tr>
<td>52</td>
<td>-</td>
<td>300</td>
</tr>
<tr>
<td>100</td>
<td>-</td>
<td>150</td>
</tr>
</tbody>
</table>

Note: the above figures represent the limits of percentage (by weight) passing sieves of the sizes mentioned.
Block shall be hard, sound, and clean with sharp, well-defined rises and shall be 20 cm in height.

The design of the cavities and webs of hollow blocks shall be submitted to the Supervisor for approval before manufacture. The thickness of the membranes of solid portions of the hollow blocks shall be not less than 2.5 cm each, in the case of 10 cm wide blocks, and 4 cm each, in the case of blocks 15 cm wide and over, and the combined thickness of the solid portions shall exceed one third of the total thickness in either horizontal direction.

Immediately after mounting, the block shall be placed on clean, level and timber pallets. Blocks shall not be removed from the pallets until inspected and approved by the Supervisor. Blocks shall be cured by being kept thoroughly wet by water sprinklers, or other approved means, for a period to be determined by the Supervisor, but in all cases for not less than 3 days. Blocks must not be left on earth in honeycomb fashion. Solid stacking will not be permitted. All blocks shall be at least one month old before use.

Blocks shall be tested for compressive strength whenever required by the Supervisor. Blocks shall have an average compressive strength of 40 kg/cm². Should any blocks prove to be below this strength then all of the blocks from the same batch may be rejected.

**6.4 HOLLOW CONCRETE BLOCKS FOR SUSPENDED SLABS (HOURDIS)**

Hollow concrete blocks for suspended floor and roof slabs (hourdis) shall be precast blocks of the dimensions indicated on the approved drawings and obtained from an approved local manufacturer.

Blocks shall be at least 21 days old before use and shall have wetted and cured for 12 days. The blocks shall be capable of withstanding a compressive strength, applied to the ends of the blocks, of 30kg/cm² based upon the total gross area of the cross section. Special closed-end blocks are to be used at the ends of rows of blocks, and specially made half blocks shall be used, as required, in narrow widths. Any damage blocks shall be taken cut and replaced prior to the start of concrete pouring.

Blocks shall be laid true to line, continuing in the same exact alignment in adjacent spans.

**6.5 CONCRETE CLAUSTRA BLOCKS**

Precast concrete clasutra blocks shall be manufactured generally as for concrete blocks, but using white cement instead of ordinary Portland cement and moulded to the pattern and sizes shown on the approved drawings in purpose made steel moulds.

Concrete clasutra blocks shall be hard, sound, square and clean with sharp well-defined rises. The faces of the blocks shall be finished fair.

**6.6 MORTAR**

Mortar for blockwork shall consist of 1 part cement to 3 parts sand by volume. For work not in contact with earth or sand, one quarter lime by volume may be added to the mix.

Should the Contractor wish to use a plasticizer with mortar, then the mortar shall consist of 1 part cement to 4 parts sand with plasticizer added and used strictly in accordance with the manufacturer's instructions. The plasticizer must be approved by the Supervisor before use.
Mixing shall be carried out by means of an approved mechanical batch mixer. The mortar shall be fixed dry until a uniform is obtained. Sufficient water shall then be added and the mixing continued until a homogenous mix is obtained. Excess water shall not be used in the mix.

In the case of cement-lime mortar, the sand and lime shall be mixed first and cement added. It shall be assumed that the lime has not increased the bulk of the sand.

All mortar shall be used before the initial set has taken place, and on no account shall mortar, which has commenced to set, be remixed with water or new batches, and used.

### 6.7 WORKMANSHIP

All blockwork shall be set out and built to the respective dimensions, thickness and heights, shown on the approved drawings.

Unless otherwise ordered, hollow blocks shall be used. In any case all closures, and blocks such as at door jambs, window opening, etc., shall be solid. The blocks shall be well soaked before being used and the tops of walls left off shall be wetted before work is recommenced.

Blocks shall be laid in true and regular courses on a full bed of mortar of 1 cm average thickness, exclusive of any key in the jointing surfaces of the blocks. Sufficient mortar shall be used in bedding and jointing to ensure that all keys are solidly filled.

All horizontal joints shall be properly leveled. The vertical joints shall be properly lined and quoins, jambs and other angles plumbed as the work proceeds. All walls shall be plumbed vertical.

Standard size blocks shall be used wherever possible. Broken blocks shall not be used except where required for bonding purpose. Walls and partitions shall be bonded to one another at angles and junctions.

Joints on faces of blocks walls which are to be rendered or plastered shall be raked out for a depth of 1 cm as the work proceeds.

Walls shall be carried up regularly without leaving any part more than one meter lower than another unless the permission of the Supervisor is first obtained. Work which is left at different levels shall be raked back.

Blockwork built against concrete columns shall be bonded by means of horizontal strips of galvanized expanded metal lathing 8 cm wide, cast into concrete and left protruding for building into horizontal joints of blockwork at every third course, and/or means of galvanized mild steel cramps 30 mm wide x 3 mm thick x 200 mm girth “gun shot” fixed to concrete columns at one end with the other end split and built into joints of blockwork.
7 JOINERY AND IRONMONGERY

7.1 SCOPE OF WORK
Carpenters and jointers work shall be carried out in accordance with the principles of good construction.

Unless otherwise stated, all timber is deemed to be wrought all round.

7.2 TIMBER
Timber shall be classified in accordance with the groups listed below:

- Softwood is to be Swedish whitewood ("Swede") or equivalent;
- Blocking timbers or the like shall be ("Shuh") Russian softwood;
- Hardwood if not otherwise specified shall be Canadian Yellow Birch or ("Zein") first grade dense grade timber.

All timber shall be properly seasoned and shall be placed square, straight and true and shall be free from the following defects:

- Sapwood, splits, rings shakes, soft pitch;
- Checks exceeding 30 cm long;
- Checks exceeding in depth one quarter of the thickness of the timber;
- Knots of any description in surfaces for staining or polishing;
- Knots of any description in glazing bars;
- Knots exceeding half the width of the surface;
- Decayed or dead knots unless cut out and plugged;
- Pitch pockets;
- Decay and insect attack including pinworm holes.

In jointed panels each piece shall be of the same species. Joinery for oiling or polishing shall have all surfaces of the same species and same character of grain.

All plugs inserted after cutting out defects shall be the full depth of the hole, and the grain of the plug shall run in the same direction as the grain of the piece.

Sample of the timber which the Contractor proposes to use in the works shall be sent to the Supervisor for his approval. Timber used in the works shall be equal in strength, characteristics and appearance to the approved samples.

7.3 PLYWOOD
Plywood shall comply with BS 1455, WBP Bonded Type. Plywood to be polished or varnished shall be Grade 1, and other plywood shall be Grade 2. The Contractor will not be allowed to make up thickness by gluing together sheets of thinner plywood.

Plywood shall be free from end joints (including scraft joints in veners) overlap in the core veneers, dead knots, patches and plugs, open defects, depressions due to defects in core,
insert attack, fungal attack and from discoloration differing from the normally associated with species.

Face veneers shall be hard and durable and shall be capable of being finished to a smooth surface. Face veneers shall closely match the general joinery timber supplied.

7.4 BLOCKBOARD

Blockboard (latte) shall be built-up board with a core of softwood strips 2 cm to 3 cm wide glued edge, and faced with plywood or other facing. Blockboard shall comply with BS 3444.

7.5 LAMINATED PLASTIC SHEETING

Decorative laminated plastic sheet is to be formica or melamine, 1/16" thick to comply with BS 3794 Class1, or shall be an equal substitute acceptable to the Supervisor. The plastic laminate is to have a decorative finish on one side only, to the approval of the Supervisor. The plastic laminate is to be free replaced. When the adhesive is set the plastic laminate is to be neatly beveled off along all rises with a plane.

Where plastic laminate is fixed to surfaces without a laminate to the outer edge, a raised lipping is to be provided and the laminate finished flush against the lipping.

7.6 DOORS

Doors shall be fitted to give a uniform clearance of not more than 3 mm all round and hung to the frames or linings.

Flush doors shall be of blackboard construction and covered on both sides with wood veneer facing. The facing shall be glued to the blockboard under pressure with synthetic insect repelling waterproof glue. Doors shall have hardwood lipping on all edges.
7.7 DOOR FRAMES

Jointing or framing shall be carried out in accordance with BS 1567.

Door frames shall be securely fixed to the wall by means of galvanized mild steel cramps, 30mm wide x 3mm thick x 200mm girth, once bent, twice counter sunk drilled and screwed to the frame with one end split and built into the joints of the walling. Three cramps shall be fixed to each joint of the walling. Three cramps shall be fixed to each frame's side.

7.8 JOINERY FIXTURES

Shelves, benches, divisions, counter tops, panels, drawers and the like shall be screwed to bearers framing or brackets.

Blockboard in shelves, divisions, counter tops, panels, drawers and the like shall hardwood lipping to all edges.

7.9 WORKMANSHIP

Joinery shall comply with BS 1186 Part 2 and, where possible shall be fabricated in a manufacturer's shop prior to delivery. It shall be accurately, properly and soundly constructed with all moulding and rises clean and sharp. Joinery shall be protected from damage during storage at site and throughout the construction period subsequent to fixing and until completion of the works. Should any damage be caused it shall be made good to the satisfaction of the Supervisor at the Contractor's expense.

The arrangements, jointing and fixing of all joinery work shall be such that shrinkage in any part, or any direction, shall not impair the strength and appearance of the finished work, and shall not cause damage to continuous materials or structures. Loose joints shall be used where provision must be made for shrinkage or other movements acting other than in the direction of the stresses of fixing or loading. Glued joints may be used where provision need to be made for shrinkage or other movements in the connections, and where sealed joints are required. All glued joints shall be cross-tongued or otherwise reinforced. Members in construction to be joined by gluing, shall be of similar conversion. All surfaces to be glued shall be kept clean, free from dirt, dust, sawdust oil and any other contamination. Adequate pressure shall be applied to glued joints to ensure intimate contact shall be maintained while the glue is setting.

The terms "frame", or "framed" or "framing" more work put together by proper carpentry or joinery, such as mortising and tenoning, dovetailing doweling, etc., and the joints shall be as specified or directed. Butted and screwed or nailed joints or halved joints and the like will not be deemed framed and will not be accepted for framed work.

Fixing of all joinery work, including fillets, architrave, frames, glazing beads and the like shall be by means of screws. Nailed work will not be permitted.

All screws and bolts for fixing joinery shall be countersunk and puttied, or pellated, and all springs shall be punched and puttied.

Veneering shall be carried out in approved manner.

Reasonable tolerance shall be provided at all connections between the joinery works and the building carcass so that irregularities, settlements, or other movements shall be adequately compensated.
Joinery shall be accurate scribed to fit the contour of any irregular surface against which they may be required to form a close but connection.

The joiner shall take all reasonable measures to check or prevent capillary penetration of water in the joints and open connections of external joinery works, and in all other positions where joinery works may be exposed to water.

Mortises and holes for ironmonger shall not be larger than is necessary for the easy insertion and withdrawal of the ironmonger fitting.

Ironmonger shall be fitted and shall be taken off before any painting work is commenced and shall be refixed after all painting operations are completed.

Hinges shall be housed or let into doors, windows frames and the like. Nailed work will not be permitted.

All joinery which is to be oiled, painted, or polished shall be finished smooth and clean by rubbing down by hand with fine glass paper.

7.10 IRONMONGER

Ironmonger shall be first quality and be obtained from an approved manufacturer. Locks, latches and furniture for doors shall be "Yale" brand or an approved equal.

Ironmonger shall comply with the appropriate BS listed hereunder:

- BS 455 Locks and latches for doors
- BS 1227 Hinges
- BS 1228 Door bolts
- BS 1331 Builders hardware for housing
- BS 2008 Performance tests for locks

Samples of all ironmonger items which the Contractor proposes to use in the works shall be sent to the Supervisor for his approval.

All ironmonger is to be supplied with matching screws of the type, size, material and finish to suit the piece of ironmonger and the Contractor has to fix all in accordance with the manufacturer’s detailed fixing instructions.

On completion of the works all, latches, bolts, catches and the like shall be cleaned, oiled and tested to the satisfaction of the Supervisor. All keys shall be clearly labeled with hardboard tags sizes 5 cm x 2 cm, securely fixed to they keys and handed to the Supervisor.

7.11 MASTER – KEYING

The Contractor shall set up locks for a system of master keying in accordance with a schedule to be furnished by the Supervisor. Two change keys shall be furnished for each lockset.

7.12 GLAZING

7.12.1 GENERAL

This section of the Specifications covers glazing work intended to be used for glazing doors all aluminum elements.
Samples, not less than 15 cm square, of all glass use in the words shall be submitted for approval before any glass is cut.

Glass shall be uniform thickness free from waviness, air bubbles and all other defects.

### 7.12.2 MATERIALS

Clear glass shall be clear sheet glass complying with British Standard No. 952 Section 1 Table 1, “Ordinary Glazing Quality” of the substances show below:

<table>
<thead>
<tr>
<th>Nominal Substance</th>
<th>Limits of thickness (mm)</th>
<th>Approximate weight (lbft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>¼” (6mm)</td>
<td>6.25 to 6.75</td>
<td>3 ½</td>
</tr>
<tr>
<td>32 oz (4 mm)</td>
<td>3.80 to 4.20</td>
<td>2 ½</td>
</tr>
</tbody>
</table>

Plate glass shall be floats glass and complying with BS No 952 Section 1, Table 3, "Glazing Quality", of the substances shown below:

<table>
<thead>
<tr>
<th>Nominal Substance</th>
<th>Limits of thickness (mm)</th>
<th>Approximate weight (lbft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 /16”</td>
<td>3.97 to 5.56</td>
<td>2 ½</td>
</tr>
<tr>
<td>¼”</td>
<td>5.56 to 7.94</td>
<td>3 ¼</td>
</tr>
<tr>
<td>3/8”</td>
<td>9.13 to 10.72</td>
<td>5</td>
</tr>
<tr>
<td>½”</td>
<td>11.91 to 13.49</td>
<td>6 ½</td>
</tr>
</tbody>
</table>

Mirror glass shall be 6mm thick silivering quality polished plate silvered on one side, electrocopper-backed and followed by coating of shellac varnish and painted to the satisfaction of the Supervisor.

Obscured glass shall be glass complying with BS No. 952 Tables 6 and 7.

Wired glass shall be glass complying with BS 952 Section 4, Table 12.

Neoprene strips for aluminum elements shall be supplied by the manufacturer of aluminum elements. Neoprene strips shall be stored in a safe location and shall be protected from the sun and excessive heat.

The glazing bead in aluminum frames for doors and windows shall be special PVC sections that fit into aluminum frame and hold it firmly in position. Approved special mastic possessing the required adhesion and elasticity shall be used. In the case of beads where one end is free, mastic alone shall not be allowed, additional cleats of timber or metal shall be used to secure the proper fixing of the glass.

Timber glazing beads shall be of hardwood supplied with the timber doors. They shall be splayed or chambered and mitred and fixed with brass screws and cups.

### 7.12.3 WORKMANSHP

Prior to proceeding with any work, the Contractor must take all necessary measurements on site to verify and supplement dimensions and conditions shown on the approved drawings.
The Contractor shall protect all glazing work from damage during subsequent operations, make good any defects, clear away upon completion, clean throughout and leave all work in perfect condition to the satisfaction of the Supervisor.

All accessories and other items essential for the proper execution of the glazing work shall be provided under this Section.

The Contractor shall fix all glass frames with all the required gaskets, clips, points, etc. He shall protect all glass from damage and shall replace any damaged unit. All glass shall be cleaned by the Contractor before the completion of the works.

All glass panes shall be cut to allow a 2mm gap all round each opening to be glazed and shall have rounded edges to prevent any damage to the gasket.

All glazing rebates and beats in wood shall be sealed or primed before glazing is commenced. Glazing to metal shall be curried out using beads. The rebates shall be treated with "Galvafroid" primer and the bedding putty inserted before glazing is commenced. The glass shall be trimmed off level with the sight line to form a neat back putty, and painting shall be carried out. Glazing in timber doors shall be bedded in chamois leather glazing strip or black ribbon velvet in lieu of glazing putty.

Mirrors shall be fixed to walls with rubber sleeves and chromium plated dome-headed screws driven into rawl plugs set into walls.

7.12.4 PROTECTION AND CLEANING

The Contractor shall protect all work in this Section until completion, replace all cracked or broken glass and clean all glazing on both sides and all mirrors before handing over.
8 METAL WORK

8.1 SCOPE OF WORK

The Contractor shall furnish and install the metalwork, necessary for the completion of this contract, as indicated on the approved drawings and as herein specified. All miscellaneous metal work shall be fabricated as detailed or approved, and shall be installed complete with all necessary anchors, bolts and other accessories.

All materials shall be free from scale, rust, damage or defects.

As required by the Specifications and the Conditions of Contract, the Contractor shall submit for approval completely detailed and certified shop and erection drawings of all metalwork. All coatings or other protection against corrosion to be applied at the shop or in the field shall be indicated on these drawings.

8.2 MATERIALS

Steel plates and structural steel shapes and bolts, nuts, etc. shall conform to ASTM Standard Specification for Structural Steel.

Cast steel shall be grade N2 conforming to ASTM standard specifications for Mild-to-Medium-Strength Carbon Steel Casting for General Application, unless otherwise indicated or specified.

Stainless steel shall be type 304, unless otherwise indicated or specified.

Aluminum elements shall be manufactured of extruded sections of aluminum alloy and mechanically jointed. Aluminum members shall be of a commercial quality 50s (AL. Mg.Si) heat-treated, free from defects impairing its strength and durability and containing not more than 0.4% copper. All exposed surfaces shall be polished to a mirror-like surface, free from defects, and shall be light etched and anodized in a satin or a matt, silver finish as directed by the Supervisor.

Aluminum shall be treated to comply with BS 1615 and BS 3987.

All aluminum sections shall present clear straight and sharply defined lines and shall be free from defects and imperfections that may impair their strength.

All screws, bolts and other necessary accessories shall be of aluminum or other non-corrodible metal, and shall match in color and consistency the finish of the aluminum.

Aluminum elastic glazing beads shall be provided to all windows and doors which are assembled by pressure to fit with the relevant groove in the profile.

The glazing bars shall be threaded or interlaced at point of intersections and machine tenoned to frame.

The Contractor shall submit to the Supervisor a signed statement from the manufacturer that all aluminum work furnished is of approved alloys, and that the entire aluminum content is of virgin aluminum.

8.3 ERECTION

All metal work shall be accurately set and properly secured in place. Where bolted connections are used, the bolted parts shall be drawn closely together and the nuts shall be drawn up tightly.
All anchors and anchor bolts shall be properly located. Except in the case of expansion bolts, indicated on the drawings to be inserted into drilled holes, all anchors and anchor bolts shall be built into the connecting work when the work is built.

8.4 ALUMINIUM DOORS AND WINDOWS

The Contractor shall furnish and install all aluminum units which shall be obtained from an equal aluminum supplier.

Work shall include all parts and accessories for all variations of fabricated technique required for a complete installation, caulking, priming and back coating and detailed shop drawings.

Shop drawings for aluminum windows, doors, frames, etc., showing the profiles, dimensions, sizes, thickness, materials, finish, joining, attachments, fasteners and the relation of this section to adjoining work, shall be submitted to the Supervisor for approval before ordering such items. All work shall be fabricated and erected in accordance with the approved drawings.

All aluminum windows, doors, frames, etc., shall be factory assembled and reinforced according to the approved drawings, complete with hinges, glazing gaskets and anchor. The only site work allowed on aluminum units is fixing in position and glazing. The finished surfaces shall present a clear surface free from alloy, defects, scratches, streaks, or other surface blemishes.

All items shall be installed plumb, straight, square, level and proper elevation, plane, location and alignment with other work. All work shall be designed for adjustment to field variations, fitted with proper joints and intersections, adequately, anchored in place. All workmanship and finishes shall be first class in every particular, strictly in accordance with best practice. All work shall be complete in every detail.

Aluminum work shall be designed and anchored so that the work will not be distorted nor the fasteners overstressed from the expansion and contraction of the metal.

Before shipment from the factory, aluminum surface requiring protection shall be given a coating which will protect the metal during construction.

Aluminum surfaces which after erection would otherwise be in contact with concrete blockwork or with mortar, shall be protected from contact therewith by a heavy coat of bituminous paint. Areas where the paint has been damaged by abrasion or other cause, shall be cleaned and repainted as directed, so that the aluminum will have a complete protective paint film when brought into contact with the material against which it is being protected. Before application of coating, the surface shall be cleaned of all dirt, heavy deposits of grease or oil, and other foreign substances, and shall be immersed in, or swabbed with, an approved solvent. Next, the surfaces shall be rinsed with clear water and thoroughly dried.

Upon completion, the Contractor shall clean all aluminum work as required by removing protective tape or other coating, using mid soap or detergents, and clear petroleum spirits.

Acids caustics and abrasive shall not be used. Where cleaners are used to remove excess sealing compounds care shall be exercised to prevent damage to seals or staining or damage to adjacent work.

Finished work shall be approved by the Supervisor before the job will be accepted. The Contractor shall be responsible for the protection of all aluminum work until the completion of the works, and only units imperfect working order and in perfect condition shall be accepted.
The Contractor shall provide and fix the aluminum alloy hardware in accordance with BS 1331, to be supplied by the manufacturer of the aluminum elements complete with all necessary finger plates, door stops, cabin hooks, screws, rawl plugs and other fittings.

The hinges on which doors and windows are hung shall be carefully housed or let in the door, etc., and the frames. Each door-leaf shall have three hinges minimum.

Prior to installation of ironmongery items, all mobile parts and mechanisms shall be carefully lubricated in accordance with the manufacturer's recommendations. Screws, nuts and rivets shall be carefully adjusted so that they are present flush on the finished surface. Marred or scratched screw heads, face, etc, shall be replaced at the Contractor's expense.

The strength of the fastenings shall be as required for their intended use.

All doors shall be provided with an approved rubber door stop plugged and screwed to the floor.

The Contractor shall be up the locks for a system of master keying in accordance with a schedule to be furnished by the Supervisor. Two change keys shall be furnished for each lock and a total of six master keys shall be furnished.

8.5  METAL FRAMES FOR DOORS

Metal door frames shall be purpose made and as manufactured and supplied by an approved supplier and shall be made to the profiles and sizes shown on the approved drawings. The door frames shall be from 1.5 mm thick laminated steel sections, and be delivered to site complete with a factory applied anti-corrosive plastic coating, ties cast on the backs of frames, and rubber silencers on the locking site. The door frames shall be fixes all in accordance with the manufacturer's printed instructions.

The frames shall be stored in a clean, dry place, off the ground and protected from the weather.

The frames shall be free of all dents, bumps, splits, and cracks and any defective frame shall be made good or replaced at the Contractor's own expense.

8.6  PROTECTION OF METALWORK

Pieces and parts made of abrasive metal, stainless steel, aluminum, or which have been galvanized, shall not be painted in the shop. Materials to be welded in the field shall not be painted within 7cm of the joints to be welded. Before exposure to the weather or shipment from fabrication shop, all other metal work shall be cleaned and painted as specified below, and in accordance with the instructions of the manufacturer of the coating to be used.

Articles of carbon steel and other ferrous materials shall be cleaned by appropriate methods (including power wire brushing, flame cleaning, and brush-off blast cleaning) to remove all loosely attached mill scale and all rust, dirt, grease and other foreign matter.

Unless otherwise specified or indicated all ferrous metalwork to be painted shall be given one shop coat of an approved rust inhibitive primer.

Items of ironwork and steel work shall be zinc coated by the hot dip process in conformity with ASTM standard specification for zinc (hot galvanized) coating o products fabricated from rolled, pressed, and shapes, plates, bars, and strips, or ASTM standard specification for zinc coating (Hot dip) on iron and steel hardware, as appropriate.

Where aluminum surfaces come in contact with metals other than stainless steel, zinc, white bronze or small areas of others metals, compatible with aluminum, they shall be kept from
direct such parts by painting the dissimilar metal with a prime coat of zinc-chromate primer or other suitable power, followed by one or two coats of aluminum metal ad masonry paint or other suitable protective coating, excluding those containing lead pigments, or a non-absorptive tape, or gasket, shall be placed between aluminum and dissimilar metals. Steel anchors and connecting members shall be hot dip galvanized or zinc plated after fabrication.

8.7 LOUVERS

The louvers shall be extruded aluminum louvers of the shape shown on the approved drawings, the frames and blades of the louvers shall be fabricated from aluminum alloy having a minimum thickness of 2mm and shall be provided with reinforcing bosses. The head, sill, and jamb members shall be fabricated from identical structural members and be provided with integral caulking slot retaining bead. All fasteners shall be stainless steel or aluminum.

8.8 ROLLING METAL GRILLES

The rolling metal grilles shall be jam-mounted made of aluminum of the sizes indicated on the approved drawings.

The grille curtain shall be formed of interlocking flat-faced rib-reinforced slats made from sheet aluminum, not less than 1 mm thick, or from extruded aluminum, not less than 1.5 mm thick, and perforated with apertures not exceeding 13cm wide x 4.6cm deep, each alternate shall be furnished with endlocks, incorporating locking lugs, which shall keep the curtain in alignment and hold the curtain in the guides.

The guides shall be furnished with a locking bar to work in conjunction with the locking lug on the endlock

The bottom rail of the curtain shall consist of two aluminum angles with a compressible rubber astragal applied to the bottom; the curtain guides shall be formed of not less than 5 mm thick aluminum angles of sufficient depth to retain the curtain under heavy wind pressure.

The curtain hood shall be formed from sheet aluminum, not less 1 mm thick, neatly fitted to the brackets and reinforced with stiffener flanges at the top and bottom edges.

The curtain shall be coiled on a pipe of a size sufficient to carry the door load with a deflection not to exceed 2.5 mm per meter of opening width, and shall be evenly balanced by helical springs contained in the pipe. All springs shall be anchored to the same tension rod and held in position by the same adjusting wheel which shall be easily accessible.

The brackets shall be steel plates attached to the curtain guides.

Rolling metal grille shall be operated through reduction gear by hand chain.

8.9 NON-SLIP NOSING TO STAIR TREADS

Non-slip nosing to stair treads shall be abrasive cast aluminum nosing securely fastened with stainless steel or aluminum flat heat bolts and anchors set into fresh concrete. The nosing shall be the width of the stair tread and fitted with non-slip carborandum inserts.

8.10 ALUMINIUM TUBE RAILINGS

Aluminum tube railings shall be all welded railings fabricated. The railings shall be fabricated in panels as large as practicable with joints between panels made in a neat an inconspicuous manner. All exposed welds shall be ground smooth.
The prior stanchions shall be secured to the stair stringers and to the concrete platforms. All connections of the stanchions shall be as indicated or approved.

8.11 LADDERS

The aluminum ladders shall be fabricated from aluminum flat bars and rump. The rungs shall be mortised and welded to the uprights, and the uprights shall be secured to the wall with bent plates welded to the uprights, and expansion bolts bolted to the walls. All welds shall be ground smooth. Ladders shall be secured to the concrete slabs and intermediate tread plate platforms with floor flanges.

Intermediate ladder platforms shall be 6mm thick aluminum tread plate having an approved non-slip surface. The plates shall be secured to structural aluminum bracket supports and reinforced with stiffener angles as required.

All ladders rising more than 4.50 m from lower platform or ground level to the top rung shall have safety cages, which shall be constructed of three flat verticals supported by flat hoops with a diameter of 750 mm. The hoops shall be approximately 700 mm centres and the first hoop shall be 2.4 m above ground or platform level.

8.12 FLOORS HATCHES GRATINGS AND FRAMES

The floor hatches gratings and frames shall be flush floor hatches and gratings as manufactured by Kassarjian or approved equal products. The hatches shall be single and double leaf, and of the sizes and types indicated on the approved drawings, the hatches and gratings shall be factory assembled and shipped complete with frame for installation on the job.

The hatches and gratings shall be furnished with hinges, hold open safety lock, bars and flush lift handles.

The floor hatches and frame shall be fabricated from cast iron or structural steel with 6mm frames and 6mm diamond reinforced to be capable of withstanding a live load of 1500 kg per sq.m.

All floor hatches shall be set flush with finished floor level.

Hatches shown on the drawings as sealed, should be effectively airtight to the satisfaction of the Supervisor.

8.13 EDGE ANGLES

Structural steel angles shall be installed at the edges needing protection or as required by the Supervisor. The angles shall have bent strap anchors welded on at 60cm centers for securing the concrete. The angles shall be 10cm by 10cm by 1 cm thick as indicated.

The angles shall be hot dip galvanized after fabrication.

8.14 MOTOR AND GATE STAND BASE PLATS AND PIPE THRUST ANCHORS

The base plates for motors and gate stand shall be fabricated from steel plate of the thickness indicated on the approved shop drawings, with structural steel angles frames. The frames shall be constructed of angles and plates of the sizes indicated, with welded, bent strap anchors, and welded and mitered corners, with exposed welds ground smooth. The frames shall be set flush with the concrete surfaces. The plates shall be bolted to the frames with stainless steel
bolts, of the diameters, indicated, set into the concrete. All base plates and frames shall be hot dip galvanized after fabrication.

8.15 GRAB BARS
Aluminum grab shall be provided at walls above the ladders. The grab bars shall be fabricated aluminum bar stock of the diameters shown on the approved drawings and built into masonry walls.

8.16 SUNDRIES
All necessary bolts, anchor bolts, nuts, washers, plates and bolt sleeves shall be furnished by the Contractor in accordance herewith. Anchor bolts shall have suitable washers and, where so required, their nuts shall be hexagonal.

All anchor bolts, nuts, washers, plates, and bolt sleeves shall be galvanized unless otherwise indicated or specified.

Expansion bolts shall be malleable iron and lead composition elements of the required number of units and size.

Unless otherwise specified, stud, tap, and machine bolts shall be of the best quality refined bar iron. Hexagonal nuts of the same quality metal as the bolts shall be used.

All threads shall be clean cut and shall conform to AN Standard B1.1-1960 for Unified Screw Threads.

Bolts, anchor bolts, nuts and washers, specified to be galvanized, shall be zinc coated, after being threaded by the hot dip process in conformity with the ASTM Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars, and Strip, Designation A123 - latest edition, or the ASTM Standard Specifications for Zinc Coating (Hot-Dip) on Iron Steel Hardware, Designation A 153 - latest edition, as is appropriate.

Bolts, anchor, nuts and washers specified to be stainless steel shall be type 316 stainless steel.

If anchor bolts are set before the concrete has been placed, they shall be carefully held in suitable templates of approved design. Where specified or required, anchor bolts shall be provided with square plates at least 10cm by 10cm by 1cm or shall have heads and washers, and be in the concrete forms with suitable pipe sleeves, or both. If anchor or expansion bolts are set after the concrete has been placed, all necessary drilling and grouting or caulking shall be done by the Contractor and care shall be taken not to damage the structural or finish by cracking, chipping, spelling, or otherwise, during the drilling and caulking.

8.17 GLAZING
Glazing shall be done in accordance with instructions given in section 7 of these specifications.
9 FLOOR WALL AND CEILING FINISHING

9.1 SCOPE OF WORK

This section of the specifications covers plaster work and other floor, wall and ceiling finishes intended to be used for the Project in accordance with the Schedule of Finishes, and as directed by the Supervisor.

The Contractor shall perform all attendance upon other, and protect all works specified under this section from damage during subsequent operations, make good any defects, clear away debris upon completion, clean throughout, and leave all work in perfect condition to the satisfaction of the Supervisor.

The Contractor shall be responsible for the design and stability of the scaffolding and for all safety precautions in connection with works under this section.

All material and/or manufactured item that are liable to damage shall be delivered in the original package, containers, etc., bearing the name of the manufacturer and the brand.

Materials and/or manufactured items shall not be carefully loaded, transported, unloaded, stored in an approval manner, protected from damage and exposure to weather or dampness during transit, and after delivery to the site.

Damaged materials and/or manufactured items shall not be used in the works specified under this section. Any materials and/or manufactured items damaged during and after bedding or setting in position shall be removed and replaced at the Contractor's expense.

9.2 PLASTER WORKS

9.2.1 PLASTERING MATERIALS

The cement and water used for plastering shall be as described in Concrete work, section 3, and the sand shall be a before described in blockwork, section 6.

Lime for use in internal plaster shall be of the hydrate type complying with Class B of BS 890.

Waterproof additive for use in rendering plaster to internal surfaces of water tanks shall be "Sika" 1 as manufactured by R.W.I. products Co. Ltd, or approval equal. It shall be delivered in containers bearing the name of the manufacturer and the instruction for its application.

Color pigments shall be obtained from an approved manufacture and shall be lime proof non fading complying with BS 1014.

9.2.2 THICKNESS OF PLASTER AND RENDERING

The proportions and minimum thickness of finished plasterwork and rendering shall be in accordance with the following:

<table>
<thead>
<tr>
<th>Plaster or rendering</th>
<th>Mix</th>
<th>Minimum thickness</th>
</tr>
</thead>
</table>
| Lime, sand and cement gauged plaster for use internally but not to surfaces in contact with sewage | 1 part time 2 ½ parts cement, 16 parts sands | - Two coats total
|                                                               |                                 | - 15mm finished to walls                |
|                                                               |                                 | - 12 mm finished to ceiling             |
Cement and sand plaster for use externally and to surfaces in contact with ground and/or sewage

| 1 part cement, 4 ½ parts sand | - Same as above |

Waterproof plaster to be applied to surfaces of structures in contact with water shall be 1 ½ parts of sulphate resisting cement to 4 ½ parts sand, and with a waterproof additive as specified added in accordance with printed instructions of the manufacturer. Waterproof rendering shall be cured for a minimum of 7 days.

With regards to lime mortars gauged with cement, the addition, just before use of the cement, to small quantities of the lime/sand mix shall take place in a mechanical mixer and mixing shall continue for such time as will ensure uniform distribution of materials and uniform color and consistency. It is important to note that the quantity of water used shall be carefully controlled.

Except where hand mixing of small batches is approved by the Supervisor, mechanical mixers of an approved type shall be used for mixing of plaster.

Hand mixing plaster, and rendering, shall be first mixed in the dry state being turned over at least three times. The required amount of water should then be added and mix again turned over three times, or until such time as the mass is uniform in color and homogeneous.

Mechanical mixers, mixing boxes and tools shall be cleaned after mixing each batch and kept free of plaster from previous mixes. Plaster shall be thoroughly mixed with the proper amount of water until uniform in distribution of materials color and consistency. The plaster shall be completely used within thirty minutes of mixing and hardened plaster shall not be remixed but removed from the site.

9.2.3 PREPARATION OF SURFACES FOR PLASTER, ETC.

All surfaces to be plastered shall be clean and free from dust, grease, loose or projecting mortar all traces, of salts are to be thoroughly spayed with water, but all free water shall be allowed to dry and disappear from the surface before the plaster is applied.

Irregularities in the surfaces to be plastered or rendered shall be fitted with mortar without lime, twenty five hours before plastering is commenced. Joints in blockwork are to be well raked out before plastering to form a good key. Smooth concrete surfaces to be plastered shall be either treated with an approved proprietary bonding agent or grouted with a spatter-dash of cement and sand which contain 500 kg of cement per one cubic of sand and must be allowed to dry before rendering is commenced.

Plastering shall not be applied until all mechanical and electrical services, conduits, pipes and fixtures have been installed. It shall be noted that no plaster containing lime shall be applied directly galvanized pipes, or other steel conduits.

Before plastering is commenced all junctions between differing materials shall be reinforced, this shall apply where walls join columns and beams, particularly where flush, and similar situation where cracks are likely to develop and as directed by the Supervisor. The reinforcement shall consist of strips of galvanized wire mech (10 to 15mm hexagonal mesh) 15 cm wide which shall be plugged, mailed or stapled as required at intervals of not exceeding 45 cm at both edges.
9.2.4 APPLICATION OF PLASTER

After preparation of the surfaces the undercoat shall be applied to the required thickness between screeds laid, ruled and plumbed as necessary. When set, the surface of the undercoat shall be scratched, allowed to set hard and shall be kept moist with a fog spray for 2 days and then allowed to dry out. Where sprayed finish is to be applied, the scratching shall be omitted. The finishing coat shall be applied to the required thickness by means of a laying-on trowel and finished to give the required surfaces.

The finishing coat shall not be applied until the undercoat has seasoned for 7 days. Just before the application of the finishing coat, the undercoat shall be wetted evenly with a fog spray. Where cement plaster with a smooth trowelled finish is specified, the finish coat shall be first floated to a true even surface, then trowelled in a manner that will force the sand particles down into the plaster and with the final trowling, leave the surface finishes smooth free from rough areas, trowel marks, checks or other blemishes.

Cement plaster in all other spaces, where a smooth finish is not specified, shall be given a sand float finish of a uniform texture, as approved by the Supervisor.

Spayed finish shall be applied with an approved machine to give a finish of even texture and thickness. The sprayed finish coat shall be applied in four separate applications allowing time for drying between each application. Application in one continuous operation to build-up a thick application shall be not less than 3mm, the spayed finish shall not be applied until all repairs and making good to the undercoat are completed. Curing shall take place after the application of the fourth coat.

All plastering shall be executed in a neat workman like manner. All faces shall be true and flat and angles shall straight and level or plumb. Plastering shall be neatly made good up to wood or metal frames and skirtings around pipes or fittings, angles shall be rounded to 5mm radius.

Surfaces of undercoats shall be well scratched to provide a key for finishing coats.

Screed marks or making good on undercoats shall not show through the finishing coats. Surfaces to be trowelled smooth shall be finished with steel or celluloid trowel to a smooth flat surface free from trowel marks. Surfaces to be floated shall be finished with a wood or felt float to a flat surface free from trowel marks.

All tools, implements, vessels and surfaces shall at all times be kept scrupulously clean and strict precautions shall be taken to prevent the plaster or other materials from being contaminated by pieces of partially set materials which would tend to retard or accelerate the setting time.

9.2.5 PLASTER EXPANSION JOINT STRIPS

Plaster expansion joint strips, where shown on the approved drawings, shall be of a minimum channels maximum size 2 cm x 2cm x 1mm thick, and shall be perforated at sides to form a suitable bond to plaster.

Plaster expansion joint strips shall be securely and correctly affixed and plaster joints truly plumb and straight to line.

9.2.6 TROWELLED SCREED FLOOR FINISH

The screed bed floor finish shall be cement and sand (1:4) mix, 10 cm and 5 cm thick bedded to the correct level and steel trowelled to a smooth surface finish.
A 1 cm joint shall be felt at perimeter of each room's floor screed to the full depth of the screed and shall be filled with celotex board or equivalent and sealed with polysulphide sealant.

The floor screeds are to be hardened and dustproofed with a proprietary compound of magnesium fluosiclicate applied in strict accordance with the manufacture's printed instructions.

9.3 TILE SLAB AND BLOCK FINISHINGS

9.3.1 MATERIALS GENERALLY

The cement sand and water for backings, screeds, etc, is to be specified for "Institute Finishings".

Color pigments shall be as specified for "Insitu in approved gauge boxes on a clear, dry level surface. Materials shall be mixed by either hand or machine.

9.3.2 WALL TILING

The tiles for wall tiling shall be first quality wall tiles, 15 cm x 15 cm x 6 mm thick, conforming to BS 1281. The external angles, side and top edges of the tiling shall be formed with rounded edge tiles. At intersections returned rounded edge tiles shall be used.

Screed for wall tiling shall be cement and sand (1:4) and the materials, method of mixing, preparing and applying the screed shall be similar to those described for plaster.

The surface of the screed shall be scratched in an approved manner when nearly set to form a key. The surface of the screed shall be well wetted before the tiling is applied.

All tiles shall be immersed, prior to placing, in clean demineralized water for six hours or until saturated and all surplus water shall be drained off before bedding. Tiles shall be bedded in cement and sand (1:4) to a true vertical face with continuous tight horizontal and vertical joints which shall be straight, level, perpendicular and of even width not exceeding 1.5mm. The vertical joints shall be maintained plumb for entire height and shall be maintained in a plane by uniformly applied pressure under a straightedge or rubber faced block.

Misfits as well as damaged or defective tiles shall be removed and replaced by the Contractor at his own expense.

Joints shall be pointed with neat white cement and any surplus which adheres to the face to the tile shall be wiped off with a damp cloth before it sets hard.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes, etc, it shall be carefully cut and fitted to form a close, neat joint.

Precast terrazon tiles shall be obtained from an approved manufacture. Tiles shall be formed with a 1:2 ½ mix of white or colored cement, or white cement with a color pigment added and marble chippings applied as a facing (wearing layer) not less than 7mm to a cement and washed sand (1:5) mix backing.

Tiles shall be 20 x 20 x 2 cm thick, and shall be cast in heavy metal moulds and hydraulically pressed during manufacture to give a non-absorbent surface. The color of the cement and the color and the grading of the aggregates shall be selected by the Supervisor.

Precast units and tiles shall be cured by totally immersing them after the initial set has taken place in a tank of clean potable water for at least 24 hours or others approved means and then ground, filled and polished on exposed surfaces before distribution to site.
The first grinding shall be done in the factory by means of a No 80 carborundum stone. Fixing shall be carried out with a neat cement grout of the same color as the facing mix and this shall be worked into the surface with a wooden scrapper to fill all voids and air holes. Surplus grout shall be removed with a dry cloth. After a minimum period of 24 hours polishing shall be carried out by means of a No 140 carborundum stone.

Terrazzo skirting shall be 10cm high a square top edge and terrazzo treads and rises shall be produced in the same way as for tiles using the same mixes.

All tiling shall be laid with square joints and grouted up on completion, care being taken to fill all joints completely.

Grout shall consist of neat cement of a color to match the tiling. Any surplus grout shall be cleaned off the face of the tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned off.

All terrazzo surfaces shall be polished on completion. Large areas such as floors shall be wet polished by means of approved machines using a No 140 carborundum stone. Any surface too small for convenient machine polishing may be polished by hand using a No 140 carborundum stone and water. Care must be taken during any polishing operating not to damage any angles or rises.

All tiles shall be well shaped with straight edges perfectly flat and free from defects which affect appearance or serviceability.

Tiles shall be cut with a suitable cutting tool and rough edges shall be rubbed smooth. Cut –the misfits shall be replaced with properly cut-tile. Straight edges shall be accurately intervals to keep the joints parallel over the entire areas. Tiles shall be laid to the straight edges.

Wall tile operations in spaces requiring floor tiles shall not be started until after the floor tiles installation has been completed. Surfaces to receive tile shall be clean and free of dirt, oil grease or other objectionable matter.
9.3.3 CERAMIC FLOOR TILES

Vitrified ceramic floor tiles shall be non-slip ceramic tiles of the quality and obtained from an approved manufacturer.

The floor tiles are to be size 10 cm x 10 cm x 8 mm thick. The Contractor shall submit a sample of the Supervisor for approval. The color and pattern of the ceramic tiles shall be selected by the Supervisor.

Ceramic floor tiles shall be thoroughly soaked in water for a minimum of twenty-four hours before laying.

Ceramic floor tiles shall be laid on top of cement and sand screeded bed (1:4) mix and bedded and pointed in cement and sand (1:4) the overall thickness of the floor finish shall be 10cm. all tiles shall be laid square neat joints.

All tiling shall be pointed on completion, care being taken to fill all joints completely. The pointing shall consist of cement mortar (1:4) and be of a color to match the tiling. All surplus mortar shall be cleaned off of the tiling and surrounding surface immediately, and all tiling shall be carefully cleaned off.

9.3.4 PRECAST CONCRETE PAVING

The precast concrete paving tiles shall as described in concrete works, section 3, but with maximum 10mm coarse aggregate mixed with a sufficient quantity of water to give a suitable plasticity for casting, and reinforced with 6mm diameter mild steel bars placed at 15cm centers each way at mid depth.

The tiles are to be size 40 x 40 x 5 cm thick and cast in accurate moulds. The concrete is to be well tamped into position to form a homogeneous, dense mass. Trowelling shall be kept to a minimum necessary to obtain maximum compaction of concrete. The top face of the tile shall be treated with silicate and soda until the concrete will absorb no more of the solution.

The precast concrete paving tiles shall be bedded in a (1:4) cement and sand mortar 2 cm thick to give the required slope. Joints shall be jointed and pointed in cement mortar with a smooth recessed joint.

9.3.5 JUNCTION STRIPS

Junction strips at the abutment of differing floor finished shall be formed by the stem of an inverted aluminum. "T" section 30 x 30 mm fully set in the floor screed to correct level and position as to form a perfect straight line edging. Aluminum section shall be protected by giving it one coat of zinc chromate primer. Strips shall extend to the entire length of the surface where such separation is required.

9.4 PROTECTION AND CLEANING

All wall, floor ceiling finishes shall be protected from damage until the completion of the works. Should any damage be caused it shall be made good to the satisfaction of the Supervisor at the Contractor's expense.

Clean all floors, skitings and unpainted wall finishing and leave perfect on completion.
10 PAINTING AND DECORATING

10.1 SCOPE OF WORK

The painting materials shall be obtained from an approved manufacturer and shall be supplied ready mixed in the manufacturers sealed and branded containers.

Each container shall bear the maker’s band, and name identification of contents and directions for its proper use. All materials must be thoroughly stirred before use.

All sealers, primers, undercoats and thinners shall be products recommended by the manufacturer’s of paint used for the finishing coat.

Materials shall conform to the applicable ASTM or BS standards.

Colours shall be selected by the Supervisor.

10.2 MATERIALS

10.2.1 EMULSION PAINT

Emulsion paint shall be of the polyvinyl acetate (PVA) type such as Super Tinol emulsion or an approved equal. It shall be washable and of a satin finish.

10.2.2 ALKYD ENAMEL PAINT – INTERIOR

High gloss alkyd resin enamel paints for decorative use over well primed interior surfaces of wood and metal, such as Tinolux Gloss Enamel or approved equivalent shall be used internally whenever a high enamel gloss finish is required. Priming for wood and metal surfaces shall be in accordance with manufacturer’s recommendation.

10.2.3 ALKYD ENAMEL PAINT – INTERIOR, EXTERIOR

Semi gloss alkyd resin enamel paints for general interior and exterior decorative application, such as Tinilux Semi-Gloss Enamel or approved equivalent shall be used on plaster, wood, or metal surfaces wherever a high enamel gloss finish is required. Priming for different surfaces shall be in accordance with manufacturer’s recommendation.

10.2.4 COAL TAR-EPOXY PAINT

Coal tar-epoxy paint shall contain not less than twenty five (25%) percent of epoxy and have an exceptional resistance to water, grease and sewage as well as to most acid and alkali solutions. It shall be applied to prepared surfaces without any primers and shall seal surfaces with a tough, abrasion resistant film of a minimum thickness of 0.4 mm.

10.2.5 EPOXY PAINT

Epoxy paint shall have a high degree of resistance to acids, alkalis and water. It shall be easily applied over surfaces that have been primed with a primer containing an inhibitive pigment and shall present a glossy finish. One (1) coat of primer and two (2) finishing coats shall be applied with a minimum thickness of 0.0075 mm per coat.
10.2.6 COLD GALVANIZING PAINT
Cold galvanizing paint shall be a zinc rich paint containing not less than ninety six (96%) percent of zinc dust in the dried film which shall give galvanic protection to the underlying metallic surface.

10.2.7 ALKYD BASE ALUMINUM PAINT
This paint shall be applied to exposed metallic surfaces and shall be resistant to exposure to sun rays and weather conditions. Thickness of the dried coating shall not be less than 0.15 mm.

10.2.8 SILICON CLEAR PROTECTIVE COATING
Silicon clear protective coating on exposed fair face concrete surfaces shall be a colorless silicon proprietary solution to Dow Corning’s DRI-SIL 48, DRI_SIL 29 or FEB’S FEBSILICON or approved equal product, conforming to the test method BS: 3826 : 1969 (Class A for clay and brickwork and Class B for natural and cast stone masonry).

10.3 WORKMANSHIP

10.3.1 GENERAL
All work shall be performed in accordance with the manufacturer’s instructions.

Before application of any paint or finish all surfaces shall be cleaned, dried and prepared as specified hereinafter.

The Contractor shall coordinate work to insure that factory primed items are primed or painted as required in these specifications.

All metal fittings such as ironmongery and fastening, etc, not required to be painted shall first be fitted and then removed before the preparatory process is commenced. When all painting is completed the fittings shall be cleaned and refixed in position.

Before painting, floors must be washed and every possible precaution shall be taken to keep down dust before and during the painting processes. No paint shall be applied to surfaces if superficially damp, and all surfaces must be ascertained to be free from condensation, efflorescence, etc, before the application of each coat.

No exterior or exposed painting shall be carried out under adverse weather conditions such as rain, extreme humidity, dust storms, high temperature of surfaces, etc.

Emulsion paint shall be applied in three coats. The first coat may be mixed with equal parts of water but the two further coats shall be applied undiluted.

Oil paint shall be applied in three coats in accordance with manufacturer’s printed instructions.

All new woodwork to be properly primed before being fixed in position. All woodwork not previously painted, or from which defective paint has been remove, to be given a coat of approval priming, well brushed in.

All iron and steelwork to be primed with selected primer or paint conforming to BS 2521 / 4:1966.
Primed or undercoat woodwork and metalwork, should not be left in an exposed or unsuitable situation for an undue period before completing the painting process.

All coat of paint must be thoroughly dry before subsequent coats are applied, and rubbed down fine waterproof abrasive where necessary.

All coating shall be well applied, leaving no sags, laps, brush or other defects. Each coat must thoroughly dry before next coat is applied. All work must be carefully cut into a true line and left smooth and clean.

Thickness of coating where specified, shall mean the dry film thickness. Where the number of coats is specified, it shall mean the minimum number of coats to be used, however, additional coats shall be required if necessary to obtain the film thickness specified in the manufacturer’s literature, which shall be considered as part of these specifications.

Details of mixing and application shall be in accordance with the specifications of the manufacturer concerned and the approval of the Supervisor. The mixing of paints, etc, of different brands before or during application will not be permitted. No dilution of painting materials shall be allowed except strictly as detailed by the manufacturers and as approved by the Supervisor.

On surfaces which are not accessible to paint shall be applied by spraying or with sheep skin daubers. All surfaces to be painted shall be thoroughly covered with paint.

Brushes, pails, kettles and all other tools and equipment use in carrying out the work shall be maintained in good working order, and shall be claim and free from foreign matter. They shall be thoroughly cleaned before being used for different types or classes of materials.

The Contractor will be required to repaint, at his own expense, any work on which the paint is found to be incorrectly applied. The Contractor shall be responsible for protecting from damage the paint work and all other work during and after operations including the provision of all necessary dust sheets, covers, etc.

All loose and defective paint to be removed from previously painted surfaces before repainting. All burning off must be done by skilled workmen. The below lamp must not be used on surfaces adjoining glass.

Paint removers must be of approved quality, from soda and other caustic substances, and must be used in accordance with the makers instructions. Alkaline paint removers must not be used, except under exceptional circumstances, and with the approval of the Supervisor.

10.3.2 SURFACES PREPARATIONS OF STEEL WORK

Heavy deposits of grease or oil shall be removed from the surface with oil cleaner prior to any other surface preparation. Any chemical contamination shall be neutralized and/or flushed off prior to any other surfaces preparation.

All welds, edges and sharp comers shall be ground to a smooth, rounded contour and all weld splatter removed.

All surfaces to be coated that are normally immersed in water or sewerage shall be sandblasted to “white metal” and removing all mill scale rust, dirty paint or other foreign matter. The surface shall be of a uniform gray color, and shall be slightly roughened to form a suitable anchor pattern for the coating application. Do not leave blasted surfaces overnight before coating. Remove all sand from the surface by brush or industrial vacuum.
All surfaces not normally immersed, shall be cleaned by a “near-white” blast in accordance with the steel structures painting, and all steel surfaces in new construction exposed to alternative wet any dry environments may be blast cleaned.

All dry-service steel may be brush-off blasted and shall be given a phosphate wash treatment prior to the application of the printer.

10.3.3 SURFACE PREPARATION OF GALVANIZED STEEL

Galvanized steel which have been welded during manufacture shall be cleaned at the weld joint as described above and painted with zinc rich (or cold galvanizing) paint as specified herein above.

The galvanized surfaces shall be roughened by washing with a mild acid solution such as acetic or phosphoric acid and a special primer shall be applied to give the necessary bond with the overcoats.

10.3.4 SURFACES PREPARATION OF CONCRETE WORK

All concrete surfaces to be coated shall be clean dry and free from previously applied coatings or chalky material. Any chemical contamination shall be neutralized and/or flushed off.

No coating shall be applied to surfaces which contain air or water pits, splatter, protrusions, or other surface irregularities. Such areas shall be made good preferably while the concrete is still “green”.

Surfaces shall be free of curing compounds, loose surface materials, and other foreign matter before application of coating.

The surface shall be thoroughly dried application of the coating.

10.3.5 SURFACES PREPARATIONS OF PLASTER

Requirements for the preparation of concrete surfaces shall be enforced where applicable.

Plaster surfaces which are to be painted shall be washed down prior to painting a toxic wash applied brush or spray. A second wash shall be applied two days after the first wash; the surfaces shall then be rubbed down smooth and all defective plaster shall be cut and made good with plaster of same type as previously used. Slight cracks to be cut out with the edges undercut, and filled with approved cement flush with surrounding surface.

All internal plastered surfaces to be emulsion painted shall receive two complete coats of filler recommended by the manufacturer.

10.3.6 PAINTING OF WOODWORK

Woodwork shall be washed down prior to painting with a toxic wash applied by brush or spray. A second wash shall be applied two days after the first wash, the wood work surfaces shall be cut out and properly plugged and filled. All nail holes, cracks or other defects shall be filled and leveled up with hard stopping. The woodwork shall then receive one priming coat.

The exposed work shall then be lightly sand papered, dust removed and two undercoats and one finished coat applied, each coat smoothed down before the next is put on.

Part of timber to be enclosed in walls or embedded in concrete shall be treated by impregnation with creosote or other preservative.
10.3.7 HOT DIP GALVANIZED COATINGS
Hot dip galvanized coatings for iron and steel articles shall meet the requirements of BS 729 and shall be carried out at the manufacturer works. Minimum average coating weight shall be 610 g/sq.m.

10.3.8 FAIR FACE CONCRETE PROTECTIVE COATING
All exposed fair face concrete surfaces to be treated with silicon solution. As specified, it shall be dry and free from loosely adhering matter, fungus growth, etc. The latter should be removed and treated before application of the silicon.

Application shall be by brush or low pressure spay in two coats in accordance with the manufacturer’s instructions, the surface being well covered with each coat too insure that three are no “misses”.

10.4 SHOP PAINTING
All steel members which are not to be further welded in the field shall be given their priming coats and part of the overcoats at the shop. The final coats shall be given after erection.

Steel members which are to be welded on site shall be given a priming coat in the shop. After field welding, the weld joints shall be sand blasted, given a prime coat and furnished with the necessary overcoats on site.

All hidden surfaces shall be painted prior to being closed in.

Erection marks for field identification of members and weight marks shall be painted on surface areas which have been previously painted in the shop.

Materials shall not be loaded for shipment until it is completely dry and in no case earlier than twenty four hours after the paint has been applied.

All areas of paint work, which become damaged during handling storage, loading and off loading, transportation, assembly and erection or have deteriorated in any way whatsoever shall be freed of all loose paint and rust and must be cleaned down to the bare metal and touched up with paint of the same type as the shop coat even to the extent of applying an entire coat if necessary. Such touch up works shall be in addition to, and not considered to the first fields coat.

10.5 FIELD PAINTING
When the installation work is complete including welding, steel work shall be generally prepared and cleaned and receive one priming coat followed by two undercoats and one finishing coat, each being applied when the previous one is perfectly dry.

A field touch-up coat shall be applied to all shop painting members.

If concreting or other operations have damaged the paint, the surface shall be repainted.

The final coat shall be applied when all construction work testing and acceptance have been made.

If any paint work is in the opinion of the Supervisor defective or unsatisfactory the paint shall be removed and the surface thoroughly cleaned and repainted to the satisfaction of the Supervisor entirely at the Contractor’s expense.
10.6 CLEANING AND PROTECTION

During the progress of coating surfaces, all other work shall be covered and fully protected and care shall be exercised not to be splatter paint, enamel, etc., on adjacent work should any paint be applied on a surface where it is not called for, the defaced surface shall be thoroughly cleaned and the original finish restored. Name and data plates on equipment shall not be painted and shall be left clean and legible upon completion.

Before being erected or set, those parts of steelwork and metalwork which are to be embedded in concrete or other masonry shall be given one field coat of the same type of paint as the shop coat. This provision shall not apply to concrete reinforcement, steel conduits and accessories.

Steelwork and metalwork, either exposed to view or embedded in masonry, and for which no other painting is specified, shall be given two field coats of the same type of paint as the original coat.

Aluminium surfaces which after erection would otherwise be in contact with concrete, brick, or other masonry, shall be protected as specified under metalwork.
11 ROOFING AND WATERPROOFING

11.1 ROOFING

11.2 SCOPE OF WORK
The Contractor shall supply and lay where required the roof waterproofing including: foam concrete screed, bitumen felt coverings and skirtings including flashings, as described in the specifications.

The Contractor shall submit to the Supervisor for approval, the method of execution, details, and shop drawings, corresponding to the works to be executed.

11.3 MATERIALS

11.3.1 BITUMEN
Bitumen shall be non susceptible to temperature and with good adhesive properties.
The primer shall be “cut back” bitumen solution of suitable viscosity.
The bonding compound shall be oxidized or “blown” bitumen melted and applied hot.
The dressing compound for chipping shall be oxidized or “blown” bitumen solution.

11.3.2 FELT
Felt used in built up felt roofing with chipping finish shall comply with BS 747, Part 2. The bottom layer shall be type 2C self-finished bitumen asbestos felt weighing not less than 13kg per 10 meters square. The top layer shall be type 3B fine sand surfaced bitumen fiber glass felt weighing not less than 18kg per meters square.

11.3.3 ROOFING VENTILATOR
Roofing ventilator shall be of the tube end cap design manufactured on 16 gauge aluminium, the tube shall have a 10cm. Base and tapering up to 5cm, at throat which is covered by a mushroom cap. Design shall be of type manufactured by Briggs Amasco Ltd., approved equivalent.
11.3.4 FOAM CONCRETE SCREED

Foam concrete screed shall be “Alveolite” or other approved light weight concrete having a density after setting and in dry condition of 500 kg/m³ cast in place for obtaining the required falls.

Foam concrete screed when set shall also have a strength and thermal conductivity as follows:

- Strength not less than 12 kg/sq.cm.
- Thermal conductivity not greater than 0.11 kcal/sq/hrl/°C at 40°C.

11.3.5 METAL CAPPING AND FLASHING

Metal capping and flashing shall be of aluminium sheet of minimum 0.4 mm, thick as per B.S 1470.

11.3.6 LIMESTONE CHIPPINGS

Chippings shall be of an approved hard type of white limestone and shall be well-graded as required.

11.3.7 ROOF INSULATION

Roof insulation shall be 50 mm thick extruded "Roofmate" or similar approved polystyrene foam board with rebated edges.

11.3.8 REGLET

Reglet shall be of a performed plastic dovetail section.

11.3.9 EXPANSION JOINT SEALANT

Expansion joint sealant shall be an oil based mastic such as “Secomastic” as manufactured by “Expandite Ltd”. Or approved equal.

Sealant shall be supplied together with suitable primer and backing material recommended by the manufacturer.

The Contractor shall supply from the manufacturer complete written instructions for application of products.

11.3.10 EXPANSION JOINT FILLER

Expansion joint filler shall be non-bituminous filler such as Celotex board or equivalent; quality and manufacturer to be approved by the Supervisor.

11.4 METHODS OF CONSTRUCTION

11.4.1 GENERAL

Only specialists in roofing work shall be employed in the execution of the work. Special care shall be exercised to ensure complete protection to all members being protected.

Heaters and pots especially designed for work shall be used to avoid overheating and damage to the materials. The materials shall be heated to the temperatures recommended by the
supplier and shall be carefully controlled by means of special thermometers which shall be available on the site at all times.

All paddles, brushes and other tools used in the work shall at all times be kept in clean condition and cleaned after every use.

The surfaces against which roofing layers are to be laid, shall be thoroughly cleaned from any dust or loose materials, all projections shall be removed and all holes and cracks shall be patched. The surface shall be clean, smooth and dry before the application of waterproofing material commences.

11.4.2 BUILT UP FELT ROOFING

i) Foam concrete screed

The roof slab shall be thoroughly cleaned and smoothed. The light weight concrete shall be mixed in a special high mixer and in accordance with the manufacturer’s directions.

Foam concrete screed of 50 mm. minimum thickness shall be cast in place in alternate bands not exceeding 1.50 meter in width and the whole surface shall be given the necessary slope.

The surface of the foam concrete shall be thoroughly cleaned from any dust or loose material. All projections shall be removed and all holes and cracks shall be patched.

ii) Waterproofing course

Waterproofing membrane shall consist of two (2) layers of roofing felt.

The first layer of felt shall be applied from rolls over a layer of bonding compound on to the screed or concrete surface ahead of the felt which shall be unrolled from the rolls and pressed into the asphalt immediately, this is applied to ensure complete adhesion and avoidance of air bubbles and empty spaces.

All internal and external corners shall be further reinforced after each layer of left with additional coats of asphalt and 200mm wide of felt extending equally along the two adjoining planes.

Allow for neat cutting and additional reinforcing of waterproof membrane at all pipe outlets, vents etc.

The felt shall be laid with 15 cm side and end overlaps which shall be staggered.

The second layer of felt shall be laid at right angles to the direction of application of the first layer and shall be fully bonded to its underlayer with bonding compound. The bonding compound shall be laid either by pouring and rolling or mopping to an even thickness of not less than 1.5 mm thick. Upon completion of laying of the top layer of roofing felt it shall further be surfaced with dressing compound evenly applied by brush and finished by spreading one layer of hard crushed limestone chippings.

At junction of the roof surface with any parapet or vertical surface, the roofing, material shall be bent and extended with the same thickness to form a base continuous with the
roof coverings and tucked into grooves, or reglets, formed in parapets or vertical surfaces.

Grooves or regrets shall be clean and filled with the specified joint sealant as directed by the Supervisor.

At expansion joints, special concrete and elements shall be provided as directed by the Supervisor.

Felt shall be dressed and bonded into rainwater outlets, under flashings and the like.

All adjoining work shall be protected from damage due to laying and all strains shall be removed and made good.

iii) Roofing ventilators

The underside of the roof waterproofing membrane shall be maintained at normal pressure by the provision of vents as specified. Each vent shall serve an area not exceeding twenty (20) sq.m and shall be installed as such to eliminate passage of water to underlaying layers.

11.4.3 EXPANSION JOINTS

Expansion joints shall be filled with a non-bituminous filler and sealed with joint sealant as per instructions of manufacturer and as directed by the Supervisor.

11.4.4 LAYING OF ROOF INSULATION

If required, insulation boards shall be laid loose with staggered joints and shall be cut as necessary to fit tightly around protruding elements and against parapets.

11.4.5 LAYING OF ANTI-PUNCHING GEOTEXTILE

An anti-punching geotextile of 350 grams per square meter, non-woven polypropylene, shall be installed above the waterproofing system.

11.4.6 LIMESTONE CHIPPINGS

A layer of limestone chippings with a depth of 7 cm shall be executed.

11.5 PROTECTION

All roofing materials and finishes shall be protected from damage until completion of the works. Should any damage be caused due to any reason whatsoever, it shall be repaired and made good in accordance with the instructions of the manufacturer and to the entire satisfaction of the Supervisor at the Contractor’s expense.

11.6 WATERPROOFING

11.7 SCOPE OF WORK

The Contractor shall provide all labor, materials, scaffolding, tools and implements required for preparation of surfaces, laying of waterproofing membranes, application or coating, making good any defects and cleaning of any paint splashes to other works.
All material shall be obtained from manufacturers approved by the Supervisor and shall be supplied to site in the manufacturer's sealed and branded containers. Samples of materials proposed by the Contractor and all relevant information from the manufacturers shall be submitted to the Supervisor who shall have the right to request tests to be conducted on site or in the Industrial Institute Laboratory or other approved laboratory prior to approving such materials for use on the works. The said information shall include technical data, tests carried out in laboratories and sewage plants attesting the successful application of such materials in similar installations and under similar conditions. Materials shall conform to the applicable requirements of ASTM or BS standards.

The mixing of materials of different brands before or during application shall not be permitted. Brushes, pails, kettles and other implements or other foreign matter. They shall also be cleaned thoroughly before being used for different types or classes, of material or colors.

The undercoats and finish coat shall have different color shades so as to distinguish between the first, second and final coat.

All paints and paint materials such as thinners shall be purchased form the same manufacturer to ensure their compatibility. The Contractor shall strictly adhere to the manufacturer's instructions regarding storage, mixing, pot life after mixing, safety precautions, and any other details.

11.8 MATERIALS AND METHODS OF CONSTRUCTION

11.8.1 PROTECTION OF EXTERNAL CONCRETE SURFACES IN CONTACT WITH SOIL

a) Materials

i. General: provide waterproofing materials that are suitable for high temperature use.

ii. Torch applied water proofing membrane: a polymer modified bitumen, membrane, minimum 4 mm thick with a carrier of 180 gm/m² non woven polyester, surfaced on both sides with polyethylene film for torch application.

iii. Primer: Compatible with self-adhesive membrane and as recommended by manufacturer.

iv. Protection: The water proofing membrane shall be protected from damage with a skin wall of concrete blocks 100 mm thick.

b) Installation

i. General: install waterproofing membrane on prepared, even, smooth and dry substrates. Ensure that substrates are thoroughly cleaned from any dust or loose material. Remove all projections, sharp edges and patch all holes, local depressions and sudden changes, and ensure that construction operations do not puncture the membrane. Extend coverage to extremities of areas to receive membrane. Seal joints in membrane and seal to other surfaces at extremities of coverage by lapping and bonding.
ii. Laps and corners: provide not less than 150 mm side and end laps. At internal and external corners, provide additional membrane strips and carry out cutting and fitting of the membrane as recommended by the manufacturer to achieve suitable and watertight construction.

iii. Fillet: where indicated and at internal angles formed by horizontal projections, such as footings or blinding layer, provide plain concrete fillets against concrete surfaces trowelled smooth to provide adequate backing for the membrane.

iv. Primer: carry out application of primer evenly on prepared substrates in accordance with manufacturer's recommendations.

v. Application of membranes

1. Install waterproofing membrane strictly in accordance with manufacturer's instructions. Ensure that air is excluded from under the membrane and all joints adequately overlapped providing a continuous adhesion and watertight construction.


3. Concrete surfaces below grade: install membrane waterproofing on concrete surfaces below grade, well dressed and tucked in performed regrets and properly sealed.

v. Application of protection sheet: Provide the required protection for the waterproofing membrane and comply with the membrane manufacturers instructions.

11.8.2 PROTECTION OF CONCRETE SURFACES IMMERSED IN SEWAGE OR SUBJECTED TO CORROSION BY SPLASHING AND/OR CONDENSATION

The coating system required for protection of the surfaces of concrete immersed in sewage or subjected to corrosion by splashing and/or condensation (as listed below) shall be an approved anti-corrosive epoxy resin coating. The coating shall be formed by a two or more part coal tar epoxy resin paint. The coal tar constituent shall be supplied separate from the epoxy resin component.

The binder shall contain no more than 50% of good quality coal tar or coal tar pitch. The curing agent shall be a polyamide. The mineral extender shall be of an approved non acid soluble type together with thixotroping agents as necessary to give body to the coating and enable thick films to be applied without sags or runs.

The dry film thickness shall not be less than 0.7 mm. Adhesion to concrete surface after curing shall not be less than 10 N/sq. mm.

The primer shall have a viscosity of not more than 20 seconds as measured by B4 Ford cup and shall be capable of penetrating the pores of the concrete give an adhesion of not less than
10 N/sq mm. It shall consist of coal tar epoxy resin diluted with solvent unless the moisture content of the surface as measured by wetcheck meter is more than 5% when a water dispersed primer shall be used. The dried film thickness of the primer shall be not more than 0.02 mm. The Contractor may propose, or the Supervisor’s consideration, alternative protective coating system for the above mentioned concrete surfaces. No work may commence on any protection nor order placed for materials relating to such alternative coating system until the Supervisor’s approval has been obtained in all respects.

The coating system specified above shall apply to all surfaces of pumping stations wet wells, grit chambers and influent chambers and screw pumps compartments and inflow and outflow compartments of all lift stations.

Protections of concrete surfaces in contact with sewage or H2S gas shall be PVC liner as specified in section 4.6 of these specifications.

Alternatively and where directed by the Supervisor, built up fiber glass epoxy impregnated layers shall be used.

11.8.3 PROTECTION OF STEEL SURFACES IMMERSED IN SEWAGE OR SUBJECTED TO CORROSION BY SPLASHING AND/OR CONDENSATION

See article 3.8.1, section 3.

11.8.4 PROTECTION OF STEEL SURFACES IN HIGH HUMIDITY CONDITIONS NOT IMMERSED IN SEWAGE AND NOT SUBJECTED TO SPLASHING OR CONDENSATION

a) The coating system required for protecting the surfaces or steel located indoors in high humidity conditions, but not immersed in sewage and not subjected to splashing condensation (as listed below) shall comprise two coats of zinc chromate primer and two coats of alkyl base undercoats and finishing coats. Such undercoats and finishing coats shall be resistant to industrial gases, hydrogen sulphide fumes and high humidity.

b) The coatings system required for protection of steel surfaces located outdoors shall comprise two coats of zinc chromate primer and two coats of aluminium pigmented alkyd base undercoats and finishing coats. Such undercoats and finishing coats shall be resistant to industrial gases, hydrogen sulphide fumes, high humidity and exposure to tropical sun, and sea water.

The total dry thickness shall not be less than 0.13 mm.

The coating system specified above shall apply to surfaces of steel used inside all pumping stations, dry wells, and superstructure.

11.8.5 PROTECTION OF COLD GALVANIZING STEEL SURFACES

See corresponding section

11.8.6 PROTECTION OF GENERAL INTERIOR AND EXTERIOR DECORATIVE APPLICATIONS

a) Metal
Interior or exterior surfaces of metal shall be well primed and painted with one undercoat and two coats of high gloss alkyd resin enamel paint. Priming for metal surfaces shall be in accordance with clause 13.8. hereof.

b) Plaster and concrete

Plastered and/or fair faced concrete surfaces shall be well primed or sealed and painted with two or more coats of water base latex emulsion paint and pigmented to the required colors.

11.9 WORKMANSHIP

11.9.1 APPLICATION GENERALLY

No exterior or exposed painting shall be carried out under adverse weather conditions such as rain, extreme humidity, dust, storms, direct sun etc.

Painting work shall preferably be shaded from direct sunlight to avoid blistering and wrinkling. Wherever possible, painting of exterior surfaces shall follow the sun such that it is carried out in the shadow. No work shall be done when the ambient temperature is below 5°C or relative humidity above 80%.

Every possible precaution shall be taken by the Contractor to keep down dust during the painting process or preparation therefore, including as necessary the cleaning of each room or area before hand and the dampening of floors.

Prepared, primed or undercoat work shall not be left exposed or in an unsuitable condition for an undue period before completion of the painting process.

Metal or other fittings such as ironmongery, etc, not required to be painted or to be embedded in concrete, shall first be fitted and then removed before the preparatory processes are commenced. When all painting has been completed the fittings shall be cleaned and refixed in position.

No paint shall be applied to works which are internally or superficially damp.

All surfaces shall be freed of loose matter, dust, etc., before the application of each coat.

Paints shall be stirred in their original container until smooth before use, unless, of the particular type that do not require stirring.

Thinning or dilution of paints shall be in strict accordance with the recommendations of the manufacturer in each case.

Paint removes shall be of approved quality, free from soda and other caustic substances, and shall be used in accordance with the manufacturer's instructions. Alkaline paint removes shall not be used, except under exceptional circumstances, and with the approval of the Supervisor's Representative.

All materials shall be applied by skilled painters only. The workmanship shall be executed in accordance with the best acceptable practices applying to the class of work and grade, type and kind of material specified. The Contractor shall take all precaution to avoid hazardous application and storage of paint materials.
11.9.2 SURFACES PREPARATION

a) General

Prior to starting of any work, the Contractor shall carefully inspect all surfaces to be painted, and take action to correct any defective workmanship, materials or any other condition which will affect the satisfactory execution and/or permanency of the work.

If rust appears in prepared steel surfaces, before painting is done such surfaces shall be recleaned by the Contractor at his own expense. The first coat of paint shall be applied on absolutely clean rust free surfaces.

b) Steel surfaces in locations of extreme exposure (clause 13.6.3)

The steel surfaces shall be sand blasted to near white (i.e. 95% of each element of area is in white metal condition). All oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint or other foreign matter shall be completely removed from the surface.

c) Steel surfaces in locations other than extreme exposure

This shall be as specified for extreme exposure except that two third of each element or area, shall be in the white metal instead of 95%.

d) Non ferrous metals

Where galvanized steel is required to be painted, it shall be cleaned thoroughly by swabbing with thinners or solvents and any rust, wire brushed and scrapped. Two or more coats of calcium plumbate primer shall then be brushed on.

Where aluminium is required to be painted it shall be thoroughly cleaned by swabbing with neutral detergent or solvents, roughened by use of abrasive paper or powder and further cleaned by washing. Two coats of zinc chromate primer shall then be brushed on (red or white lead primers will not be permitted).

e) Protected concrete surfaces

No work on the coating of concrete surfaces shall commence until the Supervisor has approved the materials and methods proposed by the Contractor.

Immediately before priming, all concrete surfaces to be coated shall be cleaned free of dust, and loose material by vigorous brushing and vacuum cleaning and shall be acid etched in an approved manner. Any foreign matter, oil or grease, etc. shall be thoroughly washed off with clean water only, and allowed to dry, or cut out with the underlying contaminated concrete repaired with epoxy resin mortar as required by the Supervisor before being brushed down and cleaned as above. Any particular specification for surfaces preparation by the coating manufacturer shall be followed, but the degree of preparation shall not be less than what is specified above.

Damaged areas of coating shall be rubbed down and wiped with solvent before repairing.
11.9.3 SHOP PAINTING

All steel members which are not to be further welded in the field shall be given their priming coats and part of the cover coats at the shop; the final coats shall be made after erection.

Steel members which will be welded in the field shall be given a priming coat in the shop. After field welding, the weld joints shall be smoothened by chipping hammer and thoroughly sand blasted and then given a prime coat a thickness not less than 50 gm (care being take to cover uneven surfaces completely) and finished with the necessary overcoats.

All hidden or inaccessible surfaces shall be painted prior to welding, bolting or riveting.

Erection marks for field identification of members and weight marks shall be painted on surfaces previously painted in the shop. Material shall not be hours after the paint has been applied.

11.9.4 FIELD PAINTING

When the installation work is complete including any welding and straightening of bent metal, all adhering rust, scale, dirt, grease or other foreign material shall be removed before painting is done as described earlier.

A field touch-up coat shall be applied to all shop painted members.

If concreting or other operations have caused any damage to the paint, the surface shall be repainted.

The final coat shall be applied when construction work, testing, etc, have been made and performed.

11.9.5 REMOVAL OF PAINT

If any paint is considered unsatisfactory by the Supervisor, the paint shall be removed, thoroughly cleaned, and repainted.

11.10 CLEANING AND PROTECTION

During the progress of coating surfaces, all other work shall be covered and fully protected, and care shall be exercised not to splatter paint, enamel, etc, on adjacent work. Should any paint be applied on a surface where it is not called for, the defaced surface shall be thoroughly cleaned and the original finish restored. Name and data plates on equipment shall not be painted and shall be left legible upon completion.

Parts of steelwork and metalwork which are to be embedded in concrete or other masonry shall be given one field coat of the same type of paint as the shop coat, before being erected or set. This provision shall not apply to concrete reinforcement.

Steelwork and metalwork, either exposed to view or embedded in masonry, and for which no other painting is specified, shall be given two field coats of the same type of paint as the shop coat.

Aluminium surfaces in contract with concrete, brick or other masonry, shall be protected as specified under Metalwork before erection.

The Contractor shall properly protect all painted work and shall provide adequate facilities for the storage of painted prior to erection.
12 PAVING AND LANDSCAPE WORK

12.1 SCOPE OF WORK

The Contractor shall furnish all plant, labor, equipment, appliances, materials and tools and perform all operations necessary for the construction or repair of roads, parking and other paved areas including all necessary earthwork, filling, base course, asphaltic concrete pavement, and kerbstones, all in accordance with the specifications.

Excavation, filling, grading and preparation of sub-grade shall be in accordance with the specifications and the Contract documents.

12.2 AGGREGATE SUB-BASE AND BASE COURSES

The aggregate sub-base and base courses shall be constructed on the approved road subgrade after constructing all utility lines and compacting their trenches, and shall have a compacted thickness of fifteen (15) cm. The sub-base and base course material shall conform to ASTM D 1241, latest edition, in all respect, and shall consist of clean and durable particles free from foreign and deleterious matter.

The aggregate sub-base and base courses shall be conform to standards of the Ministry of Public Works; crushed or uncrushed gravel or crushed stone; structurally and chemically stable; free of shale, clay, friable material, debris, impurities, organic matter, or dust; graded in accordance with ASTM C136; within the following limits:

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<tr>
<th>Sieve Size</th>
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<td>50 mm</td>
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<td>425 micro m</td>
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<td>75 micro m</td>
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Sub-base and base materials shall have a 4-day soaked CBR of not less than 30% and 70% respectively when compacted at 100% modified Proctor (AASHTO T180-D) and tested in accordance with AASHTO T193.

a) Laying and compacting of base course

The sub-base course and base course material shall be spread on the approved road bed in an even layer such that a compacted thickness of fifteen (15) cm is achieved. It shall then be pulverized, watered to the optimum moisture content, scarified, shaped and rolled to a density not less than ninety five percent (95%) of the Optimum Proctor Modified (OPM) maximum dry density as determined by ASTM 1557, latest edition, method D for the whole thickness of the layer.

b) Testing
The density and thickness of the base course layer shall be ascertained by obtaining a specimen from the layer after compaction, at the rate of at least one specimen per four hundred (400) square meter of the roads or paved areas, as directed by the Supervisor, using Standard Test ASTM D 1556 – latest edition.

The evenness of surface shall be checked by the Supervisor using a 4 meter straight edge, and the maximum gap between the surface and testing edge shall not be greater than one (1) cm.

12.3 ASPHALTIC CONCRETE PAVEMENT

Asphaltic concrete pavement shall consist of an asphaltic concrete binder course 6 cm thick after compaction, and an asphaltic concrete wearing course 4 cm thick after compaction all constructed on the completed and approved soil aggregate base course.

A prime coat shall be sprayed on the soil aggregate base, before the binder course is laid, and a tack coat shall be sprayed on the binder course before the wearing course is laid.

The asphaltic courses shall be composed of mineral aggregates and asphalt cement thoroughly mixed in an approved plant until all aggregate particles are coated completely with asphalt.

a) Materials

i. Aggregates for asphalt concrete

All mineral aggregates shall be of such nature that a thorough coating of the bituminous material to be used in the work when applied to the aggregate, will not slough off under contact with water.

Coarse aggregates: coarse aggregates, retained on No 10 sieve, shall be crushed stone consisting of clean, sound, durable fragments free from an excess of flat, elongated, soft or disintegrated pieces, and free from materials coated with dirt, clay or other objectionable material. The maximum size shall not be more than 8 cm and the amount of large size stones shall not be more than 10%.

Fine aggregate: Fine aggregate shall consist of material sand or aggregate prepared by crushing gravel or stones, or a combination thereof all of which shall pass No 10 sieve, and shall be such gradation that, when combined with the coarse aggregate, the prescribe asphaltic concrete can be produced.

Mineral filler: Mineral filler shall be obtained by crushing hard lime stones or other stones and conforming to ASTM D242, latest edition. It shall be free from clay or any injurious material. It shall consist of not less than 65% by weight passing No. 200 sieve, and not less than 90% passing No. 100 sieve. Mineral dust shall consist of all the mineral matter passing No. 200 sieve.

ii. Asphalt cement
The asphalt cement for use in the asphalt mixes shall be 85-100 penetration grade resulting from the refining of petroleum and meeting the requirements of ASTM D 946, latest edition.

iii. Liquid Asphalts

The liquid asphalt for use in prime and tack coats, shall be of the medium curing type of MC-70. It shall be the rapid-curing type of RC-250 both meeting the requirements of ASTM D2027, latest edition and D2028, latest edition respectively, or approval equal.

iv. Prime coat

The liquid asphalt MC-70 shall be heated to working temperature and applied at the rate of 0.70 to 1.20 kg/sq.m evenly distributed over the approved base course surface after its thorough cleaning, all as directed by the Supervisor. It shall be allowed to set and cure for at least twenty four (24) hours and shall be well protected from traffic.

v. Track coat

The liquid asphalt RC-250 shall be heated to working temperature and applied at the rate of 0.60 to 1.25kg/sq.m to the approved asphalt binder course after its thorough cleaning, all as directed by the Supervisor. It shall be well protected and cured to a proper condition of tackiness prior to the construction of the asphalt wearing course.

b) Preparation mixing and placing of asphaltic course

i. Weather limitation

Asphaltic concrete shall be placed only when the surface to receive it is dry, when the atmospheric temperature is above 55 degree F, and when the weather is not foggy or rainy.

ii. Prime coat

Immediately prior to the spaying of the prime coat, the surface of the granular base shall be thoroughly cleaned of all soil or foreign materials. Any irregularities of the surface shall be repaired and recompacted.

The bitumen heated from 65 to 95 degree centigrade shall be sprayed to the full which of the road.

The distribution rate of the prime coat shall be from 0.70 to 1.20 kg/sq.m of hot bitumen, depending on the absorption quality of the base course.

iii. Asphaltic concrete

Preparation of mixture: The coarse and fine aggregates shall be dried and heated to a temperature not exceeding 180 degrees C; prior to their admission into the mixer.

Mixing process: The size of the batch will be determined by the Supervisor. The dried aggregates, prepared as described above, shall be combined in the proportionate amounts of each fraction of aggregate to meet the job mix formula.
The aggregates shall be mixed dry for a minimum of 15 seconds; the bitumen shall then be added in an evenly sheet over the full length of the mixer. The filler shall then be added uniformly after the introduction of the bitumen. The mixing shall be continued for a minimum of 45 seconds.

When continuous mixing is used, the dry aggregate shall be thoroughly mixed before the addition of the bitumen. The bitumen shall then be added in an evenly spread sheet over the full width of the mixer. The mixing shall be contained for a period of not less than 30 seconds.

Under no circumstances shall the total mixing time be less than 45 seconds; however, the Supervisor may extend the mixing time in order to obtain a thoroughly mixed and homogeneous product.

**Spreading and finishing:** The asphaltic concrete shall be spread after the priming coat has been fully set and cured. The temperature of the product shall be as general rule, between 135 and 150 degree C.

Immediately after any course is screeded, and before compaction is started, all droppings such as fat sandy accumulations from the screed shall be removed and replaced with satisfactory material. Irregularities in alignment and grade along the outside edge shall also be corrected by the addition or the removal of mixture before the rolling of the edge is performed. Special attention shall be given to the straightening of each edge immediately following the initial rolling.

**Rolling binder course:** Rolling of the asphaltic concrete shall start after the spreading, when the temperature of the product is low enough to ensure a good workability.

Compression shall be effected with 3 wheel rollers.

Rollers shall be kept moist to prevent adherence of the freshlaid material. Rolling shall start longitudinally at the sides and gradually progress to the center of the pavement, or at the curves from the low side to the high side. Overlapping on successive trips shall be at least one half of the width of the rollers and uniformly lapping each preceding track or covering the entire surface with the rear wheels when three wheels roller are used.

Rolling shall progress continuously until all roller marks are eliminated. The speed of the roller shall vary between 10 and 20 m per minute or as ordered by the Supervisor to avoid displacement of the hot mixture.

Joints between successive days work shall be made so as to ensure thorough and continuous bond between old and new mixture. Transverse construction joints in previously laid material shall be constructed by cutting the material back for its full depth so as to expose a fresh face. The joint shall be smeared with hot bitumen before the new mix is applied.

The thickness of this binder course, after full compaction shall be 6cm.

**Testing finished surfaces of binder course:** For the purpose of testing the finished surface, a 5m long straight edge shall be used. Any irregularities more than 3 mm shall be corrected by loosening the surface mixture and removing or adding material as may be required, compaction shall then be resumed on the corrected spots.
Tack coat: After the compaction, the Contractor shall spray on the binder course a layer of hot bitumen with a penetration that varies between 100 and 150. The tack coat shall be applied at the rate of 0.06 to 1.25 kg/sq.m depending on the time left before the wearing course is applied.

Spreading and rolling wearing course: Spreading and rolling this course shall start immediately after the tack coat is sprayed, set and cured in order to prevent this coat from being contaminated with dust or other foreign material.

The process of spreading finishing, rolling and testing of the wearing course is the same as for the binder course except for the compacted thickness which shall be 4 cm.

The asphalt road shall not be used before the temperature of the wearing course reaches the surrounding air temperature.

12.4 KERBSTONES

Concrete, formwork and reinforcing steel shall be as specified under “Concrete Works”.

Kerbstones shall be of Class A precast sections. Kerbstones shall be fair faces and finished smooth on top of one face, they shall be hard, sound, durable, shaped, clean with well defined surfaces free of cracks and flaws or other defects.

Samples of precast concrete kerbstones proposed to be used shall be submitted to the Supervisor for approval, prior to order or manufacture.

Concrete foundation for kerbstones shall be of class B plain concrete.

The precast concrete kerbstones shall be used prior to one (1) month after the date of manufacture, nor shall any kerbstone be used that have not been inspected and approved by the Supervisor.

Each kerbstone unit shall be cleaned, and the ends which are to be mortared shall be saturated with water before being set. All kerbstones shall be well bedded and settled in place true to line and level with a suitable wooden maul. The top surface shall be set to true elevation above the gutter line, before the joints are mortared.

Any kerbstones which are set in such manner that their top surfaces are not in a uniform plane or their front faces are not in correct alignment, when ordered by the Supervisor shall be removed and reset at the Contractor’s expense.

Joints of concrete kerbstones shall be not less than 5 mm nor more than 10 mm in width, and thickness shall be uniform from top to bottom. Joints shall be completely filled with cement and sand mortar (1:3) and shall be pointed before the mortar has set, if possible.

Exposed surfaces of the kerbstones shall not be smeared with mortar during pointing. If not possible to complete the pointing before the mortar has set, the joint shall be raked out to a depth of approximately 2cm. When the pointing is to be done, the joint will first be thoroughly wetted with clean water, then filled with mortar. The mortar shall be well driven into the joints and finished with an approved pointing tool. The kerbstones shall be kept wet while pointing is being done and the pointed kerbstones shall be protected from the sun, and shall be cured with clean water for at least three (3) days after completion. After the pointing has been
completed and the mortar has set, the kerbstones shall be cleaned and left in a neat and workmanlike condition to the satisfaction of the Supervisor.

12.5 PRECAST CONCRETE PAVING
For precast concrete paving refer to “Floor, wall and ceiling finishing” Section 9.

12.6 STORM WATER CHANNELS
The Contractor shall perform all excavation, filling and grading operations necessary for the construction of storm water channels.

Channels shall be built to the dimension and of the material shown on the approved drawings. The cover shall be precast concrete with asphalt pavement on top.

12.7 PARKING SHED
The specifications for similar works included in previous sections shall apply equally to items in this Clause.

Sheets shall be secured to pre-installed pipes in concrete beams through the crown of the corrugations, using 2 No. galvanized steel hook bolts, 0.37 meter long each, per sheet, with nuts and plastic washers.

12.8 BOUNDARY WALL
Boundary walls shall be constructed where as required by the Supervisor.

Fair faced precast concrete claustra blocks, formwork and reinforced steel shall be in accordance with the applicable sections of these specifications.

12.9 ENTRANCE GATES
Steel entrance gates shall be provided to the dimensions and at the locations indicated on the approved drawings or as directed by the Supervisor, they shall be made of welded steel section as specified in these specifications.

Samples of ironmongery items shall be submitted to the Supervisor for approval.
12.10 CHAIN LINK FENCING

12.10.1 GENERAL

Chain link fencing with three stands of barbed wire shall be furnished and erected.

The natural ground shall be graded and leveled along the fence’s center line and for a suitable width that will allow construction of the fence. Excavation of high level areas, filling and compaction operations shall be carried out to erection of the fence.

The Contractor shall submit manufacturer’s shop drawings showing final dimensions and details together with specifications and other information for approval.

The fence shall be set true to line, plumbed vertical to the satisfaction of the Supervisor.

12.10.2 FENCES

The fences shall be of the height shown on the approved drawings and the line posts shall be of an H-section, galvanized steel, with an arm for three stands of barbed wire. The chain link fabric shall be 2 inch mesh of No. 5 gauge, hot-dip galvanized after weaving.

Line posts shall be provided at 3 meters centers. Hollow circular steel posts shall be provided at corners with an extension arm drilled for three strands of barbed wire and braced by brace posts. The corner posts shall be supplied with two stretcher bars and all necessary hot-dipped galvanized fittings and attachments.

Continuous top hollow circular brace rails shall be supplied with an outside sleeve type coupling spaced at maximum 6 meters centers. Every fifth brace rail coupling shall be of the spring type for expansion.

Tension line wire shall be No. 7 gauge, and typing wire shall be double strands No. 13 gauge. Lines wires and barbed wires shall be hot dipped galvanized after weaving.

End fencing panels and corner shall be provided with intermediate hollow circular brace rail complete with circular and square end bands and tensioned with round truss rod complete with bar bands and truss tighter fittings.

All posts shall be set in Class A reinforced concrete bases.
13 MANHOLES AND VALVE BOXES

13.1 SCOPE OF WORK

The Contractor shall design and furnish all plant, labor equipment, appliances, materials and tools and perform all operations necessary for the construction of the manholes and valve boxes in accordance with this section of the specifications.

For manholes in connection with the drainage of buildings refer to Section 5 hereof.

13.2 MATERIALS

Plain concrete, reinforced concrete, reinforcement and concrete grading blocks shall be specified under “Concrete Works”.

Waterproofing to manholes below the normal water table level shall be as specified for base slabs and under ground walls under section 11, Roofing and Waterproofing.

Waterproofing to outside walls of manholes whose beds are above the normal water table level, shall be two coats of coal tar compound (Interol Thick L or equivalent).

Cast iron fittings and rubber rings shall be as specified under Section 4, pipes and pipelaying.

Cast iron frames and covers shall be according to BS 497 Grades A and B for Heavy Duty and Medium Duty. All cast iron items shall be factory dipped in coal tar as specified in BS 497. Frames shall be single seal, square, and covers shall be circular. Manhole covers and frames used in carriageways shall have a rubber ring installed at the inner face of the cover and frame seating to ensure non rocking under traffic. The covers shall be clearly stamped with the word “SEWER” in block letters at least 5cm in size and shall be vented. Manhole covers and frames shall be tested in accordance with BS 497.

Step iron to be installed inside manholes or chambers shall be hot-dipped galvanized cast iron, as locally manufactured, in conformity with BD 1247. The steps shall be 300 mm wide, having a non slip surface protruding a distance of 125 mm and two tails for fixing inside the concrete of 120mm.

Wrought iron chains shall be of 10 mm diameter wrought iron link with 20 x 50 mm free internal dimension. Galvanization shall be at the rate of 700 grams of zinc per square meter of surface area.

The Contractor shall submit samples of both types of cast iron frames, covers, and step irons, for approval, prior to commencing supply.

13.3 CONSTRUCTION OF MANHOLES

The cast iron frames and covers to manholes shall be brought to grade by a maximum of three courses of concrete blocks and a reinforced concrete kerb into which the cast iron frame is embedded. Class B concrete is cast around concrete blocks for rigidity purpose.

Benching to the manholes shall be Class A concrete, “U” channels shall be formed with bottom flush with inside surfaces of pipes and the sides of the channels shall extend to the full height of the largest pipe and then sloped back at a minimum fall of ten percent. The benching and channels shall be furnished with 2 cm thick rendering composed of 1:2 cement sand mortar, steel trowel finish and surface hardened with two coats of sodium silicate solution brushed on.
The finished diameter of channels shall be as the diameter or pipes entering or leaving the manhole.

Step irons and galvanized wrought iron safety chains shall be installed as directed by the Supervisor.

Internal surfaces of manholes shall be coated with an approved two coats of coal tar compound (Internol Thick L or equivalent), or lined with PVC liner as indicated by the Supervisor.

Manholes shall be completely constructed as the works progress and as each one is reached by pipework. Manhole frames and covers shall be placed immediately after the completion of manholes.

13.4 VALVE DRAIN AND VENT BOXES

The boxes shall be constructed of reinforced concrete. More than one valve may be housed in one box. The cover slab of the boxes shall be of removable precast concrete construction and the walls and base slab shall be of cast in place concrete construction. Concrete pipe and valve supports and anchor blocks shall be provided as ordered by the Supervisor.

Waterproofing to the base slab and walls of the boxes shall be applied as specified for base slabs and under ground wall under Section 11, roofing and waterproofing.

All pipe fitting shall be fitted in chamber walls with puddle in order to ensure a good and firm anchorage of valves under testing as well as working pressure conditions. The cover slabs shall have access opening provided in them, and openings shall receive heavy duty cast iron frames and covers with a minimum clear opening 60cm in diameter, as specified.

Circular openings 20cm in diameter shall be provided in the roof slabs centered above the operating nut of the valve. The opening shall be fitted with a heavy duty cast iron frame and cover. Step irons shall be provided and cast in the walls to the satisfaction of the Supervisor.

13.5 CLEANING

All manholes shall be cleaned of any accumulation of silt, mortar, debris, or any other foreign matter of any kind, and shall be free of any such accumulation at the time of final inspection.
14 GENERAL FOR MECHANICAL ELECTRICAL AND INSTRUMENTATION WORKS

14.1 GENERAL REQUIREMENTS

The Contractor shall design, manufacture, deliver to site, test and commission the plant and its associated supports and shall ensure that the completed Plant meets the performance requirements and objectives.

The plant, material and equipment shall be finished complete in all respects to provide a complete installation. Any items necessary for the completion and operation of the works as particularly specified in the scope of works shall be provided under the contract and shall be deemed to be included in the contract price. Any clause in the general specifications which relates to work or materials not required by the scope of works shall be deemed not to apply.

The Contractor shall provide competent Supervisors and installation personnel to carry out the erection of the plant, perform the test on completion, and to give instructions on the operation and maintenance of the Plant to the Contracting Authority’s staff.

14.2 LEVELS, DIMENSIONS AND EQUIPMENT DUTIES

The Contractor shall define the levels and dimensions and obtain the Supervisor’s approval before any item of plant for that installation is ordered.

The Contractor shall execute the plant to be installed. The Contractor shall collect all information, data, dimension and details form the Contracting Authority’s detailed design documents and the BoQ provided to him and use that for the supply and installation of the Plant and equipment.

The drawings provided for the new installation show detailed designs and layouts. These shall be adhered to as closely as possible. Minor variations to the arrangement of the buildings and plant may be necessary for the particular plant to be supplied and to suit the site particular requirements. After the Supervisors approval of the Contractor’s submittal sheets on the equipment the detailed design drawings have to be adjusted accordingly. The Contractor has to provide the respective drawings as CAD files in format AutoCAD *.dwg not older than version 2010 early enough for final approval by the Supervisor.
14.3 INFORMATION TO BE SUPPLIED BY THE CONTRACTOR

Within the times stated in clause 14 of the conditions of contract the Contractor shall submit to the Supervisor for his approval a detailed manufacturing and delivery programme.

In accordance with the requirements of clause 7.2 of the conditions of contract the Contractor shall submit to the Supervisor for approval detailed submittal sheets giving information for all items of plant. The Information shall include, but not by way of limitation, pipework isometric drawings, manufacturer’s drawings, specifications for the valves, motors, pumps and all other equipment layouts, cable routing, cable schedules, electrical wiring diagrams and switchboard drawings, fixing details and the like. Where appropriate, performance curves shall be submitted. Electrical single line diagrams shall include make, type and ratings of all equipment, a systematic wiring identification system and a clear legend. The information submitted for approval shall be sufficient to enable the Supervisor to check that the materials of construction and performance of the plant are in accordance with the specifications and suitable for the purpose intended. In the case of installations for rehabilitation the information shall clearly indicate those items of the existing plant which are to be retained. The Contractor shall furnish information and additional calculations if requested by the Supervisor. The Contractor shall allow three weeks for the Supervisor to check the details, from the receipt by the Supervisor of complete information. No plant shall be manufactured or ordered from suppliers for a particular installation until the Supervisor has given approval of the information.

At least 6 weeks prior to delivery of the plant to site, the Contractor shall submit to the Supervisor for approval workshop designs and a program for the erection and commissioning of the plant.

All drawings and documents shall be submitted for approval in three copies. Drawings and documents which have been approved by the Supervisor shall not be departed from without the approval of the Supervisor.

14.4 INSPECTION AND TESTING DURING MANUFACTURE

The plant shall be subject to inspection, examination, and testing during manufacture in accordance with the conditions of contract to demonstrate that it complies with the specifications and that the performance is suitable for the intended purpose.

The Supervisor shall be given three weeks notice in writing before such tests are to take place. The performance of each item of plant shall be tested in accordance with the specifications, appropriate standards and regulations, and to the requirements of the Supervisor.

Pumpsets shall be witness tested in accordance with ISO 3555. each pump shall be tested with its motor as an integral pumpset, and with similar starting equipment and electrical supply conditions to those pertaining in the permanent installation, unless otherwise directed by the Supervisor. Additional tests shall be performed on borehole pumpsets to include the incorporation of any stage spacer pieces. Pumpsets shall be tested with suction conditions and water temperatures corresponding to those under which the pumpsets will operate on site.

The works test results shall be evaluated and the guaranteed duty point verified in accordance with clause 9.4 of ISO 3555. the following tolerance values shall be used:

\[ X^{QV} = \pm 0.04 \]
\[ X^{H} = \pm 0.02 \]
The evaluated combined motor and pump efficiency shall be at least 0.975 of the guaranteed value.

All parts of a pump subject to pressure shall be submitted to a hydraulic test pressure not less than 1.5 times the maximum pressure which can occur within the system under any site operating condition.

Pipework, valves and fittings shall be submitted to a hydraulic pressure test in accordance with the applicable standards.

Valves shall be tested for operation against the maximum operational unbalanced pressure.

Electric motors shall be tested in accordance with IEC 34. In addition to routine tests, one electric motor of each type and size above 45 KW shall be subject to a full performance test, including a temperature rise test.

All rotating machinery shall be tested for vibration in accordance with the principles of ISO 2372. The maximum “rms” vibration velocity acceptable for factory testing shall not exceed the limits set out in ISO 2372 for the particular class of equipment.

Switchboards shall be tested to the respective standards. All functions shall be tested by means of wiring auxiliary switches to the outgoing terminals protective relays and instruments shall be tested with their respective instrument transformers by injection of the operating current and voltage.

Test shall include the following:

a) Visual inspection,

b) Inspection of provisions for cable entries,

c) Checking access, type of cable gland etc.,

d) High voltage pressure test (2000V) for 1 minute followed by insulation test,

e) Test relays with varied controlled supply to ensure relays close a 85% nominal voltage and hold closed down to 65 % nominal voltage,

f) Test tripping of relays occurs at 60% nominal voltage,

g) Any special tests applicable to the installation,

h) Injection testing of current transformers for correct polarity and ratio, and protection relays for correct operation,

i) Functional testing including simulation of operation of sequence controls (e.g. level controls, etc),

j) Checking of time delay settings and protection relay settings,

k) Checking of fuses for correct type and rating,

l) Any other test required by the Supervisor.

Three copies of test certificates shall be submitted by the Contractor to the Supervisor within two weeks of the date of the tests. Test on equipment, similar to the equipment being supplied, are not acceptable. Test certificates shall be supplied for tests carried out on the actual equipment being supplied.

Packing shall be subject to inspection.
Plan shall not be dispatched from the manufacturer’s works until approval has been received.

14.5 TESTS ON COMPLETION

The Contractor shall submit to the Supervisor a detailed description and schedule of the tests to be carried out on completion. These descriptions shall be submitted not less than 21 days prior to the Contractor giving notice, in compliance with sub clause 37.6 of the conditions of contract, of the date for carrying out the tests on completion.

As part of the tests on completion, each individual item of plant shall be operated to demonstrate its correct functioning, and instruments shall be checked and zeroed. Copies of all test certificates shall be submitted to the Supervisor.

Each item of Plant which is designed for continuous operation shall be operated for a period of not less than 24 hours. Items of plant not designed for continuous operation shall be demonstrated to the satisfaction of the Supervisor.

Test on completion shall include the following:

a) The plant protective devices shall be demonstrated to operate satisfactory,

b) All rotating machinery shall be tested for vibration in accordance with the principles of ISO 2372 and 3945. Vibration shall not exceed the limits set out in ISO 2372 for the particular class of equipment,

c) All plant shall be tested mechanically and electrically to shown that each item function safely as designed,

d) The sequence of operation and control systems of all plant shall be tested,

e) The rotation of all pumps shall be checked. The performance of all pumps shall be tested and compared with the specified duties and the characteristic curves prepared from the tests at the manufacturer’s works,

f) All pipework, valves and fittings shall be pressure tested,

g) Load tests shall be carried out on all lifting equipment. The lifting equipment shall be tested over the full range of travel in all directions,

h) Calibration tests shall be carried out on all instrumentation,

i) Greasing and lubricating systems shall be tested on all plant,

j) Test of all alarm systems, overloads and safety equipment,

k) Any other test requested by the Supervisor.

The Contractor shall also carry out tests of all electrical equipment. The tests shall include insulation resistance and earth continuity for all cabling, polarity of switches and resistance of main earths. Test, as applicable, shall be carried out on electrical installations and electrical panels prior to their use, such tests shall include.

a) Visual inspection,

b) Test relays with variac controlled supply to ensure relays close at 85% nominal voltage and hold closed down to 65% nominal voltage,

c) Test tripping of relays occurs at 60% nominal voltage,

d) Insulation resistance,
e) Injection testing of current transformers for correct polarity and ratio and protection relays for correct operation,

f) Functional testing including simulation of sequence and automatic controls,

g) Checking of time delay and protection relay settings,

h) Checking of fuses for correct type and rating,

i) Any other tests required by the Supervisor.

The Contracting Authority’s operational staff will normally be in attendance during the test on completion.

The Contractor shall ensure that the Contracting Authority’s staff is familiar with the operation and maintenance manuals and aware of the appropriate diagnosis and rectification action to be taken in the event of a fault.

14.6 TEST – CABLE INSULATION AND EARTHING

On completion of the separate parts of the electrical installations, the Contractor shall carry out, as and when required by the Supervisor, tests for the insulation of cables and continuity of conduits and earth connections, together with the ability to withdraw conductors from any conduit and re-draw in conductors, and shall submit signed copies of the results of the tests in triplicate to the Supervisor.

The following tests results shall be submitted:

   a) Insulation resistance tests to earth and between phases on sections of the installation as completed and also on the whole of the installation when completed,

   b) Earth continuity test on each main, sub-man circuit and sub-circuit installed,

   c) Polarity of switches and socket outlets and continuity of ring main circuits,

   d) Resistance of main earth.

In addition to these tests the Contractor shall provide readings of potential drop at various points in the installation and current balance over the phases on all mains.

The Contractor shall provide all instruments necessary for carrying out such tests and shall provide attendance on the Supervisor when tests are being carried out. The Contractor will receive notice in advance of the timing of such tests.

14.7 SPARE PARTS AND STORES

Spare parts shall be interchangeable with the corresponding parts of the plant. Spare parts shall be adequately protected and packed in suitable containers to withstand storage under site conditions and shall be handed over with six copies of a detailed itemized list of the spare parts, prior to issue of the taking over certificate. Any parts needed within the defects liability period shall be provided by the Contractor at no cost to the Contracting Authority.

Where the contract includes the provision of a spare parts store the Contractor shall instruct the Contracting Authority’s storemen in the placing of the parts and tools into store and shall familiarize the staff with the proposed inventory system. He shall also instruct the Contracting Authority’s staff in the operation of the stores including the correct identification of parts, and tools by reference to drawings and maintenance manuals, analyzing rate of parts usage and identification of ordering intervals.
14.8 TOOLS

Complete sets of maintenance tools, including spanners and special tools, necessary for the servicing, maintenance and dismantling of the plant shall be supplied by the Contractor and shall be contained in suitably fitted painted steel boxes marked with the contents and fitted with good quality locks and keys.

Tools shall be handed over to the Contracting Authority upon satisfactory passing the tests on completion. Instruments such as ammeters, voltmeters and vibration meters shall remain the property of the Contractor unless specified otherwise.

14.9 OPERATING AND MAINTENANCE

The operation and maintenance of the plant requires on the one hand the control of a number of parameters and one the other the implementation of advanced technologies involving the interference multi-disciplinary qualifications, namely electromechanical, automation, instrumentation and information technologies.

14.9.1 DEFINITION

Operation and Maintenance involve the combination of various techniques and systems that aim, through a regular follow-up of the equipment and a well-scheduled inspection program, at preventing failures, and should this occur, at providing prompt and effective repairs with minimum effect on the process. It is hence a combination of technical, administrative and management activities, and can be tailored into preventive and curative maintenance.

14.9.2 PREVENTIVE MAINTENANCE

Preventive maintenance corresponds to the variety of regular interventions allowing the preservation of all conditions that are deemed necessary for a proper functioning of all equipment as well as maintaining their level of performance over time. It aims at reducing the probabilities for failure or degradation of the treatment plant equipment.

The corresponding activities are initiated according to:

- a pre-established schedule based upon the manufacturers’ recommendations and the Contractor’s expertise in terms of plant operation (systematic maintenance)
- and/or significant pre-determined criteria related to the state of degradation of the equipment (conditional maintenance, effective when any of the monitored parameter exceeds the corresponds threshold value, and provisional maintenance, effective further to the analysis of the monitored evolution of significant parameters related to the degradation of the given equipment, hence allowing to delay and plan the foreseen interventions).

Preventive maintenance encompasses mainly the following operations:

- Greasing: oil inspection (level, quality), oil supply and disposal, grease supply and changing.
- Mechanical maintenance: inspections (fixing, clearance), filters replacement, operating temperature and pressure control, vibrations control, chains and tighteners’ tension control, security features inspection, cleaning and dust removal, requesting inspection,
tear and wear verification, small parts replacement, waterproof control, systematic manoeuvres, testing, etc.

- Electrical and instrumentation maintenance: controls (isolation, stator, brushes, protections, intensity, heating, position detection), contactors' cleaning, automation testing, cabinet dust removal, connections' verification – maintenance – control, adjusting of torque limiters, security checks, regular calibration, data reporting control.

14.9.3 CORRECTIVE OR CURATIVE MAINTENANCE

It involves the set of interventions that are indispensable to re-establish the conditions deemed necessary to ensure the proper functioning of any equipment, further to its failure or to the degradation of the results obtained therefrom. It encompasses the following operations:

- Material dismantling,
- Parts' replacement,
- Equipment renewal,
- Complete sets' replacement.

These interventions can may be planned for, on short or long term, on the basis of the inspections undertaken during preventive maintenance, the number of operating hours, or an alarming factor (abnormal sound, repeated disjunctions, insulation weakening, etc.), or may rather be imposed by an unforeseen failure.

14.9.4 SETTING UP A MAINTENANCE PROGRAM AT THE LAUNCHING OF PLANT OPERATION

The implementation of the treatment plant maintenance program starts with the adjustment of the precise lists for the equipment based on the lists provided to the final stand after completion of the installation works, the parameters to be monitored, and the regular operations to be foreseen. During site inspection, the maintenance operators identify all the plant equipment and fill in, for each of these equipment, the baseline maintenance form, while specifying the anticipated plans for preventive maintenance based upon these forms, the manufacturers' recommendations and the maintenance notices.

14.9.5 QUALITY CONTROL

Each specific activity shall be standardized according to a typical procedure to be followed (precise and coded mode of execution) to meet quality control requirements in the execution of the required tasks.

14.9.6 TASKS PLAN

a) Lubrication

The basis of preventive maintenance lies in the implementation of a control program relative to the lubrication of the concerned equipment and the setting up of adequate dates for oil and grease changing that are necessary for the proper functioning and conservation of the rotating equipment. The lubrication program encompasses, for each equipment:

- greasing points,
- required oil levels (minimum, maximum),
- date of first oil change and frequency of subsequent changes.
### Task Designation

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<th>Task designation</th>
<th>Daily</th>
<th>Hourly</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Half-yearly</th>
<th>Yearly</th>
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The above plan, while not exhaustive, shall be precisely specified upon launching of plant operation depending on the mode of operation of each equipment.

### Mechanical and Hydraulic Standard Maintenance

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The above plan, while not exhaustive, shall be precisely specified upon launching of plant operation depending on the mode of operation of each equipment.

c) Electrical and Instrumentation Maintenance

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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily</td>
</tr>
<tr>
<td>Verification of the control system alarm</td>
<td>X</td>
</tr>
<tr>
<td>Control of switches, contactors and lamps panel</td>
<td></td>
</tr>
<tr>
<td>Control of alarm systems and emergency stops</td>
<td>X</td>
</tr>
<tr>
<td>Control of cabling</td>
<td></td>
</tr>
<tr>
<td>Internal cleaning of panel boards</td>
<td></td>
</tr>
<tr>
<td>Control of electrolytes, batteries levels and charging</td>
<td></td>
</tr>
<tr>
<td>Control of insulation and waterproofing of engine connections</td>
<td>X</td>
</tr>
<tr>
<td>Control of electrical apparatus, engines, command boards and panels</td>
<td></td>
</tr>
<tr>
<td>Complete inspection of feeding station</td>
<td></td>
</tr>
<tr>
<td>Control of immersed power generators</td>
<td></td>
</tr>
<tr>
<td>Control of immersed electrical devices (level switches, detectors, etc.)</td>
<td></td>
</tr>
<tr>
<td>Control of the buildings’ electrical installation (bulbs, exterior lighting, fluorescents, electrical outlets, etc.)</td>
<td>X</td>
</tr>
<tr>
<td>Maintenance of automation and registering devices</td>
<td>X</td>
</tr>
<tr>
<td>Cleaning of panels (compressed dry air)</td>
<td></td>
</tr>
<tr>
<td>Control of the values displayed by the indicators (U, I, kVA, kWh, R, etc.)</td>
<td>X</td>
</tr>
<tr>
<td>Control of instruments functioning (values indicated: normal)</td>
<td>X</td>
</tr>
<tr>
<td>Control and cleaning of level measuring systems and transmitters</td>
<td>X</td>
</tr>
<tr>
<td>Control and cleaning of detectors</td>
<td>X</td>
</tr>
<tr>
<td>Calibration (variable frequency based upon the type of instrument and its operating conditions)</td>
<td>X</td>
</tr>
<tr>
<td>Verification of installations</td>
<td></td>
</tr>
</tbody>
</table>

The above plan, while not exhaustive, shall be precisely specified upon launching of plant operation depending on the mode of operation of each equipment.

d) Cleaning

<table>
<thead>
<tr>
<th>Task Designation</th>
<th>Minimum frequency required</th>
<th>Daily</th>
<th>Hourly</th>
<th>Monthly</th>
<th>T</th>
<th>S</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning of valves, hourmeters</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control of synoptic control apparatus</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaning of captors and panels</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External dust removal of electrical and mechanical equipment</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust removal of ventilations, conduits, etc.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust removal of electrical cabinet</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Localized cleaning following works</td>
<td>Non programmable included</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above plan, while not exhaustive, shall be precisely specified upon launching of plant operation depending on the mode of operation of each equipment.

e) General Maintenance

The corresponding tasks shall be distributed among the concerned maintenance personnel, namely with regard to the cleaning operations that call for particular attention in terms of security and electromechanical particularity.

The general installations’ maintenance encompasses the activities aiming at:
- Limiting the aging of installations due to their age, climatic conditions and other external factors independent of their operating conditions,
- Taking care of the external aspect if the installations in view of conserving the plant aesthetic value and ensuring an agreeable environment both for the workers and the visitors.

A specific maintenance program shall be put in place to define the anticipated operations pertaining to:
- the control of civil works, buildings and external infrastructures,
- the cleaning of premises,
- the maintenance of all surfaces and painted installations,
- the repair of internal lighting, door locks, plumbing, domestic electrical installations, etc.
- the maintenance of green spaces.

f) Necessary Means

The following elements are essential for the maintenance to be successfully undertaken and always ready to meet the needs:
- A workshop equipped with collective and individual tools,
- A shop containing the spare parts and consumables necessary to meet the emergency demands,
- A suppliers’ file including the names and coordinates of the suppliers of plant equipment as well as the specialists to be called upon for very specialized operations.

The shop and workshop shall be managed according to internationally recognized stock management procedures.

14.9.7 OPERATION AND MAINTENANCE MANUALS

At least two weeks before commencement of tests on completion the Contractor shall submit to the Supervisor four draft copies of the Operation and maintenance (O&M) manuals for approval, and shall take account of any amendments or additions required by the Supervisor in the production of the final manuals. A separate set of manuals shall be provided for each installation.

Two copies of the draft O & M manuals for each installation shall be available on site at all times during testing and commissioning of the plant for the instructions to be verified. Any modifications found necessary shall be incorporated in the final version.

Upon completion of commissioning of the works or section of the works the Contractor shall supply six sets of the final operating and maintenance manuals for the respective section or part of the works. Each volume shall be bound in a stout plastic or other approved cover, and shall be suitably labeled.
The manuals shall be compiled in accordance with BS 4884 part 1 and 2 sections 5, 8, 9 and 10 and shall include the following:

i) Full and detailed instructions for operating the works. Such instructions shall be specifically written for the plant provided under the contract. Manufacturer’s standard instructions relating generally to the type of plant being provided will not normally be acceptable.

ii) Full detailed instructions, diagrams, etc. for maintaining the plant, including dismantling and stripping down for repairs, and maintenance schedules for daily, weekly, monthly and annual servicing.

iii) Manufacturer’s instruction leaflets for component parts of the plant, including instruments, switchboard components, and other specialist equipment.

iv) General arrangement, schematics and P&ID’s as appropriate including all pipework, equipment etc.

v) Comprehensive parts list for all plant.

vi) Copies of all approved “as built” drawings of the works, as completed. Amended to the drawings required as a result of changes during erections shall be made by the Contractor.

vii) Records of factory and site test figures and all settings for timers relays etc.

viii) Operation and maintenance manuals shall be written in the English language. All parts and equipment listings shall be in English.

14.10 GUARDING OF MOVING MACHINERY

All moving machinery shall be adequately guarded to prevent injury through accidental contact. In particular, exposed shafting and couplings shall be protected with suitable guards, except where they are in normally inaccessible positions.

14.11 RATING PLATES, NAME PLATES AND LABELS

Each item of plant shall have permanently attached to it, in a conspicuous position, a rating plate of durable material engraved with the manufacturer’s name, type and serial number, together with relevant details such as the duty or output, speed, pressure or loading.

Each item of plant shall be provided with a name plate or label designating the service of the particular item. The inscription shall be to the approval of the Supervisor.

All switchboard cubicles shall be clearly labeled with their function and the function of each instrument, indicator or control. Each cable shall be fitted with identification labels. The type of labels and the inscription shall be to the approval of the Supervisor.

All rating plates, name plates and labels shall be in two languages, Arabic and English.

Labels shall be engraved on to durable material, metal or plastic and shall be securely fixed by screws on or alongside the item to which it applies. Sticking is not acceptable.

14.12 PACKING

The Contractor shall be responsible for the proper packing, storage and crating and clear identification of all plant prior to dispatch and shipment from its place of manufacture.
All items of plant shall be packed and marked in accordance with international standards for exports from the country of manufacture. The plant shall be packed and protected against deterioration during shipment and for at least 12 months storage on site. Straw or similar organic materials shall not be used for packing.

Materials liable to deterioration from water or moisture shall be packed in cases with waterproof lining. Switchboards, control panels and similar items of plant liable to deterioration from moisture shall be specially packed to prevent ingress of moisture. Unless otherwise agreed by the Supervisor the protection shall include packing in a sealed 0.13mm thick polythene bag and silica gel or other approved air dryer shall be placed within the unit and sufficient air drawn out to cause the polythene bag to adhere to the outline of the unit.

Electric motors (and similar equipment) shall, where applicable, be dispatched with rotors locked to prevent damage to the bearings from vibration during transit.

All packages shall be clearly and conspicuously marked with the Contractor’s identification mark and the Contracting Authority’s reference mark.

All separate component parts of the plant shall be identified by metal tags tied by wire and referenced to drawings, installation instructions, packing list etc. details of the referencing system shall be submitted to the Supervisor for approval.

### 14.13 CORROSION PROTECTION

If not stated other in the Bill of Quantities, corrosion protection is to be executed as follows:

Where dissimilar materials are in contact or close proximity and corrosion may occur through electrolytic action, or differences in electrical potential, protection shall be afforded by electroplating, suitable gaskets, cathodic protection, or other means approved by the Supervisor.

Chromium plated parts shall not be used on sewage works or in any other damp or corrosive atmosphere

After cleaning and inspection, but before the plant leaves the manufacturer’s works, the machined surfaces of steel and iron work shall be covered with a preserving fluid of an approved type, or otherwise protected, to the Supervisor’s satisfaction.

All surfaces shall be adequately protected in transit, and any damage shall be renovated immediately on off loading and on completion of erection.

All external steel screw fixings shall be supplied in the galvanized condition, stainless steel, or sheradised to comply with BS 4921, class 1 or class 2 with passivation treatment

### 14.14 ABBREVIATIONS

The following abbreviations are used in these documents:

- **CDR**: Council for Development and Reconstruction
- **EDL**: Electricité de Liban
- **ITS**: Institute of Technical Studies
- **FIDIC**: Federation International des Ingenieurs – Conseils
- **BS**: British Standard
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>Code of Practice</td>
</tr>
<tr>
<td>GRP</td>
<td>Glass reinforced plastic</td>
</tr>
<tr>
<td>AC</td>
<td>Asbestos Cement</td>
</tr>
<tr>
<td>DI</td>
<td>Ductile Iron</td>
</tr>
<tr>
<td>CH</td>
<td>Chainage</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>kPa</td>
<td>Kilo Pascal</td>
</tr>
<tr>
<td>g</td>
<td>acceleration due to gravity</td>
</tr>
<tr>
<td>gpm</td>
<td>gallons per minute</td>
</tr>
<tr>
<td>mgd</td>
<td>million gallons per day</td>
</tr>
<tr>
<td>mm</td>
<td>millimetres</td>
</tr>
<tr>
<td>m</td>
<td>metres</td>
</tr>
<tr>
<td>mhd</td>
<td>metres head</td>
</tr>
<tr>
<td>m³</td>
<td>cubic meters</td>
</tr>
<tr>
<td>m³/day</td>
<td>cubic meters per day</td>
</tr>
<tr>
<td>m/s²</td>
<td>meters per second per second</td>
</tr>
<tr>
<td>1/head/day</td>
<td>liters per head per day</td>
</tr>
<tr>
<td>kW</td>
<td>kilowatts</td>
</tr>
<tr>
<td>kVA</td>
<td>kilovolt ampere</td>
</tr>
<tr>
<td>kWh</td>
<td>kilowatt hour</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organization</td>
</tr>
<tr>
<td>CFM</td>
<td>Cubic feet per minute</td>
</tr>
<tr>
<td>AOD</td>
<td>Above ordnance datum</td>
</tr>
<tr>
<td>SWL</td>
<td>Static water level</td>
</tr>
<tr>
<td>PWL</td>
<td>Pumping water level</td>
</tr>
<tr>
<td>GL</td>
<td>Ground level</td>
</tr>
<tr>
<td>EOH</td>
<td>End of hole</td>
</tr>
<tr>
<td>DTU</td>
<td>Document Technique Unifie</td>
</tr>
<tr>
<td>NFE</td>
<td>Normes Francais (Electrical)</td>
</tr>
</tbody>
</table>
15 ELECTRICAL WORKS

15.1 FUNCTIONAL PRECEPTS

This section describes the minimal requirements for the electrical installations that should be executed by the Contractor.

The Contractor is responsible for the electrical installations related to the treatment plant from the main HV and telecommunication posts to the station, including HV/LV switchgear, transformers, motors, panels, lighting, ventilation, low current, control system, etc…

15.1.1 PLANT OPERATION

The plant will be unattended and all constituent units shall be arranged to be fully automatic and maintained ready for service at all times.

In order to simplify the operation and maintenance, all control schemes shall as far as possible, follow the same operating pattern, have similar control cubicle layouts and employ similar items to minimize spares holdings.

Electrical system design shall reflect the hydraulic system design as far as possible and shall be directed to making each major item of plant capable of running substantially independent of others. Where common equipment is employed then every effort shall be made to ensure that no single fault can affect the entire plant and particular care must be taken to protect the overall integrity of the system.

Provided that the principle of segregation is not infringed, solid state or microprocessor based equipment may be incorporated within the various control panels in lieu of electromagnetic relays, timers, etc. in order to perform the necessary control functions. In this event, full details of the proposal to achieve segregation shall be submitted for approval with the tender. All costs for programming, setting up, proving and training of Contracting Authority's staff in the operation and maintenance of such equipment shall be separately identified in the schedule of prices.

15.1.2 CONNECTION TO THE MAIN DISTRIBUTION NETWORK EDL

The Contractor shall make all the necessary arrangement towards the EDL for the connection of the treatment plant to the main distribution network. He will settle all the fees to the EDL, these fees will be paid out of the Provisional Sums contained in the Contract.

All required coordination and negotiations with the EDL shall be carried out through the Contractor. All requirements for EDL concerning the maximum voltage drop in the point of common coupling, power factor, harmonics content, earthing, standards, start-up measurements, etc. shall be fulfilled.

EDL will be responsible to bring the power feeder to the grid of the station; the Contractor will provide the EDL with all necessary cable ducts with a reservation of 25%. The complete power supply including all necessary equipments and buildings such as cable ducts, draw pits, etc. to bring power from the grid to the main HV-switchgear as well as any other costs associated with the supply etc. shall be borne by the Contractor.

Any control or operation shall be carried in conjunction between the EDL and the Contractor.
15.1.3 MEDIUM VOLTAGE SWITCHGEAR

15.1.3.1 Equipements

15.1.3.2 The definitions and general characteristics are as follows:

- Voltage: 24 kV/15 kV,
- Nominal current: Defined by the Contractor (400 A min),
- Lightning impulse withstand voltage: 125 kV,
- Over-voltage withstand 1 mn - 50 Hz: 50 kV,
- Short circuit current: Defined by the Contractor: (12.5 kA mini),
- Protection level: IP 2 x C.

Switchgears should be tested; they must be manufactured satisfying the requirements set down in the test specifications with regard to the insulating capacity, protection against contact, current-carrying capacity, switching performance and mechanical function. Evidence of this is obtained by type-testing a prototype cubicle. In addition, a routine test shall be performed on each individual completed cubicle or each transport assembly.

The necessary power for the extension of the waste water treatment plant for the horizon 2035 should be considered in the design of the equipments.

The Contractor shall design, deliver to site, install, connect, test and commission all the equipments related to the medium voltage switchgear including and without being limited to: HV protections, LV metering and general isolation, auxiliaries, earthing, connection to the control system, etc.

15.1.3.3 15.1.3.2 HV electrical room

The HV switchgear shall be installed in a specified HV electrical room.

The room will equally contain the HV/LV transformer. The room dimensions shall conform to the prescriptions of the EDL; it shall be sufficiently ventilated to insure the good functioning of all equipments.

15.1.4 HV/LV TRANSFORMER

The Contractor shall deliver to site, install, connect, test and commission a three phase transformer HV/LV sized for continuous operation at its maximum rating under the specific climatic conditions. The load factor shall cover the necessary load demanded by the extension of the waste water treatment plant for the horizon 2035, a reservation of 15% shall be respected.

The transformer shall be installed in the HV electrical room.

15.1.5 ELECTRICITY SUPPLY SECURITY

Works or pumping stations shall be provided with single or duplicate electrical supplies to a level of security determined by the Contracting Authority’s operating principles and practices, as specified herein.

Duplicate supplies shall be derived from different sections of the supply system network.
Alternative or additional security may be specified by the provision of on-site stand by generating capacity.

15.1.6 SUPPLY INTERRUPTION
To ensure that the effects of incoming electrical supply disruptions have minimal effects on pumping capacity, the main switchgear shall be fitted with overload over-current and earth fault protection. The switchgear shall not require manual resetting or closing after a supply interruption. Where Contractor controls are used for main and auxiliary transformer circuits, these shall be latched so that they are energized when the supply is restored.

Re-starting of main motor circuits under automatic control shall be staggered to reduce system disturbance (see pump duty control)

15.1.7 OPERATING VOLTAGES AND FREQUENCIES
15.1.7.1.1.1.1 Unless otherwise indicated all apparatus and wiring shall be suitable for use with a 3 phases, 4 wire, 400/230V, 50 Hz earthed neutral supply.
15.1.7.1.1.1.2 The supply wave form shall be a sine wave in accordance with the appropriate standard.
15.1.7.1.1.1.3 Control circuit supply voltage shall be not more than 110V single phase, 50 Hz via double wound transformer.

15.1.8 SIZE OF EQUIPMENT
15.1.8.1.1.1.1 The Contractor shall investigate each space in the building through which equipment must pass to reach its final location.
15.1.8.1.1.1.2 If necessary, the manufacturer shall be required to ship his material in sections sized to permit passing through such restricted areas in the building.

15.1.9 PUMP UNITS
All pump units shall have means of isolation from their associated pipework system.

In dry well installations, the suction valve will normally be left open, unless used for isolation when the pump is out of service.

The delivery side of the pump set shall include a non-return device to prevent back circulation when the set is not running. This shall be a fail safe device such that in the event of pump failure or loss of external services, the devices shall independently close. A isolation valve will normally also be installed on the pump delivery side, downstream of the non return device, for pump isolation.

15.1.10 PUMP UNIT CONTROL
The pump unit control panel shall include all control and indication elements for the pump motor, together with any associated valve actuators, lubricating systems and valves, cooling fans, flushing pumps and other ancillary control equipment required by a pump drive, all arranged to operate in a safe and proper sequence.
Where external services are required to open the delivery valve, the control system shall initiate the valve opening procedure as soon as the pump is up to a speed sufficient to overcome any existing delivery pressure.

Normal stopping sequence will therefore cause the pump to run-up to operating speed the initiate opening of delivery valve. Normal stopping sequence will first initiate delivery valve closure; after valve has closed then pump motor will be de-energized.

Failure of the valve to open within the time allowed or closure occurring whilst running, shall initiate an alarm and shut down the pump set.

15.1.11 PUMP DUTY CONTROL (3 OR MORE PUMPS)

Each of the pump units shall be capable of operating in any combination of duty sequence. The Contractor should supply a clear and reliable method of pump duty allocation and duty rotation, to evenly distribute running times for each pump unit.

Any starting sequence, including those following restoration after a supply failure, shall be time sequenced to prevent excessive load on the supply system. Each duty circuit shall include its own timer, arranged to be initiated in the selected duty sequence by the preceding duty, and the delay periods between each re-start being adjustable up to 20 seconds.

Where a microprocessor based pump control system is employed using common modules, two modules shall be provided, each capable of controlling at least 50% of the pumps available, the duty set points being interleaved between each modules to limit the effect of failure of one module.

15.1.12 LEVEL CONTROL

The water level shall be monitored by a system providing the necessary duty set points, each being adjustable over the full range of control specified.

To achieve performance stability under all environmental conditions and variations, all necessary signal compensation devices shall be included.

The monitoring system shall be damped to prevent spurious switching due to transient wave motion, but shall respond sufficiently to allow adequate time for plant reaction to stabilize in order to prevent hunting.

The system shall include a duplicate backup monitoring device or have built in self monitoring circuitry with alarm facilities.

Any high level settings which may be provided as part of a level control system may be linked with the independent high level alarm sensors specified.

15.1.13 ALARMS AND INDICATIONS

Separate indication of the following conditions shall be provided by means of annunciators grouped as indicated on the front of the panel. All indications shall have a lamp test facility.

Alarm annunciators shall be provided with accept and reset facilities together with an audible alarm and an audible/mute selector switch.

Each of the alarm conditions specified shall initiate its individual annunciator with a flashing indication which shall become steady when the “accept” button is pressed and be extinguished by the “reset” button once the alarm condition is removed.
In specified unattended locations, self reset facilities shall be provided to enable the system to restore itself to normal operation after the fault has passed.

With the audible/mute switch set to “audible” the audible alarm shall sound when the indication is flashing and be silenced when the “accept” button is pressed. In the “mute” position the audible alarm shall be muted and any alarm initiation shall give a steady lamp indication only.

To prevent false alarms occurring during mains failures or on restoration of mains supply, the common alarms specified shall be supported by a battery backed supply, either or via an inverter.

15.1.14 CONTROL SELECTOR

A three position Hand/Off/Auto selector switch shall be mounted on the front of the panel to give the following control facilities.

In the Hand position operation shall be by means of the start and stop push buttons mounted on the front of the panel with all plant protective devices retained in circuit.

In the “Auto” position the plant shall be operated automatically under the control system specified, together with the plant protective devices.

The switch shall be lockable in each position by means of barrel locking device incorporated in the handle and the switch handle, shall clearly indicate the switch setting.

15.1.15 EMERGENCY STOPS

Where means of stopping are required adjacent to a motor or the driven plant to prevent danger, emergency stop push buttons, trip switches or interlocks shall be provided, arranged to immediately isolate the supply, so long as a greater risk is not hereby introduced.

Emergency stop buttons shall have a stay-put lock off feature, with “twist to release” manually operated reset facility. Such a button shall be located on the motor starter panel. A key operated reset facility shall be provided where specified.

Where plant is normally enclosed or has fixed guards to prevent accidental contact from moving parts, stop buttons are not normally required adjacent to such parts.

Stop buttons shall be hard wired direct to all motor control circuits and not by way of any semiconductor logic control circuitry.

Means of equipment isolation for maintenance purpose shall be provided. This may be either by use of key operated emergency stop buttons, or lockable isolators, which may be at the control panel, or local to the plant.

15.1.16 MAINS STANDBY SUPPLY CHANGEOVER

If the site is supplied from two alternative mains supplies, the changeover section shall monitor the three phase voltages of each of the two incoming supplies, and automatically close the contactor to the healthy supply. The two incoming supply contactors shall be mechanically and electrically interlocked to prevent paralleling two healthy supplies.

Where a bus section switch is provided for manual switching arrangements to allow both supplies to be utilized without paralleling the contactors must be electrically interlocked between each other and the bus section switch. Voltage monitoring settings shall be adjustable.
and nominally set to operate on a rising voltage of 90% nominal, with low/high voltage settings at ±15% nominal on each of the three phases.

a) **Automatic operation**

   Mains supply: closing the incoming isolator or restoring a healthy supply will initiate the closing of the mains contactor via the monitoring relays, subject to the generator operating condition.

   Momentary supply drop-outs to 5 secs shall allow the plant to resume without further action. Breaks of supply greater than 5 secs shall initiate the generator supply. Delayed start timer setting to be adjustable 0-3 min.

   On restoration of mains supply a minimum period of 10 sec shall elapse before a signal is given to stop the generator. Delayed stop timer setting to be adjustable 0-3 min.

   Generator supply: after the generator has been initiated, the monitor relays shall control the closing of the generator supply contactor to the load. The generator shall continue to run until signaled to stop by the restored mains supply. A timer provided by others in the generator control panel shall ensure that the generator shall run for a minimum on time (adjustable 0-60 min). All timers shall be set to suit operational requirements.

b) **Manual operations**

   If the generator is to be connected to both halves of the switchboard (bus-section closed) whilst the mains supply is still available, the mains supply switch shall be opened and the generator will receive its automatic start signal due to apparent loss of mains supply. The generator will start and take on load automatically as if for a normal mains failure. The generator will continue to run until the mains switch is closed, generator shutdown will then occur as defined for automatic mode.

   If the generator is to be connected to its own half of the switchboard only, with the other half still fed a healthy mains supply, opening the bus-section switch will allow both contactors to be closed. The generator must then be manually started from the “generator run up” buttons as mains failure will not be detected. When the generator is running and ready to take load, the generator supply contactor will close automatically and the drives may be started in sequence as required. The generator will continue to run until the “generator run down” button is operated. This will immediately stop the generator and de-energize its supply contactor, allowing the mains supply contactor to be restored after the bus section switch has been closed. The generator minimum run timer being over hidden for the manual facility.

   If the generator is to be run off load only, then its incoming supply switch may be opened, alternatively the bus section may be left closed, thus preventing the generator Contractor from closing whilst the mains supply is in use. The “generator run up/run down” buttons or the “start/stop” buttons on the local generator control panel shall be used.

c) **Restoration of loads**

   After any changeover of supplies, automatic or manual, the pump motor loads may be restored automatically or manually (remotely or locally) as specified, but with sequential 20 seconds, re-start delay timers incorporated in each pump starter circuit to prevent co-incident starting surges.
15.1.17 VOLTAGE DROP

The volt within the installation shall not exceed a value suitable for the safe functioning of any fixed current using equipment.

15.1.18 EQUIPMENT AND CABLE RATINGS

All busbars, cables, switchgear, fuses, motor starters, relays, instruments, panel wiring, etc, shall be sized and rated in accordance with normal operational requirements of the associated plant and equipment, taking into account maximum load currents, volt drop, frequency of motor starting, maximum ambient temperature, etc.

The Contractor shall be responsible to ensure that all equipment is properly insulated and adequately rated to handle operational loads and, in the case of fusegear and circuit breakers, to deal with prospective fault currents.

15.2 SWITCHBOARD COMPONENTS

15.2.1 PANEL CONSTRUCTION

Panel shall be constructed of sheet steel having a minimum thickness of 2.0 mm (14 SWG) or other approved material, and similar equipment shall be of the same manufacture and units of the same type and rating are to be interchangeable. The use of toxic, hygroscopic or flammable materials shall be avoided.

LV panels shall be damp and dust protected (IP 52) for indoor situations, and hoseproof (IP 65) for outdoor or wet situations, or as otherwise specified.

HV panels shall have covers and partition affording a degree of protection IP 53 to BS5227 or equivalent for drought sections. Internal partitioning instrument and control sections, etc. shall be to IP 52.

Switchboards shall incorporate a rigid steel frame and be suitable for ready extension at each end without further cutting or drilling. Composite switchboards shall be assembled by the principal electrical manufacturer and shall be sectionalized as necessary to facilitate handling.

Switchboards shall include barriers between each of their units to ensure safe maintenance or any circuit during normal operation with the remainder of the board live. When a functional unit is isolated and open, the degree of protection to any remaining live part shall be at least IP20. Barriers or covers to live components shall have warning labels attached.

If any compartments are provided within a section of outgoing units which are not fully equipped, they shall be arranged so that they can be fully equipped without de-energising that section of the switchboard.

Cubicle type switchboards shall be totally enclosed, flush front and rear pattern, arranged in a multi-tiered formation if practicable, with at least 300mm clearance between floor level and any operational item of fuse gear or control gear. Kicking strip protection shall be provided by a 100m high plinth forming the base of the switchboard.

The overall height of control panels, including plinths, shall not exceed 2300mm. isolator handles, control switches, push buttons indicator lamps and instruments shall be centered not more than 1900mm above finished floor level.
All components mounted on the front of the panel shall be matching uniform appearance, orientation and color, with all bezels and escutcheons finished black. The layout and grouping of components shall be as approved or specified.

Within each control cubicle a reduced sized schematic diagram of the control circuit, printed on durable material shall be permanently fixed.

15.2.2 DOORS AND COVERS

Each section or compartment shall be provided with full width access doors or covers, with individual doors or covers not exceeding 750mm width.

All doors and covers shall have turned edges for rigidity and incorporate dust seals of flexible material secured in channel rebates. Covers exceeding 0.5m² in area shall be provided with a supporting lip within the lower edge or have lift off hinges. All doors shall be supported on strong hinges of non corrodible material and shall be secured by adjustable quarter turn cams, operated by small TEE handles incorporating key operated barrel locking facilities or flush locks with drive key inserts. Covers shall be secured by similar fastenings or captive bolts.

All additional fittings such as handles, hinge brackets and locks shall be a black finish, polyamide molding or epoxy coated metal.

Doors shall open at least 90° with the opening positively limited such that doors and their appurtenances are prevented from fouling adjacent panels when opened.

15.2.3 SWITCHBOARD RATING AND BUSBARS

Switchboard busbars, droppers, switchgear and its associated cable boxes shall be mechanically and electrically designed to withstand the fault level and duration specified herein and (except for LV switchboards rated less than 800A) shall be an ASTA certificated design rated at not less than 80kA RMS for 1 sec, or 50 kA for 3 sec. LV switchgear and motor control gear shall comply with BS 5486 form 4 segregation of busbars, functional units and terminal chambers, unless otherwise specified.

Busbars and droppers shall each be air insulated and formed from solid drawn, high conductivity copper bars, having a constant current rating with a uniform cross sectional area throughout their length. Each shall be clearly marked with the appropriate colors to indicate each phase, neutral and earth. Droppers shall be as short and as straight as possible. Busbar compartments shall be fully segregated and shrouded from all other sections of the switchboard.

All busbar connections shall have at least two bolt fixings, and due consideration shall be given to high stresses at bolted connections on high voltage equipment.

Where flexible busbar connections are used these shall be secured by high tensile steel bolts and nuts with anti vibration locking devices.
15.2.4 EARTHING

All metal cases of meters, relays, instruments, starters, and control switches shall be connected to the switchgear frame earth terminal by means of green and yellow PVC insulated cable, not less than 2.5 mm² cross section.

An earthing terminal or group of terminals shall be provided in the panel for termination of panel earthing connections and incoming cable earth or connection to a main earth bar.

A main earth bar of copper shall be provided to run the full length of each board so that all cable sheaths and armoring may be bonded to it. Where the fault level at the switchgear is 33 kA or less the minimum size shall be 31.5mm x 6.3 mm. For short circuit duty in excess of 33 kA the size shall not be less than 50mm x 6.3mm.

15.2.5 PANEL PREPARATION AND FINISHING

The whole preparation and paint system shall be suitable for the operating environment specified, and a painting schedule giving details of preparatory treatments, types of paint, number of coats and method of application shall be submitted with the tender. Proprietary items may be used in their standard finish subject to the approval of the Supervisor.

The system proposed shall conform to the following minimum requirements.

After all machining and forming has been completed, all steelwork surfaces protected by an approved zinc based corrosion resistant primer, followed immediately by one intermediate and two finishing coats of paint to give a minimum total dry film thickness of 50 microns (0.002").

Panels for damp situations or outdoors shall have the surfaces grit blasted and zinc sprayed within 4 hours to BS 2569 part 1 to thickness of 125 microns (0.005") at the works. The final paint finish shall be one of two pack epoxy primer and two coats of epoxy paint to give a minimum total dry film thickness of 75 microns (0.003").

Steel fixings and fastenings shall be treated to prevent corrosion by Hot dip galvanizing to BS 729 or sheradized to BS 4921 Class 1 before painting chromed fittings shall not be used.

Any damage occurring to any part of a painting scheme shall be made good to the same standard of corrosion protection and appearance as originally employed. Any finish coat applied on site shall be considered for decorative purposes only.
15.2.6 PAINT COLORS

The colors of the primer, intermediate and finishing coats of a paint system shall be easily distinguishable from each other, and the materials used shall be suitable for the application employed and preferably be supplied by one manufacturer who shall ensure that all coatings are compatible.

Electrical control panels shall be gloss finished in the following final colors:

<table>
<thead>
<tr>
<th>Details</th>
<th>Color</th>
<th>BS 4800 Ref</th>
<th>BS 381 C Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel exterior</td>
<td>As advised by the Supervisor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior equipment</td>
<td>White</td>
<td>10 B 15</td>
<td>-</td>
</tr>
<tr>
<td>Trays</td>
<td>White</td>
<td>10 B 15</td>
<td>-</td>
</tr>
<tr>
<td>Busbar shutters</td>
<td>Signal red</td>
<td>04 E 53</td>
<td>537</td>
</tr>
<tr>
<td>Circuit shutters</td>
<td>Lemon yellow</td>
<td>10 E 53</td>
<td>309</td>
</tr>
</tbody>
</table>

15.2.7 LABELS

Each switchboard shall be provided with a title and have circuit designation labels fixed to the front and rear cover of each circuit compartment. Rear covers for more than one sub-section shall have labels for each sub-section. In all cases, the label shall be positioned so as to leave no doubt as to which item it refers.

All indicators, instruments, relays, control switches, push buttons, fuses and other ancillary apparatus shall be provided with labels clearly stating their function.

Character sizes for main title and circuit designation labels shall be at least twice those for ancillary items.

All label inscriptions shall be to the approval of the Supervisor and the abbreviation “No” shall not be used.

Labels fitted to the front of the switchboards/control panels/starters shall be of transparent perspex with radiussed or chamfered front edges, reverse engraved with white infill then sprayed on the rear to match the color of the board. Other labels shall be sandwich type white/black/white, or yellow/black/yellow for danger labels, or as approved by the Supervisor.

All labels shall be fixed square to the equipment by means of screw or rivets of nylon or non-corrodible material. Labels affixed with adhesive will not be accepted.

15.2.8 CABELING FACILITIES

Cable boxes and glands shall be accommodated within the cubicles except where otherwise approved and all removable access, sealing and gland plates are to be provided with gaskets to form an adequate seal against the external atmosphere.

Adequate space within each compartment shall be allowed for external cable tails to be connected without stress on the terminations, bearing in mind the type and size of such conductors. Where multicore in excess of 95 mm² or any single core cables are to be
terminated, a minimum distance of 450mm free space shall be allowed between the gland plate and the terminal connection point.

In multi-tier compartments, individual terminal covers and gland plates shall be provided for each circuit such that additional circuits may be terminated safely whilst the switchboard is energized.

For paper insulated cables, a suitable cable end sealing box shall be provided for each circuit as specified. Where the cable enters from beneath the panel, the bottom of the whipping gland shall be at least 150mm above floor level. Removable split sealing plates are to be provided for subsequent fitting around such cables.

Un-drilled removable gland plates shall be provided for cables requiring compression glands entering from beneath the panel. The plate shall be located at least 300 mm above the panel floor level and shall form part of a compartment constructed within the panel to seal the interior from the exterior of the panel. Access for glanding-off shall be provided by removable covers fitted to the available vertical sides which may extend the full width of the panel as necessary.

Where single core cables are to be accommodated, a non-magnetic or slotted gland plate shall be provided.

Terminals, studs, or drilled holes shall be provided to accommodate all necessary cable terminal lugs and, prior to manufacture, the Contractor shall confirm cabling termination requirements with the Supervisor.

15.2.9 PANEL WIRING

Panel wiring shall be run neatly within the cubicle in suitable cable looms or panel trunking, and in the case of instrument, intrinsically safe or safety extra-low voltage circuits, run in separate groups accommodated within cubicles. The looms or trunking shall be adequately secured without the use of adhesive material. Wiring carried across door hinges shall be neatly loomed and rolled in torsion in the plane of the hinges to minimize flexing of the wiring, thus wiring shall enter and leave at different levels as widely spaced as practicable. Bushings or grommets shall be used where wiring passes through sheet metal or plastic.

All components and auxiliaries in repetitive units shall be wired in an identical pattern to match the arrangement of each component.

Wiring cables shall be adequately rated, tinned copper stranded conductors of not less than 1.00 mm² (32/0.20) PVC insulated 600V grade, except wiring to PLC or other light current equipment which shall be not less than 0.5 mm² (16/0.20)

Wiring insulation shall be colored as follows:

AC Circuit

- Mains supply (LV) - Black
- Uninterruptible power supply (LV) - White
- ELV supplies (up to 50V AC) - Yellow
- Intrinsically safe circuits - Blue
DC circuit
Battery supply (ELV, not exceeding 120 DC) - Grey

Where various voltages exist within the above definitions, the color coding shall be subject to agreement with the Supervisor.

Each wire shall be terminated with suitable ring or spade crimps or bootlace ferrules and identified at both ends by means of white or resistor color coded ferrules imprinted to correspond with the diagram of connections. Wires linking common points in the circuit shall bear the same reference at each termination. Alternative identification methods require prior approval of the Supervisor.

15.2.10 TERMINALS

All terminal blocks for the connection of small wiring shall comprise of shrouded anti-tracking mouldings of melamine phenolic, or comparable material, with provision for securing conductors either by high tensile screws and clamps or by solder tag connection.

Terminal blocks shall be arranged so that both terminals and wiring ends are readily accessible and have separate terminals provided for incoming and outgoing wires, together with insulated barriers between adjacent connections and transparent insulated covers. Blocks accommodated on common mounting rails shall have a foot designed to ensure a secure fit to the rail. Foot springs shall be of stainless steel and have a locking device fitted to prevent accidental release of the block.

Each terminal shall be labeled to correspond with the diagram of connections and terminal identification labels shall be attached to the fixed portion of the terminal blocks only. Terminals for intrinsically safe circuits shall be clearly segregated and colored blue.

Terminals which may be live when the equipment is isolated from the main supply shall be adequately shielded from accidental contact and be clearly identified and inscribed accordingly.

15.2.11 CURRENT TRANSFORMERS

Each current transformer shall bear a label showing the ratio, class, short time factor and accuracy limit factor. The inscription must be readable when the transformers are installed within the gear without the necessity of dismantling any equipment other than removing cover panels.

Bar type current transformers shall be supplied in preference to those with wound primaries. Short time current factors shall relate to the full fault level specified. For over-current protection, the product of VA rated burden and rated accuracy limit factor shall be 150 unless otherwise agreed with the Supervisor.

One secondary terminal of each current transformer shall be earthed at the switchgear.

15.2.12 VOLTAGE TRANSFORMERS

Voltage transformers shall be vacuum impregnated or encapsulated resin insulated type. Each transformer being fully isolatable and accessible for maintenance purposes and fitted with primary and secondary fuses.
15.2.13 INDICATING INSTRUMENTS

All indicating instruments shall be of a similar flush vertical mounting, rectangular pattern, enclosed in black colored, dust and damp proof cases, one side being not less than 90mm (3.5") long or as specified. Scaling shall be in approved metric units normally ranged from zero to 20% - 40% above the system designed operating value, except where finite limits exist (e.g. p.f indicators, synchroscopes), or where restricted ranges are specified. Adjustable set points within the instrument ranges shall be incorporated as specified.

Instruments having a mechanical movement shall provide at least a 90° scaled arc. 240° scales shall be employed on principal specified indicators.

Ammeters for motor circuits shall have an extend scale to cater for the starting current. These shall have adjustable red pointers or red markings on the scale to indicate the normal circuit current for the associated plant and shall be connected to each of the three phases of a three phase motor circuit.

15.2.14 INDICATION LIGHTS

Indication lights shall be flush panel mounted types with bodies fastened and keyed so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lampholder or panel wiring. Lens colors shall be as specified in the specific requirements. Bezels shall be colored black.

All light sources shall be operated at extra low voltage. Single units shall be fitted with MES caps and be illuminated by LED clusters where colors permit; otherwise filament lamps shall be used.

To extend lamp life, filament lamps shall be arranged to operate at approximately 20% below their rated voltage and details of voltage and type of indication lamp shall be submitted to the Supervisor for approval. Particular consideration shall be given to circuits operated from a battery supply permanently floating across a charging circuit, where the terminal voltage may be higher than the nominal voltage.

When annunciator style indicators are used they shall incorporate two lamps wired in parallel for each fascia which shall have a window area of not less than 48mm x 24mm. the engraved characters shall be not less than 3mm in height and shall be filled black on a translucent background colored as specified.

Alternatively where specified (particularly for unattended situations) self-contained LED annunciator display modules shall be used and configured for panel mounting. Legend plates shall be provided adjacent to each indicator. Where message display indicators are used, they shall have programmable legends and adjustable pulse rates.

15.2.15 PUSH BUTTONS

Push buttons shall be heavy duty, double break pattern with fully shrouded molded buttons having a spring return action through a flexible oil tight seal. Each button shall be colored in relation to its function as specified herein, and bezels shall be colored black.

Emergency stop buttons shall be arranged to de-energize without delay the drive motors for the whole of the associated plant whatever control mode of operation may be selected. They shall be of the stay put type having a large red mushroom head with twist to release manual reset, suitably labeled and have at least two poles, 1 N/O and 1 N/C with contacts suitable for the circuit operation.
Where key reset heads are required, the key shall be common for all buttons.

15.2.16 CONTROL RELAYS
Control circuit relays for switching 5A/250V or less shall be of the multi-pin plug-in type having the following features:

- Neon or LED indication of relay energization,
- Mechanical On / Off indication,
- Manual test button with provision for retention of the button in the operated condition for test purposes,
- Legend plates on relay and base,
- Relay retaining clip,
- Be mounted on molded bases having recessed screw terminals.

If sufficient contacts are not available in one relay, not more than two relays may be connected in parallel.

Any relay used to switch an external alarm circuit shall have a volt free contact for the purpose.

15.2.17 PROTECTION RELAYS
Electro-mechanical protection relays and associated devices shall be provided as specified, suitable for flush mounting in dust proof cases; withdrawable types being provided where they are fitted in fixed panels.

Where not monitored on a battery sourced alarm monitoring display, the relays shall have hand rest flag indicators unless a self reset or electrically reset facility is specifically called for. Hand reset indicators shall be capable of being reset without opening the relay case. Flag indicating relays shall be de-energized once the flag has fallen.

Where two or more elements are included in each case, separate indicators shall be provided for each element.

15.2.18 FUSE LINKS AND HOLDERS
Suitably rated fuses shall be provided at all points necessary for circuit protection and isolation, separate fuses being provided for instruments, indication, alarm, heater and coil circuits. Fuse ratings shall be rationalized as far as possible to limit spares.

i) LV fuses in circuits exceeding 50V shall, where practicable, be housed in all insulated carries with fully shrouded bases of matching color, which shall not be interchangeable with carriers and bases provided for removable solid links which shall be colored white.

LV fuse links shall be HRC cartridge type to BS 88, class Q1, having provision for screw fixings for attachment to the carrier.

ii) Control and instrument fuses may be accommodated in moulded terminal blocks suitable for DIN rail mounting. Fuses rated up to 6.3 A 250V shall be 20 x 5mm (G type DIN 41660) having a hinged fuse carrier housing.

Fuses rated up to 13A 250V shall be 25 x 6.3 mm cartridge type to BS 13362, secured by a screw cap. The live connection being made to the lower terminal.
15.2.19  LOCKS AND KEYS

Lockable selector switches or panel doors in a multi-unit installation shall employ a common interchangeable operating key, but keys for each function may be non-interchangeable, subject to the approval of the Supervisor.

For each key pattern employed, three keys shall be provided, each having a permanently attached brass identification label, embossed with the following:

i) Key number

ii) Location of lock/item of equipment ref.

15.2.20  KEY CABINETS

Key cabinets shall be provided to accommodate, on suitably number/colored, adjustable hook bars, one set of all the above keys and padlocks. The keys shall be fitted with corresponding number/color coded tabs. The cabinets shall be of stove enameled sheet steel material, suitable for surface wall mounting and be fitted with lockable hinged cover doors.

15.2.21  INSULATING MATS

Black rubber matting shall be supplied complying with BS 921 for all indoor control or switch gear panel. It shall extend the complete length of the control panel and the minimum width shall be one meter.

15.3  HV CIRCUIT BREAKERS AND DISCONNECTORS

15.3.1  CIRCUIT BREAKERS

For AC circuits, circuit breakers shall be triple pole of the vacuum interrupter, SF 6 or air break type as specified, suitable for the short circuit fault duty specified herein. Low voltage breakers shall incorporate a neutral link, unless in special cases a neutral pole is called for on the breaker under the specific requirements. Air or oil break circuit breakers shall be “trip-free” and whole of the operating mechanism shall be suitable for such conditions of operation.

The whole equipment shall be robust and capable of withstanding repeated closing and opening impacts satisfactorily.

Each breaker shall be provided with the following:

i) Mechanical “Flag” indicator giving reliable indication that it is either “OFF” (open) or “ON” (close).

ii) Means of isolation so that the breaker may be maintained with busbars alive.

iii) An operating handle that can be concealed when not required, to ensure a flush fronted appearance.

iv) An adequate number of auxiliary switches with the addition of one normally open and one normally closed spare switches, all to be wired to a terminal board of approved design in the fixed portion of the switchgear and arranged in the same sequence on all equipment.

v) Protection relays and tripping devices as specified

vi) Facilities for connection of appropriate auxiliary circuits when the circuit breaker is in the isolated position to permit operation of the breaker for test and indication purposes.
vii) Key operated interlocks between breakers as specified.

15.3.2 HV DISCONNECTORS

HV disconnectors shall be triple pole, oil free switch disconnectors rated for fault making/load breaking duty to IEC 265, mounted on a non withdrawable chassis and enclosed in a metal clad enclosure in accordance with BS 5227 or equivalent.

The contact breaking mechanism shall incorporate expulsion quenching techniques to ensure positive arc extinction and high closing speeds to enable the switches to close onto existing short circuits without harming the equipment or the operator.

The switch shall be either manually or electrically closed and manually or electrically tripped as detailed in the specific requirements. All operations shall be effected with the panel door closed and include an On/OFF indicator. Contact separation shall be clearly visible through a viewing window on the cover.

15.3.3 SAFETY SHUTTERS

Where withdrawable circuit breaker units are used, the housing shall be arranged to accurately locate the movable portion prior to engagement and accommodate automatic safety shutters.

Each group of busbar and circuit spout orifices shall be fitted with an individual automatically operated safety shutter, the appropriate shutters being positively opened or closed when the circuit breaker is racked in or out.

When closed, the shutters shall effectively prevent any contact with either the busbar or circuit connections and seal the spouts against the ingress of dust. The shutters shall be painted in bold characters “BUSBARS “ or “CIRCUIT” as appropriate, the busbar shutter being colored red and the circuit shutter being colored yellow.

For testing and inspection, each shutter shall be separately hand operated from the front of the unit and latched in the open position. Any movement of the circuit breakers either in or out of the housing shall automatically restore the automatic failure.

Provision shall be made for each shutter to be locked only in the closed position.

Non-withdrawable HV switchgear shall have a three phase test access point incorporated in the design such that cable and injection tests may be carried out on each circuit. The test access point shall be fitted with a lockable cover and interlocked to prevent access to live circuits.

15.3.4 PROVISIONS FOR EARTHING

Provision shall be made for earthing the busbars and each circuit outlet through the circuit breaker, either integrally or by means of a portable device as specified such an arrangement being suitable to withstand the full short circuit rating of the switchgear.

Where integral earthing facilities are included, selection of the locating mechanism shall prevent the breaker being engaged into any position other than that selected. Visual indication of such circuit breaker locations shall be clearly marked, e.g., “CIRCUIT EARTH”, “BUSBAR EARTH”, “SERVICE/ON” and “ISOLATED/OFF”.

Facilities shall be provided so that padlocks can be fitted to prevent the selection of either “EARTH” positions.
Facilities shall be provided for padlocking the circuit breaker while it is closed on to an earthed circuit to prevent unauthorized tripping electrically or mechanically.

The circuit breaker truck (or carriage) and oil tank if applicable, shall be effectively earthed when in the “service/on” position.

HV switches shall have facilities for earthing the circuit by means of a selector, and the ON, OFF, and EARTH positions shall be visibly indicated, appropriately labeled and provided with locking facilities in each position. Inspection windows shall be provided so that the position and condition of the selector contacts and insulators can be observed.

15.3.5 INTERLOCKS

Each circuit breaker unit shall be provided with mechanical interlocks to prevent incorrect operation or accidental contact with live metal, and to protect the equipment and operator from the dangers of mal-operation and designed to prevent the following where relevant:

- The circuit breaker being closed unless it is in the fully engaged or fully withdrawn position.
- The circuit breaker being engaged and plugged into the busbar and circuit spouts unless the tank is bolted to the top-plate.
- The circuit breaker unit being withdrawn from or pushed into the unit housing unless the breaker is in the fully withdrawn position.
- The circuit breaker being positioned in the unit in any position other than that indicated on the locator.
- Access to voltage transformers unless they are in the isolated position.

15.3.6 HANDLING TRACK

For each switchboard and different type of breaker supplied, one purpose designed, manually operated lifting and handling track shall be provided to enable safe removal of a circuit breaker from its compartment.

15.3.7 SWITCH OIL

The first change of switch shall be provided for each oil circuit breaker or switch. An oil level indicator shall be provided on each tank with maximum and minimum limits marked.

15.4 LV DISTRIBUTION SWITCHGEAR

15.4.1 SWITCHES

Switches shall be of the air break pattern, enclosed in zinc sprayed heavy duty, cast metal or sheet steel cases providing enclosure protection to at least IP55 unless otherwise specified, suitable for industrial surface mounting or flush cubicle mounting as specified.

They shall be rated in accordance with BS 5419 or equivalent and be fitted with solid or HRC fuse links as appropriate in each phase and a neutral link, all contained within the switch case, with the terminals accessible from the front of the switch. Phase barriers and contact shrouds shall be provided with an interlock to prevent withdrawal or access when the fuse switch is in the ON position.
Each switch shall have a free handle control mechanism to prevent inching and damage to contacts, be fitted with ON and OFF position indicators and have provision; interlocks shall prevent the unit door from being opened.

The moving contacts of fuse switches shall be readily withdrawable as a complete unit for maintenance when the remainder of the board is live.

15.4.2 DISTRIBUTION FUSEBOARDS
Fuseboard cases shall be of rust proofed, zinc sprayed, heavy gauge sheet steel, having a flush fronted door with concealed hinges and a resilient sealing gasket, providing enclosure protection to at least IP 55 unless otherwise specified.

The interior shall be assembled from all insulated shrouded fuse carriers and bases of the 380V pattern, fitted with phase dividing barriers and all live parts being fully shrouded, all in accordance with BS 5486 or equivalent.

Circuit identification charts shall be fitted to the inside of all fuseboard doors.

All fuse carriers shall be fitted with fuse links rated to suit the circuit duty. Spare ways shall have fuse links of the same current rating as the carrier, unless different current ratings are called for under the specific requirements. The Contractor shall, however, confirm fuse ratings with the Supervisor before fitting fuses to the carriers. Fuse-links shall be of the HRC cartridge type to BS 88, class Q1, having screw fixings to the carriers.

15.4.3 MOULDED CASE CIRCUIT BREAKERS
Moulded case circuit breakers shall be of the quick make, quick break, trip-free type, complying with BS 4752 and shall be complete with thermal/magnetic release, except for those units serving as isolators only. Multiple breakers shall have a common trip bar and trip elements on each pole to ensure that any abnormal condition on any one pole will cause all poles to open simultaneously.

Visual indication of open, close and trip conditions shall be provided. Facilities for padlocking in the “OFF” position shall also be provided.

15.4.4 MINIATURE CIRCUIT BREAKERS
Miniature circuit breakers shall be of the quick make, quick break, trip-free type, complying with BS 3781 Part 1. Circuit breakers shall be complete with thermal / magnetic or magnetic / hydraulic releases. Multi-pole breakers shall have a common trip bar and trip elements on each pole to ensure that any abnormal condition on any pole will cause all poles to open simultaneously.

Visual indication of open, close and trip condition shall be provided. Facilities for padlocking in the “OFF” position shall also be provided.

15.4.5 DISTRIBUTION MCB BOARDS
Miniature circuit breaker distribution boards shall be totally enclosed, metal clad, flush fronted units, with a hinged front door, all in accordance with BS 5486 Part 12. The interior shall be assembled from all insulated miniature circuit breakers with bolted connections and with switch
dollies arranged for vertical operation. Phase dividing barriers shall be provided and all live parts shall be screened from the front. Circuit identification charts shall be fitted to the inside of all distribution boards.

15.4.6 TERMINALS
All terminal boards and terminal blocks shall provide a positive mechanical clamp type connection. Pinch screw type terminals shall not be used. Terminals for the connection of all external cabling shall be situated at least 100mm from their respective gland plate or further if the cable size requires a greater distance for dressing.

All main phase terminals shall be suitably marked to ensure correct phase identification.

15.4.7 LABELS AND CIRCUIT LISTS
All electrical equipment enclosures shall be clearly labeled to indicate the plant designation. Individual items not subject to switchboard requirements shall have labels of non-corrodible. Traffolyte sandwich type white/black/white, or yellow/black/yellow for danger labels or as approved by the Supervisor. They shall be fixed square to the equipment by means of screws or rivets of nylon or non-corrodible material. Labels affixed with adhesive will not be accepted.

Inscriptions on labels and circuit lists shall be in English and be submitted for the approval of the Supervisor. The abbreviation “No” shall not be used.

A list of circuits, in an approved form, shall be supplied and fixed behind a “Perspex” sheet on the inside of all distribution boards which are provided or rewired under this contract.

15.4.8 RESIDUAL CURRENT CIRCUIT BREAKERS
The circuit breaker shall be arranged to isolate each live conductor simultaneously within 30ms if the residual leakage current through the device exceeds 30mA.

It shall be housed separately, or incorporated into other composite enclosure. Include provision for testing the tripping operation under earth leakage conditions by means of a built – in resistor and push button, and require manual resetting.

15.5 MOTORS STARTERS
15.5.1 GENERAL
Each starter shall contain all the necessary equipment to control the circuit load and isolate it from the supply in the event of a fault and shall be equipped to comply with the following general requirements unless otherwise specified under the relevant starter duties.

For starting LV Motors direct on line, the starter shall be rated for intermittent duty class 0.3 (up to 30 operating cycles/hour), and utilization category AC-3 in accordance with BS EN 60947, or as otherwise specified.

15.5.2 ISOLATION
Each unit shall be housed in a separate compartment or enclosure and be completely isolated by means of an isolation switch interlocked with the door or cover to allow access only when the switch is open. The isolation switch shall be operated by means of an external handle and shall have provision for padlocking in the “OFF” position. When in the “ON” position, interlocks
shall prevent the unit door being opened. Any components still live after this switch has been
opened, shall be adequately shrouded and have warning labels attached thereto.

The switch shall be capable of carrying continuously the full rated current of the conductor and
shall be rated for making and breaking stalled motor current duty as specified in BS 5419. Off-
load isolators shall be suitably interlocked to ensure that they do not make or break load
currents and be provided with locking facilities in the “ON” position.

Additional physical isolation by means of withdrawable units for ease of maintenance may be
offered but is not a specific requirement. For such an arrangement the live poles shall be
automatically shuttered when the unit is withdrawn and the shutters shall have provision for
padlocking in the closed position.

15.5.3 CONTACTORS

All Contactors shall be of the air-break electromagnetically held-on type. All contact pieces
shall be readily replaceable and the necessary auxiliary contacts for control, indication and
alarm shall be mounted in accessible positions and arranged in the same sequence on each
contactor.

Vacuum interrupters shall be used for high voltage circuits. They shall be solenoid operated
and designed to fail-safe, so that in the event of failure of any part of the closing mechanism
the contacts will open.

15.5.4 PROTECTION

Each starter shall be provided with an adjustable motor over-land and single phase protection
device suitable for the motor load and have adjustable trip and reset delays provided, together
with manual resetting facilities. Ambient temperature compensation shall be provided where
relevant. Other protection features shall be as specified relevant to the particular drive.

Protection devices shall be arranged to trip the load and initiate the fault indications specified
and accept normal switching of load.

Where starters are fed directly from busbars or other systems having a high prospective fault
level, suitably rated or other means shall be provided with the starter to limit the fault let through
to a value within the rating of the starter components. Protective overload devices shall be
arranged to ensure that any such is cleared by such fuses and provide type “2” co-ordinated
protection to BS EN 60947.
15.5.5 CONTROL CIRCUIT

All control circuits shall operate at not more than 110V and be derived from a double wound screen earthed isolation transformer with one side of the secondary winding connected to neutral/earth. The primary supply that normally be from one phase to neutral if available.

Individual transformers shall be provided for each starter. Sequenced groups of starters having a common isolator shall use a common control transformer.

Fuses shall be provided on each primary and secondary supply and be clearly labeled and segregated. A link shall be fitted in the neutral/earth connection.

The control circuit and the main supply must be isolated before opening the cubicle door but provision shall be made to re-energise the control circuit when the main supply to the cubicle is isolated, so that the operation of the control gear may be inspected without energizing the motor. The necessary control circuit normal/test switch shall be mounted within the cubicle and so arranged that it is not possible to close the door with this switch in the “Test” position.

15.5.6 CONTROL AND MONITORING

The method of control and operation shall be as called for under the specific requirements for the starter.

Control selector switches fitted to the front of starters shall have matching operating handles which are clearly shaped to show the selected position.

Specified function switches shall have a key operated barrel locking device in the handle, or be key operated alone, with the key removable in each lockable position.

All fault conditions relevant to each mode of operation shall stop the derive and prevent it re-starting until the particular fault is cleared and individually reset; lock – out relays and a reset button being provided for any self-resetting devices such as excess torque switches etc.

Specified fault conditions shall be identified by separate indication on the starter. Volt – free contacts shall be provided and wired to terminals in each starter unit for remove signaling of all status indications specified. Minimum status indications shall be auto available /Un-available and running/fault.

Where the starter is to be remotely controlled by a remote terminal unit (RTU), interposing relays with 24 volt DC coils complete with back EMF suppression diodes shall be provided in each starter unit to facilitate remote control and watchdog capability.

“Hours-run” meters shall be of the non-resettable cycrometer type indicator having a flush and driven by a synchronous motor connected to show the hours (up to 99,999.9) run by the main motor. They shall incorporate visible indication of operation but need not necessarily be of the same bezel size as the instruments.

All starters for motors of 3 KW and above shall have ammeters, local “running” indicator lamps being provided for loads less than 3kW.

15.5.7 HEATERS

Anti-condensation heaters shall be fitted in each starter (and motor, where specified), fed from a separate fuse through the starter isolating switch and an auxiliary contact on the motor contactor, arranged so that the heaters are disconnected when the motor is running.
In multi-tiered starter panels, the heater shall be located at low level within each tier and fed from a clearly identified common distribution supply with local isolating links in each tier.

### 15.5.8 STAR DELTA STARTERS

Star/Delta starters shall be of the closed transition “Wauchope” type, having starting resistors, mechanically and electrically interlocked, star and delta contactors, plus a timing relay in addition to DOL starter requirements, all rated for up to 10 starts per hour.

### 15.5.9 AUTO-TRANSFORMER STARTERS

Auto transformer starters shall be of the closed transition “Korndorffer” type, having suitably rated mechanically and electrically interlocked “start” and “run” Contactors plus a timing relay in addition to DOL starter requirements. The auto transformer shall be air cooled with tappings provided at 50%, 65% and 80% of line voltage and be suitably rated for up to 10 starts per hour. The transformer shall be contained within its associated starter compartment. Contactors of one starter shall be of the same type and rating. The current rating of the contactors shall be chosen 10% higher than required by the driving motor in utilization category AC3.

### 15.5.10 STATOR/ROTOR STARTERS

Where separate stator and rotor cubicles are provided, a key interlock shall be fitted to prevent access to the rotor cubicle unless the stator isolating switch is in the “open” or “earth” position. Rotor resistances shall have suitable interlocking facilities to prevent operation of the starter switch until all sections of rotor resistance are in the starting condition.

The resistor enclosure shall be ventilated to IP41, and a thermostat shall be incorporated to trip the starter if the resistance overheats due to excessive use or bad operation. Rotor resistances may be metal or liquid material as specified to suit the drive characteristics. Metal resistors shall consist of rustles unbreakable resistor grids which may be readily replaced. Where tiered banks of resistors are provided, it must be possible to readily remove from the front any section without disturbing any other section of the resistance bank. Liquid or derived vapor resistors shall have the electrolyte contained in leakproof containers, and incorporate means of restricting evaporation and detecting loss of electrolyte.

### 15.5.11 ELECTRONIC ASSISTED STARTING

Starters for specified squirrel-cage induction motors shall incorporate a solid state device designed to provide a smooth acceleration up to the motor’s rated speed. The acceleration time shall be adjustable by means of control settings provided, to enable optimum maximum starting current and torque as well as initial threshold starting current and torque to be selected. The starting current of the largest motor shall be limited as specified.
Where specified to reduce system shocks, provision shall also be made for motor stopping under controlled deceleration.

a) Protection

The thyristors shall be protected by high speed semi-conductor fuses and heat sink thermal cut-outs.

The device shall shut down in the event of single phase loss or open circuited thyristors.

In the event of short circuited thyristors, the drive shall continue to run at full voltage by automatically transferring to an override condition.

b) Indications

Alarm indications shall be provided for each of the above faults.

An auxiliary relay shall be used to control the function of the main contactor.

c) Energy saving facility

For continuous running drives, an energy saving control shall be provided, where the voltage applied to the motor is automatically matched to the actual power demand. The control shall be effective after run-up and a dwell time at full voltage has been allowed to enable the motor load to stabilize.

The device shall respond immediately to any sudden load changes to prevent a potential stall condition.

15.5.12 FREQUENCY CONVERTERS

The motor speed control shall be a frequency converter of an approved type and manufacture, providing a variable frequency output of adequate capacity to drive the specified motor over the specified speed range, and suitably matched to the starting torque and the speed torque characteristics of the driven plant. (details to be determined by the Contractor from the driven plant/motor manufacturer during the contract).

The converter unit with the associated control electronics shall be housed in a steel, free standing, drip protected (IP 21) panel, mounted in the position specified. The unit shall be suitably air-cooled by means of an integral fan and all the components within the unit shall be readily accessible for easy servicing and removal without disturbing other components. Chassis units shall be suitable for rack mounting.

The incoming supply shall be via an isolator interlocked with the panel door and have suitable fuse protection.

The drive unit shall be capable of operating with the motor disconnected for test purposes.

A current limiting circuit shall be incorporated to give short circuit and overcurrent protection in the output circuit, and undervoltage detection shall be incorporated to protect the drive against fan failure. A thermostat shall be fitted for protection against fan failure and overheating.

a) Harmonics

The unit shall be protected from any harmonic distortion or switching surges in the power supply system, and incorporate contactors to automatically isolate the input and output, and to protect the unit from component damage arising from a power supply interruptions which shall,
if necessary, include automatic shutdown. If the converter will not perform correctly when running from a specified standby generator, an interlock shall be provided to prevent such operation.

To prevent distortion of the supply system wave from (and dependent instrumentation), harmonic voltage and current distortion introduced into the mains supply by the drive unit shall be within the limits specified in Electricity Council Engineering Recommendation G 5/3. The point of common coupling shall be regarded as the output connections of the first upstream transformer.

The supplier shall list with the offer the expected harmonics generated by the drive under running conditions (worst case).

Where an input filter is used to limit the harmonic currents, the design shall minimize the possibility of resonance with any power factor correction capacitors fitted.

The supplier shall include any shielding necessary in accordance with BS 800 to prevent any interference that may affect other surrounding instruments.

b) Monitoring and control

The control of each variable drive unit shall normally be from a PLC outstation which will provide a start/stop facility and a 4-20mA Speed control signal. Where the distance between the drive unit and PLC exceeds 20m, special care shall be taken to ensure that radio frequency interference and distortion are kept to a minimum.

The following signals will be required from the drive unit and wired to clearly marked terminals:

(a) Common fault (motor overload, emergency stop operator initiated etc.)
(b) Control status indicating Hand/Off/Auto
(c) Control “ON”
(d) Motor available
(e) Motor running
(f) RS 232 serial interface (where required by the specification).

The following items shall be included along with other control devices and instrumentation:

a- Control potentiometer for speed setting on hand control, (scaled with linear graduation over the range and arrows indicating clockwise rotation to “INCREASE SPEED” and anti-clockwise rotation to “DECREASE SPEED”).

b- Output ammeter
c- Frequency /speed meter
d- Test and fault diagnostic card for circuit checking, having a front of panel display and facility for serial link remote indication.
e- Isolated inputs for 0-10/4-20mA auto control, start/stop, external reset etc.
f- Adjustments for ramp up/down, duration, frequency range, base/maximum speed, current limiting facility and economy mode

The following items shall be monitored for fault conditions:

- Phase failure
- Earth fault
- Over-current
- Over voltage
- High temperature / fan failure
- DC link fuse failure

15.6 ROTATING ELECTRICAL MACHINES

15.6.1 GENERAL

Machine type and starting or driving arrangements together with type of enclosure protection shall be as specified herein. Vertically mounted machines shall be fitted with a drip-proof to end cowl and those fitted with skirts shall have a skirt depth in excess of the shaft extension. Each machine shall comply with the current BS 4999 and the relevant parts of BS 5000 and shall be designated to run at a high power factor and efficiency at the prescribed plant duty.

15.6.2 RATING

The output of each machine shall be a continuous maximum rating (Duty type S1) determined by the tender in relation to the power requirements and the normal working environmental conditions for the plant offered in accordance with this specification. The maximum temperature rise of any machine winding shall not exceed 80°C above a 40°C ambient when operating at the above rating. Where the insulation is rated up to 120°C only, the maximum plant loading shall not exceed 95% of the rated output of the machine.

15.6.3 GENERATORS

Alternators shall be star connected machines producing a 3 phase 4 wire 50Hz supply at the specified rated voltage within a standard waveform deviation, when being driven at the rated speed and connected to the plant load specified therein.

i) Regulation

The generator automatic voltage regulation system for single set running shall be capable of maintaining the voltage for all loads between no load and rated load at rated power factor.

Due allowance shall be made for the current peaks associated with starting the motor loads connected to the alternator, and the regulation system shall be designed such that the transient voltage reduction following the load application does not exceed 15% of the rated voltage and shall be restored to within 97% of rated voltage in less than 1.5 seconds. The transient voltage rise when the rated load is thrown off shall not exceed 25%.

Where voltage regulation equipment is mounted on the alternators, the components shall be readily accessible and detachable for servicing, having terminations separate from the main terminals.

ii) Excitation

The alternator shall be the brushless self-excitation type with rotating armature and verifier assembly mounted on the alternator shaft, electrically interconnected with the fields.
winding. Radio noise suppression shall be in accordance with BS 800 and the exciter fields shall be safely discharged when the alternator is tripped.

15.6.4 MOTORS

Motors shall be suitable for operation from a 3 phase supply having the star point earthed and the phase sequence running R-Y-B anticlockwise. Motors rated less than 0.5 kW may be arranged for single phase operation.

The torque available during starting of each motor shall be at least 10% in excess of the maximum required at any speed to satisfactorily start and accelerate the mechanical plant load under all service conditions.

i) Over speed and reverse rotation

Each motor shall be capable of satisfactory performance during a period of 2 minutes whilst it is run at 1.2 times its rated speed and subsequently at normal speed continuously.

Where specified (to cater for backflow consequent upon delivery valve failure), pump motors shall be capable of reverse rotation up to these speeds without damage.

ii) Electromagnetic brakes

Where an electromagnetic brake is fitted to a drive, the brake shall be continuously rated. It shall be suitable for direct connection across the associated motor terminals or for individual supply and interlinked control, depending on the method of operation and control specified herein.

The brake shall be arranged to fail-safe by holding on under spring return passage when the coil is de-energised and have provision for hand easing for maintenance purpose. All control circuits for brakes shall be arranged to be fail-safe.

Coil and terminals shall be totally enclosed in a fully weatherproof housing.

iii) Power factor correction

Where specified, a power factor correction complying with BS 1650 and suitable for operation over the temperature range -10°C/+40°C shall be connected to improve the overall power factor of each machine to not less than 0.9 when running at full load.

Each capacitor bank shall be fitted with HRC fuse protection enclosed within a sheet steel housing having a terminal box with separate bolted access cover and an external earthing terminal.

Means shall be provided for monitoring fuse failure visually. For HV applications, striker pin fuses shall be provided and arranged to operate a trip bar which shall initiate an alarm contact for remote indication.

Resistors shall be fitted to provide a controlled discharge on de-energization except where such discharge is effected by the machine windings.

Warning labels shall be fitted to the capacitor and motor terminal boxes, inscribed as follows:

“WARNING – EQUIPMENT CONNECTED TO STORED ELECTRICAL CHARGE.
ISOLATE AND EARTH ALL TERMINALS BEFORE HANDLING”
iv) Submersible pump motor

If not stated different in the Bill of Quantities the following conditions apply:

The pump and its associated motor shall form a compact integral pumping unit suitable for installation within the area specified. The motor shall be of squirrel-cage construction suitable for starting method, and rated for continuous submerged operation in water having a maximum temperature of 22°C where a sealed coolant motor is used, the coolant shall be distilled water.

The stator windings shall be insulated against heat and humidity to Class F and shall incorporate at least three thermal overload devices.

A length of butyl rubber insulated, CSP sheathed flexible cable shall be provided and connected to the motor. Unless otherwise specified, the cable length shall be at least 20 meters without joints. The cable cores shall be phase colored and be suitable for carrying the motor full local current under the specified operating conditions. The cable sealing gland shall be a watertight design and, where included within the pressurized pipework, shall be capable of withstanding a water pressure of 1.5 times the closed valve head generated by the pumping plant.

15.6.5 TERMINAL BOXES AND CONNECTIONS

Terminal boxes shall be provided, suitable for PVC/SWA/PVC cables for all external cabling connections.

All boxes shall be bonded to the main frame earth and the frame of each machine shall be provided with means of connecting an earth protective conductor.

Each machine rated 10kW, or above, shall have the six ends of the stator winding extended to the terminal block with the necessary linking effected there, adequate clearance being provided between phase terminations to permit the use of cable sockets.

For high voltage machines the terminal assembly shall be capable of satisfactorily withstanding the full fault capacity specified herein for 1 second.

15.6.6 HEATERS

Anti-condensation heaters shall be provided in all non submersible machines as an integral part of the machines, and wired with butyl rubber insulated tails to a terminal box adjacent to the main terminal box, the cover being clearly labeled "Heater supply – 220V".

Heaters shall be of the embedded element having a low surface temperature and be impervious to moisture. They shall be arranged to operate on a 220V supply from the associated control unit when the motor winding is de-energized.

15.6.7 MAINTENANCE FACILITIES

Machines rated over 50 kW shall have lifting ears or eyes forming part of the main frame of the machine, and both ends of the rotor shaft shall be drilled and tapped for maintenance lifting and pulling facilities with a single tapped hole in accordance with the tables given in BS 4999 (Part 10). Depth of tapped hole shall be 1.5 times the diameter.
15.6.8 BEARINGS
Bearings shall be the heavy duty ball or roller type greased for life, enclosed in a substantial housing designed so that lubricant cannot escape on to the windings, and fitted with adequate seals to prevent contamination, or escape of lubricant down the rotor shafts. Means of lubrication shall be made available from outside the machine car case or enclosure. The shaft shall be suitably located to prevent the rotor from moving out of magnetic center while starting or running.

The rotor of any vertical spindle machine shall be provided with a suitable thrust bearing to support the weight of the rotor and its half coupling only.

15.6.9 SLIP RINGS
All machines which incorporate slip rings shall be so designed that the slip rings and associated slip ring mountings shall form a single unit which can be readily detached from the shaft for repairs and replacements. The slip rings shall be continuously rated and to the totally enclosed type.

15.7 POWER TRANSFORMERS

15.7.1 GENERAL
The transformers will be used for distribution purposes on electrical power and lighting installations as specified.

Each transformer shall comply with the requirements of BS 171 for outdoor, naturally cooled types, having an insulation level in accordance with part 3, table II list 2.

They shall be mineral / silicone oil cooled or dry type /cast resin as specified and shall operate satisfactorily at any supply voltage between ±15% of the rated voltage as specified herein, and within ±2.5% of 50Hz. Simultaneous variations in voltage and frequency will not be in opposite directions.

All connections between the transformer coils and the items mounted on the enclosure shall be provided, adequately braced, and supported to withstand the specified fault conditions.

15.7.2 TAPINGS
Tapping at ±7% and ±15% nominal voltage shall be provided on the HV windings as specified herein, preferably arranged at positions in the coils to preserve the electromagnetic balance of the windings at all voltage ratios, and the transformer shall give its full rated output on any taping.

In any dual voltage units, the changeover facilities shall be by means of internally mounted, off-load links within the enclosure.

15.7.3 TAPPING SWITCH
An externally operated, off circuit taping switch of robust construction shall be provided, especially designed against risk of damage from short circuits and having all contact surfaces of ample area for satisfactory operation during overloads.
The mechanism shall be hand-operated and shall come to rest only when the switch is making full contact, giving clear indication of the ratio at which the transformer is operating. The switch shall operate simultaneously on all three phases.

Approved means shall be provided for locking the tapping switch mechanism in the positions corresponding to each voltage ratio.

15.7.4 RATING AND IDENTIFICATION PLATES

Each transformer shall be provided with a terminal marking and rating plate, together with a distinguishing number plate, of approved type, bearing a specified designation reference in raised characters not less than 75mm in height.

15.7.5 CONSTRUCTION

The core shall be built up interleaved laminations, stepped to give optimum magnetic contours and insulated on one side, of cold rescued, grain oriented silicon steel working at a flux density not exceeding 16.500 lines /sq cm (1.65 Tesla). Corner and yoke joints shall have minimum gaps for quiet and efficient operation and shall be securely clamped and braced with channel section frames to reduce vibration.

Oil filled enclosures shall comprise a tank of sheet steel construction incorporating facilities for lifting and jacking the complete units, and have a channel section skid base fitted with rollers. Holes shall also be provided in the skid base at each end for haulage purposes such that, after installation, the rollers maybe re-located therein and the transformer will stand on its base.

Cooling shall be by means of flange mounted radiators. Top cover plates shall be weld sealed for ratings up to 800 kVA. Ratings of 1000 kVA and above shall have gasketted removable top cover plates.

All flanged joints shall have gaskets of suitable non-absorbent material to prevent entry of water or leakage of coolant.

Each tank shall be provided with a flanged drain valve (minimum 1" BSP) fitted with a blanking plate. All valves shall be of gunmetal and the sluice type with internal screw, unless otherwise approved.

15.7.6 PAINTING

All associated enclose, steelwork to be shot blasted on completion to ensure freedom from welding slag, rust or grease prior to spraying.

Oil filled tank interiors shall be given a high quality coolant resisting anti-corrosion finish coating.

The outside of the tank shall be covered with a minimum of 3 coats of paint, consisting of primer, intermediate and final high gloss, weather resistant finish, applied by the flooding process to ensure complete coverage of tubes and areas inaccessible to brush and spray.

15.7.7 EARTHING

The core and any conductive parts of any protective enclosure shall be earthed by means of substantial connections to a common terminal provided for this purpose. An earthing terminal
15.7.8 CABLE TERMINATIONS
Terminal boxes shall be provided suitable for connecting the external cables specified herein, and terminal assemblies shall be capable of withstanding and the specified prospective fault rating. Where single core cables are to be accommodated, a non magnetic or slotted gland plate shall be provided.

15.7.9 LINK BOXES
Where PLC cables are terminated in compound filled boxes, disconnecting link boxes shall be provided to enable tails to be pressure tested without the need to remove cables. Links shall be of the bolted type and should be readily accessible without disturbing the cable connections or the transformer enclosure.

15.7.10 OIL GAUGE
A gauge of adequate size shall be fitted to indicate the oil level at 15°C and when the temperature has risen to the limit permitted by BS 171. The level in the gauge shall be clearly visible from the ground and the gauge shall be protected against accidental damage.

15.7.11 THERMOMETERS
A dial type indicating thermometer shall be provided and mounted on the side of the enclosure for ease of reading arranged to measure the temperature in the hottest areas of the transformer coolant or winding. This may incorporate the temperature protection requirements specified below.

Oil cooled transformers shall be provided with a thermometer pocket in the tank and a thermometer to register the coolant temperature. The pocket shall be fitted with a protective thimble when not in use.

15.7.12 PROTECTION
The following protective facilities shall be provided as specified for each transformer. All switches contacts shall be rated at least 125V, 0.5A DC.

Restricted earth fault protection shall be arranged such that the star connection of the secondary windings shall be earthed via an air insulated, removable link which will accommodate a current transformer provided by the switchgear manufacture. The CT shall be (CT) provided with adequate supports and terminating facilities and both the link and CT shall be housed in a box with a removable cover. The box shall have a 20mm ET threaded entry for CT cable.

i) Sealed type transformers shall be fitted with a spring loaded self resetting pressure relief device actuated by excess pressure within the transformer tank. The setting shall be suitable for application with the coolant used and actuate a manually resettable switch to initiate a remote trip.

Over temperature protection shall be provided by means of a scaled dial indicating thermometer fitted with two adjustable contacts arranged to initiate a remote alarm and trip circuit respectively.
ii) Aspirated type transformers shall be fitted with oil sealed de-hydrating breather of the visible indicating pattern.

Over temperature protection shall be provided by means of a scaled dial indicating thermometer fitted with two adjustable contacts arranged to initiate a remote alarm and trip circuit.

Transformers having a conservator shall be fitted with a Buchholz gas and oil actuated protective device of approved make. The protector shall be of the double float pattern with both alarm trip contacts, an inspection window and a terminal box suitable for conduit entry. A petcock shall be provided at the top for the release of gas and a second petcock fitted at a lower level for testing the operation of the relay by compressed air.

15.7.13 CONSERVATORS

Oil filled, aspirated transformers rated in excess of 2MVA shall be provided with a conservator vessel fitted with a sump and suitable means of drainage. The oil connection to the transformer tank shall project at least 50 mm vertically inside the conservator, and the oil sight gauge fitted to conservators shall be arranged to indicate oil in the conservator tank only when the oil connection to the transformer tank is submerged.

The transformer top plate shall be removable without disturbing the conservator mountings or connections.
15.7.14 **DRYING OUT AND FILLING**

Each transformer shall be dried out and filled to normal working level with coolant at the manufacturer’s works. It shall be transported, installed and put into service without the necessity for further drying out on site.

15.7.15 **DRY TYPE TRANSFORMERS**

For indoor use only and where specified, dry type transformers shall comply with all the proceeding clause except that:

i) Coils windings and impregnation shall be designed to minimize stresses induced under normal and abnormal circuit conditions. Assembled coils shall be impregnated under high vacuum with epoxy resin, and cured to relieve stress, prevent voids and be non-hygroscopic.

The coils shall be located concentrically and firmly on their formers with allowance for axial movement due to temperature changes. All air ways shall be smooth and unobstructed.

The core frame shall incorporate lifting lugs and be mounted on a base frame having towing holes and cross members for stability.

ii) Enclosure shall be ventilated housings formed of fire resistant building materials, glass fiber molded panels with steel mesh reinforcing or sheet steel panels, providing a minimum protection, to IP 21, against water and accidental contact. Access doors for maintenance shall be provided and interlock with the controlling HV and LV switchgear to prevent access when either switch is closed.

The construction, preparation, and painting details for sheet steel panels and doors shall be as specified under the switchgear requirements.

iii) Protection: over temperature protection shall be provided by thermistors located in the three phases of the LV coils. These shall be set to suit the operating characteristics of the transformer, one set to provide a high temperature alarm and a second set to provide a higher temperature trip.

Where enhanced cooling by fans is specified, additional thermistors shall be provided for switching control of such fans.

All thermistors shall be wired to relays housed in a box mounted externally on the enclosure. The box shall include suitable terminals for external cabling; a 20mm ET threaded entry, and a removable cover.

15.8 **CABLING AND WIRING**

15.8.1 **ELECTRICAL INSTALLATION**

The electrical installation shall comply with the current edition of the regulations for electrical installations published by the institution of Electrical Engineers (IEE Wiring Regulation) and the requirements specified herein where these differ from the IEE wiring regulations.

The installation shall be arranged in a neat and orderly manner which may involve running out of direct lines in order to conform to building outlines, etc, and to utilize any holes provided for cabling purposes in the structure. Unnecessary crossing of cables will not be accepted and
due care should be given to this when selecting runs. Each cable shall be in one continuous length and no straight through joints will be permitted except as approved by the Supervisor.

It shall be the entire responsibility of the Contractor to programme the whole of his work and co-operate with other Contractors to ensure that the various parts of the electrical installation are executed at the proper stages of the construction, special care being taken with concealed work.

Care should be taken that sleevings and sheathings of cables are not damaged during installation. Should any part be damaged, the damage shall be made good to the entire satisfaction of the Supervisor. Cables shall only be installed when the ambient and cable temperature is above 0°C and has been so for the previous 24 hours.

Cables shall, wherever possible, be arranged to enter equipment from below, particularly equipment located externally or in damp situations. Cables entering cubicles provided with sealed covers of timber or sheet steel shall be accommodated by drilling or dividing the covers with clearance holes as necessary to allow the cable to pass through and be terminated at glands or gland plates provided within such cubicles, so that the covers when replaced prevent entry of dust and vermin.

15.8.2 PROTECTION OF EXPOSED CABLES

Where cables emerge through steel platforms or concrete floors, the Contractor shall provide and position protective curbing or sleeves, made from galvanized material extending 75mm above finished floor level. Sleeves shall be finished flush with the underside of the floor. Final details shall be agreed with the Supervisor on site in respect of all situations.

Cables rising into, or against floor mounted equipment shall be secured to the equipment in a neat manner to ensure that the cables are properly supported and that no undue strain is put on the cable termination or the plant. Where vibration or expansion is a consideration, adequate precautions and vibration loops shall be made at the appropriate position.

Where cables emerge in an area exposed to vehicular traffic and no overhanging projection exists up to one meter above ground level, a galvanized steel pipe or protection cover fabricated from 3.0mm (10SWG) galvanized mild steel (or heavier as appropriate) shall be provided and fixed to the associated structure for a minimum height of 1.5 meters above the local finished ground level.

15.8.3 SELECTION OF CABLE RUNS

The route and arrangement of all cables and the position of equipment and wiring points shall be marked out on site by the Contractor and agreed by the Supervisor before any work is put in hand. Where cable routes have been agreed, the Contractor shall be entirely responsible for measuring the lengths of cable to be ordered and ensuring that the cables are supplied in the correct length.

15.8.4 CUTTING AWAY AND MAKING GOOD

The Contractor shall be responsible for making out the agreed positions of all chases, holes and fixings required for the passage of cables and conduit, and shall arrange with the main Contractor for making good with a weak mix of concrete.

The Contractor shall carry out all the necessary drilling for fixing up to 25mm diameter in the building fabric for the support and fixings of all items supplied or specified herein. Such work
shall be carried out in a neat and workmanlike manner without unduly defacing concrete or brick surfaces. The use of stud fixings employing cartridge guns will not normally be permitted.

Where indicated on the specification drawings, holes have been incorporated in the structures for the passage of cables and any additional cutting away and making good necessary to such structures will be done by the main Contractor with the agreement of the Supervisor.

15.8.5 CABLE MATERIALS

Cables shall be approved design from an approved manufacturer having a certificate of assessed Quality Management. They shall be manufactured within the 12 months prior to delivery and be delivered to site on cable drums or with protective wrappings.

The overall sheath of the cables shall be colored as follows:

- High voltage: Red
- Low voltage: Black
- Earth continuity conductor: Green/Yellow
- Instrument: Grey
- Intrinsically safe: Blue

Cables shall be of the voltage grade, conductor size and type detailed in the specific requirements general specification of the cable type to be used are detailed hereunder:

i) Paper insulated mains cables shall be stranded plain annealed copper conductors, insulated with helically wound paper tape, mass impregnated with non draining insulating compound.

Multi core shall be laid up in a belted construction having a lead sheathing applied overall, protected by a steel wire armouring and having an extruded PVC sheathing overall (PLW/PVC type).

Single core cables shall have a lead alloy sheath without armouring but with an extruded PVC sheathing overall (PLY/PVC type).

ii) Cross linked polyethylene cables shall have stranded, copper conductors with cross linked polyethylene insulation. Multi – core cables shall be laid up in an extruded bedding, steel wire armoured and sheated overall with PVC, to BS 5467 (XLPE/SWA/PVC type).

Single core cables shall have aluminium wire armour cables rated over 6350V shall incorporate graded semi – conducting tapes and core screens in accordance with IEC 502.

Low smoke and fume emission cables shall be as above except that the bedding and sheathing shall be of low smoke and fume emission material, all in accordance with BS 6724 (XLPE/SA/LSF type).

iii) PVC armoured cables shall have stranded copper conductors with extruded PVC insulation, PVC sheated, steel wire armoured and sheated overall with PVC (PVC/SWA/PVC type). Cables shall be in accordance with BS 6346. Conductors of 1.5 mm² and 2.5mm² shall have stranded conductors (7/0.50 and 7/0.67 respectively).
iv) PVC insulated wiring cables shall be 450/750 volt grade single core stranded copper conductors PVC insulated to BS 6004 wiring type)

v) Mineral insulated cables conductors and sheaths shall be solid annealed high conductivity copper separated by highly compressed mineral insulating powder. The cable shall be sheathed overall with PVC.

Light duty rated up to 600V, heavy duty up to 1000V all as BS 6207 (MICS/PVC type).

vi) Telephone cables shall be thermoplastic insulated multipair cables having twisted pairs of copper conductors (telephone type).

vii) Instrumentation cables shall be polyethylene insulated copper conductors with twisted individual pairs screened, polyethylene bedded, steel wire armoured and PVC sheathed overall, all in accordance with BS 5308 part 1 type 2. Conductors shall be 0.5 mm² stranded 16/0.2mm (PE/IS/SWAA/PVC type).

viii) Earth and bonding cables shall have stranded copper conductors PVC insulated and sheathed (PVC/PVC type).

ix) Flexible cables shall have stranded, tinned copper, flexible conductors, EP rubber insulated and CSP sheathed all in accordance with BS 6007 (flexible type).

x) Flame retardant cables shall be EP rubber insulated, tinned copper conductors in a CSP sheath, braided with galvanized steel wire (single cores having phosphor bronze wire) and protected with a CSP sheath overall, generally in accordance with BS 6883.

The sheathing shall have heat and oil resisting characteristics to BS 6899 with an oxygen index value not less than 35 (HOFR type).

15.8.6 COMPRESSION GLANDS FOR CABLES

All glands shall be supplied by the Contractor, and shall be of the brass compression pattern, so designed that any strain on the cable is taken by the steel wire armouring. The glands shall incorporate watertight seals on both inner and outer sheaths and have a separate armour clamping ring to ensure a good with heavy duty locknuts, and the whole assembly is to be protected by an overall plastic sleeve, suitably sealed to prevent atmospheric attack.

Glands fitted to unthreaded gland or adaptor plates, non-metallic equipment, or where specified for circuits likely to pass high fault currents, shall include a brass earthing tag and connections arranged to effectively bond the gland body via a protective conductor to an effective earth point. Were instrument cable screen termination need to be isolated, insulated gland adaptors or non metallic plates shall be used.

Glands and earthing tags shall be compatible with the gland plate and cable armouring materials to prevent electrolyte corrosion; eg. Brass for steel wire armouring / gland plate and aluminum for aluminum wire armouring/gland plates.

Glands fitted in potentially explosive atmosphere shall be similar to those described above, but shall be classified Ex (d) in accordance with BS 5501 Pt 5 and be suitable for use with apparatus groups IIA and IIB.
Where cables to BS 6346, BS 6116 or BS 5467 having an extruded or taped bedding are used for direct entry into such apparatus groups, a sealing stopper box or compound sealed barrier gland shall be used in accordance with BS 5345 Part 3.

### 15.8.7 TERMINATION OF GLANDED CABLES

All cable compression glands shall be fitted by the Contractor, with the insulated conductors and sheathing being carried through the gland. The sheathing shall be preserved where required within the equipment and the insulated conductors properly connected to the terminals of the equipment concerned.

The armouring shall not be cut off short of the gland but shall be properly laid up and secured under the clamping ring provided. The gland shall be fitted finally with an overall PVC sealing sleeve.

All cable tails shall be of sufficient length to connect up to the equipment terminal boards, and in addition to making off the gland, the Contractor shall strip, insulate, ring through and identify the individual cores, fit suitable termination lugs, rings or spade crimps or bootlace ferrules as appropriate, and fit numbered reference ferrules, lace the tails in a workmanlike manner and finally connect up.

All spare conductors within multi-core cables shall be terminated or be folded back with sufficient surplus to allow them to be connected if required in the future.

### 15.8.8 WIRING FERRULES

These shall be of durable materials suitable for permanently affixing to the cable cores and be of the interlocking slide on type, such that the interpretation of the reference is unambiguous.

All control circuits consisting of more than two wires shall be identified by means of wiring ferrules attached to the individual cores at each of the conductor where it is connected to any apparatus or junction box.

Unless otherwise specified, it shall be the responsibility of the cabling Contractor to obtain interconnection terminal data and references from the equipment manufacturer to enable proper connections to be made.

### 15.8.9 CABLE CLEATS

Cleats for fixing cables to walls, structures etc, shall be of the non-corrodible hook and clamp type made of high impact plastic or cast aluminum comprising two halves fixed by means of galvanized rawlbolts or on to galvanized backstraps where the number of cleats makes this more economic.

All assemblies to be complete with necessary galvanized bolt, nut and washers. The spacing of supports or cleats shall in any case be not greater than shown in the following, table but where circumstances merit, closer spacing arrangements may be required by the Supervisor.

The vertical spacing shall be applied to runs sloping up to 30° from the vertical. For greater deviations, the spacing for horizontal runs shall apply.

For outdoor and damp situations, fixing bolts or studs, for cleats, shall not be less than 13mm overall diameter unless otherwise agreed by the Supervisor.

**Cable Support Spacing (mm)**
### Cable Specifications

<table>
<thead>
<tr>
<th>Overall Dia (mm)</th>
<th>Horizontal (mm)</th>
<th>Vertical (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 15</td>
<td>350</td>
<td>450</td>
</tr>
<tr>
<td>15 - 20</td>
<td>400</td>
<td>550</td>
</tr>
<tr>
<td>21 - 40</td>
<td>450</td>
<td>600</td>
</tr>
<tr>
<td>41 - 60</td>
<td>700</td>
<td>900</td>
</tr>
<tr>
<td>Over 60</td>
<td>1100</td>
<td>1300</td>
</tr>
</tbody>
</table>

### 15.8.10 Segregation of Duties and Services

Cables of different circuit categories shall be segregated as defined in the IEE Regulations. Instrument control cabling shall, as far as possible, be routed separate from electrical power cables and long parallel runs to these, or pipework, should be avoided. Where parallel routes and crossovers are necessary, a minimum separation of 250 mm, shall be maintained. Power cables shall not occupy the same as instrument cables.

Similar, separation between the three categories of instrument cables shall also be maintained as scheduled below.

**Separation**

<table>
<thead>
<tr>
<th>Categories to BS 6739</th>
<th>CAT 1</th>
<th>CAT 2</th>
<th>CAT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category 1</strong></td>
<td></td>
<td>200 mm</td>
<td>300 mm</td>
</tr>
<tr>
<td>Instrument power &amp; control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(over 50 V, under 10 A, AC or DC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Category 2</strong></td>
<td>200 mm</td>
<td></td>
<td>300 mm</td>
</tr>
<tr>
<td>High level signals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(less than 5V to 50 V DC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Category 3</strong></td>
<td>300 mm</td>
<td>300 mm</td>
<td></td>
</tr>
<tr>
<td>Low level signals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(less 5V DC)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Only conductors carrying signals of the same category shall be contained within any one multicore cable. Similarly, conductors, forming part of intrinsically safe circuits, shall be contained within multicore cables reserved solely for such circuits.

All screens for instruments cables shall be earthed at one point only, preferably at the main control center.

15.8.11 CABLES IN CONCRETE TRENCHES

Where cables are run in concrete trenches, they shall be supported along the side of the trench on galvanized mild steel hangers, racking, cleats or on a suitable tray run supported from the side of the trench, whichever is specified. The spacing cleats or hangers shall be as specified under “Cable Cleats”.

Where use is made of existing trenches with existing cables installed, it may be necessary to reposition certain cables so that the new cables can be laid in a proper manner and the whole of the cables (new and old) left in an arrangement which is tidy and fulfills the Engineering requirements. Such repositioning work shall be carried out to the directions of the Engineer.

15.8.12 GALVANIZING AND FASTENINGS

Where manufactured or purpose-made steelwork, ladder, racking, tray supports and all fixing nuts, bolts and washers are specified as galvanized, this shall mean hot dipped galvanized finish to BS 729 as far as practicable. Bolts and nuts shall be in matched condition.

Fixings screws for boxes, saddles, clips and other accessories shall be of brass or other non-corrodible type, e.g. cadmium plated steel.

15.8.13 RACKING

Cable racks shall be robustly constructed of mild steel, not less than 2.5 mm (12 SWG) in thickness and galvanized after manufacture. Where cleats are not used, the rack shall be provided with a toe at the outer end racks of proprietary construction may be used subject to approval.

Main rack supports, where fixed to brickwork or concrete, shall be secured with bolts of not less than 13mm diameter. The fixing bolts shall be of the self-securing type with expanding sockets and shall not require grout to hold them in position.

Where fixed to walls in places subject to dampness and in cable subways, the racks shall be set off from the walls by 35 mm x 18 mm thick galvanized packers placed at the bolt fixing positions.

In cable basements, the lower tier of any row of racks, etc. shall be not less than 100mm above finished floor level.

15.8.14 CABLE LADDER

Cable ladder shall be heavy duty type, fabricated from mild steel not less than 2mm thick and galvanized after manufacture. The side rails shall be at least 120mm deep with rungs set towards one edge, spaced at regular intervals of approximately 300mm and having elongated slots to accommodate the cable fixings.
Lengths of ladder shall be coupled and changes in direction, level, and width shall be achieved by means of standard accessories designed for the system, such as radiused risers and gusseted intersections. Cable tray shall be accommodated on the ladder system for cables less than 15mm overall diameter.

15.8.15 CABLE CHANNEL

Cables requiring mechanical support across voids may be accommodated is not less than 40mm square galvanized channel section fitted with plastic closure strips and suitable end caps in preference to tray, and subject to the Supervisor's approval.

15.8.16 CABLE TRAY

Cable tray shall be heavy duty pattern formed from galvanized steel sheet, perforated with elongated holes for cable fastenings. The tray shall have side flanges not less than 25mm deep with returned edges and be galvanized after fabrication. Material gauge shall be 1.5mm (16 SWG) minimum, except that for tray widths less than 400mm, the gauge may be reduced subject to the flange depth and the approval of the Supervisor. Factory made tee sections and bends shall be used where possible.

The cutting of trays shall be kept to a minimum but where unavoidable, all cut edges shall be rounded or folded over and protected with zinc rich cold galvanized paint, holes for cables shall be bushed with nylon/PVC strip edging material. Mushroom headed bolts and nuts shall be used to join sections of tray and accessories and arranged not to present any obstruction on the tray. Capacity amounting to 25% usable tray area shall be left spare.

Where specified herein for dump or corrosive conditions, the trays shall be of unplasticised PVC with non-corrodible nuts and bolts.

15.8.17 CABLES TRAY OR LADDER

Cables shall be laid flat and straight, properly dressed into position and fastened by cable ties or straps of metal reinforced PVC strip material, secured at intervals not greater than 1m for horizontal and vertical runs. Where the run is horizontal but arranged in the vertical plane, support spacing shall be as specified under “Cable Cleats”. Care shall be taken to space the cables to allow adequate cooling. Not more than seven cables shall be embraced by one group tie and not more than two layers of cables shall be run on one tray.

15.8.18 CABLES IN DUCTS

Before drawing any cables in ducts, the Contractor shall ensure that they are clean and free from obstructions.

Adequately spaced temporary supports and cable rollers shall be provided for the drawing in of cables such that abnormal strains and damage to the cable is prevented; approved lubricants shall be used as necessary. Cable stockings shall be used for general drawing work, core pulling eyes being specially fitted for heavy hauls.

Stresses shall not exceed: 10 MN/m² (1500 lb/sq in) on the lead sheath

70 MN/m² (10,000 lb/sq in) on the core
Maximum pulling tension shall not exceed 20 kN (4500 lb).

15.8.19 DUCT SEALS AND CABLE TRANSITS

After the cables are drawn in, the Contractor shall seal the ends of all ducts, pipes or trenches leading into buildings, passing through walls or floors within buildings or underground chambers containing equipment for cabling associated with this contract, whether occupied or not.

All cables, conduits, or pipes shall be sealed into the ducts by means of a secure and effective water, gas, vermin and fire proof material which will accommodate settlement and vibration. This may be a self supporting non-setting mastic packed into the annulus to a depth at least equal to the sleeve diameter, or approved multi-cable transit units with appropriate fillers and insert blocks. All steelwork on such transit assemblies and frames shall be not dip galvanized.

Where specified, transit frames will be incorporated in the construction by the civil works Contractor.

15.8.20 CABLE LAID IN GROUND

Where cables are laid direct in the ground, they shall be well bedded in fine soil or sand, and shall be covered with protective tiles. A minimum of 60mm thickness of fine soil, or sand, shall be supplied around the cables. All cables running along any one portion of route shall be laid at the same time and no extra payment will be made for re-excavation should any cable be overlooked at the time of laying. The Contractor shall be responsible for all excavation, for the supply of fine soil or sand for bedding, and for the backfilling and reinstatement of cable trenches along previously agreed runs. Trenches shall not be backfilled until the installed cables have been inspected by the Supervisor.

15.8.21 CLEARANCE AND COVERAGE FOR BURIED SERVICES

Trenches shall be excavated or ducts laid at such a depth that where cables are laid in the ground, the minimum coverage to the top of the duct or the cable shall comply with the following:

### Minimum Coverage

<table>
<thead>
<tr>
<th>Type of service</th>
<th>Vehicle Roadways</th>
<th>Open ground or footpaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>1000 mm</td>
<td>750 mm</td>
</tr>
<tr>
<td>Others</td>
<td>750 mm</td>
<td>500 mm</td>
</tr>
</tbody>
</table>
Where possible, electric cables and their ducts shall be routed so that subsequent excavation to expose another service will not disturb cables and electrical ducts. Where separated routes are not practicable then the following clearance shall be ensured:

### Minimum clearances

<table>
<thead>
<tr>
<th>Type of Cable</th>
<th>To HV</th>
<th>To LV</th>
<th>To other</th>
<th>To Gas/Water etc</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>150mm</td>
<td>300mm</td>
<td>300mm</td>
<td>300mm</td>
</tr>
<tr>
<td>LV</td>
<td>300mm</td>
<td>150mm</td>
<td>250mm</td>
<td>300mm</td>
</tr>
<tr>
<td>Others</td>
<td>300mm</td>
<td>250mm</td>
<td>150mm</td>
<td>300mm</td>
</tr>
</tbody>
</table>

The spacing of cables installed at the same time shall be generally in accordance with the above table, but where circumstances permit a more economical arrangement may be specified by the Supervisor.

As far as possible, electric cables shall avoid the same route as other services except where otherwise directed. Where such segregation is not possible then 50mm thick concrete slabs may be used as separators with the Supervisor’s approval. Adequate slack shall be left at each bend for cables laid direct.

15.8.22    **PROTECTIVE COVER TILES**

These shall be of the concrete apex pattern engraved “Danger Electricity” or similar, of dimensions appropriate to protect the number of cables along a particular route.

Following the installation and compaction of the bedding soil or sand over the cable, covers shall be laid by the Contractor so that they overlap by approximately 30mm each side of the cable run. Where cables are displaced by no more than 300mm vertically, covers shall be installed only over the upper cable run.

15.8.23    **BACKFILLING AND REINSTatement**

Reinstatement of soil following laying of cable shall be effected by backfilling in 100 mm layers. Hand ramming shall be employed for the first two layers and power ramming for subsequent layers.

After hand ramming to a depth of 200mm, a yellow colored plastic type approximately 150mm wide with the words “CAUTION CABLE BELOW” shall be provided by the Contractor and run over the center of the route of each cable run by the Contractor.

Top soil is to be removed from the site and areas surrounding the excavation shall be restored to their original condition.
Where tarmac surfaces have been excavated, the final 200mm backfilling after allowing the settlement shall consist of 120 mm of compacted, graded hardcore, followed by a 60mm concrete screed and a 20mm top dressing of tarmacadam.

15.8.24 ROUTE MARKERS
These shall be of reinforced concrete with the words “ELECTRIC CABLES" cast in one face. They shall either be of the flush block type approximately 300mm x 300 mm x 150 mm, or the pillar type approximately 600mm high erected with 300mm projecting above the ground, as directed by the Supervisor.

As soon as site conditions allow, the location of each group of buried cables and every joint shall be accurately marked. Concrete marker posts or blocks shall be set at the origin, changes of direction, joints and otherwise at intervals of 20 meters or as described by the Supervisor.

15.8.25 CABLE IDENTIFICATION
Identification labels of durable material shall be provided suitable for permanently affixing to the cable sheath by means of buckle type straps, and shall carry the cable reference in PVC channel strip. The reference character sizes shall be not less than 4mm.

Cable identification labels shall be fitted to each cable end below its respective cable gland, where the cable passes through ducts or trenches, and at each entry and exit to a room or building.

15.8.26 TRUNKING MATERIALS
All trunking bends, cover plates, tees, flanges, supports, fixings, etc, shall comprise of an approved complete system capable of adaptation and erection without size modification and with compatible manufactured bends and accessories being used as far as practicable. The trunking access covers shall comprise of easily removable convenient sized lengths retained over the entire length by clip-on features or suitable fastenings which shall not obstruct cable entries. Overlapping covers and internal flanges or coupling sleeves shall be provided at all trunking junctions. All cable supports, edges, sharp internal angles, etc. shall be protected with PVC or formed to present a smooth edge.

i) Metal trunkings and fittings shall be zinc coated or galvanized mild steel not less than 1.2mm thick (18 SWG). Copper earth bondings straps shall be fitted at the junction of adjacent lengths of trunking and fittings.

ii) PVC trunkings and fittings shall be of high impact heavy duty rigid PVC.

15.8.27 TRUNKING INSTALLATION
As far as practicable, trunking shall be installed clear of other services and positioned so that future access is not restricted. Drawings detailing supports, terminations, sizes, and center lines of trunking shall be submitted to the Supervisor for approval prior to commencement of the installation. Provision for expansion of the trunking materials shall be made in accordance with the manufacturer’s instructions. Trunking shall include fire barriers of fiberglass wadding fitted at each point where the run passes through fire walls and floor levels. All cable and
conduit exits shall be fitted with bushes without decreasing the effective cross-sectional area of the trunking.

All trunking shall be protected against damp and corrosion, and where entries, joints and/or bends have been installed, cut and/or sawn wedges exist, all damaged galvanizing shall be made good by a minimum of two coats of primes (zinc based galvanized or similar approved equivalent) and two top coats of aluminum paint of an approved quality. For extensively damaged galvanized coatings the items shall be re-galvanized or replaced with acceptable components.

Conduits shall be connected to the trunking by means of couplings and male bushes to obtain a good earth connection.

To assist identification within trunking, final circuit wiring shall be formed into groups held by buckle clips or PVC straps. Each group shall be labeled where wiring enters or leaves the trunking and at intervals of approximately 15 meters in long trunking runs. In vertical runs the trunking shall be fitted with PVC coated pins at approximately 600mm centers to be used as cable supports.

Separate conductors comprising the same circuit shall be run enclosed together throughout their length.

**15.8.28 CABLES IN CONDUIT**

For wiring installations carried out with PVC insulated cables in conduit, the wiring throughout is to be on the “looping in” system and not “tee” or other intermediate joint between fittings will be permitted, and in no case must the cable be drawn into the conduits until all such conduits, bends, boxes or other fittings have been fixed permanently imposition and approved by the Supervisor.

Any water which may accumulate in the conduit during erection shall be removed before any cables are drawn in. sufficient slack shall be allowed at each point to ensure that all conductors are under no physical strain or tightness.

Separate conductors of the same circuit shall always be drawn into one conduit, but cables forming final circuits connected to different distribution boards shall not be drawn into the same conduit or box.

The cables shall be colored Red or Black as required to distinguish opposite poles, a Black conductor shall be used throughout for neutrals and connected to the neutral pole of the supply system.

No reduction of the strands forming the conductors will be allowed at switch or other terminals; all the stands shall be efficiently secured by screw, nuts and washers or other approved means and all conductors shall be so proportioned that the drop of potential does not exceed that indicated by the IEE wiring regulations.

After the contract award, six copies of a table showing the proposed arrangement of wiring circuits and the size of cables to be used, shall be submitted to the Supervisor for his approval before any work is put in hand.
15.8.29 CONDUIT MATERIALS

i) **Metal:** all conduits and fittings shall be class 4 galvanized steel, heavy gauge welded and screwed smooth bore tube employing threaded couplings and complying with BS 31 and BS 4568. As an exception, lengths of conduit completely encased in structural concrete may be finished with black enamel.

Conduit boxes shall be of malleable cast iron. For surface work the lid shall be of cast iron machined or ground to make good contact with the boxes. Adaptable boxes for surface work shall be of malleable iron.

ii) **PVC:** all conduits and fittings shall be heavy duty gauge PVC in accordance with BS 4607.

iii) **Flexible:** Flexible conduits shall be waterproof metallic type PVC sheathed and adaptors to rigid conduit shall be of the internally rifled split brass type.

Flexible conduit shall only be used for bridging expansion joints in a building, or for final connections from the rigid conduit system to the terminal boxes of equipment subject to vibration or adjustment. All such conduit shall have an earth continuity conductor connected through the flexible adaptor at each end. Individual lengths of flexible conduit should not exceed 400mm.

15.8.30 CONDUIT INSTALLATIONS

The conduit system shall be continuous throughout so that the cables are fully protected. No conduit smaller than 20mm shall be used. Provision shall be made for draining condensed moisture where directed by the Supervisor. The conduit throughout shall be of adequate capacity in accordance with the IEE wiring regulations, and shall be arranged with draw in boxes to allow for easy draw in or out of any one or all of the cables in the conduit. For multiple parallel conduit runs, draw boxes may be combined by an appropriately sized adaptable box, provided segregation of services is maintained.

Wherever possible, conduits shall be installed either horizontally or vertically and changes in direction shall be effected by easy bends or well formed sets without altering the section or opening joints; solid or inspection tees or elbows shall not be installed.

The inside surfaces of the conduit ends and all fittings shall be smooth and free from burrs and all other defects.

For surface work the conduits shall be fixed by means of spacer bar saddles or substantial distance saddles. Where conduits pass directly through concrete or similar floors and where washing down is likely to occur, the conduits shall be sleeved. The sleeve shall be grouted flush with the underside of the floor and extend 75mm above the top surface of the floor. Where conduits are run on steel work, they shall be fixed by means of purpose made clips. If the Contractor requires to drill any steel work, permission in writing must be obtained from the Supervisor.

In exterior situations, all joint box lids, etc, shall be made waterproof with compound or gaskets as appropriate.
i) **Metal conduit**: installation shall be electrically continuous throughout, and at all terminations conduits shall either be screwed into approved spigot boxes or coupled by means of screwed couplings and smooth bore hexagon bushes. In no case shall the length of the thread into which the conduit is screwed be less than the outside diameter of the conduit. Where tapped entries are provided and where internal space permits, a ring bush shall be used as a lock nut.

All exposed threads and damaged galvanizing shall be cleaned and thoroughly coated with zinc rich paint. If black enamel conduit has been approved for use, then where the black enamel is damaged the conduit shall be satisfactorily repainted to the approval of the Supervisor.

Contact between conduit and gas pipes shall be prevented wherever possible by adequate spacing, or by means of insulating distance pieces. Where the conduit is or may be in contact with any other pipes or metal work, an efficient metallic connection shall be made between the conduit and the pipes or metal work and the incoming gas, water and electricity services shall also be bonded together, all as required by the IEE wiring regulations.

ii) **PVC conduit**: installations shall have couplers and spouted fittings joined with a permanent solvent adhesive, and provision shall be made in surface conduit installations for expansion by using a semi-permanent mastic jointing seal in expansion couplings as necessary.

Conduits shall be fixed by means of spacer bar saddles spaced as defined in the IEE wiring regulations.

These figures apply to surface runs at normal room temperature. Where high ambient temperatures or rapid fluctuations are likely, these spacings shall be reduced as agreed with the Supervisor. Conduit shall also be secured 150mm on either side of a bend.

The bending radius of PVC conduit shall be not less than 4 times the diameter of the conduit and bending shall be achieved by the use of the correct size bending spring. If bending is to be carried out in temperatures below normal room temperature, frictional heat shall be applied to the conduit before bending commences.

iii) **Potentially explosive area**: conduit installations shall employ metal conduit and comply with the relevant parts of BS 5345 for the specified zone classifications.

All screwed joints whether entering into switchgear, junction boxes or couplings, must be secured by a standard lockout to ensure a tight and vibration-proof joint which will not slacken during the life of the installation and thus impair continuity and flameproofness. The length of thread on the conduit must be the same as the fitting plus sufficient for the lockout. Due to the exposed threads, the use of running joints is not permitted and specially designed flameproof unions shall be used for securing conduit to an internally screwed entry. All unwanted outlets shall be plugged with approval blanking plugs.

When a conduit passes from a hazardous to a safe area, the flameproof section must be terminated by a stopper box or sealing device mounted in the safe area.

All conduits entering directly into a flameproof enclosure, where exposed terminals are fitted, shall be sealed at the point of entry by means of stopper boxes, which must be entirely filled with a non-oxidizing compound. Conduit boxes or indirect entry compartments not containing exposed terminals do not require sealing.
Conduit stopper boxes of certified design must be used, having splayed, plugged filling spouts in the cover to facilitate the entire filling of the interior with compound.

15.8.31 INTRINSICALLY SAFE CIRCUITS

Circuits complying with the requirements of BS 5345 for intrinsically safe circuits shall be arranged such that all cables are identified and segregated as detailed in BS 6739.

Conductors forming part of an intrinsically safe circuit shall only be contained within multicore cables reserved solely for such circuits and must be terminated separately.

Intrinsically safe circuits shall be connected to a separate earthing system as detailed in BS 6739 and any shunt diode barriers shall be installed in accordance with the certification requirements.

15.8.32 MINERAL INSULATED CABLES

Cables shall be installed saddled to trays, run on the surface or as otherwise specified. The spacing of saddles shall be in accordance with the IEE regulations. Cable termination accessories and saddles shall be brass or copper and shall be supplied by a particular cable manufacturer. All cables shall have a temporary mastic seal applied during installation. Once cut to length, each, cable shall be permanently terminated without delay by using an approved seal. Termination seals shall be anchored in approved glands and locked into screwed conduit entries or gland plates forming part of accessories or equipment. Wherever possible, glands shall be locked in position with locknuts. Shrouds shall be fitted over glands except where they are encased in the structure of the building.

In cables where dampness may be present or where dissimilar metals are present, corrosion inhibiting paste shall be interposed in all voids between surfaces in contact.

Where MICS cable serves an inductive circuit liable to voltage surges or circuits subject to lightning surges, appropriate surge diverters shall be connected across the inductive sources (coil etc) or between lines and earth at the point of entry in the case of lightning protection.

15.8.33 SEALING BOXES FOR LEAD SHEATHED CABLES

For terminations at plant items, these will be provided by others except as specified herein and will be of cast iron, compound filling type, provided with filling plugs in the appropriate position for filling with compound when mounted on the associated equipment. Each will be complete with wiping cone armour clamp. For through joints or tee joints, the Contractor shall provide suitable boxes as detailed herein.

All necessary jointing materials, filling compounds and earthing requirements shall be included for all joints to be made under this specification.

15.8.34 LEAD SHEATH CABLE TERMINATIONS

The Contractor shall submit to the Supervisor, for approval, the proposed method for terminating lead sheathed cables. Terminations must ensure that moisture cannot creep along the cores of the cable nor in between cores.

Where cable tails are to be brought out, cores shall be cut back below the level of the sealing compound and connected to the tails using a brass ferrule sweated to provide a solid damp and oil migration barrier between tail and core.
Paper insulated tails shall be double half lapped with an approved non-hygroscopic insulating tape. Alternative for LV cables, instead of an approved tape, a length of temperature sensitive, PVC sleeving may be heat shrunk over the tail, joint and cores.

The continuity of armoured cables shall be maintained by an efficient bond between the cable armour, the gland and the metalwork of the equipment at which the cable terminates, in order that a reliable path provided for fault currents.

Compression glands shall be to an approved pattern providing adequate bonding and armour clamping facilities.

Cables cores shall be fitted with suitable termination lugs and be phase colored as appropriate and marked with an approve label to correspond with the diagram of connections.

Glands exposed to weathering shall be totally wrapped in impregnated tape to exclude all moisture from the gland connection and have an outer wrapping of PVC tape.

15.8.35 JOINTING

Personnel employed for jointing power cables including types of terminations for aluminum conductors shall have received specialized training. Joints in all buried or stranded cables shall be sweated, but compression joints will be permitted for stranded copper or solid aluminum conductors at terminations only.

Joints shall be completed without pause or unnecessary delay. Reduction in the number of strands is not approved but limited reduction in the cross sectional area of solid conductors by an approved method is permitted. Cable cores shall be cut with due regard to fanned out terminations, leaving a neatly arranged minimum of slack core between cable and terminal. As far as practicable all HV joints shall be made to avoid crossed or twisted cores, final phasing out being arranged in the cable box termination.

Where a crossed joint is approved, a sleeve, at least 30% longer than standard, shall be used to minimize the distortion of cores. The Supervisor shall witness the final termination in order that the Contractor may prove the phasing before the last joint in a cable run is made.

Cables shall be jointed color to color or number to number. Where numbered cores are to be jointed to existing colored cores etc. the Supervisor will direct the system to be used.

A reliable continuity path shall be provided for fault currents flowing via the lead sheath and/or armouring by means of an efficient earth bond between the cable armouring and sheath on each side of the joint.

15.8.36 SEALING COMPOUND

The outer protection boxes for joints or terminations shall be fitted with compound of the hot or cold pouring variety of a type compatible with the cable materials to be agreed by the Supervisor.

Compounds which require heating shall be evenly heated, well stirred and the temperature maintained within the recommended pouring ranges. Cable accessories shall be thoroughly dried fillings and pre-warmed where possible.

Where cable sealing boxes are fitted beneath oil filled compartments or where inverted cable sealing boxes are used due to cables entering from overhead, the compound shall be of the oil resisting type to prevent any risk of softening due to contamination from the insulating oil.
Cold pouring resin encapsulation materials shall be carefully mixed to avoid entrapped voids or uncured filler materials.

15.8.37 SINGLE CORE CABLES

Circuits, utilizing single core cables, shall be installed under IEE “defined conditions” but to minimize mutually induced voltages, three phase circuits shall be run for as long as possible throughout the route in close trefoil formation. Where a circuit employs more than one cable per phase, each trefoil group shall contain one cable of each phase, allowing at least 50mm clearance between adjacent groups. Cleat spacing shall not exceed 1.2 meters.

Ferrous screens or armour shall not be used on such cables and associated terminations or enclosures, and the use of magnetic material which would provide a flux path in service shall be avoided.

To control induced voltages, single core cables shall have their metallic sheathing and/or aluminum armouring bonded together at both ends of the run, the bonding being connected directly to the system earth bar or other approved points. Cables having no insulating oversheath shall have their metallic sheaths or armouring bonded together by the use of normally spaced, well fitting, no-magnetic metallic trefoil cleats.

In all case the bond shall be sized to carry the prospective fault current and have a conductivity not less than that of the cable sheath and/or armouring. Bonds for cables laid in a flat formation shall also allow for the unequal sheath currents.

To prevent circulating currents, bonding and earthing at the supply end only of short runs of single core cables will be permitted where it can be shown to the satisfaction of the Supervisor that the induced voltages are safe under fault conditions.

15.8.38 BUSDUCTS

Connections between major electrical items shall, where specified employ a fully integrated, totally enclosed, busduct system to BS 5486 (IEC 439-2), comprising HDHC copper conductors embedded in a non-flammable, self extinguishing, cast epoxy resin insulation.

To complete assembly including junctions shall be completely free of condensation and watertight to IP 68. Fire resistance shall be class M1 (F) and class B1 (D) to IEC 332.

All parts of the system shall be from the same manufacturer and comprise factory made lengths, bends, tees and terminating pieces to suit the physical application and layout of the installation.

The voltage and prospective fault ratings of the system shall be suitable for the application and the current rating shall be based on the most onerous method of installation for the circuit. The cross sectional area of the conductors shall not be reduced throughout a given circuit.

The installation shall allow for any necessary expansion, be properly supported and connected in accordance with the manufacturer’s instructions. Fire and damp-proof barriers shall be provided when passing through walls, floors, ceiling etc.

Conductors shall be jointed by means of double junction plates, one on each side to ensure low joint resistance. The junction shall be compressed by means of high tensile steel nuts and bolts. After assembly, all junctions shall be overcast with the same materials mixed under
vacuum, as used for the busduct elements thus maintaining a homogenous and weatherproof enclosure throughout.

Provision for conductor shifting, transfers and paralleling, shall be made within the terminal elements.

**15.8.39 EARTHING AND BONDING**

All no-current-carrying metal parts of the electrical installation and other services shall be properly bonded together and connected by means of a protective conductor to an efficient earth in accordance with IEE wiring regulations.

All connections shall be by means of an approved mechanical joint or adjustable clamp which shall be accessible and made secure with brass nuts and bolts. On no account shall paint or spring washers of ferrous metal be used.

Protective conductors shall provide earth continuity either through the conduit, armouring, lead sheathing, cooper sheathing, steel trunking or by independent earth tapes or PVC sheathed wires, according to the system of wiring employed. Where PVC conduits or trunking systems are employed the protective conductor shall be routed within the conduit or trunking.

Wherever cable armouring is used as a protective conductor, care must be taken to ensure an adequate earth bond and additional bonds to the metalwork shall be provided as required.

**15.8.40 MAIN EARTH CONNECTIONS**

Where a main earth bar is to be installed it shall be connected in a ring with the earth bar provided on the switchgear and any existing main earth ring in the building. The glands and wire armour of cables shall be connected to the switchgear earth bar or directly to the earth ring.

The main earth bar shall be formed from high conductivity, hard drawn copper bar grade C101 to BS 1433 of not less than 31.5 mm x 6.3 mm cross section. Any joints in the earth bar are to be brazed together using brazing alloy type CP1 to BS 1845 or pan head riveted and sweated. The bar overlap/thickness ratio shall be not less than 5.

The earth bar shall be secured to an inside wall in accessible position. Connections to the metalwork of electrical plant shall be made in soft drawn copper tape or equivalent sized cables. Where plant is subject to vibration, connections shall be made using flexible conductors. All earthing conductors and equipotential bondings cables shall have a green and yellow PVC sheath, and earth bars shall have a green/yellow marker tape or sheathing applied.

Reinforced concrete or sheet steel piling shall be connected to the earthing system as directed by the Supervisor. Structures of steel-framed buildings shall be bonded to the main earth bars.

Earth rods are to be 16mm (5/8”) diameter driven by an automatic hammer to a depth of approximately 4 meters. Spacing between rods is not to be less than the depth of the rod. Inspection pits shall be provided for each electrode to allow subsequent access for testing.

Where copper earth tape is buried below ground level it is to be served with PVC or double half lap wrapped with an approved grease-impregnated tape for a distance of at least 300mm above and below ground level.
The routing, dimensioning and arrangements of all main earth bars and connections shall be detailed on the schedules and approved drawings. Disconnecting links for testing purposes shall be provided as shown therein.

15.9 CIVIL WORKS FOR CABLE INSTALLATIONS

15.9.1 GENERAL

The works involved are associated with the cable installation and comprise trenching, excavation, supply, laying and jointing of cable ducts; building of jointing and draw in pits; application of bedding sand or soil; temporary reinstatement of ground. The installation of cables, supply and laying of cable covers and preparation of route record drawings will be carried out by the Contractor appointed to undertake the cable installation. Excavation, duct and cable laying and backfilling shall proceed in accordance with an agreed programme ensuring that all cables and ducts are satisfactorily covered immediately following laying and after approval from the Supervisor.

15.9.2 TRENCHING MEASUREMENTS

The depths and widths of individual trenches for cables or ducts, and the clearances from other services, shall be determined by reference to the clauses in this part. For contracts let with scheduled rates it will be assumed, upon re-measuring, those excavations have been in accordance with this specification unless the Supervisor advises the contrary.

15.9.3 COVERAGE OF BURIED CABLES OR DUCTS

Unless otherwise specified, trenches shall be excavated or ducts laid at such a depth that the minimum coverage to the top of the duct or the cable shall comply with the following:

<table>
<thead>
<tr>
<th>Type of service</th>
<th>Vehicular Roadways</th>
<th>Open ground or Footpaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>1000mm</td>
<td>750mm</td>
</tr>
<tr>
<td>Others</td>
<td>750mm</td>
<td>500mm</td>
</tr>
</tbody>
</table>

15.9.4 CLEARANCES BETWEEN OTHER SERVICES

Where possible, electric cables and their ducts shall be routed such that subsequent excavation to expose another service will not disturb cables and electrical ducts. Where separate routes are not practicable then the following clearances shall be ensured.

<table>
<thead>
<tr>
<th>Type of Cable</th>
<th>To HV Cable</th>
<th>To LV Cable</th>
<th>To Other Cable</th>
<th>To Gas/Water etc Pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>150mm</td>
<td>300mm</td>
<td>300mm</td>
<td>300mm</td>
</tr>
<tr>
<td>LV</td>
<td>300mm</td>
<td>150mm</td>
<td>250mm</td>
<td>300mm</td>
</tr>
</tbody>
</table>
Where such spacing are not possible then 50mm thick concrete or stone slabs may be used as separators with the Supervisor’s approval. Each cable shall be at least 50mm clear of the side of the trench excavation.

15.9.5 EXCAVATIONS AND PRECAUTIONS
Turf and topsoil shall be carefully removed and positioned as directed by the Supervisor for subsequent reinstatement in their original position.

Broken land and damage to other services shall be reported to the Supervisor and marked on site.

Excavation shall be kept free of water and properly shored up. Other services uncovered shall be adequately supported by slings or other means, and protected.

15.9.6 BEDDING FOR CABLES
Prior to laying the bedding for the cable, the bottom of the trench shall be cleared of loose and projecting rubble, etc, and evenly graded.

A sand bedding shall be applied below and around the cables and shall be thoroughly compacted. Thickness of bedding around the cable shall be 60mm except where soil contains coke, ash or other corrosive matter where the thickness shall be 200mm. Bedding shall be well graded sand, free of clay with minimum particle size of approximately 0.08 mm (BS sieve No 200) and maximum particle size of approximately 2mm (BS sieve No 7) 60% of the material shall pass through BS sieve No 72. Where the Supervisor directs, local soil may be used for bedding after passing through a 10mm mesh sieve provided the material is evenly graded.

15.9.7 DUCTS AND COUPLINGS
Buried cable ducting shall be smooth bore UPVC pipe to BS 4660 (or medium density polyethylene, where greater flexibility is required) jointed by spigotted ends or couplings of compatible, non-deteriorating material. These couplings shall be a self-aligning, push fit and incorporate seals to prevent the ingress of water and other fluids as far as possible and the joint so formed shall be equal in internal diameter to the duct itself.

Ducts entering below ground level into a building or structure shall emerge inside the building either directly into an accessible trench or void, or the duct shall have an upturned bend to emerge adjacent to an inside wall face, or as otherwise specified.

All exposed upturned duct ends shall project at least 75 mm clear of the finished floor or ground level to prevent unwanted collection of water or debris and protect the cable exit.

15.9.8 BEDDING OF DUCTS
Prior to laying ducts in trenches, trench bottom shall be evenly graded, cleaned of loose rubble, etc, and compacted to form a solid foundation. In rocky soil a layer of loose, rock-free earth shall be used for this foundation.

Where ducts are laid beneath vehicular access roads, the ducts shall be haunched in C20 concrete for the full width of the road and extend each side beyond the curbside by at least 300mm.
15.9.9 DUCT ALIGNMENT AND CLEANING

Ducts shall be laid in straight lines as far as possible with minimum deviation. Where bends are required, these may be manufactured, pre-formed bends with a radius of not less than 10 times the bore diameter. No continuous duct run shall incorporate more than two bends nor turn through a total of more than 135° in any plane. No single bend shall exceed 90°.

Where greater changes of direction are necessary, cable draw pits shall be incorporated in the run as required or defined by the Supervisor.

A non-corrodible draw wire or rope shall be left in each duct and plugs shall be inserted at the ends of each section of duct to prevent entry of soil or stones. On completion of the ducts and prior to drawing in cables, a circular wire brush 6mm greater in diameter than the duct shall be pulled through each duct.

15.9.10 CABLE DRAW PITS

Cable draw pits shall be brick enclosed construction fitted with suitable removable access covers and have bellmouthed duct entries into the pit interior. Unless otherwise specified, the interior dimensions shall be determined by the Supervisor but shall be not less than 750 x 600mm in plan and the depth shall be determined by the invert of the lowest duct with a minimum of 50 mm clearance to the base of the pit.

Where specified, a pulling eye for the use of a 2000 kg pulley block shall be provided opposite each group of ducts in the wall of the pits, and positioned to facilitate as straight a pull as possible on the cables with the use of a pulley block.

The base of the pit shall be formed with a fall towards a sump, suitably placed for pumping dry.

15.9.11 BACKFILLING AND REINSTATEMENT

Reinstatement of soil following laying of cable shall be effected by backfilling in 100mm layers. Hand ramming shall be employed for the first two layers and power ramming for subsequent layers. Backfilling shall only proceed in the presence of the Contractor responsible for laying cables.

After hand ramming to a depth of 200mm a yellow colored plastic tape approximately 150mm wide with the words “caution electric cable below” shall be provided and run over the center of the route of each cable run.

Top soil is to be replaced and the level of the finished reinstatement shall not protrude more than 50mm above ground level. All surplus spoil is to be removed from the site, and areas surrounding the excavation shall be restored to their original condition. Where tarmac surfaces have been excavated, the final 200mm backfilling after allowing the settlement shall consist of 120mm of compacted graded hardcore, followed by 60mm concrete screed and a 20mm top dressing of tarmacadam.

15.9.12 CABLE TRENCHES

Trenches cast in floors or ground shall be of specified internal dimensions to suit the specific installation. They shall have smooth vertical sides and bottom with provision for cover plates to finish flush with the finished floor surface.
Inside bends shall be either radiussed (150mm min), or chamfered at least 100mm back, equally angled from each direction. Such radiusssing or chamfers shall extend the full height of the trench; however the top 100mm may be corbelled out to simplify the cover plate arrangement.

Trench covers shall be of aluminum or galvanized mild steel chequer plate (min 8mm thick) supported to prevent undue flexing and having suitable holes to allow removal by standard lifting keys. Support shall be by means of steel curbing rebates cast into the trench top edges, providing a landing width of at least 30 mm.

Additional or alternative support for switchboards, etc., shall be front at least 75 x 35 mm channel section cross bearers and transverses trimmers, fixed or cast into the floor and located to suit equipment fixings, access requirements and floor cover spans.

To prevent differential deflection, butt straps shall be fitted to the underside of floor plates which have no other support.

Edging curbs suitable for mild steel chequer plate shall be painted in red oxide primer; the curbing may be tapped to accept cover securing screws. Where aluminum plates are used in contact with any mild steel supports, a bitumen coating on the points of contact shall be used.

15.9.13 CABLE TROUGHS
Pre-cast concrete trough section shall be laid either flush or upon the finished ground level as specified.

The section shall be sized and provided with rebated covers to suit the span and any imposed load conditions specified, e.g. at road crossings. Provision shall be allowed for handling/removal of such covers. Pre-formed junctions and turn-outs shall be provided with suitable chamfers on inside bends.

15.9.14 TRANSFORMER BAYS
The dimensions and weight of the transformer are specified herein in order that access clearances and loadings may be determined. The transformer bases shall be located at ground level, accessible from a made up road or hard standing to the bays.

Each transformer bay shall be separately enclosed to prevent unauthorized access and be partitioned by plain brick blast walls up to a height of 2.2m., with one side being fitted with full width, lockable open-mesh gates or louvered doors for access and ventilation. Where roof covering is necessary, it shall be of non-flammable construction and allow 800mm clearance at least for natural ventilation of the transformer.

The bay shall be sized at least 1.5m greater than the transformer width (across terminal boxes) and at least 1.0m greater than the transformer depth. A level concrete mounting ramp shall be located within the bay area suitable for rollering the transformer into position, and a pulling eye shall be fitted centrally in the rear wall at ground level.

Provision shall be made for the oil to be conducted to underground drainage tanks having access for pumping out. Separate tanks shall be provided for each transformer.

Cable ducts shall be arranged to suit the cable routes and have up-turned spouts projecting clear of the designed oil/pebble level for the bund.
Alternatively, the area surrounding the plinth within the bay, and enclosed after transformer installation by a low bund wall if required, shall be excavated sufficient to accommodate 10% in excess of the transformer oil capacity when filled with fire quenching 50mm graded pebbles having 30% voids. Provision shall be made for drainage of accumulated rainwater.

For silicon cooled transformers of sealed construction, quenching pebbles will not be required, but an oil catchments area shall be provided where specified.

15.9.15 EARTHING CONNECTIONS

Two earthing connection tables shall be welded the concrete. Reinforcing bars in the positions shown on the specification drawings and be incorporated in the concrete encased, reinforcing steel network of the building foundations. The network shall be not less than 30m in length, buried at least 1m below ground level. The total length may comprise more than one bar, welded together to form the required minimum length.

Each earthing tab shall be of hot dip galvanized flat bar steel 50mm wide x 6mm thick, attached by welding to at least two parallel reinforcing bars (9mm diameter minimum) and of sufficient length to project beyond the finished concrete surface by at least 100mm in an accessible position.

The welding shall be of good mechanical strength over full 50mm tab width and shall be located in an area of the rebar not required to provide structural strength, such as a trimmer or surplus length of the bar.

The reinforcing steel of existing buildings may be used to provide the electrode for a new installation or to replace a damaged or deficient conventional earthing system. A substantial rebar of a main beam or column shall be exposed by chipping away its concrete cover. The earthing terminal plate shall be welded to the rebar and the removed concrete replaced by mortar.

15.10 ELECTRIC ACTUATORS

15.10.1 GENERAL

Electric actuators shall be suitable for outside installation and all components shall be housed in waterproof enclosures to IP67 or better, which shall incorporate an anti-condensation heater.

The whole actuator shall be of easily maintained, robust construction and shall be sized to guarantee the penstock, or valve, or closing, at the maximum differential pressure specified herein. The operating speed shall be approximately 300mm/minute unless otherwise specified.

All actuator component items shall be coupled via flanged mating faces secured by stainless steel bolts except valve mounting fixings subject to thrust forces which shall be means of suitably sized, high tensile steel bolts.

The gearbox shall be of the worm gear totally enclosed, oil bath lubricated type, having a cast iron enclosure suitable for opening at any angle and provided with the appropriate filling and drain plugs. The actuator drive bushing shall be easily detachable for machining to suit the valve stem or gearbox input shaft and the length of the drive nut shall not be less than 1.25 x the spindle diameter.

The drive shall incorporate a lost motion feature to provide the additional torque required to unseat the valve from the “Open” or “Closed” position in the event of the valve being in either
for an extended period. This movement shall give a hammer blow of sufficient force to free the valve.

The output shaft shall be hollow to accept a rising spindle where appropriate, and incorporate thrust bearings of the ball or roller type. The design shall preferably permit the gear case to be opened for inspection without releasing the spindle thrust or taking the penstock / valve out of service.

15.10.2 MOTORS
All motors fitted to actuators shall be specially designed for the application and of the squirrel cage induction type for operation from the supply system specified.

The rated output of the motors shall be determined by the tender in relation to the requirements of the mechanical plant described elsewhere in this specifications, and starting torque shall be at least 10% in excess of maximum service requirements.

If not stated different in the Bill of Quantities the following conditions apply:

The motors shall preferably be 4 pole 1440 revs/minute machines designed with adequate thermal capacity to ensure that the actuator and starter can adequately perform, without overheating, the number of successive opening and closing operations called for in the specific requirements, and in no case shall this number be less than three.

Each motor shall be fitted with a thermostat or thermistor arranged to stop the motor in the event of dangerously high temperature in the motor windings due to over-current or an abnormally high number of starts per hour.

15.10.3 MANUAL OPERATION INTERLOCK
The actuator shall have a handwheel for manual operation which will be at standstill during motor operation. A lever shall be provided for engaging handwheel drive, and this shall be interlocked so that when starting the motor the handwheel is automatically uncoupled without danger to the operator. Provision shall be made for the lever to be padlocked in either position to prevent hand or motor operation as required.

15.10.4 POSITION MONITORING
A mechanical position indicator, showing the open, closed or intermediate positions of the valve on a visible dial, shall be incorporated in the actuator housing. Alternatively, where specified, a continuous position indicator shall be provided.

Remote position indicators, where specified, shall be controlled from a suitable potentiometric drive arranged to provide a continuous proportional signal from “Open to “closed” positions.

15.10.5 POSITION CONTROL
Where specified for control purposes, a current position transmitter shall be provided to give a positive 4-20mA signal proportional to the valve position, and shall incorporate zero and span adjustments to suit the actual valve travel.
15.10.6 TORQUE AND LIMIT SWITCHES

All switches shall be accommodated within the actuator housing and all contacts and mechanism shall be of sealed, rustproof and robust construction and have a self-cleaning wiping action. Adjustable torque limiting devices and switches shall be provided to trip the starter in the event of mechanism latched to prevent torque tripping during unseating.

Limit switches shall be arranged to trip the starters when the fully open or fully closed positions are reached. Should the manufacturer consider it desirable (to ensure proper seating) the travel may be stopped in the fully closed position by the torque limit switches, but in this case the fully closed limit switches shall still be provided, although they will be adjusted to be inoperative.

15.10.7 AUXILIARY SWITCHES

Auxiliary changeover switches shall be provided to operate at each end of the travel, in order that they may be used for remote controls, or indications monitoring the “open” and “closed” positions.

15.10.8 TERMINAL FACILITIES

All electrical components shall be wired out to terminal blocks in a common terminal chamber incorporated in the actuator housing but separated from all actuator components by means of a watertight seal.

Each terminal shall be labeled to correspond with the diagram of connections and shall be capable of accommodating not less than 2.5 mm² copper conductors. AC and DC terminals shall be clearly segregated.

Terminal blocks shall comprise shrouded anti-tracking mouldings of melamine phenolic or comparable material with provision for securing conductors by screw clamp connectors or other approved vibration proof devices.

The terminal chamber shall be provided with three tapped conduit entries, 1 x 32mm ET and 2 x 25mm ET or as otherwise specified. These holes shall be plugged with suitable plugs during transit and storage to prevent ingress of moisture or foreign matter.

Any conduit entries not used after cabling is completed shall be plugged with threaded aluminum blanks and the threaded joints made watertight by using suitable tape or jointing compound.

15.10.9 STARTERS AND CONTROL GEAR

The actuator motor shall be controlled through integrally mounted electrically and mechanically interlocked contactors, rated for switching the motor direct on-line, adequate for the duty requirements and complete with all necessary auxiliary contacts for the functions specified herein.

The control circuit shall operate at 24V DC derived from a suitably rated transformer / rectifier with one side of the secondary winding connected to earth or as otherwise specified. Primary and secondary windings shall be protected by cartridge type fuses.

The method of control and operation shall be as called for under the specific requirements and the actuator shall be provided with any facilities called for therein to suit the method of control,
whether this be automatic or by hand, local controls integrally mounted on the actuator shall consist of push buttons for “open”, “close” and “Stop” functions, together with a remote /off/local selector, lockable in all positions. The “stop” button shall be effective in both local and remote settings and operate directly in the contactor control circuit.

Facilities by means of volt-free contacts shall be provided for remotely monitoring:

i) Motor running
ii) Actuator is available for remote operation
iii) Actuator opened and actuator closed

15.10.10 PAINT FINISH

The finish color shall be full gloss, crimson, color No 540 to BS 381 C (or 04 D 45 to BS 4800).

15.10.11 ACTUATOR ISOLATORS

The switch shall have a slow make and break mechanism of the two position rotary pattern arranged to isolate the 3 phase supply and all other control circuit supplies to the actuator. The ratings and number of poles required for each duty shall be as detailed in the specific requirements, the isolator rating being based on the actuator average load current being switched normally off load, but emergency on-load.

Each switch shall be incorporated in a heavy duty, hoseproof, cast aluminum enclosure to IP65, having external fixing lugs and adequate seals and drip shields on the operating shaft and cover. The switch shall be austinite type EXO 190 or equal.

Switch positions shall be 90° apart, clearly and permanently inscribed or embossed as “OFF” and “ON” on the cover, and the switch handle shall incorporate provision for the switch to be padlocked in both the OFF and ON position. The “OFF” position to be the left of center or vertical, the “ON” position to the right or horizontal.

It shall be possible to remove the switch cover for access to the terminal without disturbing the switch or its mounting base. The enclosure shall be suitable for mounting on, or adjacent to, the penstock pedestal. If mounted on the penstock pedestal, cabling between the isolator and the actuator above may be arranged through conduit connections, suitable for disconnection should it be necessary to remove the actuator assembly complete.

(This item preferably to be provided by the Contractor who is responsible for the cabling).

15.11 MISCELLANEOUS EQUIPMENT

15.11.1 BATTERY CHARGER

The battery charger shall operate from the mains supply and be suitable for the battery provided, and shall include over current protection and automatic voltage regulation, irrespective of the load on the battery. Where permanent loads are connected, the charger shall be capable of supplying a normal float charge designed to meet the standing loads and maintain the battery in a fully charged condition. Provision shall be made for a boost charge, selected by means of a normal/boost switch mounted within the panel with a label adjacent giving instructions on the use of the boost control.
The charger shall incorporate a provision for adjustment of the charging voltage and have protective devices to initiate the “battery fault” indication on the specified panel in the event of charge failure and low battery voltage. Mounted on the front panel shall be mains supply indication lamp and meters showing the charging voltage.

When associated with engine starting duties, the charger shall be automatically isolated during the engine starting procedure. During engine operations, battery charging shall be automatically maintained by an engine driven generator working through a regulator and cut-out.

15.11.2 STARTER BATTERY

The battery shall be a 24V lead acid, stationary, high performance, low maintenance, plant type, suitable for standby engine starting duty and continuous normal charging.

Its capacity shall be sufficient to provide at least three successive 10 second attempts to start within a period of 2 minutes at 0oC.

The battery shall be accommodated securely in a wooden stand supporting a protecting cover, all finished with 2 coats of black chlorinated rubber paint.

15.11.3 BATTERY SUPPLIES

Batteries for switchgear, control and alarm duties shall be of pocket plate nickel cadmium structure with an alkaline electrolyte and shall be suitable for constant trickle charging.

Each trip battery shall be rated for performing three successive tripping duties and for alarm relay circuits required for the associated circuit breakers. The trip battery shall not be used for other than these purposes.

Closing and general control or alarm circuit batteries, where required, shall be rated as detailed in the specific requirements.

15.11.4 WARNING SIGNS

Automatic plant warning signs shall be provided and erected by the Contractor in the building or on the plant in a prominent position as approved by the Supervisor. The 500mm x 300mm x 0.7 mm (22SWG) signs shall be located approximately 1.6 m above the adjacent floor level to the sign center.

The sign shall be of 22swg. Vitreous enameled aluminum sheet or plastic, having black letters on a yellow background, (see appendix 5) inscribed as follows:

“CAUTION”

“PLANT UNDER AUTOMATIC CONTROL AND LIABLE TO START WITHOUT WARNING”

“ISOLATE AT SOURCE BEFORE ATTEMPTING ANY MAINTENANCE OF MECHANICAL AND ELECTRICAL PLANT”
15.11.5  
EQUIPMENT FOR POTENTIALLY EXPLOSIVE ATMOSPHERES

Equipment for use in potentially explosive atmospheres shall be selected and installed in accordance with BS 5345, subject to the temperature classification of the specified gas, vapor or liquid. Classified equipment shall be certified for apparatus groups II A and IIB.

In such areas, aluminum and other light metal alloys shall only be used for enclosure of electrical apparatus and fittings where such enclosures conform to the material requirements of BS 5501 Part 1.

Aluminum and light metal alloy fans on motors may be used if adequately protected, or if plastic fans or cowls are used they shall be of anti static material.

Where no British standard is applicable, equipment to an equivalent European standard may be submitted, subject to the approval of the Supervisor.

15.11.6  
FIELD MOUNTED EQUIPMENT

Individual starters, fuse-switches, distribution boards and other equipment shall be housed in robust, heavy gauge, rustproofed, metal – clad enclosures having external fixing lugs except where otherwise specified.

Components, fittings and housings shall be as specified elsewhere in this specification.

Equipment housings shall be mounted such that the terminal and covers are readily and safely accessible and are not obstructed or affected by the adjustment or mounting arrangement.

Push button stations shall be single or composite units suitable for accommodating the required buttons in the above enclosures. Each button top shall be fitted with a durable protective flexible boot.

Junction boxes shall be equipped with rail-mounted, feed-through terminals adequately sized to accommodate the cables to be terminated. An earth connection facility shall be provided for each box.

Auxiliary switches shall be mechanically and electrically suitable for the duty and circuit operations specified herein and intended by the switch manufacturer. Roller-lever operated switches shall be of the snap action type.

Where employed for crane or gantry duty, spring failure within a limit switch shall not render it inoperative.

Handgear interlocks shall be fitted to any driven equipment which has provision for manual operation to ensure that it is not possible for drives to start with the handgear in position.

15.11.7  
HEAVY DUTY ELECTRODES

Each electrode shall comprise a single element mounted in an insulating high impact phenolic moulding, impervious to corrosion and having separate fixings for the flange mounting base and for the cover.

The base shall have a 20mm screwed conduit entry and be suitable for accommodating the electrodes, and incorporate provision for adjusting the electrode length by means of a substantial clamping collar which shall also have a provision for terminating the cable conductor.
A sealing gasket shall be fitted between the base and cap and the whole head shall be sealed to prevent the ingress of water after installation is completed.

The electrodes shall be formed of \( \frac{3}{4} \)” BSP galvanized steel tubes (approximately 27mm diameter), sealed at one end and cut to suit the specified length, cut ends being dipped or coated with galvanizing paint or similar. Where intermediate steady brackets are required or when otherwise specified, the electrodes shall be sheathed with an insulating material to within 150mm of the electrode tip.

Spacing between electrodes and to the adjacent wall shall be not less than 150mm.

15.11.8 LIGHT DUTY ELECTRODES

Each electrode shall be mounted in an insulating moulded body having a 20 mm screwed conduit entry and a screwed cover such that the whole head may be sealed to prevent the ingress of water after installation is completed.

The electrodes shall be formed from not less than 6mm diameter stainless steel rod and should not exceed 1.5m length for light duty applications. Spacing between electrodes and to the adjacent walls shall be not less than 100mm.

15.11.9 ELECTRODE CIRCUITS

All electrode circuits and components shall comply with BS 5345 and the BASEEFA requirements for an intrinsically safe system for apparatus groups IIA and IIB.

The system shall operate by the circulation of on AC current when the circuit is completed by the liquid into contact with the electrode, this current operating a relay to initiate the events specified herein. The relay operation shall incorporate a five second time "ON and "OFF" to allow for spurious initiation.

Intrinsically safe electrode circuits shall be completed by a separate return electrode for each circuit.

15.11.10 ELECTRODE MOUNTING

The electrode heads shall be mounted on a suitable support bracket at a height well above the expected maximum water level as shown on the specification drawings.

Intermediate steady brackets shall be provided and fitted for every 2m of electrode length. Insulated lengths of electrode shall be fitted where these are used.

Support brackets and steady brackets shall be hot dipped galvanized to BS 729 or otherwise protected to prevent corrosion.

15.11.11 EMERGENCY LIGHTING

Emergency lighting shall be provided to maintain sufficient illumination in accordance with BS 526 for escape routes within the building during mains supply failures.

The luminaires shall comprise at least a single 8W fluorescent tube with a solid state changeover circuit and high efficiency, high frequency inverter all contained within a die-cast aluminum bulkhead body, having a corrosion resistant, stove enamel finish. The diffuser shall be unbreakable, opal polycarbonate material, secured by an oil and water proofsealing gasket to result in a luminaire rated to IP 65.
The luminaires shall be self-contained and shall incorporate a maintenance free, nickel cadmium battery, capable of preserving the light output for a period of at least 3 hours without mains supply, together with an automatic recharging circuit to restore the charge within 24 hours of total discharge. Each luminaire shall incorporate an indicator to show that the charger circuit is healthy and have a hinged gear tray and fused terminal blocks.

The luminaries shall be either of the following forms, as detailed in the specific requirements.

a) **Maintained:** form, normally lit from the mains and automatically switched from main to battery during mains failure.

b) **Non-maintained:** form, energized automatically from the battery supply only when the main fails and the associated local lighting circuit is switched on.

c) **Sustained:** form, having two lamps, one of which is main fed only, the other operating from the battery supply during mains failure.

### 15.11.12 LV OUTLET TRANSFORMER

Isolating transformers shall be of air cooled, double wound construction in accordance with BS 3535, fitted with an earthed metallic screen between primary and secondary windings and suitable for operation from a 220V, 50HZ single phase supply.

The secondary winding shall have a rated output of 100 VA continuous (1500 VA intermittent tool rating) at 110V and have a centre tapping connected to earth.

The transformer shall be enclosed in a wall mounting sheet steel or moulded casing with external fixing lugs and separate cabling connections. The secondary output shall be via fuses incorporated in the enclosures.

### 15.11.13 WATER HEATER

Single point water heaters shall be thermostatically controlled, and it shall be of the free outlet single point heater suitable for wall mounting. The water inlet shall be 0.5” BSP fitted with a control tap, and the outlet swivel spout shall have a reach of approximately 300mm. the heater shall have a capacity of approximately 1.5 gallons (7.0 liters) and an electrical loading of approximately 3kW.

### 15.11.14 SPACE HEATERS

Wall mounted single tier tubular heaters rated at 250 watts/meter and suitable for 220V operation shall be provided.

The heaters shall be mounted approximately 300mm above floor level. They shall be directly connected heater circuits controlled by the room thermostat, the final connection to the heaters being made by means of flexible conduit and a protective conductor. The flexible conduit shall enter from below the heater.

### 15.11.15 SPACE HEATER THERMOSTAT

The thermostat shall be a surface mounting 14 Amp bi-metallic strip type, adjustable over the range 0-30°C and lockable to prevent unauthorized adjustment of the setting.

The room thermostat shall be mounted approximately 2.0 m above the floor level.
15.11.16 ELECTRIC TRACE HEATING

Heating cables shall comprise of a self regulating conductive polymer core or double insulated heating elements within a waterproof outer PVC sheat having sealed ends with a cold lead at one end. The cable shall have a flat section to provide efficient heat transfer.

The cable shall be straight laced along the underside of pipes and secured with cable tiers at 300mm spacing or be spiraled around the pipe and secured at each end. All heating cable must be in intimate contact with the pipe and must not be overlapped on itself, additional ties being positioned on either side and close to all flange joints. To avoid mechanical or leakage damage, the cable shall be run over the sides of flanges at 90° to the invert on horizontal pipe runs.

After any thermal insulation has been fitted, wiring labels shall be fitted in prominent positions on the pipework to indicate the presence of trace heating.

15.11.17 TRACE HEATING THERMOSTAT

A wall mounting air sensing thermostat set at 5°C shall be provided and arranged to switch on the heater for frost protection. If non-self regulating heating tapes are used and where lagging is applied, or on PVC pipework, a thermostat shall be located on the pipework and arranged to switch off the heater if the temperature exceeds 60°C. Liquid filled sensing bulbs and capillary tube connections to the thermostat shall be of stainless steel with a stainless steel flexible sleeve fitted over the capillary tube for mechanical protection.

The air measuring thermostat shall be mounted on the outside wall, 600mm above ground level and adjacent to, but not above the protected pipework.

Enclosure and terminal arrangement to be as specified for field mounted equipment.

15.11.18 LIGHTNING PROTECTION

The building shall be protected against lighting strikes by a system consisting of an air termination network, down conductors and a ground termination network. Ground termination shall be achieved by installation of electrode rods (in pits) connected via tape tails to the bottom of the down conductor.

The installation shall be complete with a bonding connection taken from a down conductor position to the building main earth terminal bar.

The protection system shall be designed and installed in accordance with BS 6651 by a specialist Contractor with horizontal conductors on the roof and down conductors on the outside walls of the structure.

All metalwork on, or around the structure shall be bonded to the lightning protection system. Where connection between dissimilar metals are made, precautions shall be taken to prevent corrosion.

The horizontal and down conductors shall be of 25mm x 3mm copper strip, fixed with leaded gunmetal clamps, secured by phosphor bronze screws or bolts. Each down conductor shall take the most direct route from the air termination network to the earth termination and be provided with a bolted test joint in a position accessible from ground level.

Earth electrodes of 1mm² copper bonded, steel cored rods shall be driven into the ground as close as practicable to the structure at the end of each down conductor. The rods shall be installed in sections connected by screwed couplers and driven to a depth sufficient to achieve
a resistance to earth such that the whole of the lightning protection system shall have a combined resistance to earth not greater than 3 \( \Omega \) ohms. The screwed couplers shall be long length aluminum bronze material, counter bored to protect the threaded ends from damage and corrosion.

15.12 MOBILE PLANT COMPONENTS

15.12.1 CRANE CONTROLS

The electrical controls shall be designed to prevent excessive acceleration, retardation, skidding, and load swinging, and all motions of the crane shall be arranged to switched through the slower speed where provided.

The control circuits for the crane/hoist shall operate at not more than 110V and be derived from a double wound, screen earthed isolating transformer with one side of the secondary winding connected to neutral/earth. The primary supply shall normally be from the phase conductors.

Fuses shall be provided on each primary and secondary supply and be clearly labeled and segregated. A link shall be fitted in the neutral/earth connection.

15.12.2 CONTROL PANELS

The crane control panel shall be constructed of sheet steel or other approved material and shall be damp and dust protected (IP 51) for indoor locations and hoseproof (IP 65) for outdoor or wet situations.

The control panel shall be mounted on the traveling crane hoist bogie in a convenient position for inspection and maintenance, and shall house all the fuses, motor protection devices, starters and control equipment for controlling the crane/hoist. All contactors shall be of the air – break, electrically operated hold-on type with all necessary auxiliary contacts. Reversing contactors shall be mechanically and electrically interlocked to prevent conflicting operations. The panel shall be fitted with a main isolating switch interlocked with the door to allow access only when the switch is open.

The motor starters shall be provided with adjustable overload protection devices suitable for the motor load at each speed and having manual resetting facilities within the panel.

All control equipment shall be fitted with suitably rated fuses. Fuse ratings shall be rationalized as far as possible to limit spares. Where practicable, fuses shall be housed in all-insulated carriers with fully shrouded bases.

Fuse links shall be HRC cartridge type to BS 88, Class Q1, having provision for screw fixings for attachment to the carrier.

15.12.3 PENDANT CONTROLS

A heavy duty, industrial pattern pendant push button control station shall be provided, having sets of non-maintained push-buttons for each hoist speed and function specified.

Each set of buttons shall be electrically and mechanically interlocked so that conflicting operations are prevented and only one function can be initiated at one time.
The push button enclosure shall be of a tough neoprene rubber suitable for withstanding arduous duty and provide full electrical safety, each button being suitably labeled with its function.

The pendant shall be divorced from the crab and capable of independent cross travel. It shall be suitable for vertical adjustment for operation from alternative levels by means of sprig loaded reeling drum fitted with a ratchet device or motor driven reeling drum and have a cable guide runner to assist re-coiling.

Pendant control cables shall be designed for reeling drum application and have stranded copper flexible conductors, EPR insulated to 300/500V, multicores laid-up with an internal central textile strain carrier and heavy duty, textile braid reinforced, PCP sheath.

For non reeling applications, the outlet sheath may be flexible PVC, incorporating externally laid, galvanized steel, nylon coated strainer wires.

N.B Cale material descriptions:
PVC: Polyvinyl chloride (BS 6746)
EPR: Ethylene propylene rubber (BS 899)
CSP: Chlorosulphated polyethylene
PCP: Polychloroprene (propelene/clorisulphated polyethylene)

15.12.4 RADIO CONTROL
Where specified, the crane remote control shall be by means of radio transmitter and receiver units operating within the UHF waveband range approved by the relevant authority. The receiver shall be accommodated on the crane in a metal enclosure to IP 55, having shock absorbing, rubber mountings, an external receiving aerial and incorporate an output relay for each transmitter function.

The transmitter shall be a lightweight, hand held device enclosed in a heavy duty impact resistant enclosure to IP 67 complete with a bandolier carrying strap.

The unit shall be powered by rechargeable batteries having capacity for 10 hours continuous operation on fully charged batteries. To conserve battery life, a time out when not in use function shall be incorporated and the stop button shall be fitted with a key switch to prevent unauthorized use. All push buttons shall be spring returned to the off position and interlocked to prevent conflicting operations. Programmable security coding shall prevent operation from unwanted signal interference.

A suitable wall mounted, metal enclosed charger shall be provided to enable the transmitter to be connected and maintained in a fully charged condition when not in use.

15.12.5 FLEXIBLE CABLE SYSTEMS
The supply to the crane for both cross travel power together with pendant cross travel connections, shall be by flexible round or flat form cable systems suspended on trolleys sliding in galvanized track from the cane structure.
The trolleys shall be formed from stainless steel side plates and axles with nylon runners. Sufficient trolleys shall be provided to effect a maximum cable loop of 0.5m.

The cables shall be PVC insulated and flexible PVC sheathed type designed for the application, incorporating flexible stranded copper live and earth conductors, terminated in suitable junction boxes as specified with weatherproof glands designed for the cable shape.

15.12.6 BUSBAR COLLECTOR SYSTEM

The power supply and earth connection for the long travel shall be from a current collector system of fixed busbar conductors which shall each be fully shrouded with PVC covers suitable for outdoor use.

The conductors shall be suitable for the current capacity, voltage drop and temperature conditions for the installation. Current collectors shall be of the sliding contact type with insulated contact heads mounted on spring loaded trolley arms. No current carrying surfaces shall be exposed.

15.13 ENCLOSURES

15.13.1 DEFINITIONS

The genetic term enclosures shall be taken to mean any housing which encloses overall any items of plant or equipment. To distinguish between the different forms of enclosure, the following definitions shall be used:

a) Cabinets will be regarded as any wall or pedestal mounted, thermally controlled enclosure

b) Kiosks shall mean any floor standing, thermally controlled, overall enclosure which may incorporate either an integral base or use the ground or floor slab as the base of the enclosure. The kiosk shall be sized to permit man access for servicing the equipment within.

c) Shelters shall mean overall floor standing housing providing general weather protection without sealing or thermal control.

d) Housing shall mean the specific enclosure without thermal control for items of equipment, either located externally or within another enclosure.

e) Compounds shall mean areas enclosed by fencing or walls but generally exposed to the weather.

15.13.2 GENERAL

All cabinets and kiosks shall be fully weatherproof enclosures to IP55, manufactured from maintenance – free, resin bounded, glass fiber reinforced, polyester (GRP) inner and outer skins, encapsulating not less than 12mm plywood reinforcement and insulation to give a “u” value of at least 1.5W/m²°C. The doors shall have flexible neoprene seals.

All cabinets, kiosks and shelters shall have doors incorporating steel reinforcement for rigidity and self-locking stays to maintain the doors open to at least 90°.
Door hinges shall be back epoxy coated, vandal-proof pattern with stainless steel pins. Locking door handles shall also be black epoxy coated steel with stainless steel cam action locking plates.

Where double doors are provided, shoot bolts shall be fitted to the top and bottom of the left hand door, central dead-locking of latch to right hand door to incorporate a security keyed "Yale" type lock to suit lock key or other specified standards.

The closing edges of the doors shall have an external or internal overlap for weather sealing.

Ventilation to kiosks and shelters shall be provided either as under-eaves or via high level louvered vents protected by a fine mesh stainless steel / aluminum insect screen. Ventilation provided shall be equivalent to a 10mm continuous gap around the enclosure perimeter.

The interior shall be finished with a white based abrasion resistant vinyl paint. The exterior finish shall be GRP colored Dark green to BS 4800 (14 C 39) unless otherwise specified.

15.13.3 CABINETS

Wall mounted equipment cabinets shall have external fixing lugs and have removable gland plates fitted to the base for cable or pipework entry.

All cabinets shall have mounting rails bonded to the rear wall to facilitate equipment fixing and have an anti-condensation heater fitted. Outdoor mounted cabinets shall have a rear sloping top and a 50mm projecting drip canopy above the access door.

Inspection windows of toughened glass secured in a rubber gasket shall be provided where specified.

15.13.4 KIOSKS

Where control panels are to be protected in outdoor locations they shall be enclosed in a cross ventilated weatherproof kiosk, sized to allow at least 1.0m clear working space in front of the panel. Battens shall be moulded to the inside walls to provide fixings for internal equipment and fittings.

The kiosk materials shall have a ½ hr fire resistance rating for retention of stability, integrity and insulation in accordance with BS 476 Pt 8.

Sectional kiosks shall be pre-assembled and fully sealed before delivery to site.

Fixing holes shall be provided in the base sections and the whole unit shall be fixed and sealed to the concrete base by means of a mastic compound applied before and after the kiosk sections are in place, to prevent ingress of moisture.

Kiosks shall be fitted with:

a) A suitable corrosion proof fluorescent light fitting, not less than 60 watt, so arranged to illuminate the face of the control panel complete with appropriate ON/OFF switch inside the kiosk, wall mounted adjacent to the kiosk door, and wiring.

b) A suitably rated anti-condensation heater complete with thermostat, ON/OFF switch and wiring.

All electrical fittings to be connected by wiring in surface mounted PVC conduit to a 2 way metalclad consumer unit.
When space for the Electricity Supply Authority metering equipment and cut-outs is specified, a separate section within the main frame of the kiosk is to be provided complete with fire resistant chipboard panel. Details of size required and position in relation to the panel are to be obtained from the appropriate Electricity Supply Authority. Where specified, a lockable hinged door shall be provided to enable the meters to be read from outside the kiosk.

Where an external generator connection as specified, a small door or "cat-flap" shall be fitted opposite the panel mounted appliance inlet to provide access for a generator cable and connector. The door shall be large enough to pass the connector and it shall be horizontally hinged at the top, outward opening and lockable with a suitable padlock.

15.13.5 SHELTERS
Protection for plant requiring limited attention shall be of maintenance free materials, single skin GRP insulated panels or hot dipped galvanized steel panels with plastic skin external coating and alkyd paint interior. The shelter shall provide a degree of protection to IP44.

15.13.6 HOUSING
Field mounted electrical components and junction boxes shall be heavy duty industrial type, accommodated in totally enclosed hoseproof housings to IP65, of die cast, cast aluminum or rigid non-ferrous/polycarbonate materials having tapped conduit entries and recessed neoprene gaskets to seal the covers, the cover and housing fixings being outside the sealed area of the box.

15.14 ROAD LIGHTING
15.14.1 LUMINAIRES
The luminaries shall be weatherproof to at least IP 55 or otherwise specified.

15.14.2 CONTROL GEAR
The control gear for the lamps shall be mounted in the lantern head or base of the column as appropriate. The circuit components shall be suitable for the range of temperature and humidity as defined in BS 4533. power factor correction capacitors shall be included to give an overall improvement to at least 0.85.

15.14.3 CONNECTION COMPARTMENT
A connection compartment shall be provided and have a flush fitting, vandal proof with a weather skirted cover to IP 33, secured by two key headed non-corrodible latches. A non-corrodible earth terminal and non-hygroscopic back board shall be provided within the compartment.

The column shall be set such that the compartment door is fully accessible and faced away from the adjacent traffic stream.

15.14.4 COLUMNS
Columns shall be suitable for the specified duty and be manufactured and installed in accordance with requirements of BS 5649 (EN 40). They shall be made of hot dipped
galvanized mild steel or aluminum with tubular tapering or multi-sectional construction without the use of wells or swaging and having an internal cable way throughout the length.

The head of the column shall have a 76mm dia spigot extension or other means of accepting the lantern head or bracket. The head shall also incorporate an anti-rotation device to fix the arm at 90° increments to the door.

The column base shall be either a substantial surface mounting plate to BS 5649 or rooted for securely supporting the whole column on/in the ground in a vertical position. Rooted columns shall have a side exit port 500mm below ground level for cable access and be planted at depths related to column height as specified in BS 5649.

The base and root section of steel columns shall have a minimum nominal material thickness of 5mm.

The columns shall be installed in accordance with the manufacturers recommendations and concrete foundations shall be to grade C20 with a maximum aggregate size of 30mm.

15.14.5 LOCATION OF LUMINAIRES

The position of all luminaire / columns shall be as shown on the approved drawings. These positions shall be clearly marked on site to prevent obliteration before the work is started.

15.14.6 EXCAVATIONS

Holes shall be excavated to the appropriate column planting depth, unless the excavations are in hard material or loose sand, when any necessary alterations in planting depth shall be the subject of agreement with the Supervisor. The width of the holes shall be kept to a minimum compatible with the conditions encountered under the surface and the surrounding soil shall be disturbed as little as possible.

The width of holes in loose soil or sand may require to be greater to allow for heavier foundations and the dimensions should be approved by the Supervisor. In normal well consolidated soil, the width of the holes should not greatly exceed the width of the base plates or flags where these are used. The maximum width of flags placed under the base of concrete columns should normally be limited to about twice the width of the column base.

During excavation, every care shall be taken to avoid damage to underground services or other property and any paving flags shall be lifted carefully and preserved for disposal as directed by the Supervisor.

Agreement shall be reached with the Supervisor on the method to be used for excavating rock or other hard material. Explosives shall not be used except with the express approval of the Supervisor.

Excavations shall be lighted and guarded in accordance with local bye-laws, safety codes and regulations including CDR safety requirements, as applicable to the site.

Where underground obstructions are likely to necessitate the use of columns with special roots or re-siting of the column positions, trial holes should be taken out at each position or at selected positions as decided by the Supervisor.
15.14.7 ERECTION OF COLUMNS

Before erecting in position the excavation shall be examined to see that it is clear of obstructions and the foot firm and free from water, rubble or loose soil; the roots of steel columns shall be examined to ensure that the priming coats are complete. Any bare or corroded patches shall be cleaned and treated with black bituminous paint, unless it is specified that these should be left untreated for earthing purposes.

Base plates, where provided, shall be fitted securely, and where used for earthing purposes shall be electrically bonded and base stones or flags shall be placed in position where appropriate.

Any precautions necessary for the warning of traffic during erection shall be taken ad any rope slings shall be visually examined before and after each lift to ensure that no deterioration has taken place.

15.14.8 ALIGNMENT

Columns shall be correctly aligned in the vertical position or at the rake agreed by the Supervisor. The cable hole for the bracket shall be in the correct position relative to the road so that the bracket, when fixed in its correct position, will align correctly with the cable hole. Unless otherwise specified, the door opening shall face away from oncoming traffic.

15.14.9 BACKFILLING

When the columns have been placed in position, the holes shall be fitted in and well consolidated.

Excavations shall be fitted in with enough concrete to hold the columns firmly in their true position. Unless otherwise specified, the concrete shall be brought up to within 450mm of the ground surface. The concrete shall be efficiently mixed so that there is a uniform distribution of material and the mass is uniform in color.

Concrete shall normally be placed in position before the initial set has taken place i.e. 1½ hours after mixing has been completed, but in any event within such a time that it can be consolidated effectively without the addition of further water. The concrete shall then be thoroughly tamped and compacted by hand or by other satisfactory means, at intervals of not more than 150mm, at the same time ensuring that the columns does not depart from its correct setting or alignment.

15.14.10 TEMPORARY REINSTATEMENT

The remainder of the hole shall be fitted with soil which shall be well rammed at regular intervals. The finished level shall be substantially the same as that of the surrounding level.

The earth around the column shall not be disturbed for at least seven days after temporary reinstatement.

15.14.11 TREATMENT OF COLUMNS AFTER ERECTION

The exterior surface and external metal attachments of metal columns shall be painted after erection in accordance with the specifications.
15.14.12 MARKING
After erection, columns shall be clearly marked with painted numerals, number plates or separate characters firmly secured to the columns, as specified by the Supervisor.

15.14.13 ELECTRICAL EQUIPMENT
Lanterns, switches, control gear and accessories shall be fitted, wired and connected in accordance with the IEE wiring regulations for electrical installations and the work shall be done by a qualified electrician.

Fuse cut out boxes shall be made of flame retardant, resin moulded materials incorporating fuseways, looping terminals and earthing connections to suit the application. Fuse covers and other access to live parts shall be accessible only by the use of tools.

Metal columns, lanterns and the external metal work of switches and control equipment shall be electrically bonded, to the satisfaction of the local electricity authority, and unless otherwise specified, connected to earth by one of the following methods:

i) In installations served by an underground supply, by a conductor connected to the metal sheath of the supply cable (the bonding of this connection to the cable sheath is normally the responsibility of the local electricity authority).

ii) In any section of an installation served by a overhead wiring system, if a continuous earth wire is available along the entire length of the system, by a conductor suitable for connection to this wire; if no continuous earth wire is available, by individual earthing to each column in a manner to be specified by the Supervisor.

Lanterns shall be attached to the columns only after columns have been securely fixed their agreed vertical and horizontal alignment. Together with any optical component, they shall be correctly orientated with the road in accordance with the manufacturer’s instructions. Leveling devices shall be used as supplied and as recommended by the manufacturer.

The lamp shall be carefully inserted in the lanterns without subjecting them to undue mechanical shock or vibration. Care shall be taken to ensure that lamps operate in the correct burning position, in accordance with the lamp manufacturer’s instructions. Lamps, reflectors, bowls and refractors shall be clean and free from dust or obscuring films after assembly.

15.14.14 WALL AND BRACKET MOUNTING
In the absence of detailed instructions, the erector shall ensure that wall brackets and wall mounted lanterns are securely fixed to structurally – sound parts of the wall. The dimensions of fixing screws and wall plugs should be adequate for the loads to be carried. Where lanterns are mounted on long outreach brackets or where large surface areas are involved, the lanterns or brackets should be fixed to solid brick or stone walls by means of thoroughly caulked or grouted rag-bolts of adequate dimensions. The method of attachment to timbered buildings or other forms of construction should be the subject of approval of the Supervisor.

Control gear not located inside the lantern should be housed in robust waterproof and tamperproof containers, securely fixed to the wall if appropriate. Surface wiring between the lantern and control gear compartments should be protected mechanically by means of heavy gauge welded steel conduit or steel wire armoured cables.

The requirements of the statutory authority should be complied with where street lighting lanterns and accessories are mounted on poles owned by a statutory authorities.
15.14.15  FOLDING COLUMNS
Where folding columns are specified for maintenance access, the two sections shall be positively seated and hinged to prevent unauthorized interference. The extend skirt shall totally enclose the gear compartment to provide protection to IP33. The upper section may only be lowered by use of a specially designed device to assist the operation. At least one lowering device shall be provided together with one additional device for every multiple of one hundred such columns installed.

15.14.16  FEEDER PILLARS
Feeder pillars to accommodate electrical distribution components shall be made of cast iron, sheet steel, aluminum or glass resin bonded polyester material as specified.

They shall be free standing assemblies, designed for base mounting either direct to concrete plinths or for attachment to separate root extensions suitable for direct burial. The shell shall be partially removable to allow access for cable jointing and termination.

Doors shall be hinged with stainless steel pins in nylon bushes and allow 180° opening. They shall be sealed all round with a watertight gasket and be secured by wedge locks, protected by brass cover plugs requiring special keys to prevent unauthorized access.

The housing shall incorporate baffled ventilation apertures to provide overall enclosure protection to IP 34. Equipment mounting boards within the pillar shall be of non – hygroscopic material.

15.14.17  HIGH MASTS
The masts shall be manufactured from mild steel to a tapered profile using the minimum number of horizontal joints. The base flange shall be adequately welded and the base compartment opening shall be reinforced to maintain the strength of the mast.

The mast head frame and lantern carriage shall be a welded steel construction, hot dip galvanized after assembly. The head frame shall be protected overall by an aluminum canopy and the lantern carriage shall be designed to enable it to be assembled or removed from the column after erection. Guides shall be provided to ensure the carriage engages securely into the head frame.

The carriage mounted junction box shall house the connections to the lanterns and the electrical supply cable. The cable shall be a flexible multicore with EPR insulation and sheathed with heavy duty PCP. Electrical disconnection by means of a plug and socket with a threaded coupling facility shall be provided in the base of the mast. A similar electrical coupling shall be provided at the lantern carriage to enable the supply to be directly connected to the lantern when the carriage is at ground level.

15.15 DOMESTIC ELECTRICAL INSTALLATIONS FOR BUILDINGS

15.15.1  GENERAL
Electrical installation for buildings shall comply with the French standards as normally applicable in Lebanon.

Materials and works for building electrical installations shall comply with:
- D.T.U published in April 1973
- N.F.C 15-100 Electrical installations
- N.F.C 71-800 Security blocks
- N.F.C 13-200 High voltage electrical installations – regulations
- N.F.C 14-100 Sub-circuits installations – regulations
- N.F.C 15-150 High voltage gas discharge lamps installations

The works which are the subject of this specification are for the installation of the electrical power supply network in the WWTP and related buildings.

All equipment shall be to class of protection IP 55 as a minimum.

The words include:

i) Main distribution boards
ii) Secondary distribution boards
iii) Cabling and wiring
iv) Installation of wiring in conduits for lighting, socket – outlets and outlet boxes starting from secondary panels, as well as the lighting points, socket outlets, and outlet boxes
v) Internal and external lighting luminaries
vi) Earthing systems

15.15.2 DESCRIPTION OF WORKS

Works to be undertaken as part of this contract include the following:

15.15.3 ELECTRICAL DISTRIBUTION

A main distribution board to be installed in the electrical room.

A cable shall supply the power to this panel from the WWTP main panel or as indicated by the Supervisor. The main domestic distribution board shall comprise

a) A cabinet made of 2 mm minimum thickness sheet steel treated against corrosion and protected by a textured paint: finished color shade RAL 7032 or RAL 7035.

b) A frame, bus-bars analytical instruments, ammeters, voltmeters with selector switches four pole circuit breakers with instantaneous electromagnetic trip release.

One or more secondary distribution boards shall be installed according to the specifications and the electrical installation drawings. These boards shall comprise:

- A cabinet made of 2 mm minimum thickness sheet steel treated against corrosion and protected by a textured paint: finished color shade RAL 7032 or RAL 7035.
- The enclosure having a lockable door and key.
- A frame fitted with prefabricated bus-bars, the nominal rating to be determined according to the application.
- The cabling for the equipment, inside the board and the fixing items necessary for the mounting of the board.

15.15.4  SOCKET OUTLETS AND PLUGS
Socket outlets and plugs and junction boxes shall be provided as specified and in accordance with these technical specifications.

15.15.5  LIGHTING
The installation of the lighting system shall be consistent with the technical specifications generally, and particular attention shall be given to those related to humid and corrosive situations (chlorine).

15.15.6  ELECTRICAL SUPPLY
The electrical supply has the following features:
- Three phase
- 380V between phases
- 220V between phase and neutral
- Frequency 50 Hz
- Note: voltage may vary in Lebanon ±15% from the nominal value.

15.15.7  NATURE AND ORIGIN OF MATERIALS
15.15.7.1  General

All materials intended for incorporation in the works shall comply with the D.T.U in force and the regulations for constructions, and the recommendations of the International Electromechanical Commission.

Any approval of the Supervisor on the origin of materials does not release the Contractor from his responsibility in respect of the quality and the reliability of the materials supplied to site, which must always be consistent with the relevant specifications. Any change of the origin of materials previously approved shall be submitted for approval.

15.15.7.2  Distribution Boards

All distribution boards shall be metallic construction; they shall be monocellular, rectangular and have a plane front face.

They shall have class of protection IP55 and be finished with textured paint RAL 7032 or RAL 7035.

Distribution boards shall be supplied with all wiring, bus-bars, equipment, accessories cables, junction boxes, and installation material ready for installation directly on arrival at site.
The boards shall be designed to facilitate inspection, maintenance and repair and all articles having the same characteristics and dimensions shall be entirely interchangeable.

Distribution boards must not show any deformation or welding effect. They shall be rigid enough to support the equipment without deformation both during normal operation and under short circuit condition. They shall be fitted with reinforcement especially against the effect of short – circuits.

All bus-bars, equipment and connections shall withstand the nominal rated current continuously without heating beyond admissible values.

The design of distribution boards shall take into consideration every change of rating of the equipment to suit the climatic conditions specific to the site. All live terminals and parts shall be adequately insulated from the frame of the panel board. The frame shall be earthed.

Bus-bars shall be so protected as to exclude the possibility of contact with them or any live part when closing or releasing circuit breakers.

Boards comprising several cells shall be protected with an earthing bar covering the entire bar by means of approval accessories.

Each single phase distribution board shall have one bus-bar and one neutral bar. The section of the bars shall be sufficient to allow the passage of the nominal current without leading to excessive heating; the rating shall be equivalent to at least the total nominal current of incoming circuit breakers in the board.

Bus-bars shall be made of electrolytic copper. The Contractor may offer variants made of another material, but in this case, he shall submit for the Supervisor’s approval all the details concerning the accessories required for connection of cables and equipment to bus-bars.

The frames of distribution boards shall be treated against corrosion. They shall be painted internally and externally with one coat of primer and two grey finishing coats.

All circuits fed from the panel board shall be labeled.

Distribution boards shall have at each feeder, a chart or diagram describing, according to the distribution scheme, the circuits connected to this feeder. The boards shall be of fixed, non removable type. Circuit breakers shall be of the miniature type.

Connections to all equipment shall be easily reached and made from the front without having to dismantle the board.

Ammeters shall be fitted at each incoming feeder.

15.15.7.3 Circuit Breakers
   i) General specifications

   All circuit breakers shall meet the following conditions:
• They shall be designed to function under the electrical current supplied to the WWTP.

• Each phase pole shall be fitted with an instantaneous action thermomagnetic type over current trip. The trip shall act on a common tripping bar and provoke the simultaneous tripping of all poles.

• Circuit breakers shall be of automatic trip type

• Each pole shall be fitted with an arc extinguishing mechanism.

• Circuit breakers shall be compensated for ambient temperature. All thermal relays shall be compensated in order to function correctly in the ambient temperature of the site.

Three phase circuit breakers shall also meet the following conditions:

• Incoming circuit breakers from the main panel board, connected directly to the transformer station shall be four poles. All other circuit breakers shall be three poles.

• All the poles of three phase circuit breakers should trip simultaneously with one control mechanism.

Circuit breakers installed in the general panel board may be of miniature type.

Circuit breakers installed in secondary panel boards may be moulded case miniature type.

ii) Rupturing capacity

• All circuit breakers shall have sufficient rupturing capacity to switch off the highest short circuit currents.

• The minimum rupturing capacity of the circuit breakers shall be as tabulated hereunder, and consistent with the D.T.U:

<table>
<thead>
<tr>
<th>Rating (A)</th>
<th>Voltage volts</th>
<th>Rupturing capacity KA</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>240 – 380</td>
<td>6000</td>
</tr>
<tr>
<td>70</td>
<td>240 – 380</td>
<td>6000</td>
</tr>
<tr>
<td>100</td>
<td>380</td>
<td>14000</td>
</tr>
<tr>
<td>125</td>
<td>380</td>
<td>14000</td>
</tr>
<tr>
<td>150</td>
<td>380</td>
<td>22000</td>
</tr>
<tr>
<td>500</td>
<td>380</td>
<td>30000</td>
</tr>
</tbody>
</table>

15.15.7.4 Contactors

Contactors used in the installation shall be three-pole, mounted in screened boxes, protected to class IP55. They shall be designed to function under the nominal working voltage and current corresponding to the circuit breakers protecting the circuits they control.
The mechanical and electrical resistance of the contactors shall be high and they shall be protected against dust or any other factor that might harm their proper functioning.

“ON” and “OFF” push buttons shall be mounted on the cover of the box.

### 15.15.7.5 Electric Cables

The cables to be installed include the following:

- Main distribution board power supply cables.
- Connection cables between the main and secondary distribution boards.
- Power supply cables to metering.
- Connection cables between meters and secondary boards.
- Cables used for the power supply of low power motors.

Multicore cables shall be protected with an external sheath made of thermoplastic material of NYA type consistent with the most recent VDE standards or of an equivalent type consistent with other recognized standards.

All cables shall be 1000 volts rating.

Cores shall be made of pure electrolytic, resistivity = 0.01724 Ohm/mm²/m at a temperature of 20°C. They shall be multi-stranded for sections exceeding 6mm².

The insulation of the cores shall be color coded as specified.

### 15.15.7.6 Insulated Conductors

Conductors laid in polyethylene tube shall be made of copper insulated with thermoplastic materials. They shall be of NYA type consistent with the most recent VDE standards or of an equivalent type consistent with other recognized standards. They shall be of 600 volts rating.

Conductors shall be made of pure electrolytic copper; resistivity = 0.01724 Ohm/mm²/m.

The minimum section of conductors shall not be less than 1.5. mm². Conductors having sections exceeding 2.5 mm² shall be multi-stranded.

In single phase circuits the section of neutral conductors shall always be equal to that of the phase conductor. Each circuit shall have an independent neutral from the secondary panel board.

All phase conductors, neutral conductor and earth conductor in the installation shall be differentiated, one from the other, by the color of the insulation.

- Each phase conductor shall have a color different from those of the others, changing the color for a phase conductor along the same circuit is absolutely forbidden.
- The neutral conductor shall be grey throughout the installation.
- Earthing conductors shall be yellow green throughout the installation.
The connection of conductors shall be carried out exclusively inside enclosures, by means of clamping screws in order to prevent the scattering of strands.

The use of an insulating adhesive tape is forbidden.

Maximum voltage drop in comparison with the available voltage in the main panel board will be 3%.

Maximum density of current 3A/mm² for 2.5 mm² cables and 2A/mm² for larger cables.

15.15.7.7 Conduits

Where electrical wires and cables, including very low voltage wiring, are installed in plastic conduit, the conduit shall be consistent with the DTU and its addenda (class of protection IP 55).

The connection of conduits shall be carried out by means of accessories of the same type, using the materials specified in the catalogues of the conduit manufacturer (class of protection IP 55)

Adequate flexible accessories shall be used for electric lines crossing expansion joints or fixed to different structure units.

Generally, all accessories used with electrical networks shall be of the same type and shall have the same characteristics.

Conduit fixing clamps shall be made of hot galvanized steel. Screws and nuts shall also be hot galvanized.

The internal diameters of various sizes of conduit are tabulated hereunder together with the number and section of conductors that may be installed therein. The numbers stated in the table represent in millimeters the minimum internal diameters. The Contractor shall supply conduits having a diameter equal to at least that specified.

<table>
<thead>
<tr>
<th>Section of conductors (mm²)</th>
<th>Number of conductors in conduit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>16 16 16 16</td>
</tr>
<tr>
<td>4</td>
<td>16 16 16 16</td>
</tr>
<tr>
<td>6</td>
<td>16 16 16 23</td>
</tr>
<tr>
<td>10</td>
<td>21 21 21 29</td>
</tr>
<tr>
<td>16</td>
<td>21 29 36 36</td>
</tr>
<tr>
<td>25</td>
<td>36 36 36 48</td>
</tr>
<tr>
<td>35</td>
<td>6 48 48 48</td>
</tr>
</tbody>
</table>
No more than 6 conductors may be installed in one conduit unless the seventh is an earthing conductor.

15.15.7.8 Boxes

Boxes used for connections and sub circuits, as well as those installed at each feeder, shall be supplied with appropriate covers (class of protection IP55).

They shall have knockouts for conduit connections.

Switch and socket boxes shall be provided for the switches and sockets to be installed, in conformity with the recommendation of the supplier of these items.

Surface mounted boxes shall be watertight to IP55, of moulded construction with inlets fitted with glands.

Junction boxes installed outdoors or inside humid locations shall be watertight weatherproof type (class of protection IP55).

15.15.7.9 Switches

Lighting circuit switches shall be single or two way rated for 16 Amp, 250V. They shall be silent toggle switches.

The switch and cover plate shall be fixed to the box with stainless steel or chromium plated screws. Hook fixings are forbidden.

Flush switches shall have their covers made of an insulating material (class of protection IP 55).

Surface mounted switches shall have the same mechanism as flush switches, but shall be installed inside dust proof boxes, having inlets fitted with glands (class of protection IP55).

15.15.7.10 Socket Outlet and Plugs

i) Single phase

Each single phase socket outlet and plug shall have 3 terminals and one earthing contact. They shall be rated for 10/16 Amp and 20 Amp – 250V.

Fixing the switch and cover plate to the box shall be done with stainless steel or chromium plated screws. Hook fixings are forbidden.

Switches used with built in installation shall be of flush type and fitted with square or rectangular covers made of an insulating material.

Surface mounted switches shall be installed inside waterproof boxes (class of protection IP55). These boxes shall have inlets fitted with glands and shall be provided with knockouts.

ii) Three phase socket outlets and plugs
Three phase socket outlets and plugs shall be rated for 32 Amp, 380V and shall have earthing terminals.

Surface mounted socket outlets and plugs shall be installed inside water – proof boxes (class of protection IP 55).

These boxes shall have inlets fitted with glands and shall be provided with knockouts.

It shall not be possible to insert telephone plugs into sockets.

15.15.7.11 Junction Boxes

Power supply circuits of low power equipment such as fans and air convector shall be linked to junction boxes with fixed connections for the corresponding equipment.

Junction boxes shall be either single phase or three phase.

15.15.7.12 Earthing Systems

**Resistance of earthing systems**

The following independent earthing systems may be utilized:

- Earthing system of the neutral point of the standby generating set alternator
- Earthing system of the metallic frame of the main panel board.
- Earthing system of the building or metering system.

This system shall have a resistance of less than 3 Ohms.

**Earthing**

Each earthing system shall be achieved by one or several rods.

The resistance of the earthing shall not exceed the value stated in the previous paragraph.

The Contractor shall install sufficient number of rods to achieve this resistance value.

Earthing rods shall consist of a steel core covered with a copper coat.

The heads of the earthing rods shall be buried 500mm deep in the ground. A concrete manhole having a 500mm side shall be prepared for each earth terminal in order to facilitate maintenance operations and later reinforcement works utilizing additional elements if required to increase the earthing installation.

The manhole of each earthing terminal shall be fitted with a sectioning bar allowing the isolation of this earthing element from the installation and, hence, the measurement of the earth resistance.

The connection of earthing cables to the earthing system shall be carried out by means of sockets ensuring very good contact.

**Earthing conductors**
The sections of earthing conductors of the various terminal circuits or power supply circuit of a panel shall be the same as those of the neutral conductor of the corresponding circuit, in such a way that they are not less than 2.5 mm² nor more than 70mm².

Connections shall be carried out by permanent weld or by screw clamping.

Connection between the earthing network and equipment subject to movement shall be carried out by means of copper braids having the same sections as earthing conductors.

Series earthing is prohibited.

All insulated earthing conductors shall be yellow green (external color). This color shall not be used for any other part of the installation.

15.15.8 LIGHTING FIXTURES

15.15.8.1 General Conditions

Lighting installations shall be complete and shall include all necessary accessories, whether the accessories are described hereunder with the description of the lighting installation or not.

The body of the lighting fixture, its base, or support shall entirely cover the corresponding box.

External devices shall be mounted with non-ferrous accessories.

The frame of lighting devices inserted in a false ceiling shall not allow light to infiltrate between the frame and the false ceiling.

Lighting devices fixed directly to a centre box shall be solidly held by a peg and a cramping block.

15.15.8.2 Characteristics of Materials

i) General

- Lighting devices shall, wherever applicable, comply with all conditions stated below.
- The name of a supplier and catalogue number are stated for reference only as a description of type and standard. The equipment supplied shall be consistent with the specification and, if necessary, standard equipment shall be modified accordingly.

ii) Wiring

Wiring inside lighting devices shall have a section equal to or exceeding 2mm², and shall be insulated for a nominal voltage of 500V.

iii) Sheets

The minimum thickness of sheet used in lighting devices shall be 1mm.

Metallic parts of lighting devices shall be free from any scratch.

iv) Treatment and painting of sheets

- All sheets shall receive the following treatment:
Prewashing, grease removal, rinsing, passivation, drying
- Unless otherwise specified, all non reflecting surfaces, such as the frames of lighting devices, bases, etc. shall be coated with an enamel finish. The color of the paint shall comply with the specifications unless specified otherwise by the Supervisor.

- All reflecting surfaces shall be coated with a white enamel having a minimum reflection coefficient of 80%.

15.15.8.3 Fluorescent luminaries
i) General
Flush luminaries shall be so dimensioned as to allow the replacement of one or more sections of the false ceiling without requiring any cutting.

ii) Bushess
Lighting devices shall be equipped with white clip on bushes

iii) Ballasts
Ballasts shall be electronic, consistent with the standard of the D.T.U and designed for 45°C ambient temperature. Only one or two lamp ballasts shall be used.
Ballast shall be completely enclosed inside a metallic casing and shall have a corrosion resistant finish.
Windings shall be impregnated with a polyester resin suppressing every risk of softening and melting and ensuring excellent heat dissipation.
Ballasts shall be corrected to give a power factor better than 0.9
Ballasts shall be of silent type operation and unless otherwise provided for, shall be rapid start type.
Two series lamp ballasts shall be lead lag type or equivalent.

15.15.8.4 Incandescent luminaries
i) Incandescent luminaries shall be fitted with porcelain base bushes having an Edison screw E27, for lamp up to 200W, and Goliath screw E 40 for lamps of 300W or more.

ii) It shall be possible to place and remove lamps without dismantling the system.

iii) The various types of incandescent luminaries shall comply with the detailed description given by the manufacturer.

15.15.8.5 Lamps
i) General
Lamps shall be supplied and placed in all the lighting fixtures as specified.
Prior to the final commissioning of electrical installations, lamps used throughout the works shall be replaced by new ones.

ii) Incandescent lamps
Incandescent lamps shall be of the internal satin type with screw bases.
Lamps shall be designed to work at 220V (or 24V) voltage, they shall have a lifetime of a minimum 1000 hours.

iii) Fluorescent lamps

Unless otherwise specified, fluorescent lamps shall be rapid start type. They shall have a high luminous efficiency.

iv) Halogen lamps

Halogen lamps shall be tubular type, having a lifetime of at least 4000 hours and operating in all directions and positions.

The color temperature shall be 2850°C, the fuse shall be incorporated and the flux value is 5000 lumen.

Particular cases: Lighting of humid buildings

Given the humid atmosphere inside treatment plant and other similar areas, 200 volts should not be used for the lighting system without a security mechanism.

The Contractor shall install special security mechanism in the following manner:

The outgoing supply cable shall be equipped with an isolating transformer and a power circuit breaker fitted with differential protecting devices of adjustable sensitivity and delays 0.3 A, 1A, 3A up to one second.

The rupturing capacity shall be 20KA in accordance with D.T.U

N.B: All equipment used in the buildings shall be standard and shall comply with international technical regulations relating to humid and corrosive buildings (class of protection IP 55 minimum).

15.15.9 EXECUTION OF THE WORKS

15.15.9.1 Locations for installation of equipment

The general locations for the installation of materials shall be as by the approved drawings. These locations shall be agreed on site between the Contractor and the Supervisor or his representative.

15.15.9.2 Secondary distribution panel boards

Unless otherwise directed, secondary panel boards shall be centered 1.50m above finished floor level.

Distribution boards shall be totally protected and fitted with circuit breakers in three phase panel boards, the numbering of circuits indicated on the approved drawings is based on a three phase separation where circuit are connected respectively to the red, yellow and blue phase.

Internal equipment of panel boards (bus bars, circuit breakers, etc….) shall only be installed in the enclosure after installation, fixing and connecting conduits.

All opening left in the panel shall be properly sealed.
Distribution panels shall be installed vertically, under no circumstances shall the conduits serve as supports to the panel.

The sides of panels to be embedded shall be covered before installation with a thick coat of emulsified tar.

The frames of built in panel boards shall be installed squarely and in alignment with the walls.

Each distribution panel shall have at the front side an engraved plate stating the name and reference letters of the panel board. On the inside of each panel board door, there shall be a list starting the reference number for each circuit connected to the panel board and the references number of the locations supplied with power by the circuit.

**General Conditions**

Cable installations shall conform to the following:

i) The methods used for the installation of cables shall not damage the conductors and the insulators.

ii) The pull utilized for installation of cable shall be kept to the minimum necessary for installation and shall not permanently strain the conductors.

iii) The connection of wires to equipment shall not be subject to any strain.

iv) The radius of curvature of cables shall, at no point, be less than 10 times the outside diameter.

v) Between any two sub circuit boxes, cables shall be continuous, no junctions shall be allowed.

vi) The use of wooden pins for sealing is forbidden.

vii) Cables shall be marked every 10 meters in order to facilitate identification.

**Installation of visible cables**

i) Cables shall be installed on cable tray in one layer and shall in no case be superimposed. Each cable tray, shall have a 25% reserve in order to allow for the installation of future cables. Vertical sections shall be fitted with cables fixing devices.

ii) Cables shall be fixed on masonry along walls by means of galvanized steel brackets or other mean proposed by the Contractor and approved by the Supervisor.

iii) Beneath ceilings, cables shall be held by substantial supports. The supports shall be sufficiently close to avoid droop of the cables.

**Other conditions**

Length of cables mounted between ground and a height of 2.5m and those crossing masonry shall be installed inside galvanized steel tube.
15.15.9.3 Insulated wires

All wires and connection devices shall be accessible for inspection and replacement as required. They shall be so set out and installed as to allow handling without causing any mechanical deterioration.

All wires shall be installed entirely inside conduits.

The connection of wires shall be carried out exclusively inside enclosures by clamping in order to prevent the scattering of strands.

The use of adhesive insulating tape is forbidden.

The pulling of wires in conduits shall be carried out carefully in order not to damage the insulator. It is forbidden to use oils, grease or any other fluid for facilitating the pulling of wires, the Contractor can however use powder of an approved type.

Switches shall be installed on phase wires and in no case on neutral wires.

Phase wires, neutral wires and earthing conductors of the installation shall be differential from each other by the color of the insulator.

Each phase wire shall have its own specific color different from any other.

The mixing of colors for a phase wire, from point of installation to another point along the same circuit is strictly forbidden.

The color of neural wires shall be grey, and shall remain unchanged throughout the installation.

The color of the earthing conductor shall be yellow green, and shall remain unchanged throughout the installation.

15.15.9.4 Conduits

Conduits shall be so installed that the junction, sub circuit, and wiring draw boxes are always accessible for maintenance and repair.

The connection of conduits or of conduits and other accessories shall be carried out according to the instructions of the conduit manufacturer.

Surface mounted conduits shall be fixed by means of galvanized steel brackets, sufficiently close to each other to ensure a solid fixing.

After laying the conduits, they shall be fixed in cement mortar.

The Contractor shall make grooves in the walls for built in conduits; in all cases he shall fix the conduits in such a way as not to damage the finish of the structure.

The uses of wooden pegs for sealing is strictly forbidden.

No more than two 90° bends shall be permitted throughout the run of a conduit between two junction boxes. Should more than two bends be required, the Contractor shall install additional junction boxes in order to facilitate the laying and removal of wires.

In the event of the electrical conduits crossing other pipes, electrical conduits shall be so installed as to keep a free space between conduits and pipes.
A minimum clearance of 200mm shall be maintained between electrical conduits and heating or steam pipes. If this 200mm clearance cannot be achieved electrical conduits shall be externally insulated.

Conduits embedded in walls shall be vertical or horizontal. Installation of diagonal conduits inside walls is not permitted.

Surface mounted conduits shall run parallel or perpendicular to walls.

Note: all low voltage cables shall be installed in separate conduits.

15.15.9.5 Switches

Switches shall be flush or surface mounted according to the type of installation.

Switches shall, in general be installed 1100mm above the finished level of the floor, except in particular cases where their installation shall be submitted for the Supervisor's approval.

Switches intended for the same duty in different locations shall be installed at the same heights. Switches shall always be installed in the most suitable places for their operation.

15.15.9.6 Socket outlet and plugs

The exact locations of socket outlets and plugs shall be determined according to the construction details of the building. These locations shall be submitted for the Supervisor's approval.

Socket outlet shall be flush or surface mounted according to the type of the installation.

Flush mounted socket outlets shall be installed in their boxes with screws.

All single phase socket outlets and plugs shall have earthing contacts or terminals to be connected to the earthing system.

Three phase socket outlets shall be installed at heights which suit the equipment they supply with power.

Socket outlets and plugs intended for the same duty in different locations shall be installed at the same heights.

15.15.9.7 Tests

General

Installation tests shall be carried out throughout the works, whenever it is necessary, and at the end of works. Tests shall be consistent with the specifications of the contract document and the standards in force.

The Contractor shall supply, without any additional payment, all equipment analytical instruments, and labor necessary for conducting these tests. Analytical instruments shall be sealed and supplied with recent calibration certificates provided by an official laboratory.

All tests shall be carried out on the responsibility of the Contractor.
In the event of a failure of the tests, tests shall be repeated after the Contractor has carried out the necessary repairs or replacements.

The results of test shall be set out in a report signed by the Supervisor or his representative and by the Contractor.

**Types of tests**
Tests shall comprise, but shall not be limited to, the following:

**Visual inspection**
- Checking the state of the equipment and the quality of work.
- Checking levels and alignments
- Verifying the effective characteristics of the equipment

Measurement of the insulation resistance and circuit continuity

This test shall be conducted on the various circuits after receivers have been removed.

**Operation tests**
All electrical equipment shall be tested when operating in order to verify conformity with the specification of the contract documents and the installation regulations.

**Performance tests**
These tests shall be conducted in order to verify the features of the installations and conformity with the standards in force.

The Contractor shall conduct any other test deemed necessary by the Supervisor in order to verify the condition and the functioning of the installations.

15.15.10  TELEPHONE INSTALLATIONS

15.15.10.1 General
The Contractor shall be responsible for ensuring the installation of two fixed telephone lines. He shall make all the necessary arrangement towards the local telecommunication authority for the connection of the treatment plant to the main telephone network. He will settle all the corresponding fees, these fees will be paid out of the Provisional Sums contained in the Contract.

The required installation shall comprise
- i) Main distribution boxes
- ii) Secondary distribution boxes for each office unit
- iii) Distribution circuits
- iv) Telephone plugs

15.15.10.2 Distribution circuits
- i) Cables required for this installation shall have copper conductors of 0.5 mm in diameter, except for the earthing conductor which shall have a
sufficient diameter according to the number of socket-outlets and plugs it connects. All cables shall be insulated with PVC sheathing.

Cables shall be divided into three categories
- Multicore cables between main distribution and main distribution boxes of various floors and locations. The capacity of these cables shall be equal to the number of conductors required for each distribution box, in the 25% spare capacity.
- Two core cables between secondary identical to those used in electrical installations. The section of the conduit shall be, as a minimum, two times larger than the total section of cables (including insulation) it is designed to house.

ii) All cables shall be laid in conduits identical to those used in electrical installations. The section of the conduit shall be, as a minimum, two times larger than the total section of cables (including insulation) it is designed to house.

15.15.10.3 Telephone plugs

Telephone plugs shall be built in or surface mounted. They shall have the same brand name as socket outlets and plugs.

16 MECHANICAL WORK

16.1 GENERAL

16.1.1 MATERIALS

16.1.1.1 Materials in contact with potable water

The materials are in detail specified within the Bill of Quantities (BoQ). In addition the following condition applies.

Any non metallic materials, such as may be employed for bellows, packing or sleeves, coatings or linings, etc liable to come in contact with potable water shall be approved for the purpose by a recognized approval body.
16.1.1.2 Materials in contact with sewage

The materials are in detail specified within the Bill of Quantities (BoQ). In addition the following conditions apply.

Materials in contact with sewage shall be suitable for the environment but particularly all bronze materials shall be true bronze (i.e zinc free) alloys.

16.1.2 INDICATOR GAUGES

If not specified different in the Bill of Quantities the following conditions apply:

All gauges shall be constructed with non-corrodible metal cases and stainless steel bezels. They shall be located to enable easy reading by the plant operator and mounted to preclude damage due to vibration. The cases shall be at least 100mm diam unless otherwise specified, scaled in metric units and normally ranged over a 240° arc from zero to 20% - 40% above the system designed operating value for full load conditions, except where finite limits exist, e.g level/contents gauges which shall be ranged 0-100%, or where restricted ranges are specified.

A schedule of gauges shall be provided for approval, detailing arrangements, scale ranges, designation label inscriptions and any alarm contacts.

Labels shall be securely attached on, or adjacent to each gauge and groups of any such instruments shall be of matching appearance and approved layout.

Pressure gauges shall be of the Bourdon tube or diaphragm type. Each gauge shall incorporate a surge damping device and be fitted with its own stainless steel isolating cock.

Pressure gauges incorporating transducers for remote monitoring shall be damped to provide a steady output. The pressure at the tapping point shall give a direct indication on the gauge as well as driving the transducer. Any alarm contact settings shall be independent of the transducer function and neither shall interfere with the direct gauge indication.

Temperature gauges shall be of a type suitable for the application with the sensing element mounted within a thermal well. Where specified, the maximum working temperature under full load conditions shall be marked by means of a pre-set red pointer.

Pumping station water pressure gauges shall have a dial diameter of not less than 100mm and be calibrated in meters head. The gauges shall be uncorrected for datum and show actual pressure at the tapping point. The label bearing the designation given in the gauge schedule shall include the Ordnance Datum level of the tapping point.

Pump delivery and station delivery pressure gauge shall be mounted at a convenient height for reading on a gauge board of varnished hardwood, 20mm marine plywood or equivalent non-corrodible material with stainless steel capillary pipework, having an isolating cock at each end connecting the pressure tapping to the gauge. Suction gauges and their isolating cocks may be mounted direct on the tapping bosses and shall be adequately supported.

16.1.3 FASTENERS

If not specified different in the Bill of Quantities the following conditions apply:

All bolts, nuts, studs and studbolts, including those required for installation at terminal points to existing equipment, shall be provided by the Contractor and shall have metric threads to BS 3643.
After tightening, the minimum engagement of the thread shall equal the thickness of the nut. The projection of the thread beyond the outer face of the nut shall not exceed one quarter of the outside diameter of the thread. In no circumstance shall galvanized or coated bolts be shortened by cutting.

Washers shall be provided under all nut and bolt heads.

All fastenings and accessories in contact with the process water shall be of stainless steel, cadmium plated mild steel or other corrosion resistant material subject to the approval of the Supervisor. All bolts, nuts, screws, washers and other fixings for anchoring the plant to walls, floors, ceilings, etc, shall be of corrosion resistant material or shall have a protective surface treatment to the approval of the Supervisor.

All bolts in inaccessible positions shall be secured by either self-locking nuts, spring washers and nuts, or castle nuts with split pins. Fasteners associated with items requiring removal during routine maintenance shall be of stainless steel. All other items shall be sheradised or hot dip galvanized in matched condition.

All holding down or foundation bolts shall be supplied and shall be complete with hexagon nuts and washers. Bolts of steel round bar formed into a loop at one end are not acceptable.

16.1.4 FASTENINGS TO CONCRETE OR MASONRY

Anchor bolts for the fixing of small items shall be of the torque expanded type of approved make, installed strictly in accordance with the manufacturer's instructions. The size of hole required in the civil world shall not exceed 38mm.

Where the base material will not withstand the expansion stresses imposed by the torque expanded type, or where the highest degree of resistance to vibration is required, an approved type of chemically bonded anchor bolt may be used.

The minimum distance from any concrete edge shall be 100mm for expanding type fixings and 75mm for embedded bolts.

16.1.5 BASEPLATES

Separately mounted items of plant which are required to maintain an accurate alignment shall be mounted on a common baseplate, together with all associated items and guards.

The baseplate shall be of rigid construction, machined on all mating surfaces and drilled door foundation fixings. Machined datum faces shall be provided and leveling facilities incorporated in the underside.

Provision shall be made for the easy removal of any section of the drive and positive re-alignment using dowels or other approved means. Shims and packing shall be kept to a minimum and clearly identified for re-assembly.

All drain points on the assembled plant are to have easy access, and drain piping shall extend beyond the baseplate.

16.1.6 PROVISION FOR HANDLING

Suitable provision, approved by the Supervisor, shall be made by the Contractor to facilitate the handling of all items in excess of 36kg.
Any item weighting one tone or over and which may be required to be lifted during operation and maintenance shall be appropriately marked with its weight.

16.1.7 PROTECTION OF MOVING PARTS
All moving parts where accessible to operational personnel shall be protected and guarded to meet to relevant regulations. All guards shall be designed to facilitate easy removal.

16.1.8 BALANCING
All rotating parts of the machinery shall be statically and dynamically balanced unless otherwise agreed in writing by the Supervisor. The complete rotating assembly shall be designed such that any critical speeds are outside the duty running speed range of the machine.

16.1.9 LUBRICATION
Any component requiring manual lubrication shall be provided with greasing nipples of an approved type mounted on a panel and identified.

A remotely mounted electrically operated lubricator of approved type shall be provided to serve components, if any, requiring continuous lubrication by external mechanical means.

The lubrication tubes, if any, shall be of approved material suitable for high pressure use.

The Contractor shall include for all grease and oil required for testing at works and site.

The first filling after tests shall be provided by the Contractor who shall submit details, of his recommended lubricants, which shall be available from any of the major oil companies, for approval by the Supervisor.

All bearing surfaces shall be properly charged with grease before the plant is operated.

16.1.10 NAMEPLATES AND LABELS

Instruction plates, nameplates and labels shall be provided for all items of the plant giving particulars of duty, size, serial number and full information for identification and operation. Their construction and engraving shall be to the Supervisor’s approval.

16.1.11 PLANT REFERENCES

After final painting, all plant items shall be identified by a unique reference character as detailed on the specification drawings or otherwise specified. Such references to be affixed in a prominent position on the plant body with characters not less than 100mm high or as otherwise specified. Characters shall be bold capital letters and/or numerals. The abbreviation ‘No’ shall not be used.

Unit reference shall include any associated main and auxiliary drives and shall follow a logical sequence based on layout or history. In any particular installation, a set of similar duty drives where any number of units may run shall be suffixed 1, 2, 3, 4 etc, whereas alternative drives for the same duty, where only one unit may run (i.e duty/standby), shall be suffixed A, B, C, etc…,
16.1.12 TOOLS AND TACKLE FOR MAINTENANCE
The Contractor shall supply a complete set of any special tools and other equipment necessary for the dismantling, re-erection and adjustment of the plant.

The tools provided shall be in new condition, adequately labeled as to their use and contained in stout and suitable padlocked boxes. The Supervisor’s instructions as to who shall be the recipient of the tools shall be sought before delivery is made.

Any special slings required shall be provided and clearly marked by embossed labels to show safe working loads. Test certificates shall be provided where applicable.

16.1.13 LOCKS AND KEYS FOR MECHANICAL PLANT
All locks of the same size shall be of the same type and manufacture but having different keys. Three keys shall be provided for each lock.

Each key shall have permanently attached to it an embossed brass label stating the following:
   a) Key number
   b) Location of lock/item of equipment

16.1.14 NOISE LEVEL
All plant shall run without undue vibration and with the least practicable amount of noise.

Vibration levels shall exceed these set cut in ISO 2372 for the particular type of equipment.

Any items of plant which produce a noise level exceeding 65 dB (A) at 3 meters shall be listed by the tendered. It shall be deemed that all items of plant not so listed have a noise level of less than 65 dB (A) at 3 meters.

To meet the environmental requirements, the Contractor shall provide all necessary equipment to meet the following conditions, based on the site layout shown on the specification drawings and with 75% of the plant running simultaneously.
   a) The noise level generated at the site boundary by any new plant shall not exceed that generated by the existing plant.
   b) The noise level at 100m from the source does not exceed 65 dB (A)
   c) The noise level in the building (10m from the source) does not exceed 70 dB (A)
   d) The noise level in the plant room (5m from the source) does not exceed 80 dB (A)
   e) Warning notices shall be provided at all entrances to rooms were the noise level will exceed 75 dB (A).

16.1.15 FROST PROTECTION
The plant shall be adequately protected against damage from freezing, using an approved means of insulation.

Particular attention shall be given to pipework, pump casings, etc. and any part of the plant and equipment likely to stand for periods charged with static water.
Where lagging is used, it shall be suitable for outside installations and completely impervious to all weather and atmospheric conditions on the works. Lagging materials containing asbestos shall not be used.

The lagging shall be sectional and easily removed for maintenance purposes. Joints shall be sealed together with an approved waterproof adhesive type.

Areas where lagging may be vulnerable to damage shall be suitably protected by an approved means.

16.1.16 CORROSION PROTECTION

If not specified different in the Bill of Quantities the following conditions apply:

Where dissimilar metals are in contact or close proximity and corrosion may occur through electrolytic action or differences in electrical potential, protection shall be afforded by electroplating, suitable gaskets, cathodic protection or other means approved by the Supervisor.

Chromium plated parts shall not be used on sewage works or in any other damp or corrosive atmosphere.

All surfaces shall be adequately protected in transit, and any damage shall be renovated immediately on off loading and on completion of erection.

After cleaning and inspection but before the plant leaves the Contractor’s works the machined surfaces of steel and ironwork shall be covered with a preserving fluid of an approved type, or otherwise protected to the Supervisor’s satisfaction.

All external steel screw fixings shall be supplied in the galvanized condition, stainless, steel, or sheradised to comply with BS 4921, Class 1 or Class 2 with passivation treatment.

16.1.17 SURFACE PREPARATION AND PAINTING

If not specified different in the Bill of Quantities the following conditions apply:

The whole preparation and paint system be suitable for the operating environment specified, and a painting schedule giving details of preparation treatment types of paint number of coats and method of application shall be submitted with the tender. (See particulars plant).

Proprietary items may be used in their standard finish subject to the approval of the Supervisor. For specified applications, adequate supervision shall be provided for all stages of preparations, application and testing.

All steel work shall be protected in accordance with BS 5493 and based on a long time to first maintenance. The exterior environment shall be regarded as ‘polluted inland’ and the interior environment shall be regarded as frequently damp.

After all machining, forming and welding has been completed, all steelwork surfaces shall be thoroughly cleaned of rust, scale, welding slag or spatter and other contamination prior to any painting.

The system proposed shall be abrasion resistant and conform to the following typical requirements

Preparation of steel work at the works shall be either:
i) Hot dip galvanized to BS 729 with a median thickness of 85 microns (0.0034") or

ii) Grit blasted to BS 7079 grade SA 2.5 and zinc sprayed within 4 hours to BS 2569 part 1 to a thickness of 125 microns (0.005") followed by one coat of approved etch primer.

Typical finishes (with compatible primers) based on BS 5493 are given below.

   a. Steel work and ferrous castings exposed above water / sewage level:
      either high build micaceous iron oxide or chlorinated rubber to give a minimum total dry film thickness of 300 microns or, one coat of two pack epoxy primer and further coats of epoxy paint to give a total dry film thickness of 270 microns.

   b. Steelwork below water / sewage level:
      Either epoxy system as above or coal tar epoxy paint system to give a minimum total dry film thickness of 450 microns.

   c. Ferrous castings and fittings without substrate below water level:
      Coal tar epoxy paint system to give a minimum total dry film thickness of 450 microns. These coatings shall be subject to the holiday test.

The surface of all non-ferrous parts usually painted shall be cleaned, rubbed down, stopped, filled and given one priming coat of paint.

Anti-corrosion coatings for any steel or iron used in pipe work, pumps, valves, etc., in contact with potable water shall be either a compatible bitumen material to BS 3416 or a polymeric anti-corrosion coating complying with Water Industry Specification WIS 4-52-01.

Any damage occurring to any part of a painting scheme shall be made good to the same standard of corrosion protection and appearance as that originally employed. Any finish coat applied on site shall be considered for decorative purposes only.

Manufactured articles to be galvanized shall be hot dip galvanized after complete fabrication and no bending, cutting, drilling, riveting or threading shall be permitted after galvanizing.

The care of galvanized articles when transporting, storing and erecting them shall be in accordance with the recommendations of BS 729. The renovation of small areas of damaged coating not exceeding 40mm² shall be in accordance with Appendix D of BS 729 and subject to the Supervisor’s approval.

16.1.18 PAINT COLORS

If not specified different in the Bill of Quantities the following conditions apply:

The colors of the primer, intermediate and finishing coats of a paint system shall be easily distinguishable from each other, and the materials used shall be suitable for the method of application employed and preferably be supplied by one manufacturer who shall ensure that all coatings are compatible.

The final colors and finish for the equipment shall be coordinated with the Supervisor.
16.2 PUMPS

16.2.1 PUMP DUTY

Pumps shall generally be executed as specified in the Bill of Quantity. Before delivery data sheets have to be provided for approval by the Supervisor of the specified type submitted for the approval of the Supervisor.

They shall be designed to give specified output against all losses including those relating to the pump.

The Contractor shall match his pump characteristics to the pipe system network to achieve high pump efficiency and reliability.

Each set must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system characteristics given.

The pump section and arrangement shall be such as to ensure that the head available exceeds the N.P.S.H. requirements of the pump under all operational conditions.

Where the system and pump characteristics are such as to give rise to the possibility of surge in the pipeline with consequential damage, a surge investigation shall be undertaken. If the results of the investigation show that there is a problem, measures shall be proposed by the Contractor to alleviate the problem. These measures shall be approved by the Supervisor.

Centrifugal pumps shall have a non-overloading characteristic over the complete range of head and quantity delivered, and the drive shall be capable of starting the pumps against a closed valve, i.e. maximum pump head conditions.

The whole pumping unit shall be capable of withstanding without detriment, reverse rotation to a speed that would occur if the pump were to stop when the differential head was at a maximum and the delivery, and/or the non-return valve failed to close.

For sewage pumps the ability to operate with the maximum reliability is of prime importance, with efficiency being a secondary consideration. The pump shall therefore operate without clogging, being designed to pass a sphere of 125 mm dia. where the size of the delivery mains permits. Whilst the pumps shall be designed to meet a specific duty they shall also be capable of operating over the duty range specified for prolonged periods and for standing idle for long periods without attention as in the case of storm pumping.

16.2.2 CENTRIFUGAL PUMP CASINGS

Centrifugal pumps have to be executed exactly according to the specification given in the Bill of Quantity.

16.2.3 SUBMERSIBLE SEWAGE PUMPS

Submersible pumps have to be executed exactly according to the specification given in the Bill of Quantity.

16.2.4 PROGRESSIVE CAVITY PUMPS

Progressive cavity pumps have to be executed exactly according to the specification given in the Bill of Quantity.
16.3 VALVES AND PENSTOCKS

16.3.1 TYPES AND OPERATING CONDITIONS
Any valves and penstocks required are in detail specified in the Bill of Quantities

16.3.2 IDENTIFICATION
Each valve shall be identified by a unique reference as approved which shall identify the medium/plant controlled and be numbered according to the logic given in the P & ID.

The reference shall be either engraved on a 3mm thick laminated white/black/white trifoliate disc or stamped on a 1.0 mm (19g) thick brass disc. The discs shall be at least 35 mm dia. with reference letters and numerals not less than 4mm and 8mm high respectively.

The discs shall be mounted on the hub of the hand wheel or where this is impractical, they shall be attached to the valve stem by means of suitable brass ‘S’ hooks and/or jack chain through a hole at the top of the disc.

16.3.3 ACCESS
All valves, spindles and handwheels shall be positioned according to the process drawings provided to the Contractor by the Contracting Authority in order to give good access for operational personnel. It shall be possible either to remove and replace or to recondition seats, gates or gland packing which shall be accessible without removal of the valve from the pipework or, in the case of power operated valves, without removal of the actuator from the valve.

Extension spindles shall be supplied wherever necessary to achieve the specified operating requirements.

16.3.4 HAND OPERATION
All hand wheels shall be arranged to turn in a clockwise direction to close the valve or penstock the direction of rotation for opening and closing being indicated on the hand wheels.

The hand wheels shall be coated with black plastic and incorporate facilities for padlocking in either the open or closed position.

The operating gear of all valves and penstocks shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified service value and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200kg.

Power operated valves shall include equipment for manual operation by means of a hand wheel or other suitable device which shall be interlocked with, and fixed to, the power unit.

Headstocks and valves of 50 mm nominal bore and above shall be fitted with mechanical position indicators to show the amount which the valve is open or closed in relation to its full travel, i.e. 0.25, 0.50, 0.75, 1 etc.

16.3.5 VALVE MATERIALS
The valve materials are in detailed specified in the Bill of Quantities
16.3.6 SLUICE VALVES
The sluice valves respectively knife gate valves are in detailed specified in the Bill of Quantities.

16.3.7 NON-RETURN VALVES
The non-return valves respectively knife gate valves are in detailed specified in the Bill of Quantities.

16.3.8 BUTTERFLY VALVES
The butterfly valves respectively knife gate valves are in detailed specified in the Bill of Quantities.

16.3.9 PLUG VALVES
Plug valves to be executed in according to the specifications of the Bill of Quantities.

16.3.10 EXTENSION SPINDLES
Extension spindles shall be adequately sized to prevent buckling and shall be attached to the valve/penstock stem by a suitable adapter incorporating two muff couplings, scarf lap jointed and pinned with at least two coupling joints included. Universal joints and waterproof sleeves shall be provided where specified, Extension spindles shall be manufactured as specified in the Bill of Quantities.

Intermediate bearing support or guide brackets of cast iron, with slotted holes for site adjustment shall be fitted to long shafts where necessary. Bearings shall be of PTFE or similar approved type.

16.3.11 PEDESTALS AND SPINDLE COVERS
Penstock and valve pedestals shall be of cast iron or heavy duty, welded, mild steel construction with a substantial base and fixing provision. The base and top of the pedestals shall be machined normal to the axis of the drive shaft.

Where necessary, support guide bushes shall be fitted as the base of the pedestal.

The pedestal height shall be such that the hand wheel is approximately 1 meter above the operator's floor level.

Covers of an approved type shall be provided for all rising spindles to totally enclose them when in the fully raised position.

16.3.12 PENSTOCKS
All penstocks shall be executed according to the Specification in the Bill of Quantities.

16.3.13 TESTING
All valves shall be tested in accordance with DIN EN 12266-1. Pressure and material test certificates shall be submitted to the Supervisor for approval.
16.4 PIPE WORK

16.4.1 SYSTEMS DESIGN
The piping system has to be executed according to the Contracting Authority’s detailed design provided to the Contracting Authority and according to the detailed specification given in the Bill of Quantity.

16.4.2 FLANGES
All flange connections shall be executed according to the Specification in the Bill of Quantities.

16.4.3 MATERIALS
Pipe work materials, sizes, pressure rating, fittings, coupling arrangements and median carried shall be as detailed in the Bill of Quantities.

16.4.4 JOINT AND PIPE FASTENINGS
All nuts, bolts, washers, flanges, gaskets, flanged tied adapters, drain valves, special connection pieces, supporting hangers, brackets or clips and temporary supports for the pipe work, together with all terminal point connection materials shall be supplied and installed under this contract.

All flanged joints shall be fitted with suitable insertion ring gaskets which shall be carefully adjusted concentric to the bore of the pipe so that no undue strain is placed on any of the bolts or flanges of the pipe when bolting up.

16.4.5 TEMPLATE PIPES
Template, or closure pipes, shall be provided where necessary to facilitate erection. The design and construction of the template pipes shall be to the approval of the Supervisor, and the Contractor will be responsible for establishing the dimensions of the template pipes such that there will be no strain placed on the connected items after installation.

16.4.6 BY-PASSES
Where pipeline flow meters are used, particularly electromagnetic meters, by-pass pipe work and valves shall be installed to allow removal of the meter without interrupting the process flow.

Draining shall either be via back-flow or drain valves.

16.4.7 BRANCH PIPE AND BOSSES
Branch Pipes and Bosses are to be provided according to the specification in the Bill of Quantities.

16.4.8 SMALL BORE PIPE WORK
Small bore pipework up to 15mm OD shall be manufactured from stainless steel tubing with suitable compression type fittings. All small bore pipe work and capillary tubes shall be adequately and securely clipped or clamped. Compression fittings bends shall be kept to a minimum, as pipeline bends of generous radii are preferred. Compression couplings shall be heavy series to BS 4386 Part 1.
Any gauges, transducers or switches etc. fed via small bore pipe work shall have an individual isolating cock adjacent to each component with adequate space being allowed for component removal for servicing.

16.4.9 DUCT SEALS
After the pipe work is installed, the Contractor shall seal the ends of all ducts, pipes or trenches leading into buildings, whether occupied or not, for pipe work associated with this Contract. The seals shall be approved water, gas and fire sealing transit units with appropriate fillers, and insert blocks shall be fitted to duct and trench entries. All steelwork on such transit assemblies and frames shall be hot dip galvanized. Transit frames will be incorporated in the construction by the civil works Contractor.

16.4.10 REFERENCE MARKING
Prior to dispatch from the manufacturer’s works each pipe section shall be marked with an appropriate reference number for future identification.

16.4.11 PROTECTION OF PIPE WORK
Immediately after the completion of fabrication at the works or on site and during transport and storage, pipe ends shall be protected from external damage and sealed against ingress of dirt by suitable caps, plugs or other similar means. After cleaning and inspection, machined surfaces of all steel and ironwork shall be covered with preserving fluids or approved type or otherwise protected, and all flanges shall be fitted with blank discs bolted to each face.

16.4.12 STAINLESS STEEL PIPE WORK
16.4.12.1 General
Stainless Steel pipes and fittings shall be manufactured to DIN EN ISO 1127 to the pressure ratings respectively wall thicknesses specified in the Bill of Quantities. Joints and fittings shall be provided of the material and quality as specified in the Bill of Quantities. All stainless steel pipes, joints and fittings shall be prefabricated, welded under inert gas and acid-treated in a pickling bath.

16.4.12.2 Joints
Unless otherwise specified, stainless steel pipes are to be jointed as specified in the Bill of Quantities

16.4.12.3 Inspection and Testing of Pipes and Fittings
All pipes and fittings shall be hydrostatically tested at the place of manufacture to the pressure specified in the Contract.

16.4.13 CHEMICAL PIPE WORK
Chemical pipes shall be executed according to the detailed specifications in the Bill of Quantities
16.5 PLATFORMS AND WALKWAYS

16.5.1 GENERAL
All necessary platforms, toe-plates, ladders, stanchions, handrails, chains and all associated fittings, support structures and curbing shall be supplied to provide a safe and efficient installation.

16.5.2 STEELWORK
All mild steel items shall be protected according to DIN EN ISO 1461 by hot dip galvanizing after fabrication.

No cutting, drilling, bending, riveting, threading or similar operation will be permitted after galvanizing, and due care shall be exercised in transporting, handling and fixing galvanized metalwork to prevent damage to the zinc coating. Under no circumstances shall damage to the zinc coating be repaired with rust inhibiting paint.

DIN EN ISO 14713, DIN EN ISO 10684 as well as DIN EN 10240 are also to be considered.

16.5.3 PLATFORMS
All platform panels shall be individually secured to the supporting structure and be of suitable size and weight for ease of handling. They shall be cut and fixed to maintain a continuity of pattern.

Platforms, walkways and floor covers shall be adequately supported to prevent undue flexing and have supporting rebates with a minimum landing width of 30 mm. unless specified elsewhere, where the supporting structure is concrete, galvanized mild steel angle curbs shall be provided and securely grouted into rebates left in the concrete such that the tops of the panels are flush with the top of the concrete.

Unless specified elsewhere, normal access ways shall be suitable for a minimum uniformly distributed load of 5 kN/m². Where platforms and floor covers are specified for concentrated loads or machinery support, the uniformly distributed loading shall be not less than 15 kN/m².

16.5.4 HINGED COVERS
All covers have to be executed as specified in detail in the Bill of Quantities.

16.5.5 LADDERS
Ladders have to be executed as specified in the Bill of Quantities

16.5.6 RAILING
Guardrails shall be provided as specified in the Bill of Quantities

16.6 CRANES AND HOISTS

16.6.1 GENERAL
Cranes and hoists shall be of standard proven design in accordance with DIN EN 13001 and EN 15011, rated for lifting the specified working loads, utilization and service conditions shall be suitable for operation from the runway beams provided. Motions shall be motorized as specified with dual speed hoisting facility and controlled from a pendant push button unit via a
crane control panel mounted on the gantry.

All operations, whether manual or electric, shall be controlled or performed from motor room floor level unless otherwise specified.

The lifting assembly shall be rated for the highest lift that could occur during installation and maintenance operations, including allowance for friction.

The crane shall consist of a gantry or jib, crab and hoist assembly, ropes, block and hook together with the necessary running rails and all electrical supply requirements, as specified in the Bill of Quantities.

16.6.2 TESTING

All lifting equipment shall be tested at the manufacturer's works and on site. Tests on site shall comprise a full load test, including, where applicable, deflection checks on beams. Where lifting equipment is forming part of the permanent works for installation purposes the Contractor shall have the equipment tested and be in possession or a valid test certificate before using the equipment. All equipment must be tested or retested within one month of handing over to the Contracting Authority. Six copies of test certificates shall be provided. The Contractor shall be responsible at his own cost for the provision of all weights, slings and other equipment required for testing.

16.6.3 RATING PLATES

The SWL shall be clearly marked on the rating plate and shall be legible from the plant working level.

16.6.4 PAINT FINISH

Unless specified otherwise the corrosion protection finish shall be in accordance to DIN 18364

16.6.5 CRANE ACCESS

Where clearances permit, provision for safe access for maintenance shall be provided in accordance with BS 466 and shall include a walkway across the span having a height clearance of 2m and be fitted with double-tiered handrails and toe boards.

16.7 COMPRESSIONS/ BLOWERS

Execution, documentation as well as designation of compressors and blowers according to:

- EC machinery directive 2006/42/EG according to CE-manufacturers declaration, annex II B
- 2009/105/EG (87/404/EWG) directive for pressure vessels
- 97/23/EG directive for pressure equipment
- 2006/95/EG low voltage directive
- 2004/108/EG directive for electromagnetic tolerance

Important harmonised norms:
- ISO 12100-1/-2 safety of machines
- EN 60204-1 safety of mechanical and electrical equipment
- EN 1012-1 safety requirements - compressors
- EN 1012-2 safety requirements - vacuum pumps (ASV, BSV, CSV)
- EN 378 cooling devices and heat pumps (safety technical and environmental relevant requirements)

Norm for technical data:
- effective delivery rate: according to ISO 1217:2009 annex C
- noise pressure level: according to ISO 2151 and the basic standard ISO 9614-2, tolerance +/- 3dB(A)
- apparent noise power level: according to ISO 2151 and the basic standard ISO 9614-2, tolerance +/- 3dB(A)

16.7.1 AIR COMPRESSOR
The compressor including air receiver and separator shall be executed as specified in detail in the Bill of Quantities

16.7.2 AIR PRESSURE CONTROL
The compressor shall be arranged to maintain the air pressure in the system within the specified limits by means of pressure switches in conjunction with unloaded valves and timers to prevent prolonged off-load running.

The frequency of starting and stopping shall be within the limitations of the drive arrangement.

Where two compressors are operated on a duty/standby basis, the duty compressor shall operate whenever the low pressure switch closes and shall cease operation when the high pressure switch opens. Should the pressure fall to the standby low pressure, the standby compressor shall operate in conjunction with the duty compressor and shall similarly cease operation when the high pressure switch opens.

The circuits for the compressor motor starters shall be completely separate. Either unit shall be capable of duty or standby operation and periodically their modes will be reversed.

The blower shall discharge continuously the specified free air delivery at specified suction and delivery pressures.

16.7.3 AIR BLOWER ACCESSORIES
Air blowers have to be executed as specified in detail in the Bill of Quantities
16.8 DIESEL ENGINES

16.8.1 GENERAL

The engine shall be a cold starting 4 stroke water cooled, multi-cylinder in-line or "V" form, naturally aspirated or turbocharged and intercooler, totally enclosed industrial diesel of standard proven design, designed to run on liquid petroleum fuel to BS 2869 Class ‘A’, and incorporate all starting, lubricating, cooling, monitoring, alarm and shut-down systems suitable for automatic and continuous unattended operation.

The engine crankcase shall be fitted with a breather pipe and safety devices to provide protection in the event of an explosion.

Crankcase access panels shall be provided for maintenance/inspection where possible.

16.8.2 DUTY AND RATING

The engine shall be rated in accordance with BS 5514 to provide the necessary torque and power output at a rated speed not greater than 1500 rpm, to drive the specified load under the given site conditions.

16.8.3 FLYWHEEL

The engine crankshaft shall be fitted with a flywheel of suitable inertia to absorb speed variation to within the specified limits. The flywheel shall incorporate all necessary barring facilities and timing marks. Safety devices shall be fitted to prevent the engine starting when any barring gear is in use.

16.8.4 TORSIONAL AND CYCLIC CHARACTERISTICS

The rotating system of the engine and ancillaries shall be statically and dynamically balanced during manufacture. Detachable components, e.g. fans, shall either be separately balanced or permanently marked in a manner that ensures correct angular positioning.

For alternator drives, the coupling between the engine and alternator shall be a flexible type, of the manufacturer's standard arrangement, and the torsional characteristics, cyclic irregularity, angular deviation and freedom from resonance shall comply with BS 4999, Part 142 and BS 5514 Part 5. The interchange of information between the engine and alternator manufacturers as directed therein shall be observed so as to ensure this.

16.8.5 GOVERNOR AND-SPEED CONTROL

The engine shall be fitted with a governor suitable for automatically controlling the engine speed in accordance with class 2 of BS 5514, Part 4. Provision shall be made for variable hand speed control, emergency manual shutdown and an over-speed trip arranged to cut-off the fuel supply.

16.8.6 AIR INTAKE

The combustion air for the engine shall be drawn from the area specified, through an air filter having elements of a type commonly available.

Where combustion air is ducted from outside the building, the duct entry shall be fitted with a coarse mesh and fixed louvers arranged prevent the entry of debris, small animals and the
products of inclement weather.

16.8.7 FUEL SYSTEMS

The engine fuel system shall consist of an engine mounted daily service tank, filters and fuel injection equipment with solenoid operated fuel cut-off valve, a gear driven mechanical high pressure fuel pump and isolating valves for the fuel supply to and from the service tank, mounted adjacent to the engine.

Fuel leak off shall be piped back to the fuel filter assembly or the daily service tank. The high pressure fuel lines between the pump and injectors shall be sheathed to contain and return any spillage to the daily service tank. Such return pipe work shall incorporate a reservoir chamber with a float switch to detect any accumulated leakage. Fuel atomizers shall be easily removable and interchangeable.

All fuel pipe work on the engine shall be rigid tubing neatly dressed and clipped to avoid vibration or interference with maintenance procedures, have simple facilities for the relief of air locks and be spaced at least 50 mm clear of any surfaces whose temperature exceeds 200°C.

Fuel filters shall be full flow type fitted with re-usable mesh material. For continuously running, base load applications, filters shall be twin or triple compartment type with a change-over cock to enable one cartridge to be removed for cleaning without stopping the engine.

16.8.8 LUBRICATING SYSTEM

The lubrication system shall permit automatic starting of the engine and immediate load acceptance and consist of a wet sump with integral engine driven gear type pump providing forced lubrication to working parts through an oil cooler and a duplex full flow filter. The filter shall use disposable elements commonly available and be of adequate capacity to allow continuous periods of running without changing or cleaning.

Independent electric motor driven engine lubricating/pre-heating units shall be provided to give automatic periodic priming in accordance with the manufacturer’s recommendation while the engine is at rest.

A hand priming pump shall also be fitted to enable all parts of the engine to be lubricated as required.

The cooling of lubricating oil on engines with engine mounted radiators may be by an ‘oil’ section in the radiator. Engines with remote mounted radiators shall be provided with engine mounted water-to-oil heat exchangers for the cooling of lubricating oil.

The engine shall employ thermostatically controlled, liquid cooling using fresh water in a closed circuit, designed to suit the ambient conditions specified and comprise an engine driven circulating pump and a self-venting radiator. The pump shall also be capable of circulating sufficient coolant through the engine’s lubricating oil cooler. Facilities for topping up and draining the system shall be provided together with a thermostat with a warming up by-pass.

A make-up header tank and automatic float valve shall be provided, together with all necessary connections to the specified supply source and the cooling system.

The cooling water shall include a quantity of anti-freeze to give protection to minus 10 degrees centigrade. An immersion heater and control thermostat shall be fitted to the system within the engine block to protect the coolant from freezing and shall operate from a 220V AC supply
when the engine is not running.

Radiators mounted on engines shall be cooled by a 'pusher' type engine driven fan which draws air from the vicinity of the engine block and discharges it through the radiator core. They shall also include a suitable mounting flange for the attachment of air duct trucking.

Remotely mounted radiators shall be cooled by an electric motor driven fan fed from an auxiliary generator directly driven by the engine.

If the engine cannot be fitted with a suitable direct driven coolant circulating pump capable of maintaining adequate circulation through a remote radiator, an auxiliary electric motor driven pump shall be provided. This pump shall be arranged to operate from the same supply serving the electric motor driven radiator fan.

16.8.9 EXHAUST SYSTEM

Each engine shall be fitted with a suitable exhaust system from the engine to the specified discharge point. The route shall be as short as site conditions allow and minimize the number of bends, which must be of large radius. The system shall include a primary residential type silencer, flexible and rigid pipe work, roof cowl, flashing and all necessary ties and supports. The primary silencer shall be supported from the engine set and shall have a flanged outlet incorporating a flexible stainless steel bellows section for ease of disconnection from the remainder of the exhaust system. The exhaust system shall be insulated with a non-asbestos material. Removable cladding shall be provided on the exhaust system where required.

Support brackets shall allow for pipe expansion and where the pipe passes through walls, a sleeve or wall plate shall be fitted with an adequate whole clearance to prevent wall damage or fire hazard. Pipe flanges shall be fitted on each side of the wall.

The interior of the pipe work and silencers shall be metallic aluminum spray coated to BS 2569 Part 2 Class 'D'. Where insulation is not applied, the exterior shall be similarly coated and shall be finished with a coat of high temperature aluminum paint from an approved manufacturer.

16.8.10 DAILY SERVICE TANK

A daily service tank sized to hold at least nine hours supply of fuel shall be mounted on a substantial steel frame above the set. The tank shall be totally enclosed, of non-galvanized material and have the following features

a) Fuel inlet connection
b) Fuel outlet to engine with lockable valve
c) Overflow connection, piped with a fall to the drip tray or bulk supply tank as specified.
d) Gazettes inspection-plate on top
e) Fuel contents gauge (circular type) incorporating separate switches for
   • control of fuel transfer pump
   • low level alarm (mounted on remote control panel)

The fuel inlet connection shall be piped to a conveniently placed quick release pressure
coupling on the engine set for connection to the bulk fuel supply.

The fuel outlet within the tank shall be raised clear of the tank bottom to prevent water or sediment entering the fuel line.

The contents gauge shall be calibrated 0 - 100%, in 10% graduations, 100% tank capacity (in liters) being painted on the tank alongside the gauge. The drive from the float arm mechanism to the gauge and switch cams shall be transmitted by a magnetic coupling to ensure that no fuel can enter the switch compartment

16.8.11 FIRE CUT-OFF VALVES

Fire cut-off valves shall be incorporated in the fuel delivery pipe to each engine from the daily service tank and be located in an accessible horizontal position, coil uppermost, close to the tank.

The valves shall be manually operated and solenoid maintained in accordance with BS 799 Part 7, the solenoid will be arranged to release in the event of a fire signal. The emergency handle shall be labeled with a conspicuous permanent notice reading:

"FIRE VALVE LEVER DOWN TO ISOLATED FUEL SUPPLY
LIFT TO RESET"

Where specified, a dump valve shall be fitted in the pipeline immediately beneath the daily service tank so that the tank contents can be returned by gravity head to the bulk storage tank or a suitable external dump tank in the event of a fire signal.

Electrically operated valves shall open when the operating solenoid is de-energized.

16.8.12 FUEL TRANSFER PUMPS

An electrically driven fuel transfer pump shall be provided for automatic filling of the daily service tank. Valves shall be installed on either side of the pump so that it can be removed without draining the pipe work. The pump shall be located adjacent to the daily service tank or bulk supply tank as specified.

In addition to the above, a hand operated pump shall be installed, complete with adjacent isolating valves.

Where a dump tank is necessary because the service tank will not drain by gravity to the bulk tank, a hand operated pump shall be provided to enable the contents of the dump tank to be returned to the bulk tank.

16.8.13 FUEL SUPPLY

All necessary pipe work, supports, isolating valves and fittings to connect the engine set to the bulk fuel supply or terminating point shall be provided.

A length of flexible hose fitted with a quick release pressure coupling shall be installed in the line at the engine set fuel connection point.

16.8.14 FUEL STORAGE TANKS

Bulk fuel storage tanks shall be buried underground and located as approved by the Supervisor.
The tanks shall be manufactured in accordance with BS 799 Part 5 and fabricated from mild steel plate of 5 mm minimum thickness with ends dished and flanged, electrically welded throughout and spatter removed. Galvanized materials shall not be used.

Each tank shall be provided with the following features:

a) 480mm diameter raised manhole with a gasketted 8mm thick bolt on cover
b) Fuel content gauge.
c) BSP threaded male bosses for filling, venting, outlet, drainage and overflow connections.
d) Provision for clearing out the tank
e) Tank full warning alarm float and suitable boss

The fuel outlet shall be at least 90mm above the drainage cock and preferably at the opposite end of the tank. The fuel supply line shall incorporate a mesh type filter, not coarser than 120 mesh, together with a weight operated, automatic fire shut-off valve located within the bund wall. The tank shall be positioned with a fall to the drainage cock.

Isolating valves shall be fitted within the bund wall to the outlet and drainage collections.

16.8.15 BULK TANK FILL POINT

The tank filling access pipe shall be extended to the bund wall perimeter to be readily accessible for road tankers and shall be down-turned and capped to protect against the ingress of dirt and water.

The fill point shall be protected by a corrosion resistant enclosure having a pad lockable cover to prevent unauthorized access. The tank full warning alarm shall be included within the fill point enclosure. This shall be designed to prevent overfilling the storage tank and be initiated by a float operated switch in the tank, arranged to give an audible and visible indication at the fill point when the tank is full.

The circuit shall operate at extra low voltage derived from a local control transformer suitable for a 220V, 50Hz supply.

16.8.16 ENGINE STARTING

The engine shall be arranged for automatic starting and stopping arranged in conjunction with the overall control system. The engines shall not require pre-start priming of lubrication and shall be arranged for instant starting by batteries or compressed air as specified, the starter motor(s) engaging with the flywheel ring gear and disengaging automatically when the engine starts. The system when fully charged shall have sufficient capacity to crank the engine when cold, for at least three consecutive 10 second periods at 0°C. A self-contained charging system shall be provided to meet these requirements.

16.8.17 ENGINE INSTRUMENTS

An instrument panel shall be resiliently mounted on the engine complete with the necessary piping, connections, isolating cocks and indicators for the following:

- Cooling water temperature
- Lubricating oil temperature
- Lubricating oil pressure
- Revolutions per minute
- Exhaust temperature at each cylinder outlet
- Running hours totalized (showing 5 digits & non-reset table).
- All instruments shall be scaled in approved metric units.

16.8.18 ENGINE PROTECTION
The engine shall be provided with alarm and shutdown features as specified in Section 15 - Electrical Specification. Shutdown conditions shall be arranged to operate through the fuel solenoid.
A manual fuel rack release knob shall be provided for emergency use.

16.8.19 ENGINE WIRING
All wiring for engine mounted electrical components shall be carried out in suitably rated heat and oil resistant cabling fixed to the equipment where necessary and terminated in a wiring terminal box or boxes mounted in an accessible position on the bedplate, suitable for the necessary cabling to be extended to the local control panel Separate boxes shall be provided for AC and DC circuits.

16.8.20 ENGINE MOUNTING ARRANGEMENT
Engine driven sets shall be either close coupled or open coupled as specified, via a flexible coupling. The driven unit shall have two independent bearings and all major items of the rotating assembly shall be doweled to preserve alignment.
Close coupled sets shall be secured through anti-vibration mounts to a substantial fabricated steel base fixed to the floor.
Open coupled sets shall be fixed to a substantial fabricated steel base frame, secured direct to the floor, or where specified, secured through anti-vibration mounts between the base frame and floor.
The base frame shall be structurally designed and constructed to ensure maximum strength and may be used to mount engine ancillaries, set wiring marshalling boxes and control panels. The frame shall include jacking facilities where anti-vibration mountings are used. These shall not project to cause hazards to operating personnel.

Anti-vibration mountings shall be multiple neoprene bonded pattern, arranged to distribute without resonance the total weight and dynamic loads of the assembled engine set and auxiliaries supported on the base frame.

16.8.21 DRIP TRAY
A drip tray, complete with drainage cock, shall be fitted within the confines of the base frame and shall have a capacity at least equal to that of the lubricating oil contained in the engine.
16.8.22  NOISE ATTENUATING ENCLOSURE

The enclosure shall be removable pre-fabricated type designed to reduce the noise level by approximately 20 dB (A).

The enclosure shall incorporate access doors or panels such that routine maintenance can be carried out without removing the entire enclosure. It shall be possible to remove the enclosure without disconnection of the silencer mounted outside the enclosure. The operating sound pressure level of the set, measured in accordance with BS 4196 at a distance of 1 meters, with the exhaust silencer and the noise attenuating enclosure in position, shall be a maximum of 65 dB(A).

The tenderer shall submit a detailed noise study for the entire plant and he shall state the predicted sound pressure level of the plant under the specified operating conditions, with and without the noise attenuating enclosure fitted.

16.9  NOT APPLICABLE

16.10 NOT APPLICABLE

16.11 NOT APPLICABLE

16.12 NOT APPLICABLE

16.13 NOT APPLICABLE

16.14 NOT APPLICABLE

16.15 NOT APPLICABLE

16.16 NOT APPLICABLE

16.17 NOT APPLICABLE
17 INSTRUMENTATION AND CONTROL

17.1 GENERAL

17.1.1 DESIGN AND ELECTROMAGNETIC COMPATIBILITY

The instrumentation has to be provided according to Instrumentation List and the detailed P+I diagram as provided by the Contracting Authority’s within the detailed design.

All circuits and equipment shall be designed in accordance with good Engineering practice and particular care shall be taken to ensure that no component shall exceed its maximum voltage/current/power ratings at any time, including during transient surges.

All instrumentation equipment shall be protected from interference emanating from radio frequency transmissions, either radiated or cable borne, such that it shall not cause malfunction of the system or damage to the components.

All equipment supplied shall not radiate any form of electromagnetic energy in amounts that might interfere with external equipment or instrumentation.

The latest standards on interference shall be followed and the principles of electromagnetic compatibility (EMC) applied to the design and application of the plant.

17.1.2 INTERRELATION WITH OTHER SECTIONS

Requirements given in other sections shall be applicable wherever relevant to equipment or materials specified in this section.

Thus indicator gauges, meters, enclosures, panel construction, finish, components, wiring, terminations, cabling requirements and environmental operating conditions shall be in accordance with the relevant clauses of the Mechanical and Electrical Sections, unless specifically amended in this section.

17.1.3 INTERRELATION WITH OTHER CONTRACTS

Where the location, installation or connection of any components of instrumentation are arranged by the Supervisor under other contracts, it shall be the responsibility of the Instrumentation Contractor to advise and provide all relevant information on such matters to the Supervisor in order that the correct and proper performance of the Contractor’s instrumentation is not prevented or impaired.

17.1.4 TEMPERATURE AND HUMIDITY

All supplied equipment shall function without error and shall be constructed of such materials or so treated as to prevent the formation of mould, fungus or any corrosion over the ranges of temperature and relative humidity specified in the specific clauses for this site.

17.1.5 ENCLOSURE PROTECTION

Instrumentation and hardware mounted in the field shall be contained in suitable enclosures to provide ingress protection to BS EN 60529 rating IP54 indoors and IP65 outdoors as a minimum. Sensors installed below water level or liable to submersion shall be rated to IP 68. Where items are fitted in a panel or other enclosure, they shall preserve the design IP rating of that enclosure.
17.1.6 VOLTAGE AND FREQUENCY TOLERANCE

Equipment shall be capable of working from a supply whose voltage may vary ±15%, and tolerate any transients that could be experienced in such an environment without programme corruption or system failure.

17.1.7 INSTRUMENTS

Each instrument and sensor shall be selected considering all the relevant performance parameters for the principal of measurement adopted, its intended use and the particular process in question.

All instrument output signals shall be volt-free, clean contacts rated at 220V AC, 2A for digital and 4-20mA continuous proportional linear signal for analogue. Pulsed outputs suitable for integration counter drives shall be 24V DC.

17.1.8 INPUTS, OUTPUTS AND SIGNAL LOOPS

Opto-isolation shall be provided on all input and output interfaces to cards.

Digital signals shall be 24 V DC with the power supply from either the associated power pack or the external instrument. Relays shall be used where more than one instrument including I/O are fed from a single signal.

Analogue signals shall be continuous linear scaled signals with a 4-20 mA operating range. Loops with instruments wired in series (e.g. panel mounted indicator and RTU input) shall have zener diodes fitted across each subsequent instrument leg to ensure loop integrity.

17.1.9 TERMINALS

Signal terminals shall be the disconnect type. Power supply terminals shall be shrouded and clearly marked with the appropriate warning tags. LED's shall be provided for fault tracing, if not supplied on the I/O cards. LED's in either case must be clearly visible from the front, with only the enclosure door open.

For each incoming screened cable, a separate earth terminal shall be provided for screen termination to earth.

All equipment, isolators, terminals and cables shall be clearly marked. 20% spare terminals shall be provided.

17.1.10 PROGRAMMING AND MONITORING UNIT

Hand-held portable devices shall be provided for the system allowing user configurable operation and to enable the downloading or uploading of data or software and the local running of diagnostic software. For RTU PLC'S the device shall be fully compatible with the RTU and shall be supplied with:

a) Software to enable the development of programmes and the subsequent downloading to the RTU.

b) Software to enable full communications with the RTU and to:
   i. Upload data or alter data in the RTU
   ii. Access communications ports and I/O
c) Full page process mimic display capability.

17.1.11 DISCRETE COMPONENTS

All discrete resistors, capacitors, switches, relays, diodes, transistors and other electronic devices shall comply with the BS 9000 series specification for components of assessed quality. The Supervisor’s agreement must be sought before using components that are not certified, but it will remain the Contractor’s responsibility to ensure that all components are suitable for the application.

Similar types of components shall be of the same manufacture and design wherever possible.

17.1.12 INTEGRATED CIRCUITS

All integrated circuits shall be of a proven design and shall be clearly marked with the original manufacturer’s identity and device number.

17.1.13 SUB-MINIATURE SWITCHES

Where DIL or other sub-miniature switches are used they shall be provided with a cover, or other means of protection, to prevent accidental switching during handling.

17.1.14 PRINTED CIRCUIT BOARDS

Printed circuit boards shall be made of glass fiber with copper track work, all exposed copper being tinned prior to assembly, and the board and components cleared of flux before a thin layer of clear varnish is applied for environmental protection.

The board and its components shall be identified by references relating to the corresponding circuit diagram which shall be printed on the component side of each board. Where a number of boards are mounted in a rack system, the rack and boards shall be clearly marked to identify each board to its particular position.

17.1.15 SOCKETS AND CONNECTORS

The use of plug-in connectors for electronic equipment shall be kept to a minimum, and all circuit components including integrated circuit chips shall have soldered connections where this is permitted by the chip manufacturer.

Where sockets and connectors are incorporated in the design, they shall have self-cleaning, hard gold alloy plated, wiping action contact faces, and incorporate polarizing keys or similar means to prevent incorrect mating. Insulation displacement type connectors shall not be used.

All light current wiring having a cross-section of 1.0mm² or less shall have tinned copper conductors.

17.1.16 TEST FACILITIES

The electronic equipment is to include built-in test facilities to permit the detection and replacement of faulty modules without the use of oscilloscopes, signal generators, or other sophisticated test equipment.

17.1.17 SURGE PROTECTION

All telecommunication lines, data and signal cables and other items of equipment external to the building environment prone to damage resulting from induced surges due to
lightning discharges, shall be fitted with lightning surge protection barrier devices at each end of the line to suppress and divert any transients likely to cause damage to the connected equipment.

All surge diverters/lightning arresters fitted to telecommunication lines shall be of a design approved by the telecommunications authority.

Surge protection units shall be un-fused, solid state devices, designed to limit the transient over voltages to not more than twice the normal working voltage of the line. They shall have low in-line resistance and automatically return to normal operation after diverting a surge.

The units shall have provision for either DIN rail or individual panel mounting or direct bolted connection to a suitable copper earth bar.

The location of the units shall be arranged such that the earth connection shall be routed clear of the protected signal cables and have short, straight connections without sharp bends to the main earth points, using copper conductors not less than 16mm² csa and not greater than 5 meters in length to provide a low impedance path.

Surge suppression devices to provide protection from mains switching or other supply network disturbances shall be incorporated or fitted to all sensitive monitoring or control devices. They shall be designed to filter un-wanted transients and limit the 'let-through' voltage to less than twice the working mains voltage, between all conductors and each conductor and earth. Protection monitoring status indication shall be fitted,

17.1.18 UNINTERRUPTIBLE POWER SUPPLY

A rectifier / battery / inverter system shall be rated and arranged to provide a 'no-break' supply to the specified loads.

The UPS shall incorporate maintenance free, sealed batteries and operate in a continuous mode to protect the connected loads from AC supply interruptions and irregularities to maintain a controlled output of 220V, ±5%, at 50 Hz, ±1%, for up to 30 minutes.

The unit shall incorporate a static by-pass switch arrangement such that in the event of failure of the inverter, it shall automatically transfer the load to the by-pass supply with no loss of continuity in supply. This unit shall monitor the mains and output frequencies to maintain synchronization within ±0.5 Hz and ±5% voltage. Where these tolerances are not maintained, the static by-pass shall be inhibited to prevent out of sync switching. Where generator sets are to be connected, a frequency tracking inhibit switch shall be included.

A manual by-pass switch shall also be provided to enable the UPS to be taken out of service for maintenance. No feedback shall be possible and any live parts shall be fully shrouded.

During mains failure, the battery will take over the supply via the inverter, On re-connection of tile mains supply, the system shall automatically revert to its normal operating mode and the battery be recharged to its full operating capacity.

Controls, metering and indications shall be provided on the panel front, and arranged in an approved manner:

a) Start, Stop and Reset push buttons.

b) Metering shall be provided for:
   1. battery voltage
2. battery amps (centre zero)
3. output voltmeter
4. load ammeter

c) Status indications shall be provided for:

<table>
<thead>
<tr>
<th>Normal conditions - White</th>
<th>Fault conditions - Amber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains on</td>
<td>Battery volts low</td>
</tr>
<tr>
<td>Boost charge</td>
<td>Charge failure</td>
</tr>
<tr>
<td>Inverter on</td>
<td>Inverter failure</td>
</tr>
<tr>
<td>By-pass supply available</td>
<td>Static by-pass inhibited</td>
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<tr>
<td>By-pass supply to load</td>
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All fault indications shall provide ‘volt-free’ contacts for remote indication. On/Off control switches shall be provided within the panel for:

- Mains input
- Battery isolator
- By-pass supply
- Boost charge

When isolating the UPS for maintenance, separate mains input and battery supply isolators shall be provided, interlocked, such that the battery isolator cannot be closed before the mains switch is closed (to limit stress on the storage capacitors).

The UPS output shall be protected against under/over voltages and over current during load transfers. The UPS shall be capable of satisfactorily withstanding an overload of 125% for 10 minutes and maintain output frequency stability of ±5% for 100% load changes.

Current limiting and over-voltage protection shall be included in the charger circuit together with charge rate adjustment to suit the battery manufacturer's recommendations, with automatic initiation of a timed boost charge as required.

The harmonics generated shall be restricted by suitable filters to be within the tolerances defined in Engineering Recommendations G5/3 "Limits for Harmonics in the UK Electricity Supply System".

The rectifier output shall also include filters to reduce DC ripple to the batteries to maximize battery life.

The UPS shall preferably be located within the Control & Monitoring Panel, but where the panel is a separately mounted, free-standing unit, all construction; component and finish details shall comply with those specified for the switchboard panels.
17.2 INSTRUMENTATION

17.2.1 INDICATING INSTRUMENTS

Indicating instruments shall show the specified measured values in either electro- mechanical or electronic and analogue or digital form, as specified or required by the Supervisor.

Wherever possible, panel mounting indicating instruments shall be of matching size, appearance and orientation and suitably scaled all in accordance with the general requirements for electrical panels.

17.2.2 STRIP INDICATORS

Strip indicators shall be provided and arranged for the specified functions.

The indicators shall be solid state electronic type employing a column of neon gas plasma bars, illuminated consecutively in proportion to the input signal. The scale length shall be at least 100 mm and allow on-line span and zero adjustment.

All indications shall be driven from transducers or inputs giving analogue signals of 4-20 mA.

17.2.3 INDICATOR/RECORDERS

Electro-mechanical indicator/recorder shall be a flush, panel mounting, single/multi pen indicator/recorder, scaled and labeled as specified herein. The initiating signals for each pen and the trace color(s), together with any event markers and/or alarm settings, shall be as specified.

Continuously running recorders shall run at a speed of 20mm/hour with date and time annotation at 4 hourly intervals. For intermittent running, as in storm pumping applications, the recorder chart speed shall be 60mm/hour and shall only be initiated when the level approaches the first pump start level and be stopped 30 minutes after the final pump cuts out. Starting and stopping times and dates shall be printed on the chart, and each pump operation shall be individually annotated by means of a single trace for each pump showing its running time.

To provide minimum time lags between other channels on the recorder, dot printouts may be used where required.

The Z folded chart paper shall be 250/100mm wide, linearly scaled in half hourly divisions and the width shall be calibrated 0-50 divisions linearly or logarithmically scaled as specified, to adequately show the normal range of operation and include the maximum possible signal. The chart shall run for a minimum period of 30 days, and 24 spare charts shall be provided. Circular charts shall be 105mm wide, 7 day graduated.

Each channel shall provide a continuous ribbon strip visible indication over a calibrated scale (left hand zero) and an individually different colored trace on the chart by means of either fiber tipped pens fed from disposable ink cartridges, or electrical writing or sensitized paper.

Each input shall be separate and isolated from the conditioning amplifiers and all necessary computing modules shall be included in the unit to provide the required indications.

The following features shall be provided for the operator control, accessible from the front, without withdrawing the unit during operation:

(a) Pen renewal (if relevant).
(b) Power on/off switch.
(c) Chart drive on/off switch.
(d) Chart replacement and adjustment.

Adjustable high and low, volt free alarm contacts shall be provided on each channel and incorporated into the control scheme as required initiating the alarms as specified.

17.2.4 TIME INDICATOR

A mains driven synchronous type clock shall be suitable for front of panel mounting and resetting.

The display shall be either digital or analogue as specified and based on a 24 hr notation. The digital display shall be of white figures (not less than 55mm high), on a black background. The analogue display shall be dual scaled showing 0-12 hr black figures and 13-24 hr red figures on a white faced dial of not less than 220mm diameter.

The mains supply for the clock shall be via a suitably fused clock connector mounted in the panel, connected such that the clock is energized from the live side of the panel isolator.

17.2.5 CAPACITIVE DEVICES

Level monitoring shall be by means of a capacitance electrode suitable for the medium and environmental conditions specified, such that the electrode capacitance varies in proportion to the immersed electrode length and be arranged to provide a 4 - 20 mA output proportional to the specified level range on a scaled indicator giving a continuous read out.

Auxiliary switches shall be provided for high level alarm, low level alarm and control of external equipment. The position of all switches being adjustable over the level range.

Any fault in the electrode connection and in the electronic circuits shall provide an electrically isolated alarm signal for remote monitoring.

The electrode housing shall be a heavy duty pattern to IP 68 suitable for 2" flange mounting and incorporate a 20mm ET cable entry. The head shall be removable for cabling and servicing without disturbing the electrode mounting.

17.2.6 PRESSURE TRANSDUCERS

Pressure monitoring shall be by a transducer suitable for the medium and pressure/level range specified herein.

Each transducer shall be ranged to provide adequate sensitivity over the working range and be capable of sustaining a 400% overpressure without damage. They shall be of rugged and waterproof design, employing a pressure sensitive element within a stainless steel enclosure having an isolation diaphragm, suitable for either free wire suspension in the medium or fitted with a BSP thread for external connection to the relevant pipe tapping.

Suspended sensors shall be mounted in accordance with the manufacturer's instructions within a UPVC 'stilling tube' of sufficient nominal bore to enable easy withdrawal of the sensor.

Sensors shall be enclosed to IP 68, offer a long life and shall be supplied complete with a suitable signal cable to reach the approved point of termination, transmitter-converter, without intermediate joints.
The position of the equipment shall be such that withdrawal and installation can be achieved easily.

Cable entry shall be by integral sealed assembly or by 20mm conduit entry into a sealed watertight terminal enclosure with provision for transducer venting.

A transmitter shall be provided either integral with the transducer or separately mounted as specified, suitable for operation from the mains or battery supply specified (not greater than 24V), and converting the signals received from the transducer to a 4 - 20 mA signal proportional to the range specified, which shall be used as follows:

(i) To drive an indicator/recorder to give a continuous readout

(ii) To operate separate on/off pre-set adjustable points

The transmitter shall have provision for range and zero adjustment.

For use in hazardous areas as specified, the units shall be certified intrinsically safe Ex (i)

17.2.7 ULTRASONIC DEVICES

Flow or level monitoring by non-contact ultrasonic measuring devices shall incorporate ambient temperature compensation, and adjustable datum setting facilities. Where specified, the output shall be computed to give a flow reading for the given parameters and/or control of pumps:

(i) Transducer: The sensor head shall be protected to IP 68, mounted to provide an unhindered beam path, prevent unwanted reflections, within easy reach of maintenance personnel and, where possible, be clear of flood conditions. For sewer or foul pumping sumps, the units shall be certified intrinsically safe Ex (i) for use in hazardous areas.

(ii) Signal Converter: The converter shall be suitable for operation from the specified power supply and convert the signals received from the sensor head to a 4-20 mA signal proportional to the range specified.

The converter shall comprise a base unit and a programming device, all in a polycarbonate enclosure to IP 65. Communication between the programmer and the signal converter shall be in such a manner that the IP rate is not prejudiced.

A minimum of $3^{1/2}$ digit liquid crystal display shall be used to indicate key programming features, settings and output conditions, including flow calculations to BS 3680 for flumes and weirs.

Accuracy of the signal converter shall be better than ±1 % of reading and shall have the following programmable outputs:

1. mA proportional to user definable Engineering units;
2. SPDT relay contact output closing upon failure of the signal converter, lost echo or multiple echoes.
3. Two SPDT contact outputs with independently set trip points. These outputs shall be programmed to energize upon high/low level, rate of change or to allow a number of pump sequencing operations. Contacts rated at 5A, 240V AC, non-inductive
4. Serial port RS 232 for downloading data.
17.2.8 ELECTRO-MAGNETIC FLOW METERS

The flow meters shall be of electro-magnetic inductive type having a DC pulsed fielding with automatic zero error averaging and low power consumption. They shall have no moving or protruding parts nor cause any restriction in the flow path and be capable of setting adjustments without the need to stop the flow.

Each metering system shall comply with BS 5792 and comprise a flow sensor mounted in the pipe work line and a signal converter, either integrally mounted or remotely located preferably within the main control panel.

The system accuracy shall be a maximum at normal operating flow with an error not more than 1% of the reading. When operating in the lower 30% of the meter range, the accuracy shall be within ±3%.

1. Flow sensors: These shall comprise electrodes located in a meter tube which shall be of watertight construction, suitable for operation without loss of accuracy when totally submerged to a depth of 3 meters.

   The meter tubes shall be made from a non-magnetic material lined with an inert material suitable for the medium and fitted with flanges to suit the pipe work system, the lining material being applied such that it extends from the bore of the tube to fully cover the raised face of the tube flanges.

   The measuring electrodes shall be continuously cleaned by means which do not interrupt the process flow or the measurement. A sensing electrode shall also be provided to detect when the flow meter is not fully charged with liquid.

   The flow meter body shall be effectively bonded by non-corrodible, tinned copper braid links at each end, to the adjacent pipe work to ensure a good connection between the body and the metered liquid, an earthing flange being inserted where non-conducting pipe work is employed.

2. Signal Converter/Pulse power unit: These units shall be suitable for operation from the specified power supply and convert the signals received from the flow sensor into output signals having the following features:

   a. Single flow rate range adjuster suitable for the flow sensor.

   b. Independent output signals shall be provided for each flow direction as follows:

      i. +5/0/-5 volts d.c. signal for telemetry purposes with magnitudes directly proportional to flow.

      ii. 4-20 mA current signals, to be used for indication of flow, quantity, etc.

      iii. 24V impulse for integration counters drive.

   c. Works presettable system response time.

   d. Output driven downscale to zero on receipt of a ‘flow meter empty’ signal from the liquid sensing electrode.

   e. The transmitter shall have the following programmable outputs:

      i. mA, proportional to user definable Engineering units.
ii. Off multifunctional SPDT relays. Individually programmed to allow a number of sequencing operations, rate of change or high/low flow indication. Contacts rated at 5A 240V ac, non-inductive.

iii. Serial port RS 232 for downloading data.

3. Flow meter Cabling: Where remote mounted converters are specified, cables shall be provided, installed and terminated between the sensor and converter pulse power unit for the following purposes:
   - Flow signal
   - Reference signal
   - Coil supplies

Such cables and sealing glands shall be suitable for submersible operation of the sensor to the depth specified. The length of each cable shall be as specified.

4. Spool Piece: A flanged steel pipe spool piece shall be provided of the same diameter and length as the respective flow meter and flanged for insertion in the pipe should it be necessary to remove the flow meter. Isolating gate valves shall be provided on either side of the flow meter.

17.2.9 DIFFERENTIAL PRESSURE FLOW METERS AND DIFFERENTIAL PRESSURE SWITCHES

Flow meters of the differential pressure type shall be designed and installed in compliance with 150 5167-1 or an approved standard. Primary devices shall be insertion probe type or carrier-ring type orifice assemblies with stainless steel orifice plate, or venturi tubes and shall include two sets of gaskets and fixing bolts for each primary device. Gasket materials shall be appropriate to the metered fluid and service conditions. Full details of orifice or venturi tube calculations shall be supplied.

Orifices shall be square-edged and concentric. The upstream edges of orifices shall be sufficiently sharp that the reflection of a beam of light from the edge cannot be seen without magnification. Drain holes shall be provided. The diameter ratio shall be between 0.20 and 0.70. Orifice assemblies shall have identification tags showing the direction of flow, orifice diameter and position of drain hole. The identification tag shall be welded to the plate before the orifice is machined.

Insertion probe type installations shall follow equipment manufacturers' recommendations. The probe shall be mounted to a standard sized ferrule or flange plate and include appropriate 3-way valve block.

Differential pressure transmitters and switches shall have over-range protection up to 1.5 times the maximum line pressure.

Location of these devices should be such that no turbulence shall interfere with measurement of pressure either side of the device.

Signal converter - The sensor shall be of the inductive type giving an output of 4-20 mA
proportional and the flow rate and a totalizer. The sensor shall be protected to IP66 and having the following characteristics:

- Accuracy: \( \pm 0.25\% \) of FSD between 25 & 100\% of the flow measured.
- Stability: 6 months period: \( \pm 0.25\% \) of FSD
- Voltage supply: 200 VAC
- Sensitivity: \( < 0.005\%/V \) at 50\% flow and more

Differential pressure switches shall have contacts with differing "cut-in" and "cut-out" values. The nominal values at which differential pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value shall be clearly indicated by means of a scale and pointer. Contacts of differential pressure switches shall be hermetically sealed.

### 17.2.10 VARIABLE AREA FLOW METERS

Variable area flow meters shall have glass or metallic tubes according to the particular application.

Metering tubes shall be removable for range change or cleaning without disassembling the meter or removing it from the line. Metering tubes shall have ends of equal cross-sectional area and if O ring seals are used, tube retainer springs shall be outside the fluid stream. End fittings shall be rotatable to any angle. Connections shall be horizontal and plugged vertical openings shall be provided for cleaning purposes.

### 17.2.11 ULTRASONIC IN-LINE FLOW METERS

The flow meters shall have flanged steel bodies and be without probes or pressure tapings which can foul or create a disturbance to the flow. The meter performance shall not be affected by emptying of the pipeline, and servicing shall be possible without the need to remove the meter from the pipeline.

The sensor tube and associated equipment shall be capable of withstanding occasional submergence in the flow metering chambers. The contract shall include for the provision of a 230 V, 50 Hz power supply from the nearest distribution panel, and a power pack unit if required for flow meter operation.

The converter/transmitter unit and the power pack unit shall be housed in a G.R.P lockable cabinet which may be either pedestal or wall mounted as appropriate to the meter location. The cabinets shall have heaters and thermostats if required to prevent condensation.

The contract shall include for all internal wiring, and for cabling between the flow meter and cabinet. Where necessary cabling shall be screened to prevent interference.

The transmitter shall give an output signal of 4-20 mA.

The span of the instrument shall be adjustable and the range of each instrument shall be chosen to suit the particular flow range. Meters shall be able to withstand surge flows above the normal operating range. Means shall be provided for check calibrating the meter on site.

The output signals from the flow meters shall be wired back for Indication, integration and recording of flows with provision for future wiring to a telemetry outstation.
Meters on gravity lines will normally have flow, and although this could be low at some times of the day, in practice flow is unlikely to drop below approximately 20% of maximum. The meters on the pumping mains will be flow dependant on the operation of the pumps.

17.2.11.1 MECHANICAL FLOW METERS

Mechanical flow meters shall be of the helix type and incorporated into a flanged section of pipe.

Tapers shall be provided or non-standard bearings and propellers, if required, to obtain the specified degree of accuracy at the specified flow rates.

The meters shall be suitable for working pressures up to 16 bars unless otherwise stated.

An extension drive and extended head shall be fitted to meters as required. The drive shaft bearings and gears shall be designed for long life under continuous operation, and normal wear shall not significantly affect the accuracy of the meter.

Meters shall have a circular dial and rate of flow indicator registering flow in liters/sec. A flow totaliser having at least six digits shall be incorporated in the head. The totalizer shall have a capacity of at least one year's flow at maximum flow rate. A multiplying factor in multiples of 10 may be used in conjunction with the totalizer if required, however if this is the case, the factor shall be clearly marked alongside the register.

Meters shall be individually flow calibrated at the manufacturers works and shall be guaranteed to within ±2% of true flow within the rated range of the meter. Each meter shall be supplied with a calibration certificate.

It shall be possible to remove all moving parts from the meter without the necessity to remove the meter body from the pipeline. A blanking plate shall be provided for each meter, if necessary, to allow flow to pass through the meter body when the operating mechanism has been removed.

The spare parts shall include as a minimum spare, gearing and bearings, for each size of flow meter used.

Where specified meters shall incorporate a pulsed output unit and portable data logger connection to able flow rates to be monitored and transferred for plotting at a remote data port, microcomputer and printer for analysis. The pulse unit and data module shall be self supporting using dry batteries.

17.3 CONTROL SYSTEMS

17.3.1 OVERVIEW

A fully instrumented control scheme utilizing (distributed control systems, where particularly specified, shall be provided for monitoring, controlling and retrieving data from the plant. Sufficient instrumentation and hardware interfaces shall be installed to enable the control system to automatically control the process and provide sufficient information for the plant performance to be monitored.

The control system shall consist of a PC based, System Supervisory Unit (SSU) at a specified
location and a number of remote terminal units (RTU's).

Each RTU shall be capable of autonomous operation without reference to the central computer, but shall collect and transfer plant and process data and accept control or programming log information from the central computer.

User facilities provided at the System Supervisory Unit shall include:
- presentation of current data via VDU mimic diagrams and hard copy;
- display and acceptance of alarms;
- presentation of historical data via VDU graphics and hard copy;
- manual input of information/data (eg. operator's log, chemical analysis, etc);
- Management summary reports.

Access to such facilities shall be presented in a manner which requires no programming experience.

Wherever practical, control shall be through hardwired logic, e.g. relays, timers. Software control shall only be used where the complexity of the particular process control would make hardwired logic impractical. All plant shall be monitored through local telemetry units to display status/alarms at the SSU.

Safety, emergency and high priority signals must be independent of the software based control system. The Contractor shall review the control system at each stage of the design and provide all required inhibits.

All inhibit status shall be indicated visually, on the panel sections and SSU database/mimics and all alarm signals shall be hard-wired to annunciators.

17.3.2 SYSTEM PERFORMANCE

The system must be capable of accommodating the full Input/Output configuration including all options with spare I/O per outstation of 20%. In this fully expanded mode the following performance figures shall apply:

1. VDU mimic update and regeneration - 15 secs max.
2. Maximum time from field alarm or status event (eg. contact closing) to report on printer/VDU shall be 30 seconds.
3. Maximum time from completing a request to change an output to the output activating shall be 30 seconds.

17.3.3 POWER FAILURES/BACK-UP/RESTART

In the event of power failure, the entire system of control centre and distributed outstations shall restart automatically upon resumption of the supply. By a series of interrogative commands, the outstations shall determine the position in the cycle which the process had reached at the instant of interruption and shall resume control at an agreed point.

The central computer shall have an uninterruptible power supply to enable the components defined to function properly during a power supply failure of 30 minutes.

Memories for outstation PLCS shall be provided with battery back-up facilities for the same
duration or as otherwise specified.

17.3.4 OPERATIONAL CONSIDERATIONS
System users and control room operators must not be expected, or need, to have other than a superficial knowledge of computer usage.

The main methods of operator access will be via qwerty-based keyboard(s) and cursor control device (mouse) with which to point and select commands.

Operator facilities shall be available to the user in menu format. The need for the normal operational user to access the host computer's operating system shall be avoided in day to day operation.

17.3.5 EXPANSION
The system shall be designed to allow for expansion. The ultimate capability of the system shall not be constrained by the initially installed hardware and software.

As a minimum, expansion should be allowed for in the following areas:

1. Number of RTU's to be addressed and polled
2. Number and type of points to be defined, addressed and polled.
3. Range of functions to be processed
4. Number and type of peripherals to be driven
5. Amount of memory to be addressed
6. Ability to expand the control output functions of the system as a whole without reference to the Vendor for sophisticated equipment, licenses, etc.

17.3.6 RELIABILITY
The system hardware and software shall demonstrate a high level of reliability.

The application software shall prevent the input of illegal or undefined commands, prevent system lock up and have a constantly available recovery mechanism for the user.

A key design principle must be that of graceful degradation, with the ability to maintain the maximum degree of control for the maximum time under fault conditions. The loss of facilities should, as far as possible, be isolated on the principle of damage containment and shall fail in the safe mode at all times.

17.3.7 PROCESS AREAS
For control purposes, the works shall be sub-divided into process areas by the Contractor.

These areas shall not necessarily be the locations of the RTU's. At the Contractor's sale discretion, it may be possible to use a single outstation to control and monitor a number of areas; alternatively, more than one RTU may be required for a particular area.

Instrumentation, motor starters, actuators and electrically operated items of equipment shall be connected to each RTU as appropriate, which shall control and monitor its process area...
without reference to the SSU. Therefore the system software shall reside for each area in the RTU's but changes of control operating parameters shall be possible only from the SSU (under normal conditions). All plant data shall be routed to the SSU through the RTU's via either a radial or loop configuration depending upon the relative suitability of the equipment being offered. This data highway may be hard wired, fiber optic or radio based.

Process data between areas RTU's shall continue uninterrupted in the event of an SSU failure. Should the SSU fail or the RTU/SSU link break, the RTU shall be able to continue to control the plant area using the last operating parameters settings/process data until the link is restored or the OP's are changed with a portable unit.

In the event of the RTU failing, the watchdog systems under each process area shall operate.

17.3.8 OPERATING PARAMETERS
Initially the system will be operated with the operating parameters being fixed on a first estimate basis, but as information is accumulated these operating parameters will be fine tuned. All operating parameters shall be software controlled and are identified in the text by 'OP'.

17.3.9 MANAGEMENT REPORTS
An essential part of the monitoring mode shall be the production of management reports, for which data processing will be carried out at the SSU. The logging interval and signal value, instantaneous or average over the logging period, will be determined by the management report requirements.

17.3.10 COMPLIANCE WITH SPECIFICATION AND STANDARDS
The following documents shall be used and complied with in the design and installation of the control system and instrumentation

1) IEE - Guidelines for the documentation of computer software,
2) BS 6739 -Instrumentation in process control systems,
3) The relevant European or International Standard shall be used for any item, installation or application.

17.3.11 TRAINING
The Contract shall include for the training of the Purchaser’s staff in the operation and maintenance of the system.

This shall take the form of a structured training programme and shall include the costs of all course materials

Details shall be provided in the Schedule of Particulars of the training facilities offered.

The following aspects shall be included:

On-Line Training: Using built-in simulators with plant operational or non-operational.

Off-Line Training: Using oil-line simulators

The provision of high quality documentation for training, giving explicit and easy to understand step by step procedures, with explanatory diagrams, flow charts and examples shall be
required.

17.4 REMOTE TERMINAL UNITS

17.4.1 DESIGN

Remote Terminal Units (RTU) shall cater for analogue and digital inputs/outputs and have serial ports for connection to computer equipment.

The RTU shall transmit a digital report whenever a nominated alarm or analogue change-of-state condition occurs except when periodic interrogation/polling is taking place - then the alarm will report at end of session. The RTU receiver will support acknowledgement messages and periodic interrogation/polling from the CPU. The transceiver equipment shall be specifically designed for use in digital networks and incorporate the following features:

i) Ultra low power consumption
ii) Sleep and Standby modes
iii) Hardware and bit synchronization

Intercommunication between RTU's will be necessary if they are used as signal repeaters, or if the message handling of the radio network requires the RTO transmissions to be synchronized.

All RTU equipment shall be mounted in secure lockable panels, which may be housed within an instrument panel.

17.4.2 POWER SUPPLIES

RTU equipment shall operate from the specified site mains voltage, however, at locations where mains power is not available, than batteries charged from solar panels may be designated as the electrical supply source.

Instrument signals shall operate at 24V DC, derived from a suitably rated power supply to each RTU or instrument panel section and connected to the I/O terminal 'units' as necessary. The power supply units shall be sized such that the total demand does not exceed 75% of the power supply's maximum rating.

Thirty minute full function battery backup including continuous battery charging equipment shall be provided for each RTU unit and the signals required for monitoring and control at 24 V DC, 110V AC and any other voltage used for instrumentation.

17.4.3 WATCHDOG

A watchdog system is required at each RTU/process area or group. The RTU's shall be self-monitoring and any system failure (or instrumentation failure where appropriate), whether hardware or software derived, shall cause the watchdog relay(s) to de-energize/fail-safe and un-inhibit back-up control operation and/or carry out any function.

Watchdog status shall be indicated visually on the panel sections and the SSU mimics.

Failure of RTU's shall not leave the associated plant in an unsafe condition or allow a process failure.
17.4.4 MEMORY
The RTU unit shall have sufficient memory capacity such that in the event of a communications failure, information shall be retained for a minimum of two weeks with normal digital event/alarm density and all analogues at 15 minutes sample rate.

17.4.5 COMMUNICATION PORTS
The unit supplied shall have at least two communication ports for:

a) Connection of hand-held or portable programming and monitoring unit.

b) Connection to a data highway, telemetry system or other processors.

c) Item (b) shall, unless for reasons of compatibility with existing systems, conform to either RS232 or RS422 protocols.

The Contractor shall be responsible for verifying compatibility of communications interfaces and shall provide full details of the protocols used by this system or other systems needing to communicate with it.

17.5 SYSTEM HARDWARE

17.5.1 DESIGN
The System Supervisory unit shall incorporate micro processor based units of suitable operating and storage capacity to provide the specified data handling, processing and graphics performance and having non volatile or on-board battery supported RAM and hard disk data storage capacity together with floppy disk, DVD drives and tape streamed. Full auto-restart after power failure is required, without manual intervention.

Hard disk data archive capacity shall be sufficient for 90 days on line availability. Each day over 90 days, the oldest data shall be overwritten by the latest information automatically. Both RAM and hard disk shall have 100% spare capacity in excess of max working load to allow for system development in the future.

The computer, hard disk, floppy disk, DVD and tape streamer shall be supplied in one integral unit. All devices shall be easily accessible from the front of the supervisory unit.

17.5.2 VISUAL DISPLAY UNITS
VDU's shall be 19 inch VGA color monitor screens in an anti-glare finish enclosure, matching that of the computer system supplied. The VDU shall have a frequency range suitable for the computer system supplied and shall be capable of displaying information in alpha numeric and graphic form from a minimum of eight foreground and background colors. Characters shall be legibly and stably displayed. The unit shall include all necessary adjustable picture controls to adjust the image.

17.5.3 KEYBOARDS
Keyboards shall be a low profile standard QWERTY pattern, complete with all necessary special function keys. The function keys shall be clearly labeled with any symbols or descriptions necessary, and those dedicated for reconfiguration shall be supplied with means
of preventing unauthorized operation. The keyboard shall be a separate, free standing unit suitable for desk top mounting.

17.5.4 PRINTERS

Printers shall be of the latest technology, they shall be robust and designed for continuous duty, capable of supporting alphanumeric and graphic output and shall be fully compatible with the character and graphic sets of the computer system supplied. The printer shall offer both tractor and single sheet paper feeds without user modification. Text character printers for status report logging and alarm logging shall be at least 25 pin dot matrix pattern. They shall print in black, with alarm messages in red, at a speed of at least 30 ch/s (NLQ) on A4 size, fan-folded paper collected in a paper tray.

Color graphics printers shall have A4 media size capability, with manual feed of cut-sheet paper and film or sprocket feed of 2-fold paper. The printer shall be a thermal ink jet drop-on-demand type having a graphics resolution of 180 x 180 dpi and near-letter quality (NLQ) text printout of 167 characters per second at 10pitch. Graphics print speed on paper should be 4 minutes or less and 8 minutes or less on film.

Print cartridges shall be interchangeable to allow both color and black printouts and the software shall permit a choice of font types and shall including roman, Letter Gothic and Courier with between 8-12 pitch print size.

17.6 SYSTEM SOFTWARE

17.6.1 MODES AND FUNCTIONS

The complete software package shall enable the system to function in accordance with the functional design specification (FDS) and allow for the addition of future software tasks (e.g. monitoring of other process parameters) as and when required. The software shall therefore be written in a structured manner with a core of control routines that can be accessed by additional programme routines without having to rewrite the basic process control software.

17.6.2 SYSTEM SECURITY

Security of the system shall be provided by allocation of passwords and varying degrees of privilege (e.g. operator, supervisor, system Engineer/manager). Passwords shall also be required before deletion of data or other operator actions which may cause serious malfunction or loss of data by inadvertent action required for a managerial function. Any successful or unsuccessful change in security level shall be logged. Passwords shall be blanked on the screen during entry.

The software shall be capable of providing at least three levels of operation:

1) for operations personnel to monitor and control the plant (where applicable)
2) for the supervisor to change parameters
3) to enable a designated Engineer to modify or add new sequence programmes or run diagnostic programmes. These procedures shall be carried out with the minimum disruption to the system.

Supervisors and Engineer's mode shall be selectable only after a unique password/key system has been satisfied for each user.
17.6.3 COPYRIGHT AND PRODUCT SUPPORT

The copyright of software specially developed for the control system shall become the property of the Purchaser on handover of the equipment.

The Contractor shall ensure that for software of a standard nature, product support shall be available for a period of ten years from the date of supply, and submit details of the various grades of maintenance contract which he can offer for both software and hardware. These shall include the approximate costs of the supply of updates of standard software which will run on the system, as well as enhancements and improvements to specialist systeme software.

The Contractor shall be able to offer for demonstration an operational system, whose configuration is similar to the requirements of this system, which utilizes software programmed by the Contractor’s staff in-house personnel.

17.6.4 PROGRAMMING

Programmes shall be based on approved structured techniques using a high level language capable of accepting alterations and additions easily.

All programmes shall be tidy in format, logical to follow and be accompanied by flow diagrams. Programmes shall be extensively annotated with comments and be self-documenting.

17.6.5 PROGRAMME DOCUMENTATION

The Contractor shall supply the following documentation:

1. Full programme listing (including all comment/remark text)
2. Complete set of flow charts
3. Diagnostic programmes
4. Operator/instruction manual for this particular project
5. Operating philosophy

17.6.6 DIAGNOSTIC ROUTINES

The system shall be complete with a set of diagnostic routines to enable maintenance personnel to fault-find on the equipment.

The routines offered will depend upon the system supplied, but shall contain or expand on the following:

a) A routine to enable all interface cards or devices to be checked for faults or malfunctions, particularly input and output cards
b) A routine for testing individual control loops
c) A programme to send dummy information to the various input/output gates to test action of circuits
d) All routines shall be available only in the Engineer’s mode

The integrity of all plant operations must be protected at all times, therefore diagnostic programmes will require additional security when switching outputs.
17.7 INFORMATION PRESENTATION

17.7.1 DISPLAY

The visual display unit (VDU) shall be capable of displaying mimic; graphical and alphanumeric information. Mimic diagrams shall show all relevant plant status and alarm information along with process and analytical data, e.g., flows levels. All such data shall be updated at regular intervals, chosen to suit the rate of change of data.

The mimic diagrams shall be capable of being easily developed and modified to include changes at a later date. The diagrams shall be clearly presented so that the operator may readily assimilate the information contained therein. Diagrams shall be nested at several levels to enable the operator to obtain detailed information quickly and yet retain an overview of a complete area of the sewage treatment or water treatment works.

Status information shall be updated as the change takes place and parameters which are out of limits shall initiate an alarm sequence.

Alarm messages shall be displayed on a dedicated section of the VDU screen, which shall be available at all times.

Displays shall be organized into a hierarchical structure, ranging from an overview down to individual detailed RTU displays. The displays shall be user definable and details of the building/modifications package shall be provided. A real time clock shall be included on all displays giving both time and date. Hard copies of screen displays will therefore always show time or events being portrayed. In the case of a management report covering a time period, any hard copy taken within that period will clearly show the point of retrieval.

When an RTU is called up on the VDU mimic display, analogue values and the status of all units shall be displayed, i.e., running, failed, open, closed, full, empty, flowing, etc.

17.7.2 COLORS

Colors and layouts of the mimic diagrams shall be established during discussions with the Supervisor during the development phase of the software.

The minimum requirements are sixteen colors, with 'blinking' facilities.

The colors shall be consistent with the VGA 16 colour choice and allocated for plant contents and flow lines as follows and where appropriate.

a) Process Colours

<table>
<thead>
<tr>
<th>Color</th>
<th>Water Treatment</th>
<th>Sewage Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>Background</td>
<td>Background</td>
</tr>
<tr>
<td>Green</td>
<td>Raw Water</td>
<td>Raw sewage</td>
</tr>
<tr>
<td>Light Green</td>
<td>Gas (Chlorine)</td>
<td>Settled sewage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liquor/Stam tanks</td>
</tr>
<tr>
<td>Color</td>
<td>Description</td>
<td>Lagoon outflow</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Cyan</td>
<td>Filtered, well or backwash water</td>
<td></td>
</tr>
<tr>
<td>Light Cyan</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Brown</td>
<td>Dirty water</td>
<td>Raw sludge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Screenings Disposal</td>
</tr>
<tr>
<td>Yellow</td>
<td>Gas (SO$_2$)</td>
<td>Gas (Methane)</td>
</tr>
<tr>
<td>Red</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Light Red</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Magenta</td>
<td>Gas (NH3)</td>
<td>Activated sludge</td>
</tr>
<tr>
<td>Light Magenta</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Grey</td>
<td>-</td>
<td>Treated sludge</td>
</tr>
<tr>
<td>Light grey</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>Air</td>
<td>Air</td>
</tr>
<tr>
<td>Light Blue</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>Potable water</td>
<td>Final effluent</td>
</tr>
</tbody>
</table>

Colors which are not defined above may be otherwise allocated to the approval of the Supervisor.

Plant icons shall be:

- Running/open/on - Process color (see above)
- Stopped/closed/off - Light Grey
- Alarms (potential danger to personnel/major failure of plant/process) - Red
- Faults (Motor tripped etc.) - Yellow

b) Text

Text should revert to background color when not applicable (therefore not visible) or overwrite opposite condition (running/stopped).
17.7.3 TRENDS

Both real-time and historical trends shall be available for all analogue values (including summated and derived) by all the following methods.

1. As an integral part of a mimic diagram.
2. As a sub-mimic-accessed from one or more 'Poke Points' on process mimics
3. As a separate function of the SCADA package with user friendly configuration.

In any of the above methods up to four (4) values shall be available for display on the same graph simultaneously with user defined time and unit scales.

Each variable shall be presented as a graph against time, the normal period being the last 24 hours or such other time scale as is most suitable for the particular parameter, with the facility for the operator to be able to input a start time and end time. Axes shall be dearly labeled, tagged (variable name/identification) and scaled.

Each variable within a graph shall have a separate color, green, brown, magenta or blue.

17.7.4 POKE POINTS

These are any area on the screen which, when selected by cursor, cause display or control actions to occur and shall, where appropriate, follow the guidance in BS EN 60073 for push buttons.

There shall be poke points to enable movement between process mimics both upstream and downstream without use of intermediate menus or mimics. The 'active' areas shall be sized for ease of use with a cursor and shall be represented as a symbol, icon, text or function box.

Poke points shall also be utilized for trends, menus, overviews and control activation (where applicable).

All control activation or changes of operational parameters shall require a 'confirm before execute' routine.

17.7.5 OPERATING PARAMETERS AND SAMPLE RATES

These values shall be presented in a tabular form for each process area or sub-group.

It shall be possible to change analogue sample rates as an operator function (e.g. 5 secs, 30 secs, 1 min, 30 min, etc...)

17.7.6 LAYOUT AND STRUCTURE

The mimic displays of the overall process areas and RTU's, shall be configured based on the
process and instrumentation as specified and approved.

Symbols shall be used to represent items of plant in a manner which is easily recognizable by the operator. The overview mimic shall use symbols, not just labeled blocks.

Wherever possible, flow and process direction shall be from left to right, top to bottom. The crossing of flow lines shall be avoided, however if this is unavoidable, the vertical line shall be shown with a break. Junctions of flow lines shall be only single T junctions with no local increase in line size at the joint.

In general, flow lines and symbols shall not be outlined. The color shall be used in block or fill form, with graphical detail where necessary in white lines.

Plant status for running/stopped, open/close, available/unavailable, etc., shall be indicated (on the process mimics) by text in addition to symbol color.

Text associated with symbols shall be 3.5mm height. Text associated with headings shall be 5mm height. All text shall be in upper case.

Abbreviations of Engineering shall be in accordance with SI nomenclature as detailed in BS 5555 or as otherwise approved by the Supervisor. Where a percentage figure is given as data, this meaning shall be either percentage of full capacity or percentage open, e.g. 100% indicates a full tank or a fully open valve.

17.7.7 MENU HIERARCHY

On start up, the system shall automatically display the log on/off menu which shall be in the form of a graphical list offering the choice of access levels as follows:

1. Operator
2. Supervisor
3. System Engineer / Diagnostic Routines

Once logged on, the system shall display the main menu, offering the choice between the mimics/data pages.

'Help' screens shall be available for each mimic. These shall be user configurable by a combination of text and graphs via the SCADA package facilities.

Screen Burn: To minimize VDU screen burn, a changeable time out shall be used to either display a blank screen or remove all screen displays until any key reactivates the last screen display.

Legend: A mimic shall be provided to explain all symbols, icons, colors and functions of the system.

17.7.8 MIMIC DESIGN AND APPROVAL

The mimic design shall progress in parallel with the Functional Design Specification and Process and instrument diagrams. It is envisaged that at least three reviews will be required before final approval. Any changes required from these reviews shall be carried out by the Contractor and deemed to be included in this contract.
All displays shall be submitted for approval either on CD or DVD. Whichever format is selected, it shall depict simulated changes of analogue and digital plant status. In addition color hard copies of every page shall be submitted of an equal quality and content to that of the printer being supplied.

17.7.9 DATA STORAGE

All data shall be stored on the PC's hard disk drives. Data required for management reports shall be copied onto DVDs on a selectable, regular basis and Jogged as an event and indicated to the operator.

The whole system shall be backed-up on to the tape streamer in a similar manner.

17.7.10 ALARMS

Upon initiation, alarm messages shall be displayed on the VDU and an audible alarm sounded. The visual alarm indication shall utilize color and flashing effects to differentiate from normal information. When alarms are accepted by the operator, audible alarm shall be silenced. Upon clearance of the alarm the VDU display shall revert to normal.

In addition to alarms listed in the instrument index, alarms derived from process evolved conditions shall be treated, displayed, logged, etc., in a similar manner to a direct alarm. The derived alarm is intended to indicate problems occurring within the process/control system and/or site equipment not covered by direct alarms. The Contractor shall ensure all problem conditions within the above parameters are included. Additional derived alarms shall be available for user definition.

Derived alarms shall signal when:

a) any item or equipment fails to respond to an initiating signal
b) any item or equipment stops (or starts) other than when it has been instructed to
c) any item of equipment fails to respond to a set point within an adjustable time limit
d) any analogue signal becomes below 4 mA or above 20 mA
e) when there is a disparity between two measurement, i.e. analog and digital level monitoring

17.7.11 ALARM LOGGING

The alarm printer shall log all alarm events as they occur, stating the following for each:

i. Alarm flagged
ii. Process area
iii. Description of alarm
iv. Tag number (if any)
v. Time alarm initiated
vi. Time alarm accepted
vii. Time alarm cleared
17.7.12 EVENT LOGGING

The operator shall have the facility to print out any selected events such as equipment starts/stops and periodic analog outputs, all selectable via the utilities menu.

17.7.13 MANAGEMENT REPORTS

In order to configure reports and Jogs of accumulated data over a period of several years, data shall be capable of being exported from the hard disk onto separate storage devices.

The reports shall be user redefinable and take the form of charts, data tables and graphs, both on demand and periodically configured.

Preconfigured reports shall be supplied as part of this Contract. Hard copies shall be submitted for comment/change/approval by the Contractor as part of the functional design specification procedure.

17.8 FUNCTIONAL DESIGN SPECIFICATION

17.8.1 PURPOSE

The Functional Design Specification (FDS) shall be prepared by the Contractor and agreed jointly by the Contractor and the Supervisor. It shall detail the manner in which the Contractor intends to provide a system to meet the Supervisor's/user's needs as set out in this specification. Once agreed by the Contractor and the Supervisor, it shall form part of the contractual documentation.

The FDS shall describe what the system will do, how it will be operated and maintained, and what facilities and services will be provided. It shall provide a list of design objectives and forms the baseline document for the functions and extent of the proposed System.

Besides covering all system functions, the FDS shall define the reliability, maintainability, acceptability, ease of training and operation, security and overall quality policy of the proposed system.

Any divergence between the FDS and this Specification shall be resolved, agreed and clearly documented, and the FDS amended to reflect the new understanding.

When the FDS has been approved and signed by the Supervisor it shall be kept under formal change control by the Contractor to cover any subsequent amendments. Change control should also be applied to any dependent documents (see Section 7 of the "Guidelines for the Documentation of Software for Real Time and Interactive Systems" published by the Institution of Electrical Engineers (JEE) London).

17.8.2 STRUCTURE

The following structure is suggested for the functional Specification:

System Overview - provided an overall plan of the Contractors’ proposed solution. This shall take the form of a functional block diagram accompanied by a descriptive text.

System functions and Facilities - describing all the functions and facilities proposed to meet the system objectives as specified in this Specification.
System Interfaces - specifying all inputs and outputs of the system, including communication links.

System Attributes - specifying matters relating to the adaptability, availability, maintainability and usability of the system.

Design, Development and Test Factors - specifying aspects of software, design, development procedures and system acceptance testing.

17.8.3 DOCUMENTATION

The above document structure shall incorporate descriptions of operation for the following conditions:

- Normal operation
- Back-up operation
- Modes of system failures
- Modes of instrument failures
- Watchdog functions
- Modes of power failure
- Return to normal conditions
- Schedules of software adjustable operating parameters

All relative supporting documentation shall be included in the functional design specification before approval and should include the following:

- Process and Instrumentation diagrams
- VDU mimics
- Instrument panel layouts
- Access levels
- Control system and loop diagrams
- Software packages documentation
- Management Reports
- Instrument index

17.8.4 POST-INSTALLATION DOCUMENT

Documentation shall include, but not limited to, the following:

- As-built drawings
- Test, commissioning and calibration reports
- Acceptance certificate
- Standard documentation
Drawings
Warranty condition, start dates, end dates
Hardware maintenance agreement
Fault reporting procedures
Post-installation special-to-project software upgrade and enhancement procedures, including documentation updates
Notification procedure and maintenance contracts for supported software updates (e.g. operating system, language compilers)
Transfer of title ownership of software modules
Permits/certificates authorizing the use of licensed or leased software

17.9 COMMUNICATIONS

17.9.1 CONTROL AND COMMUNICATIONS

The control system shall communicate with plant via one or more Remote Terminal Units (RTU). The RTU's shall be linked by a common communications link so designed that failure of any RTU connected to it or failure of the computer system shall not cause the link or data highway to malfunction.

The configuration, communications speed and number of data highways shall be determined considering the response times, distribution and number of signals presented by the Plant requirements.

The communications network for the SCADA system shall accommodate both continuous real time and timed polling acquisition of data throughout the system. The RTU's/Outstations shall be polled on a pre-determined rate but shall have real time responses to alarms.

The means of communication shall be in accordance with the Specific Requirements and the following clauses relevant to the selected medium.

17.9.2 TRANSMISSION MODES

The telemetry system is to transmit in the Time Division Multiplex mode (TDM) with Frequency Shift keying (FSK) or Differential Phase Shift Keying (DPSK) modulation and shall employ an interrogation/response system initiated by the master station.

Suitable modems shall be provided to match the system characteristics which shall have a transmission rate to meet the system performance requirements.

The system is to detect at least 98% of all, and 100% of 1, 2 and 3 bit transmission errors.

The equipment shall be suitable for the future installation of UHF radio links as an alternative to transmission over public or dedicated private lines.

17.9.3 PRIVATE LINES

Where communications between sites is to be over 2 wire private circuits rented from the local communications authority, they shall be speech band circuits (2wire, half duplex)
Where communication links between sites are specified to comprise two independent circuits, each circuit shall use separate routes where possible. Automatic changeover to the standby line shall occur in the event of duty line failure on the links between the specified sites. The standby lines shall be continually monitored and an alarm raised in the event of failure.

It shall be the Contractor's responsibility to negotiate and agree on behalf of the Purchaser with the local communications authority for the supply of all lines which must be suitable for the proper operation of the system. Any connection charges arising shall be submitted for payment by the Purchaser.

17.9.4 RADIO LINKS

Where it is envisaged that communication between outlying locations and the works will be by radio, the Contractor shall be responsible for carrying out a site radio survey to confirm that this method is suitable.

The results and conclusions of the survey shall be collated into a report which shall contain all documents including correspondence, calculations, etc., with any statutory bodies, landowners, etc.

It shall be the Contractor's responsibility to obtain licenses from the relevant licensing authority to operate the required frequencies on behalf of the Purchaser.

The Contractor shall minimize the number of frequencies he intends to use and shall justify the use of all proposed frequencies.

The Contractor shall restrict the data transmission rates over the radio links to the minimum number required for the effective operation of the system. Calculations shall be provided justifying the signaling rates.

17.9.5 LOW POWER RADIO

Transmission between individual or small groups of instruments to local stations for monitoring purpose should be considered wherever hardwiring would be more costly. However, control functions should be hardwired or via approved PLC units and not performed within the radio station units.

The above individual or small groups of instruments should form 'cells' within the 'cells' transmitting to a master station via a radio data network. All systems using low powered radio must be approved to the appropriate British Department of Trade and Industry (DTI) specification (MPT 1328 for VHF systems and MPT 1329 for UHF systems) and shall be installed in a manner which ensures operation within the allowable frequency and power restrictions.

Antenna shall be appropriately sized, orientated and safely installed. All systems shall be of a robust nature with a full consideration given to location, access and vandal interference.

Where radio network are proposed, available network systems shall be used which optimise the available bandwidth in each channel. The network architecture shall utilize a well established protocol designed for the radio environment operating in real time and able to guarantee data security. In addition the network shall utilize an open architecture to allow for inclusion of a wide variety of devices either existing or in the future.

It may be necessary for more than one radio channel to be utilized to guarantee performance.
and response. Multiple channels may be used in a cell structure providing this can be demonstrated to be a well proven network facility and does not require custom software design.

17.9.6 FIBER OPTIC LINKS

All fiber-optic networks are to be bidirectional, e.g. the cable shall be such that if communication through the fiber should fail at a point along the network, polling shall then reverse, maintaining uninterrupted control.

17.10 COMPUTER ROOMS

17.10.1 GENERAL

Rooms accommodating SCADA computer equipment shall be designed, decorated and furnished in accordance with the following requirements

i)  Lighting and decoration suitable for VDU viewing

ii) Air conditioning and ventilation

iii) Fire detection and alarm Fire extinguishing equipment

iv)  Electrical power outlet

v)  Dust control mat

vi)  Blinds

vii) Furniture

All items of equipment (control and electrical) as detailed in this specification shall be suitably and located taking into account ease of operation, noise, visitors, storage, possible future requirements, communications and external interference from adjoining rooms. Cables shall be concealed as far as possible.

All equipment and design shall be in accordance with the relative CIBSE Guides and Codes.

17.10.2 LIGHTING

Room lighting shall be by means of low brightness luminaries incorporating high frequency, flicker free, electronic ballasts to meet the following requirements and generally in accordance with CIBSE Lighting Guide LG3.

Average illumination (Eavg at the working surface): 450 Lux minimum

\[
E_{\text{min}}/E_{\text{avg}} : 0.8 \text{ minimum}
\]

Control: 100%, 20% or less, continuously adjustable by 1 wall mounted control knob

Color Rendering: Color No. 84 (4000° K)

Emergency lighting: Minimum 2.5 hours, by self contained module attached to luminaries
17.10.3 AIR CONDITIONING

Heating, ventilation and cooling systems shall be provided to meet the following requirements.

**Maintained Temperature**
- 21°C ±2°

**Maintained Humidity**
- 50% RH ±10%

**Heat Dissipation in room**
- To be calculated by the Contractor based on 2 persons and installed equipment occupancy

**Number of Air Changes**
- 4 changes per hour minimum

The systems shall be of the heat pump type, able to provide sufficient heating when required, either of one piece or split design.

The Contractor shall determine all fabric loads.

The installation shall include materials and labor for connection of the equipment to a suitable electricity and water supply within the building.

The method of drainage for the equipment shall be in accordance with the regulations as laid down by the local authority.

The systems shall be inter-connected with the fire detection equipment such that the air conditioning equipment shall be shut off with the ventilator firmly closed in the event of fire being detected within the room.

17.10.4 FIRE DETECTION AND EXTINGUISHING EQUIPMENT

Fire detection and warning equipment shall be provided in accordance with BS 5893 to include the following items:

- Optical smoke detector
- Break glass fire alarm switch
- Single zone microprocessor controlled fire alarm panel compatible with equipment herein specified, with battery back-up and failure monitoring
- Pulsed tone alarm mounted inside control room
- Audible alarm suitable for external use and audible for a distance of at least 200m to be mounted on the building exterior

The component shall be mounted in a position to be agreed with the Supervisor.

The system shall be supplied with suitable contacts to shutdown the air conditioning system and provide an alarm contact to the SCADA system. In addition, 2 spare contacts shall be supplied.

Fire extinguishing equipment shall be supplied and mounted in agreement with the local fire authorities.
officer.

17.10.5 ELECTRICAL POWER OUTLETS
Where additional socket outlets are specified, they shall be switched socket outlets to match the local standards.

The outlets shall be installed approximately 20cm above floor level. Installation shall include for wiring back to the budding distribution panel, additional components therein and connection thereto as required.

Where outlets are supplied from the UPS, traffolyte engraved labels approximately 25mm x 50mm shall be supplied and mounted above each such socket, with the following wording, white on red background.

FOR COMPUTER EQUIPMENT ONLY

17.10.6 DUST CONTROL MAT
A dust control mat, having anti-static properties shall be supplied of approximately 1m x 1.5 m, dark grey carpet with bevelled non-trip edging to be placed in front of the door way to trap foot borne dust and dirt.

17.10.7 BLINDS
All windows shall be fitted with fully adjustable vertical louver window blinds which shall be light grey in color.

17.10.8 FURNITURE
Purpose made computer tables, sized to accommodate the specified printers, VDU's, storage drawers and working space shall be provided, together with any other chairs, cupboards etc. All items shall be supplied with the following considerations:

a) Anti-static material  
b) PC units mounting below desk top  
c) Storage of paper consumables and transportable mediums  
d) Storage of system disks and manuals  
e) Paper trays (Fan paper)  
f) Working area  
g) Phone locations  
h) Cables hidden.

17.10.9 Decoration
The walls and ceiling shall be painted in semi-matt emulsion of pastel shades to be agreed with the Supervisor.

Prior to painting, the surfaces shall be well prepared (and primed) in accordance with the manufacturer's recommended painting system for the material
18 PLUMBING, DRAINAGE AND MECHANICAL WORKS

18.1 SECTION 210500 – COMMON WORKS FOR PLUMBING

18.1.1 PART 1 – GENERAL

18.1.1.1 Related documents
A. All drawings of the Contract, including Architectural and other trades drawings, namely electrical, structural and interior design.

18.1.1.1 Related obligations
A. Examine all the other Sections of the Specifications for requirements which may affect work of this Division.
B. Coordinate work with all other trades affecting, or affected by activities of this Division. Cooperate with such other trades to assure the steady progress of all operations under the Contract.
C. Any discrepancy between the specifications and tender drawings shall be identified during the tender period and should be raised to the Contract Administrator.
D. Check design, assumptions, calculations and feasibility of tender drawings. Any abnormality or claim shall be stated before signing the contract.

18.1.1.3 Work covered by contract documents
A. The work includes design developing, supplying, installing, testing and commissioning of all mechanical works, specified and listed in the concept and the Description with the related control systems and all associated civil and electrical work, as shown on the Contract Drawings or inferable there from tender documents.
B. The work includes all equipment and/or accessories not specifically mentioned in the specification or noted on the drawings but which are obviously necessary for the proper and normal operation of the various system with all associated works such as supporting structure, building, ancillary work, attendance, etc., and the like.
C. The contractor shall include in his work:
   1. Providing and installing all electrical equipment necessary for the complete installation and carrying out all wiring from points of supply. The Contractor shall include all short circuits and overload protection to all motors and electrical equipment.
   2. All bonding of all extraneous conductive parts of the installation in accordance with the IEC Regulations (Latest Edition with Amendments). The Contractor shall also refer to and coordinate with these Specifications. All equipment shall be suitable for 380v/220v, 50 Hz supply.
   3. All loose equipment and spares as required and as detailed in these specifications and manufacturer's recommendations.
   4. Shop drawings, technical literature, operating and maintenance instruction manuals, parts lists and "as built drawings", in accordance with the requirements
of the complete works

18.1.1.2 Standards & quality assurance
A. In addition to the requirements shown or specified in the Contract Documents, all equipment shall be manufactured, tested and installed in accordance with the latest editions of the following standards or as listed equivalent to:
   1. ASHRAE. American Society of Heating Ventilating and Air Conditioning Engineers.
   3. Non-combustible material covered with a material that complies with flame spread requirements of BS 476, Part 7, Class 1.
C. The relevant standards quoted above shall be used and such other international recognized standards not stated but relevant. Wherever reference is made to an ANSI/ASTM, a British Standard (BS), or a recognized European Standard would also comply (see latest BSI Standards Catalogue, etc.). Each type of equipment/material selected shall comply fully with either the BS, ANSI/ASTM/ASHRAE, or the European Standard.
D. Equivalent standards of those stated in other divisions may be accepted
E. All Material and equipment manufacturers shall be ISO9000 certified companies.
F. Copy of all applicable used Standards, the latest edition, to be submitted by the contractor.

18.1.1.3 Schedule of works
A. Provide prior to commencing works a schedule showing all tasks and activities required for the project. A task is defined as an activity that can be performed individually and fully without interruptions of any kind, and whose duration is of more than 1 day. Indicate durations (minimum and maximum estimates) of each task and requirements from other trades in order to start or complete the task, as well as workforce required.
B. A general schedule for all the project shall be submitted as required in the contract. This schedule shall be implemented in the general works schedule.
C. Coordinate the schedule with the general works schedule of other divisions and adjust accordingly to fit into the project general schedule.
D. Submit an updated schedule as required in the contract. Modify this schedule according to the general works schedule.

18.1.1.4 Submittals
A. Approval of submittal: Approval of a submittal do not relieve the contractor from the specifications and contractual obligations. Each submittal should show a schedule of compliance sheet, addressing each point mentioned in the specifications and/or in the BOQ, these points should be numbered and each number should be highlighted with the
relative number on the original certified catalogue. Any deviation or omission from the specifications shall be clearly stated in a compliance sheet.

B. Coordination: Transmit each submittal sufficiently in advance of performance of related construction activities to avoid delay, and allow time for review as stipulated in the contract.

C. Submit all required data in the number of copies as stipulated in the contract (with a minimum of 3 copies).

D. Submittal Preparation: Place a permanent label or title block on each submittal (including shop drawing) for identification. Indicate the name of the entity that prepared each submittal on the label or title block.

1. Include the following information on the label for processing and recording action taken:
   a. Project name.
   b. Date.
   c. Reference number for the submittal with revision number if the same submittal has been submitted before.
   d. Name and address of the Architect/Supervisor.
   e. Name and address of the Contractor.
   f. Name and address of the subcontractor.
   g. Name and address of the supplier.
   h. Name of the manufacturer.
   i. Number and title of appropriate Specification Section.
   j. Drawing number and detail references, as appropriate.

E. Product Data: Collect Product Data into a single submittal for each element of construction or system. Product Data includes printed information, such as manufacturer's installation instructions, catalog cuts, standard color charts, roughing-in diagrams and templates, standard wiring diagrams, and performance curves.

1. Mark each copy to show applicable choices and options. Where printed Product Data includes information on several products that are not required, mark copies to indicate the applicable information. Include the following information:
   a. Manufacturer's printed recommendations.
   b. Type of usage and location.
   c. Reference number in contract documents (Specifications, drawings)
   d. Compliance with recognized testing agency standards.
   e. Application of testing agency labels and seals.
   f. Notation of dimensions verified by field measurement.
   g. Notation of coordination requirements.

2. Provide complete original catalogues of product when relevant or when requested.
3. Include Installation and Operation manual with each applicable submittal.

F. SAMPLES: Submit full-size, fully fabricated Samples cured and finished as specified and physically identical with the material or product proposed. Samples include partial sections of manufactured or fabricated components, cuts or containers of materials, color range sets, and swatches showing color, texture, and pattern.

18.1.1.5 Shop drawings

A. Submit newly prepared information drawn accurately to scale. Highlight, encircle, or otherwise indicate deviations from the Contract Documents. Do not reproduce Contract Documents or copy standard information as the basis of Shop Drawings. Standard information prepared without specific reference to the Project will be rejected.

B. Submit Builder’s Work drawings showing Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

C. Shop drawings shall be prepared electronically editable on Autocad similar to the edition of the original drawing and not less than R2007. Layers, sizes and all other drawing requirements shall be followed as per instructions of the Architect/Supervisor. These shall be made and presented to suit for the elaboration of composite drawings.

D. Shop Drawings include fabrication and installation Drawings, setting diagrams, schedules, patterns, templates and similar Drawings. Include information as required by individual sections, in addition to the following information:
   a. Dimensions, distances, invert levels, operating clearances, location of access required.
   b. Identification of products and materials included by sheet and detail number.
   c. Show equipment and accessories in their real actual dimensions and sizes, minimizing the use of symbols.
   d. Show piping larger than 2” in double line with accessories and valves in real dimensions, including supports, centerline clearances.
   e. Make sections on various installation intersections and as indicated by the Architect/Supervisor.
   f. Accessories, connections to other services, electrical connections, etc.
   g. Notation of coordination requirements.
   h. Sheet Size: Except for templates, patterns and similar full-size Drawings, submit general layouts on 1/50 scale, and details on 1/20.
   i. Submittal: 4 prints for the Architect’s/Supervisor’s review. The Architect/Supervisor will return one print.
   j. Do not use Shop Drawings without an appropriate final stamp indicating action taken.
   k. Submit electronic copy after approval of drawing.

E. Shop drawings are to be checked thoroughly and coordinated to avoid interference with structural elements, finishing requirements and the work of other trades.
18.1.1.6 Coordinated composite drawings

A. Participate in site meetings to coordinate shop drawings between all construction trades.

B. Submit coordinated composite drawings in color, showing interference of all trades on one sheet, including composite sections and elevations.

C. Submit coordinate composite sections on all complicated areas not obviously understandable from the layout.

D. Submit Composite drawings showing reflected ceiling plans to coordinate and integrate installation of air outlets and inlets, light fixtures, communication system components, sprinklers, drainage pipes, water supply and other ceiling-mounted items.

18.1.1.7 As built drawings

A. As-Built Drawings: On completion of the works of each area, system or floor, submit four sets of prints of each applicable drawing for the mechanical and plumbing installation, showing the exact position of all apparatus, plant, duct and pipework runs, valve positions, etc. with all appropriate labeling to the Architect/Supervisor’s requirements. All as-built drawings must conform in all respects to the pattern of the Contract Drawings, and to the approval of the Architect/Supervisor.

B. As-Built drawings shall be submitted directly after approval of the installation, and prior to testing and commissioning. A draft copy shall be submitted before closing shafts, ceiling or any obstructing element.

C. The words “As Built Drawing” shall be clearly indicated on all drawings adjacent to the title cover. As-built drawings will be subject to Architect/Supervisor approval. contractor to submit hard copies and also soft copies of all as built drawings on CD ROMS to the Architect/ Supervisor after the approval of the as built drawings.

18.1.1.8 Operation and maintenance manual

A. Before Final Handing over submit a draft copy of a complete Operation and Maintenance manual that include:

1. A documentation Directory
2. Emergency information
3. Operating manual
5. Test reports
6. As built drawings

B. Documentation directory: Submit an index of all O&M documents in a well-organized manner identified to ease the access of information and reflecting the hierarchy of the project: System, sub-system, Equipment, component.

C. Emergency information: a document that should be readily available for emergency
situation that include, for each system, information needed for type of emergency, with the notification activity and the responsibility of the personnel.

D. Operating manual: A document that contains all information needed for day-to-day operation and management of the building systems. Two parts required: one intended for the building manager focused on the systems and one for the building operators focused on the technical information of the equipment, with the normal operation, access and shut down of equipment.

E. Maintenance Manual: In addition to manufacturer supplied maintenance manuals, provide for each equipment:
   1. Description of equipment
   2. Recommended maintenance procedures and their frequency.
   3. Recommended list of spare parts with their number and reference.
   4. Original purchase order number, supplier’s name, address and phone number.
   5. Intervention needed in case of failure and Installation information.

F. Testing reports: Include test results from the testing and commissioning process.

G. Construction documents include AS-built drawings, specifications, approved submittals, schedule of equipment, warranty certificates, …

18.1.1.9 Product handling

A. Keep stocks of materials and equipment stored on the premises in a neat and orderly manner.

B. The exposed surfaces of units or equipment which have become covered with dirt, plaster or other material during handling and construction shall be thoroughly cleaned by the Contractor, before such surfaces are prepared for final finish, painting, or enclosed within the building structure.

18.1.1.10 18.1.1.12 Warranty

A. Submittal Time: Submit written warranties on request of Architect/Supervisor for designated portions of the Work where commencement of warranties other than date of Substantial Completion is indicated.

B. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.
   1. Bind warranties and bonds in heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive (115-by-280-mm) paper.
   2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.

C. Provide additional copies of each warranty to include in operation and maintenance manuals.
D. Schedule: Provide a minimum of one year warranties on all products and installations in addition to particular warranties specified in different sections.

18.1.2 PART 2- PRODUCTS

18.1.2.1 Approved manufacturers

A. The list of approved material and equipment suppliers (if any) forms an integral part of the specifications and contract documents.

B. Source Limitations: To the fullest extent possible, provide products of the same kind from a single source.

18.1.3 EXECUTION

18.1.3.1 Cutting and patching

A. Cutting and Patching Proposal: Submit a proposal describing procedures at least 10 days before the time cutting and patching will be performed, requesting approval to proceed. Include the following information:

1. Extent: Describe cutting and patching, show how they will be performed, and indicate why they cannot be avoided.

2. Changes to Existing Construction: Describe anticipated results. Include changes to structural elements and operating components as well as changes in building’s appearance and other significant visual elements.

3. Products: List products to be used and firms or entities that will perform the Work.

4. Dates: Indicate when cutting and patching will be performed.

5. Utilities: List utilities that cutting and patching procedures will disturb or affect. List utilities that will be relocated and those that will be temporarily out of service. Indicate how long service will be disrupted.

6. Structural Elements: Where cutting and patching involve adding reinforcement to structural elements, submit details and engineering calculations showing integration of reinforcement with original structure.

7. Architect/Supervisor’s Approval: Obtain approval of cutting and patching proposal before cutting and patching. Approval does not waive right to later require removal and replacement of unsatisfactory work.

B. Cutting: Cut existing construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer’s written recommendations.

1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
2. Existing Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.

3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.

4. Excavating and Backfilling: Comply with requirements in applicable Sections where required by cutting and patching operations.

5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.

6. Proceed with patching after construction operations requiring cutting are complete.

C. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other Work. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified in other Sections of these Specifications.

1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate integrity of installation.

2. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.

3. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove existing floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.

4. Ceilings: Patch, repair, or rehang installed ceilings as necessary to provide an even-plane surface of uniform appearance.

5. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition.

18.1.3.2 Protection

A. Keep all equipment, ducts, trunking, filters and conduit and pipework system openings closed by means of plugs or caps to prevent the entrance of foreign matter and cover all fixtures, equipment and apparatus as required to protect them against dirt, water, chemical, sand storm or mechanical damage both before and after installation.

B. Plugs and caps shall be of such types as to prevent transmission of flood water, dust or sand through any duct, conduit or raceway. Any fixtures, equipment of apparatus damaged prior to initial acceptance of the work shall be restored to its original condition or replaced by the Contractor. At completion, fixtures and equipment shall be thoroughly cleaned.

C. The Contractor shall be held responsible for all damage done until the time of
Substantial Completion and Acceptance of Works.
18.2 SECTION 220501 - BASIC MECHANICAL MATERIALS AND METHODS

18.2.1 GENERAL

18.2.1.1 Related documents
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Specification Sections, apply to this Section.

18.2.1.2 Summary
A. This Section includes the following basic mechanical materials and methods to complement other Sections.
   1. Piping materials and installation instructions common to most piping systems.
   2. Dielectric fittings.
   3. Flexible connectors.
   4. Mechanical sleeve seals.
   5. Equipment nameplate data requirements.
   6. Labeling and identifying mechanical systems and equipment.
   7. Nonshrink grout for equipment installations.
   8. Field-fabricated metal and wood equipment supports.
   9. Installation requirements common to equipment specification sections.
   10. Cutting and patching.
   11. Touchup painting and finishing.
   12. Puddle Flanges
B. Pipe and pipe fitting materials are specified in piping system Sections.

18.2.1.3 Definitions
A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
C. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
18.2.1.4 Submittals

A. Product Data: For dielectric fittings, flexible connectors, mechanical sleeve seals, and identification materials and devices.

B. Shop Drawings: Detail fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.

C. Coordination Drawings: For access panel and door locations.

D. Coordination Drawings: Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Show space requirements for installation and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work. Include the following:
   1. Clearances for installing and maintaining insulation.
   2. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.
   3. Equipment and accessory service connections and support details.
   4. Exterior wall and foundation penetrations.
   5. Fire-rated wall and floor penetrations.
   6. Sizes and location of required concrete pads and bases.
   7. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.

E. Samples: Of color, lettering style, and other graphic representation required for each identification material and device.

18.2.1.5 Quality assurance

A. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

18.2.1.6 Delivery, storage, and handling

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.
18.2.1.7 Products

A. Dielectric Fittings: Combination of copper alloy and ferrous; threaded, solder, plain, and weld-neck end types matching piping system materials; with insulating material suitable for system fluid, pressure, and temperature.
1. Dielectric Unions: Factory-fabricated, union assembly, for 1725-kPa minimum working pressure at 82 deg C.
2. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 1035- or 2070-kPa minimum working pressure as required to suit system pressures.
3. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 2070-kPa minimum working pressure at 107 deg C.
4. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 2070-kPa minimum working pressure at 107 deg C.

B. Flexible Connectors: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections. Include 860-kPa minimum working-pressure rating, threaded ends for DN50 and smaller, and flanged ends for DN65 and larger.

C. Stainless-Steel-Hose/Stainless-Steel Pipe Type: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose.
1. Rubber, Flexible Connectors: CR or EPDM elastomer rubber construction, with multiple plies of NP fabric, molded and cured in hydraulic presses. Include 860-kPa minimum working-pressure rating at 104 deg C.

D. Mechanical Sleeve Seals: Modular design, with interlocking rubber links shaped to continuously fill annular space between pipe and sleeve. Include connecting bolts and pressure plates. Use fire stop intumescent material on Fire rated walls and on floor penetration.

E. Steel, Sheet-Metal Sleeves: 0.6-mm minimum thickness, galvanized, round tube closed with welded longitudinal joint.

F. PVC Pipe Sleeves: Schedule 40.

G. Escutcheons: Manufactured wall, ceiling, and floor plates; deep-pattern type if required to conceal protruding fittings and sleeves. Include ID to closely fit around pipe, tube, and insulation of insulated piping and OD to completely cover opening.
1. Cast Brass: One-piece or split casting, with concealed hinge; set screw; and polished chrome-plated finish.
2. Stamped Steel: Split plate, with concealed hinge, spring clips, and chrome-plated finish.
3. Stamped Steel: Split plate, with exposed-rivet hinge, spring clips, and chrome-plated finish.
18.2.1.8 Flexible connectors

A. General: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections. Include 20 bars minimum working-pressure rating, unless higher working pressure is indicated, and ends according to the following:
   1. DN50 and Smaller: Threaded.
   2. DN65 and Larger: Flanged.

B. Bronze-Hose, Flexible Connectors PN 20: Corrugated, bronze, inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to hose. should have certificate from approved authority, CSTB, SKZ, DVGW. Supplier and manufacturer to propose a guarantee for at least five years. Do not use units in paragraph below for potable water.

C. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors PN 20: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose. Product should have certificate from approved authority, CSTB, SKZ, DVGW, supplier and manufacturer to propose a guarantee for at least five years.

D. Rubber, Flexible Connectors PN 20: CR or EPDM elastomer rubber construction, with multiple plies of NP fabric, molded and cured in hydraulic presses. Include minimum working-pressure rating at 100 deg C. Units may be straight or elbow type, unless otherwise indicated.

18.2.1.9 Identifying devices and labels

A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Sections. If more than one type is specified for application, selection is Installer's option, but provide one selection for each product category.

B. Equipment Nameplates: Metal nameplate with operational data engraved or stamped; permanently fastened to equipment.
   1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.
   2. Location: Accessible and visible location.

C. Stencils: Standard stencils, prepared for required applications with letter sizes complying with recommendations of ASME A13.1 for piping and similar applications, but not less than 30-mm high letters for ductwork and not less than 19-mm high letters for access door signs and similar operational instructions.
   2. Stencil Paint: Standard exterior-type stenciling enamel; black, unless otherwise indicated; either brushing grade or pressurized spray-can form and grade.
   3. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ASME A13.1 for

E. Plastic Duct Markers: Manufacturer's standard color-coded, laminated plastic. Comply with the following color code:
   1. Blue: Cold air.
   2. Red: Hot air.
   3. Yellow: Supply air.
   4. Green: Exhaust, outside, return, and mixed air.
   5. For hazardous exhausts, use colors and designs recommended by ASME A13.1.
   6. Nomenclature: Include the following:
      a. Direction of airflow.
      b. Duct service.
      c. Duct origin.
      d. Duct destination.
      e. Design liters per second.

F. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated.
   1. Fabricate in sizes required for message.
   2. Engraved with engraver's standard letter style, of sizes and with wording to match equipment identification.
   3. Punch for mechanical fastening.
   4. Thickness: 1.6 mm, for units up to 130 sq. cm or 200 mm long; 3.2 mm for larger units.
   5. Fasteners: Self-tapping stainless-steel screws or contact-type permanent adhesive.

G. Plastic Equipment Markers: Color-coded, laminated plastic. Comply with the following color code:
   1. Blue: Cooling equipment and components.
   2. Yellow: Combination cooling and heating equipment and components.
   4. Blue: Equipment and components that do not meet any criteria above.
   5. For hazardous equipment, use colors and designs recommended by ASME A13.1.
   6. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
a. Name and plan number.
b. Equipment service.
c. Design capacity.

7. Size: Approximate 65 by 100 mm for control devices, dampers, and valves; and 115 by 150 mm for equipment.

H. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, lettering, and wording indicated for proper identification and operation/maintenance of mechanical systems and equipment.

1. Multiple Systems: If multiple systems of same generic name are indicated, provide identification that indicates individual system number and service such as "Boiler B 3," "Air Supply No. 1H," or "Standpipe F12."

18.2.1.10 Grout

A. Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.


2. Design Mix: 34.5-MPa, 28-day compressive strength.


18.2.2 EXECUTION

18.2.2.1 Piping systems - common requirements

A. General: Install piping as described below, unless piping Sections specify otherwise. Individual piping Sections specify unique piping installation requirements.

B. General Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved on Coordination Drawings.

C. Install components with pressure rating equal to or greater than system operating pressure.

D. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

E. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.

F. Install piping to allow application of insulation plus 25-mm clearance around insulation.

G. Locate groups of pipes parallel to each other, spaced to permit valve servicing.
H. Install couplings according to manufacturer's written instructions.

I. Sleeves are not required for core drilled holes.

J. Permanent sleeves are not required for holes formed by PE removable sleeves.

K. Install sleeves for pipes passing through concrete and masonry walls, and concrete floor and roof slabs.

L. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 50 mm above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   2. Build sleeves into new walls and slabs as work progresses.
   3. Install sleeves large enough to provide 6.4-mm annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. PVC Pipe Sleeves: For pipes smaller than DN150.
      b. Steel Pipe Sleeves: For pipes smaller than DN150.
      c. Steel, Sheet-Metal Sleeves: For pipes DN150 and larger, penetrating gypsum-board partitions.
      d. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 50 mm above finished floor level. Refer to Section "Sheet Metal Flashing and Trim" for flashing.
   4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants. Refer to Section "Joint Sealants" for materials.
   5. Use Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant, unless otherwise indicated.

M. Aboveground, Exterior-Wall, Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 25-mm annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Install steel pipe for sleeves smaller than 150 mm in diameter.
   2. Install cast-iron "wall pipes" for sleeves 150 mm in diameter and larger.
   3. Assemble and install mechanical sleeve seals according to manufacturer's written instructions. Tighten bolts that cause rubber sealing elements to expand and make watertight seal.

1. Assemble and install mechanical sleeve seals according to manufacturer's written instructions. Tighten bolts that cause rubber sealing elements to expand and make watertight seal.

O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping materials. Refer to Section "Firestopping" for materials.

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

R. Piping Connections: Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping DN50 and smaller, adjacent to each valve and at final connection to each piece of equipment with DN50 or smaller threaded pipe connection.

2. Install flanges, in piping DN65 and larger, adjacent to flanged valves and at final connection to each piece of equipment with flanged pipe connection.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.


18.2.3 PUDDLE FLANGES

A. Where pipework passes through the external walls of the buildings or trenches below ground level, the Contractor shall supply and cast or built puddle flanges into the structure.

B. Puddle flanges are to be manufactured from the same material as the pipework of which they form a part.

C. Each puddle flange shall comprise a length of pipe, flanged or screwed at end according to diameter with an undrilled slip on flange welded on the outside at a point where it will be located mid way in the thickness of the wall. The puddle flange is to be painted externally with two coats of bituminous paint before being built into the structure.

18.2.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Architect/Supervisor.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
E. Install equipment giving right of way to piping installed at required slope.

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

18.2.5 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
   2. Plastic markers, with application systems. Install on insulation segment if required for hot, uninsulated piping.
   3. Locate pipe markers as follows if piping is exposed in finished spaces, machine rooms, and accessible maintenance spaces, such as shafts, tunnels, plenums, and exterior nonconcealed locations:
      a. Near each valve and control device.
      b. Near each branch, excluding short takeoffs for fixtures and terminal units. Mark each pipe at branch, if flow pattern is not obvious.
      c. Near locations if pipes pass through walls, floors, ceilings, or enter nonaccessible enclosures.
      d. At access doors, manholes, and similar access points that permit view of concealed piping.
      e. Near major equipment items and other points of origination and termination.
      f. Spaced at maximum of 15-m intervals along each run. Reduce intervals to 7.5 m in congested areas of piping and equipment.
      g. On piping above removable acoustical ceilings, except omit immediately spaced markers.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of mechanical equipment.
   1. Lettering Size: Minimum 6.4-mm- high lettering for name of unit if viewing distance is less than 610 mm, 12.7-mm- high lettering for distances up to 1800 mm, and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
   2. Text of Signs: Provide name of identified unit. Include text to distinguish between multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers; or provide stenciled signs and arrows, showing duct system service and direction of flow.
   1. Location: In each space, if ducts are exposed or concealed by removable ceiling system, locate signs near points where ducts enter into space and at maximum intervals of 15 m.
D. Dampers and valves: Install engraved plastic-laminate sign on each valve and damper except equipment shut-off valves and air terminal dampers.

E. Control Panel boards: Apply identification as described in related specifications.

F. Adjusting: Relocate identifying devices as necessary for unobstructed view in finished construction.

18.2.6 PAINTING AND FINISHING

A. Apply paint to exposed piping according to the following, unless otherwise indicated:

   1. Interior, Ferrous Piping: Use semigloss, acrylic-enamel finish. Include finish coat over enamel undercoat and primer.

   2. Interior, Galvanized-Steel Piping: Use semigloss, acrylic-enamel finish. Include two finish coats over galvanized metal primer.


B. Do not paint piping specialties with factory-applied finish.

C. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

18.2.7 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 100 mm larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 20.7-MPa, 28-day compressive-strength concrete and reinforcement as specified in Section "Cast-in-Place Concrete."

18.2.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

18.2.9 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair cut surfaces to match adjacent surfaces.
18.3 SECTION 220519 — METERS AND GAGES

18.3.1 GENERAL

18.3.1.1 Summary
A. This Section includes meters and gages for mechanical systems, thermometers, thermal energy meters (calorimeters) and water meters.
B. Utility-Furnished Products: Water meters will be furnished to site, ready for installation.

18.3.1.2 Submittals
A. Product Data: Include scale range, ratings, and calibrated performance curves for each meter, gage, fitting, specialty, and accessory specified.
B. For Flow meters: Submit manufacturer’s recommended installation, and manual of operation.
C. Product Certificates: Signed by manufacturers of meters and gages certifying accuracies under specified operating conditions and compliance with specified requirements.
D. Quality: all thermometers should be manufactured under reliable European or USA Standards and Norms, products to meet the approval of authoritative Laboratories and agencies
E. Maintenance Data: For meters and gages to include in maintenance manuals specified, include data for the following:
   1. Flow meters.
   2. Water meters.

18.3.2 PRODUCTS

18.3.2.1 Thermometers, general
A. Scale Range: Temperature ranges for services
B. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

18.3.2.2 Liquid-in-glass thermometers
A. Description: ASTM E 1.
B. Case: Die cast and aluminum finished in baked-epoxy enamel, glass front, spring secured, 230 mm long.
C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.
D. Tube: Red or blue reading, organic-liquid filled with magnifying lens.
E.  Scale: Satin-faced nonreflective aluminum with permanently etched markings.
F.  Stem: Copper-plated steel, aluminum, or brass for separable socket; of length to suit installation.

18.3.2.3 Pressure gages
A.  Description: ASME B40.1, phosphor-bronze bourdon-tube type with bottom connection; dry type, unless liquid-filled-case type is indicated.
B.  Case: Drawn steel, brass, or aluminum with 115-mm-diameter, glass lens.
C.  Connector: Brass, DN8.
D.  Scale: White-coated aluminum with permanently etched markings.
E.  Accuracy: Grade C, plus or minus 3 percent of middle 50 percent of scale.
F.  Range: Comply with the following:
   1.  Vacuum: 100 kPa of vacuum to 103 kPa of pressure.
   2.  Fluids under Pressure: Two times the operating pressure.

18.3.2.4 Pressure-gage fittings
A.  Valves: DN8 brass or stainless-steel needle type.
B.  Syphons: DN8 coil of brass tubing with threaded ends.
C.  Snubbers: ASME B40.5, DN8 brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.

18.3.2.5 Water meters
A.  Description: ultra sonic type. Registers flow in liters or cubic meters as required by utility.
B.  Instruments include flow-sensor element and meter, transmitter, microprocessor based integrator with integral battery pack, stop valves, strainer, and magnetic trap. Select size according to predicted load. Shall conform to EN1434. Meter shall be suitable for cooling or heating.
   2.  Pressure Rating: PN 20
   3.  Data Output: Remote Digital screen with readout with remote reading on central station via bus.
   4.  Protection: IP54.
   5.  Accuracy: Plus or minus 1 percent.
C.  Flowmeter shall not have more than 2% accuracy.
D.  Water meter shall be connected to a central reading and processing unit via M-Bus.
system.

E. Central processing/reading station shall centrally read all connected meters with storage capabilities.
   1. Real time clock with date function.
   2. Instantaneous readings at each meter includes: Flow, meter number, meter serial number, error time, accumulated volume of flow sensor.
   3. Storage includes daily data for each meter, accumulated for 60 days.
   4. Multi-tariff option.

F. Central processing/reading station shall be connected to a PC with software for data processing, display and printing. The central station shall have a Lon-works or Bac-net interface for connection to the Central Control Panel in the Central Control Room in the Operation Building.

18.3.3 EXECUTION

18.3.3.1 Meter and gage installation, general
   A. Install meters, gages, and accessories according to manufacturer’s written instructions for applications where used.

18.3.3.2 Pressure-gage installation
   A. Install pressure gages in piping tees with pressure-gage valve located on pipe at most readable position.
   B. Install dry-type pressure gages in the following locations:
      1. Discharge of each pressure-reducing valve.
   C. Install liquid-filled-type pressure gages at suction and discharge of each pump.

18.3.3.3 Connections
   A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
      1. Install meters and gages adjacent to machines and equipment to allow service and maintenance.
      2. Connect flow-measuring-system elements to meters.

18.3.3.4 Adjusting and cleaning
   A. Calibrate meters according to manufacturer’s written instructions, after installation.
   B. Adjust faces of meters and gages to proper angle for best visibility.
   C. Clean windows of meters and gages and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer’s touchup paint.
18.4 SECTION 220523 – PLUMBING VALVES

18.4.1 GENERAL

18.4.1.1 Summary
A. This Section includes general duty valves, regulating valves and specialties for plumbing piping systems.

18.4.1.2 Submittals
A. Product Data for each valve type. Include all components material, standard compliance, dimensions, required clearances, and installation instructions. Include list indicating valve and its application.
B. Balancing valves: Submit balancing data and selected balancing valves Kv values based on calculations done for the hydronic system (refer to submittals requirements of Hydronic Piping section).
C. Maintenance data for valves to include in the operation and maintenance manual.

18.4.1.3 Quality assurance
A. ASME Compliance: Comply with British Standards for building services piping and for power piping.
B. ISO Compliance: Comply with ISO 9001 and ISO 9002 for the Quality management systems of the manufacturer.
C. Manufacturer representative should approve the compliance sheet in the submittals and should approve the installation during erection and during commissioning of the valves.

18.4.2 PRODUCT

18.4.2.1 Basic, common features
A. Design: Non rising stem.
B. Sizes: Same size as upstream pipe, unless otherwise indicated. Balancing valves or control valves sizing to follow system balancing requirements
C. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.
D. Threads: to BS21 (ISO 7)
E. Flanges: to BS 4504.
F. Grooved-end: to pipe grooving standard.

18.4.2.2 Gate valves
A. Bronze Gate Valve .
   1. Application: Isolation of water and distribution mains up to and including
DN50.

2. Type: Solid wedge, Nonrising stem screwed-in bonnet, threaded to BS 21 or grooved and manufactured to BS 5154 PN 20 for series B rating.

3. Material:
   a. Body Bronze to BS 2872 CZ122
   b. Stem : brass, A metal or bronze
   c. Union bonnet ring: cast bronze
   d. Gland: Machined from brass bar
   e. Packing nut : machined from brass bar.
   f. Hand wheel : Die cast Aluminum
   g. Disk : Brass to BS 2872 CZ 122

B. Cast Iron Gate Valve : Not applicable for water distribution systems.

18.4.2.3 Ball valves
A. Application : Shut-off.
B. Pressure rating : PN 20 up to DN 80.
C. Type: Two-pieces, Quarter turn, lever operation or lockshield, Threaded to BS 21 or grooved.
D. Material:
   1. Ball: Brass to BS 2874
   2. Seat: P.T.F.E.
   3. Seat retainer : Bronze to BS 1400
   4. Body : Bronze to BS2874
   5. Lever : mild steel covered by PVC
   6. Packing : P.T.F.E.
   7. Gland nut: Brass to BS2874

18.4.2.4 Butterfly valves
A. Compliant to BS5155 or EN593, PN 16.
B. Application : Shut-off and / or limited flow control from DN 125 and above.
C. EPDM bonded seat, conforms to BS155.
D. Material Body : Cast iron, with extended neck to facilitate lagging on insulated pipelines, External protection is by epoxy paint.
E. Disk: stainless steel,
F. Shaft: made from high tensile stainless steel. a thrust washer and pin is incorporated into the assembly to ensure the upper shaft is fully retained under pressure
G. For smaller than DN150: Levers with position indicator and spring loaded trigger device.

H. For DN150 and larger: Weather-proof Gearbox with handwheel with a worm and quadrant operation with adjustable stops at both the fully open and fully closed positions, self-locking capable for working under dry service.

18.4.2.5 Check valves
A. Bronze Check Valve
   1. Application: Prevention of flow reversal. Provide where shown on the drawings and as indicated, pipe sizes DN 50 and below are for water transfer application.
   2. Type: Swing check type to BS 5154, series B, PN 20.
   3. Pattern: Horizontal or vertical (with upward flow). Renewable discs and side plugs and regrindable, integral seats. Discs shall be renewable and seats regrindable without removing valves from the line.
   4. Ends: Screwed to BS 21.
   5. Noiseless application with neoprene seat protection and ring
   6. Materials:
      a. Body: Bronze to BS 1400
      b. Disk and Cap: 60140 Brass (20 min dia) BS 874 CZ18 No. 4 Bronze (20-50mm) Bs 1400 - LG2

18.4.2.6 Strainers
A. Bronze Strainers up to and including DN50:
   1. Application: Inlet connection to equipment, up to and including DN 50. Use for water base fluid transfer systems.
   2. Type: Y-type, Screwed-in cap, threaded to BS 21 or grooved, PN32, 48 bar hydraulically tested
   3. Materials:
      a. Body: Bronze to BS 1400-LG2
      b. Cap: Bronze to BS 1400-LG2
      c. Cap Gasket: Compressed non-asbestos fibre.
      d. Strainer screen: Perforated stainless steel sheet, having 0.75 mm diameter and 51 holes/cm².

18.4.2.6 Automatic air vents
A. Type: Ball Float. Reference to be made to approved manufacturer with special selection for each application.

B. Application: Pipework in riser, loop in piping, cooling coils, hot water heater, (highest point). To be applied with justifications even if not mentioned on drawings.
C. Material: 30,000 lbs minimum tensile or bronze body with screwed inlet to BS 21 and stainless steel free floating lever with hemispherical chrome steel valve, with S/S internal components.

D. Attachments: Integral detachable screw down air release cock with solid conical disc with machined body seat and integral isolator.

E. Working Pressure: 20 bar.

18.4.2.7 Manual air vents
A. Bronze body and nonferrous internal parts; working pressure; 107 deg C operating temperature; manually operated with screwdriver or thumbscrew; with DN 6 discharge connection and DN 15 inlet connection.

18.4.2.8 Globe valve
A. Bronze Globe Valve
   1. Application: Throttling of water mains up to and including DN50.
   2. Type: Metal disk, screwed-in bonnet, threaded to BS 21 and manufactured to BS 5154 PN 20 for series B rating.
   3. Material:
      a. Body Bronze to BS 1400-LG2
      b. Stem: brass, A metal or bronze
      c. Bonnet: Bronze to BS 1400-LG2
      d. Disk: Brass to BS2872-CZ122.
      e. Bonnet: Cast iron to BS 1452

18.4.2.9 Water hammer arrestor
A. ASME A112.26.1M, ASSE 1010, or PDI-WH 201, bellows or piston type with pressurized cushioning chamber. Sizes are based on water-supply fixture units, ASME A112.26.1M sizes A through F and PDI-WH 201 sizes A through F.

18.4.2.10 Hose bib valve
A. Bronze body, with renewable composition disc, DN15 or DN20 threaded or solder-joint inlet. Provide ASME B1.20.7 garden-hose threads on outlet and integral or field-installed, nonremovable, drainable, hose-connection vacuum breaker.
   1. Finish: Chrome or nickel plated.
   2. Operation: Wheel handle.
18.4.2.11 Pressure reducing valves (water regulators)

A. General: water regulators, consisting of a pre-loaded spring on diaphragm regulating water pressure in system rated PN 20, of size, flow rate, and inlet and outlet pressures as required by the system. Include integral factory-installed or separate field-installed Y-pattern strainer.

1. DN50 and Smaller: Bronze body with threaded ends.
2. DN65 and Larger: Bronze or cast-iron body with flanged ends. Include AWWA C550 or FDA-approved interior epoxy coating for regulators with cast-iron body.
4. Exterior Finish: Polished chrome-plate if used in chrome-plated piping system.

B. Single-seated, direct-operated type, replaceable stainless steel seat.

C. Nylon reinforced Buna-N diaphragm.

D. Pilot-operated type, single- or double-seated, cast-iron-body main valve, with bronze-body pilot valve.

E. Low-flow by-pass capability shall be achieved by using a balanced direct acting PRV as an integral part of the main valve. At very low flows when the main valve is almost completely closed, to prevent the possibility of cavitation the dmct actmg valve shall by-pass the main valve and maintain flow.

18.4.2.12 Drain valves

A. Hose-End Drain Valves: MSS SP-110, DN20 ball valve, rated for PN 16 CWP. Include 2-piece, ASTM B 62 bronze body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.

1. Inlet: Threaded or solder joint.
2. Outlet: Short-threaded nipple with ASME B1.20.7 garden-hose thread and cap.
3. Fire-Hose-End Drain Valve Option: UL 668, DN40, bronze body, 90-degree angle or straightway-pattern hose valve, rated for 1200-kPa minimum working pressure.
      1) Option: DN65 valves with DN65 by DN40 adapter and attached chain and cap may be provided instead of DN40 valves.

B. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 1380-kPa minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with DN6 side drain outlet and cap.
18.4.2.13 Relief valves

A. Application: On hot water storage tanks, or domestic water heaters.

B. Type and Compliance: ASME rated thermostatic, self-closing, temperature and pressure relief valve, located in the relief valve openings of tanks. Valve shall have a minimum thermal discharge capacity equal to the input capacity of the heater standard pressure setting of 600 kPa and standard temperature setting of 100 degrees C.

C. Relief valve pipe to discharge to floor drain.

18.4.3 EXECUTION

18.4.3.1 Installation

A. Install valves as indicated, according to manufacturer’s written instructions.

B. Piping installation requirements are specified in other Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

C. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

D. Locate valves for easy access and provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the center of the pipe.

F. Install valves in a position to allow full stem movement.

G. Installation of Check Valves: Install for proper direction of flow as follows:
   1. Swing Check Valves: Horizontal position with hinge pin level.
   2. Wafer Check Valves: Horizontal or vertical position, between flanges.
   3. Lift Check Valve: With stem upright and plumb.

18.4.3.2 Threaded connections

A. Note the internal length of threads in valve ends and proximity of valve internal seat or wall to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads, except where dry seal threading is specified.

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

18.4.3.3 Flanged connections

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.
C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

18.4.3.4 Valve end selection
A. Select valves with the following ends or types of pipe/tube connections:
   1. Copper Tube Size, DN65 and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
   2. Steel Pipe Sizes, DN65 and Smaller: Threaded or grooved end.
   3. Steel Pipe Sizes, DN80 and Larger: Grooved end or flanged.

18.4.3.5 Application schedule
A. General Application: Use gate, ball, and butterfly valves for shutoff duty; globe, ball, and butterfly for throttling duty. Refer to piping system Specification Sections for specific valve applications and arrangements.
B. Domestic Water Systems: Use the following valve types:
   1. Gate Valves: PN20, bronze body;.
   2. Ball Valves: PN20, bronze body; or PVC.
   3. Globe Valves: PN20, bronze body; and bronze or teflon disc.
   4. Butterfly Valves: Nickel-plated ductile iron, aluminum bronze, or elastomer-coated ductile iron disc; EPDM or Buna N sleeve and stem seals, or PVC.
   5. Bronze Swing Check: PN20, with rubber seat.
   6. Check Valves: PN20, bronze body;
18.5 SECTION 220529 - HANGERS AND SUPPORTS

18.5.1 GENERAL

18.5.1.1 Summary

A. This Section includes hangers and supports for mechanical systems piping and equipment.

18.5.1.2 Submittals

A. General: Submit the following according to the Conditions of the Contract and Specification Sections.

B. Submit the piping support systems design with load and stress calculation on typical piping sections and on critical ones.

C. Submit anchor (fixed) points and sliding assemblies calculation analysis with recommendations of expansion joint movements according to design working temperatures and safety limits.

D. Submit equipment support design with selected rods, bolts and assemblies satisfying design loads requirements.

E. Product data for each type of hanger and support.

F. Submit pipe hanger and support schedule showing manufacturer’s Figure No., size, location, and features for each required pipe hanger and support.

G. Samples: Submit sample for each type of hanger.

18.5.2 PRODUCTS

18.5.2.1 Hangers materials

A. Support Channels: Zinc plated perforated with suitable sliding accessories.

B. Structural Steel: St 37-2, Hot dip galvanised >5μm, to DIN 975, hot dipped galvanized steel plates, shapes, and bars, black and galvanized.

C. Bolts and Nuts: Strength Grade 4.6 or 8.8 DIN ISO 898, DIN 555 or 934, hot dipped galvanized steel, hex-head, track bolts and nuts.

D. Washers: DIN 125, 440 and 921, steel, plain, flat washers.

E. Clamps: Hot dipped Galvanized, Single part, self securing, with rubber sound and vibration rubber roll insulation with zinc plated accessories.

F. Grout: nonshrink, nonmetallic.

1. Characteristics include post-hardening, volume-adjusting, dry, hydraulic-cement-type grout that is nonstaining, noncorrosive, nongaseous and is recommended for both interior and exterior applications

2. Design Mix: 34.5-MPa, 28-day compressive strength.
G. Pre-insulated Hangers: (690-kPa) minimum compressive-strength insulation, encased in sheet metal shield.
   1. Material: ASTM C 552, Type I cellular glass with vapor barrier.

18.5.2.2 Miscellaneous materials
A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

18.5.3 EXECUTION
18.5.3.1 Hanger and support applications
A. Specific hanger requirements are specified in the Section specifying the equipment and systems.
B. Comply with manufacturer’s recommendations for pipe hanger selections and applications that are not specified in piping specification Sections.

18.5.3.2 Hanger and support installation
A. General: Install pre-fabricated hangers, supports, clamps, and attachments as required to properly support piping from building structure.
B. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible.
C. Install supports with maximum spacings between adjacent pipes complying with MSS SP-69.
D. Install clamps with sound and vibration rubber insulation for all pipes except vents.
E. Where pipes of various sizes are supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install according to fastener manufacturer’s written instructions. Do not use in lightweight concrete slabs or in concrete slabs less than 100 mm thick.
G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
H. Heavy-Duty Steel Trapezes: Field-fabricate from ASTM A 36 steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.
I. Support fire protection systems piping independent of other piping.
J. Install hangers and supports to allow controlled movement of piping systems, permit freedom of movement between pipe anchors, and facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so that maximum pipe deflections allowed by ASME B31.9 "Building Services Piping" is not exceeded.

M. Insulated Piping: Comply with the following installation requirements.
   1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.
   2. Install pre-insulated clamps and hangers for all insulated pipes, with the same insulation thickness, and vapor barrier.

18.5.3.3 Equipment supports

A. Suspend equipment using hot dip galvanized steel u-channels and bolts and from the same support manufacturers.

B. Use anti-vibration material between supports and equipment as specified in the Mechanical Vibration Controls section.

C. Grouting: Place grout under supports for equipment, and make a smooth bearing surface.
18.6 SECTION 221116 - WATER PIPING

18.6.1 GENERAL

18.6.1.1 Summary
A. This Section includes domestic water piping from locations indicated to fixtures and equipment inside the building.

18.6.1.2 Definitions (Abbreviations if existing)
A. CPVC: Chlorinated polyvinyl chloride plastic.
B. PPR: Polypropylene Random Copolymerisate.
C. PE: Polyethylene PE-100

18.6.1.3 Performance requirements
A. Provide components and installation capable of producing water piping systems with the following minimum working-pressure ratings, unless otherwise indicated:

18.6.1.4 Submittals
A. Product Data: For pipe, tube, fittings, and couplings.
B. Sample for each: pipe, fitting and coupling.
C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

18.6.1.5 Quality assurance
A. Piping materials shall bear label, stamp, or other markings of specified testing agency to the European Norm of application.
B. All of the foregoing works shall comply with the requirements of the latest edition of European Norm.
C. Workmanship: Supplier approved skilled workmanship with proven experience in similar jobs.

18.6.2 PRODUCTS

18.6.2.1 Piping materials
A. Steel Pipe: DIN 2440, Seamless, galvanized, neoprene coated, medium weight. Include ends matching joining method.
2. Fittings Threads: ISO 7/1 or DIN 2999 outside (male) connections “gas” tapered type (1:16 taper), internal (female) connection “gas” cylindrical type.

3. Steel-Piping, Expansion Joints: Compound, galvanized, steel fitting with telescoping body and slip-pipe section. Include packing rings, packing, limit rods, chrome-plated finish on slip-pipe sections, and flanged ends.

B. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

C. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

18.6.2.2 PVC piping
A. PVC Schedule 80 Pipe: ASTM D 1785.
   1. PVC Schedule 80 Fittings: ASTM D 2467, socket type.

18.6.2.3 Steel pipe and fitting
A. Galvanized Steel seamless Pipe, DN 50 and Smaller: ASTM A 53, Type S Grade B, Schedule 40 or Standard weight, plain or threaded ends.
B. Galvanized Steel seamless Pipe, DN 65 through DN 200: ASTM A 53, Type S, Grade B, Schedule 40 or standard weight, grooved ends.
C. Unreinforced, welded, in-branch connections weaken a main pipeline; reinforcement is necessary unless wall thickness of both mains and branches is sufficient to sustain pressure.
D. Coordinate flange class with products in other parts of this Section and in related Sections to correlate face size and bolt patterns.
E. Malleable cast Iron Threaded Fittings: ASME B16.3, ASTM A197, Classes 250 and 300, hot-dip galvanized to ASTM153
F. Malleable-Iron Unions: ASME B16.39; Classes 250, and 300, Galvanized.
G. Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 galvanized ductile iron; or ASTM A 47M, Grade 32510 galvanized malleable iron;
H. Grooved Mechanical-Joint Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings. Mechanical couplings shall be rigid couplings with angle pad design (Rigid Zero Flex). Flexible couplings shall be used wherever flexibility is desired. Couplings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45-12 or malleable iron conforming to ASTM A-47, Grade 32510.
I. Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to physical properties of ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa).
J. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures. Shall be Grade “E” EPDM compound conforming to
ASTM D-2000 designation 2CA615A25B24F17Z. UL classified to ANSI/NSF 61 for cold +86 degrees F (+30 degrees C) and hot +180 degrees F (+82 degrees C) potable water service. Temperature operating range -30 degrees F to +230 degrees F (-34 degrees C to +110 degrees C). (Note: Air systems without hydrocarbons.) Use Grade “L” Silicone compound (red color coded) for dry air service operating temperatures up to +350 degrees F (+177 degrees C).

18.6.2.4 Copper piping
A. Hard Copper Tube: ASTM B 88, types L and M (ASTM B 88m. types B and C), water tube, drawn temper.
B. Copper Pressure fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
C. Bronze Flanges: ASME B16.24, class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
D. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with bass-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.

18.6.2.5 Polypropylene (beta pp-r)
A. Pipes shall be manufactured from approved Raw materials in accordance with DIN 8078, and/ or specially to EN 15874.
B. Produced pipes must be rated for at least class 2 Wall thickness. Mechanical Characteristics, Mean outside diameter and out of roundness together with their tolerances must comply with: EN15874-2 or to DIN 8077. exposed Pipes installations must be rated for class 2 and heat stabilized with aluminum foils.
C. Class 2 PP-r should be under S3.2, SDR 7.4, and should be rated for 40 Degree C. under 18 Bar; or for a rated 60 Degree C. and 12 Bar water pressure to withstand a guaranteed theoretical life time of not less than 50 years .
D. Marking of Pipe - All pipes shall bear permanent identification markings that will remain legible during the service life of the product. Marking on pipe shall include the following and shall be applied at intervals of not more than 1.5 meters:
E. Trademark and Nominal diameter and thickness
F. Standard PPr designation
G. The Standard Dimension Ratio and Nominal Pressure
H. Marking the product with the applicable standards designation
I. Quality System used
J. Date and time of manufacture reference
K. Manufacturer's name and country of manufacture.
L. Polypropylene Fittings
M. All PP-r fittings supplied under this scope of work must be pressure rated PN25 and manufactured from the same material used to manufacture pipes and shall pass all tests required under: EN 15874-3 or DIN 16962/5.
N. All inserts used in the manufacturing of threaded fittings must be made of Nickel Plated Brass CW617N EURO. All threads must be made according to DIN 2999. All male threads must be serrated to ease the application of sealing tape. Male threaded fittings must have PP-r coverage extending to the tip of the insert (on the inner surface).

O. Marking of Fittings- All fittings shall have permanent identification markings indicating the following:

P. 1- Trademark, size and pressure rating of fitting

Q. 2- Standard PP-r designation

R. 3- Month and Year stamp indicating period of manufacturing

S. Joining Polypropylene Pipes and Fittings

T. Socket Fusion Joining: This is the process used to join PP-r pipes to PP-r accessories. This form of joining requires a heating tool and sockets. In this process, a pipe end and a fitting are heated simultaneously to fusion temperature (260 °C) using a heating bush and a heating spigot, and are then pushed together. Thus resulting in a homogeneous joint.

U. Electrofusion Joining: This technique is used strictly for repair and emergency work. In electrofusion,

V. the pipe and electrofusion fitting are heated by means of resistance wires and fused together. Power is supplied through an automatic fusion control unit supplied by the manufacturer of fittings.

W. Heat Fusion Training Services: Upon request, the Manufacturer shall provide training in the Manufacturer's recommended socket fusion and electrofusion procedures to the Contractor's installation personnel, and to inspectors representing the Owner.

18.6.2.6 Cpvc piping

A. Piping:
   - CPVC Schedule 40, solvent cement joint, for hot and cold water distribution pipes.
   - HT CPVC Schedule 40, solvent cement joint for heating system high temperature.

B. Piping Material: Post Chlorinated polyvinyl Chloride non-flammable.

C. Fittings: CPVC

D. Joining: Use manufacturer supplied solvent cement.

E. Support: as per manufacturer recommendation not less than 90 cm for diameter 32 and below, 1.2 m for 40 and above.

F. Movement from expansion and contraction should be taken into consideration.

G. Transition from CPVC to metal should be done as per manufacturer recommendations.

H. Pressure rating: PN25.
I. Transitions to steel: use manufacturer’s male threaded adapters.

J. CPVC STANDARDS

1. ASTM-D2846 : CPVC Hot and Cold Water Distribution
2. ASTM-F493 CPVC Solvent Cement Specifications
3. ASTM-F402 Handling Solvent Cements
4. ASTM-F442 CPVC Plastic Pipe (SDR-PR)
5. ASTM-F437 Threaded CPVC fittings, schedule 80
6. ASTM-F438 CPVC Schedule 40 CPVC fittings
7. ASTM-F439 CPVC Schedule 80 CPVC fittings
8. ASTM-F441 CPVC Schedule 40 & 80 Pipe
9. ASTM-D1784 CPVC compounds
10. DIN8079 CPVC pipe dimensions
11. DIN8080 CPVC pipe general quality requirements and testing

18.6.2.7 Polyethylene pe100 piping

A. Polyethylene Pipe shall be manufactured from a high density copolymer resin meeting the requirements of ASTM D3035. Pipe shall be manufactured to SDR 11. The material shall achieve a minimum tensile strength of 3600 psi when tested at 73°F according to ASTM D 638. The material shall also comply with guidelines approved by the U.S. Food and Drug Administration (FDA) as specified in the Code of Federal Regulations (CFR). Piping shall conform to the requirements of ASTM D2837 for hydrostatic design basis. Pipe shall be supplied capped off at the extruder.

B. Polyethylene Fittings shall be manufactured from a high density copolymer resin meeting the requirements of ASTM D3035. Fittings in sizes through 36” shall be butt fusion type, suitable for heat fusion joining. All fittings through 8” shall have spigot lengths compatible for infrared (IR) joining technology. All fittings through 36” shall be compatible manual and contact butt fusion machines. Fittings shall be manufactured to SDR 11. All flanged connections shall utilize flange rings with bolt patterns to accommodate ANSI bolt circles. All threaded connections shall have pipe threads designed in accordance with the requirements of ASTM D2464, which references ANSI B1.20.1 (formerly B2.1) for tapered pipe threads (NPT).

C. All components of the pipe and fitting system shall conform to the following applicable ASTM Standards, D3035, D638, D2837, and shall conform to FDA CFR 21 177.160 and 178.3297. All pipes shall be marked with manufacturers name, pipe size, SDR rating, type, quality control mark and pressure rating information. Fittings shall be embossed with a permanent identification during the production process to ensure full traceability.

D. Pipe, valves, fittings and joining equipment shall be supplied by a single source provider to insure compatibility of system components and to assure proper joint integrity.

E. Acceptable material shall be PE100 Industrial Polyethylene.
F. Ball Valves: Ball valves shall be full port true union type with polyethylene true union ends constructed of the same material as pipe and fittings. Valves shall have double o-ring stem seals, seats shall be PTFE and O-rings shall be EPDM or FPM with adjustable reverse thread seal carrier.

G. Diaphragm Valves: Diaphragm valves shall be constructed with polyethylene true union ends constructed of the same material as pipe and fittings. Valves shall have EPDM or FPM o-ring seals, EPDM or PTFE Seal configurations and EPDM backing.

H. The system shall be tested in accordance with the manufacturers’ recommendations and as described below:

1. All piping systems should be pressure tested prior to being placed into operational service.

2. All pressure tests should be conducted in accordance with the appropriate building, plumbing, mechanical and safety codes for the area where the piping is being installed.

3. When testing plastic piping systems, all tests should be conducted hydrostatically and should not exceed the pressure rating of the lowest rated component in the piping system (often a valve). Test the system at 150% of the designed operational pressure.

4. When hydrostatic pressure is introduced to the system, it should be done gradually through a low point in the piping system with care taken to eliminate any entrapped air by bleeding at high points within the system. This should be done in four stages, waiting ten minutes at each stage (adding ¼ the total desired pressure at each stage).

5. Allow one hour for system to stabilize after reaching desired pressure. After the hour, in case of pressure drop, increase pressure back to desired amount and hold for 30 minutes. If pressure drops by more than 6%, check system for leaks.

Note: If ambient temperature changes by more than 10F during the test, a retest may be necessary.

18.6.3 EXECUTION

18.6.3.1 Piping applications

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground piping, unless otherwise indicated.

C. Grooved joints may be used on aboveground grooved-end piping.

D. Underground Domestic and Irrigation Water Service Piping: Use Polyethylene PE100.

E. Aboveground Domestic and Irrigation Water Service Piping: Use Polypropylene
PPR.

F. Mechanical / technical rooms, horizontal headers: Use Seamless galvanized steel schedule 40.

18.6.3.2 Valve applications

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use bronze ball or gate valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.

2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly valves internally protected with flanged ends for piping NPS 2-1/2 (DN 65) and larger.


B. Cast-iron, grooved-end valves may be used with grooved-end piping.

18.6.3.3 Piping installation

A. Refer to Section "Water Distribution" for site water distribution and service piping.

B. Refer to Section "Basic Mechanical Materials and Methods" for basic piping installation.

C. Extend domestic water service piping to exterior water distribution piping in sizes and locations indicated.

D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Section "Basic Mechanical Materials and Methods" for wall penetration systems.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gauge, and test tee with valve, inside building at each domestic water service. Refer to Section "Meters and Gages" for pressure gauges, and to Section "Plumbing Specialties" for drain valves and strainers.

F. Install water-pressure regulators downstream from shutoff valves. Refer to Section "Plumbing Specialties" for water-pressure regulators.

G. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.

H. Perform the following steps before operation:

1. Close drain valves and hose bibs.

2. Open shutoff valves to fully open position.

3. Open throttling valves to proper setting.

4. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
5. Remove and clean strainer screens. Close drain valves and replace drain plugs.

6. Remove filter cartridges from housings, and verify that cartridges are as specified for application where used and that cartridges are clean and ready for use.

I. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.

J. Check plumbing specialties and verify proper settings, adjustments, and operation.

1. Water-Pressure Regulators: Set outlet pressure at 80 psig (550 kPa) maximum, unless otherwise indicated.

K. Energize pumps and verify proper operation.

18.6.3.4 Joint construction

A. Refer to Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Soldered Joints: Use BS 864, water-flushable, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

C. Grooved Joints: Assemble joints with keyed-coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer’s written instructions.

18.6.3.5 Valve installation

A. Install sectional valve close to water main on each branch and riser serving plumbing fixtures or equipment. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.

B. Install shutoff valve on each water supply to equipment and on each water supply to plumbing fixtures without supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.

C. Install drain valves for equipment, at base of each water riser, at low points in horizontal piping, and where required to drain water piping.

1. Install hose-end drain valves at low points in water mains, risers, and branches.

2. Install stop-and-waste drain valves where indicated.

D. Install balancing valve in discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 (DN 50) and smaller and butterfly valves for piping NPS 2-1/2 (DN 65) and larger. Refer to Section "Plumbing Specialties" for balancing valves.

E. Install calibrated balancing valves in discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Refer to Section "Plumbing Specialties" for calibrated balancing valves.
18.6.3.6 Hanger and support installation
A. Refer to Section "Hangers and Supports" for pipe hanger and support devices.
B. Support vertical piping and tubing at base and at each floor.
C. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. DN 20-32: Maximum span, 2 m; minimum rod size, 8 mm.
   2. DN 40-65: Maximum span, 2.5 m; minimum rod size, 10 mm.
   3. DN 80-100: Maximum span, 3 m; minimum rod size, 10 mm.
E. Install supports for vertical steel piping every (3 m).
F. Support piping at bends, elbows and tees with 2 supports at maximum 25 cm distance from the fitting.

18.6.3.7 Connections
A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to equipment and machines to allow service and maintenance.
C. Connect domestic water piping to exterior water service piping. Use transition fitting to join dissimilar piping materials.
D. Connect domestic water piping to service piping with shutoff valve, and extend and connect to the following:
   1. Transfer Systems: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Section "Plumbing Fixtures."
   4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

18.6.3.8 Field quality control
A. Inspect domestic water piping as follows:
   1. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction/Supervisor at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction/Supervisor:
a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Test domestic water piping as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced domestic water piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Cap and subject piping to static water pressure of (500 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

4. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.

5. Prepare reports for tests and required corrective action.
18.7 SECTION 221123 – WATER DISTRIBUTION PUMPS

18.7.1 GENERAL

18.7.1.1 Summary
A. This Section includes pumps for the following systems:
1. Cold water pumps (general purpose).
2. Packaged booster water pumping sets.

18.7.1.2 Submittals
A. Product Data: Include performance curves and rated capacities of selected models, motors and drives details; sequence of operation; shipping, installed, and operating weights; furnished specialties and accessories for each type and size of pump specified. Indicate pumps' operating point on curves.
B. Shop Drawings: Show layout and connections for pumps. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.
   1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
C. Maintenance Data: For each pump specified to include Operation and maintenance manuals specified in the general conditions.

18.7.1.3 Quality assurance
A. Source Limitations: Obtain same type of pumps through one source from a single manufacturer.
B. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on specific manufacturer types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Section "Substitutions."
C. Regulatory Requirements: Comply with provisions of the following:
   1. DTU P 52-305, for piping materials and installation.
   2. EN 60204-1, EN60034-1, low voltage directive 72/23/EEC, EMC directive 89/336/EEC. EN 50081, 82,-1&-2.
   3. Hydraulic Institute's "Standards for Centrifugal, Rotary & Reciprocating Pumps" for pump design, manufacture, testing, and installation.
D. Packaged sets: The pumping package shall be assembled by the pump manufacturer. The manufacturer shall assume unit responsibility for the complete pumping package unit.

18.7.1.4 Delivery storage and handling
A. Retain shipping flange protective covers and protective coatings during storage.
B. Protect bearings flanges and couplings against damage.
18.7.1.5 Extra material
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Mechanical Seals: One mechanical seal for each pump.

18.7.1.6 Warranty
A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
B. Special Warranty: A written warranty, signed by Contractor and manufacturer, agreeing to replace any water distribution pumping station or component that do not meet requirements or that fail within the specified warranty period.
   1. Warranty Period: 5 years from date of Substantial Completion for any component of the pumping station.

18.7.2 PRODUCTS
18.7.2.1 Pumps, general
A. Description: Factory-assembled and -tested, single- or multi- stage, centrifugal pump units; suitable for potable-water service; with all-bronze or stainless-steel construction and components in contact with water made of corrosion-resistant materials.
B. Motors: Comply with requirements in Section "Motors" with built-in thermal-overload protection appropriate for motor size and duty.
C. End Connections for DN50 and Smaller: Threaded. Pumps available only with flanged ends may be furnished with threaded companion flanges.
D. End Connections for DN65 and Larger: Flanged.
E. Finish: Manufacturer’s standard paint applied to factory-assembled and -tested units before shipping.
F. Manufacturer’s Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles.

18.7.2.2 Horizontal in-line pumps
A. Description: Horizontal, in-line, separately coupled pump; rated for 175-psig (1200-kPa) minimum working pressure and minimum continuous water temperature of 225 deg F (107 deg C); and complying with HI 1.1-1.5 for in-line centrifugal pumps.
   1. Construction: Radially split, all-bronze casing.
   2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, overhung, single suction, and keyed to shaft.
3. Shaft and Sleeve: Steel shaft, with oil-lubricated copper sleeve.
4. Shaft and Sleeve: Stainless-steel shaft, with oil-lubricated copper sleeve.
5. Mechanical Seal: Carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Pump Bearings: Oil-lubricated, bronze-journal or ball type.
7. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
8. Motor: Single speed, with built-in thermal-overload protection; grease-lubricated ball bearings; and resiliently mounted to pump casing.
9. Motor: Energy-efficient design; single speed, with built-in thermal-overload protection; grease-lubricated ball bearings; and resiliently mounted to pump casing.
   a. Motor Size: For motors larger than 1/2 hp, select motor size that will not overload through full range of pump performance curve.

18.7.2.3 Vertical in-line pumps

A. Description: Vertical, in-line, centrifugal, flexible-coupled, single-stage, radially split case design. Include vertical-mounting, bronze-fitted design and mechanical seals rated for 16 bar minimum working pressure and a continuous water temperature of 107 deg C.
   1. Casing: Cast iron, with threaded companion flanges for piping connections smaller than DN65, drain plug at low point of volute, and threaded gage tappings at inlet and outlet connections.
   2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, closed, overhung, single suction, and keyed to shaft.
   3. Wear Rings: Replaceable, bronze casing ring.
   4. Shaft: Ground and polished stainless-steel shaft with axially split spacer coupling.
   5. Seals: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.

18.7.2.4 Vertical multistage pumps

A. Description: Vertical, in-line, centrifugal, directly coupled, multi-stage. Include vertical-mounting, and mechanical seals rated for 20 bar minimum working pressure and a continuous water temperature of 107 deg C. Include the following:
   1. Suction and discharge chamber and motor stand: Cast iron.
   2. Diffuser chamber: stainless steel.
4. Shaft and Sleeve: Stainless steel shaft.

5. Seals: Mechanical type, tungsten carbide mounted in stainless steel seal.

   a. Motor Size: For motors larger than 1/2 hp, select motor size that will not overload through full range of pump performance curve.
   b. Lifting and Supporting Lug: Directly mounted in top of motor enclosure.

18.7.2.5 Packaged booster sets

A. Packaged Booster sets: The pumping package shall be assembled by the pump manufacturer. The manufacturer shall assume "Unit Responsibility" for the complete pumping package. Unit responsibility shall be defined as responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.

B. Unit to be packaged type comprising multiple pumps: two, three or four… pumps running in duplex or triplex as scheduled, bladder type compression steel tank, interconnecting pipework, valves, pressure switches and electric control panel all completely assembled on steel frame, piped, wired and tested at factory and delivered as complete packaged unit ready for installation and operation with simple piping and electrical connections.

1. Operation: unit to be automatically controlled by pressure switches starting pumps on fall of pressure in tank and stopping pumps on rise of pressure and by demand flow rate. Pumps to be sized so that each of the two (or three) main pumps would supply 50% (or 33%) of the total unit demand. Pumps should operate in sequence proportional to the demand with automatic alternation of the two (or three) pumps. Such control shall be achieved by means of flowmeter located at the main discharge of all sets. Depending on flow rate, the flowmeter shall signal the operation of the pumps in sequence.

2. Staging of the pumps shall be accomplished by current sensing relays.

3. Combination pressure reducing with non-slam check feature valves only shall be mounted in each pump circuit.

4. Interconnecting piping and header shall be galvanized steel pipe.

5. Isolation valves shall be provided for each pump-PRV set.

6. Pressure gauges shall be mounted on the suction and discharge headers.

7. The pumps shall be protected from thermal buildup, when running at no-flow, by a common thermal relief valve.

8. The control panel shall be in a heavy gauge mild steel enclosure, finished with stoved hammer paint which includes motor starters, time delays, protected control circuit, transformer, current relays, hand-off-automatic switches for each pump, minimum run timers, and low suction pressure cut-out.
18.7.2.6  Interface to the Central Control Panel in the Central Control Room in the Operation Building:

1. Provide an interface to the Central Control Panel thru an RS 485 connection

2. As a minimum the following points shall be reported for each pump:
   a. Pump Enable/Disable
   b. Pump status (Hand/Off/BMS) and ON/OFF
   c. Pump drive fault
   d. Any other fault
   e. System Pressure
   f. Flow in l/sec
   g. Current
   h. Kilowatt consumption
   i. Wire to water efficiency calculation
   j. Pump instantaneous speed.
   k. Run-time (hrs) for each pump.
18.7.3 EXECUTION

18.7.3.1 Examination
A. Examine roughing-in of water distribution piping to verify actual locations of connections before pump installation.

18.7.3.2 Installation
A. Install pumps according to manufacturer’s written instructions and with access for periodic maintenance, including removing motors, impellers, couplings, and accessories.
B. Support pumps and piping so weight of piping is not supported by pumps.
C. Suspend horizontal in-line pumps independent of piping. Use continuous-thread hanger rods and vibration isolation hangers of sufficient size to support pump weight. Fabricate brackets or supports as required. Refer to Section "Hangers and Supports" for materials.
D. Suspend vertical in-line pumps independent of piping. Use continuous-thread hanger rods and vibration isolation hangers of sufficient size to support pump weight. Refer to Section "Hangers and Supports" for materials.

18.7.3.3 Connections
A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
   1. Connect water distribution piping to pumps. Install suction and discharge pipe equal to or greater than size of pump nozzles. Refer to Section "Water Distribution Piping."
   2. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Section "Valves" for general-duty valves and Section "Plumbing Specialties" for strainers.
   3. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tapings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Refer to Section "Meters and Gages" for pressure gages and gage connectors.
B. Electrical wiring and connections are specified in Sections.
C. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

18.7.3.4 Commissioning
A. Engage the manufacturer’s representative for the start-up and commissioning of the
variable speed booster sets.

B. Clean strainers on suction piping.

C. Controls: Set for automatic starting and stopping operation.

D. Final Checks before Starting: Perform the following preventive maintenance operations:
   1. Lubricate oil-lubricated-type bearings.
   2. Verify that pump is free to rotate by hand and that pump for handling hot liquids is free to rotate with pump hot and cold. Do not operate pump if it is bound or drags, until cause of trouble is determined and corrected.
   3. Verify that pump controls are correct for required application.

E. Starting procedure for pumps is as follows:
   1. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
   2. Open circulating line valve if pump should not be operated against dead shutoff.
   4. Open discharge valve slowly.
   5. Check general mechanical operation of pump and motor.
   6. Close circulating line valve once there is sufficient flow through pump to prevent overheating.

F. Issue a completion certificate and commissioning report signed by the manufacturer’s stating compliance to design requirements and specifications, including test results.

18.7.3.5 Demonstration

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain pumps as specified below:
   1. Train Owner’s maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining pumps.
   2. Review data in maintenance manuals. Refer to Section "Contract Closeout."
   3. Review data in maintenance manuals. Refer to Section "Operation and Maintenance Data."
   4. Schedule training with Owner with at least seven days' advance notice.
18.8 SECTION 221316 – SANITARY PIPEWORK AND RAINWATER

18.8.1 GENERAL

18.8.1.1 Related documents
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions Specification Sections, apply to this Section.

18.8.1.2 Summary
A. This Section includes soil, waste, sanitary drainage, vent system, and rain water inside the building and to locations indicated.

18.8.1.3 Definitions
A. The following are industry abbreviations for plastic and rubber piping materials:
   1. EPDM: Ethylene-propylene-diene terpolymer.
   2. PEHD: Polyethylene high density.
   3. PP Polypropylene
   4. PVC: Polyvinyl chloride plastic.
   5. GS: Galvanized steel

18.8.1.4 Performance requirements
A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:

18.8.1.5 Submittals
A. Product Data: Submit complete catalogue indicating selected models and sizes for each type of pipe, fitting, accessory and coupling.
B. Shop Drawings: For drainage system, include plans, elevations, sections, and details.
C. Samples: Provide a sample for each type of pipe, fitting, accessory, and complete sample for each type of drain (floor drain, roof drain, ...)
D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
E. Mock-up: Erect not less than 15m sample showing all drain system components including hangers, tees, slab penetration, connection to fixtures, connection between different pipe material, etc.
18.8.1.6 Standards
A. All of the foregoing works shall comply with the requirements of the latest edition of European Standard, not limited to the followings: DIN EN 12056, DIN 1986 (Part 100, 34, 30) and DIN EN 752, EN 877 for Cast Iron, EN 1401-1 for PVC; EN 1401-2 for PVC; EN 1451-1 for Polypropylene and/or the National plumbing codes, the Uniform plumbing code, BOCA
B. Piping materials shall bear label, stamp, size, complying standard, or other markings of specified testing agency.

18.8.1.7 Statutory undertakings/additional requirements under bye-laws
A. Verification of Local Authority and Utility Services Mains:
   The Contractor, prior to the commencement of any works shall:
   1. By consultation with the relevant Authorities, verify/determine the precise, size location, depth and extent of all existing services and any apparatus within or adjacent to the site boundaries, including the Client's existing services, which will affect the installation of new works.
   2. Should consultation with the relevant Authorities fail to satisfactorily provide the detailed information outlined above; the Contractor shall notify the Architect/Supervisor accordingly and seek direction.

18.8.1.8 Discrepancies
A. The Tendered shall identify any discrepancies between the drawings, details, specification or schedules during the tender stage and shall inform the Architect/Supervisor immediately and request formal instructions on the course of action to be taken.

18.8.1.9 Setting out
A. The Contractor shall set out the work and be responsible for the accuracy of the same and the positioning of all fittings and sanitary appliances.
B. The Contractor shall be deemed to have taken full account of the latest Architectural, Structural, and Mechanical services drawings so as to ensure that the requirements of these other services do not conflict with or vary the requirements of the particular setting out drawing.
C. The Contractor, at his own cost, shall amend any errors arising from his own inaccurate setting out.

18.8.1.10 Co-ordinate of services
A. The Contractor will be required to co-ordinate to ensure planned approach to the installation of the works. All works shall be installed so as to cause no hindrance or delay to other trades.
18.8.2 PRODUCTS

18.8.2.1 PVC piping

A. Construction: Pipe is constructed by extruding mixed materials of UPVC powder, stabilizer, crystallizer and pigment coloring depending on application of pipe. Pipes are with plain end or integral socket ends suitable for solvent cement (S.C.) or with a push-fit rubber rings (R.R.) sockets for various pressure classes.

B. APPLICABLE STANDARDS:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Main Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIN 8061/8062</td>
<td>Pressure Application</td>
</tr>
<tr>
<td>ISO 161-1/4422</td>
<td>Pressure Application</td>
</tr>
<tr>
<td>EN 1452</td>
<td>Pressure Application</td>
</tr>
<tr>
<td>DIN 19534</td>
<td>Underground Drain and Sewer Applications</td>
</tr>
<tr>
<td>EN 1401</td>
<td>Underground Drain and Sewer Applications</td>
</tr>
<tr>
<td>DIN 19531</td>
<td>Soil and Waste Water Applications</td>
</tr>
<tr>
<td>EN 1329</td>
<td>Soil and Waste Water Applications</td>
</tr>
</tbody>
</table>

C. TECHNICAL DATA – PHYSICAL PROPERTIES:

- Specific Gravity ~ 1.40 g/cm³
- Coefficient of Linear Expansion ~ 0.08 mm/mK
- Thermal Conduction ~ 0.15 W/mK
- Modulus of Elasticity ~ 3000 N/mm³
- Surface Resistance > 10¹² Ohm

D. PVC Pipe alternative and or complementary with the following: ASTM D 2665, solid-wall drain, waste, and vent.

1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

2. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Series PS 100 sewer and drain pipe.

E. PVC Special Fittings: ASTM F 409, drainage-pattern tube and tubular fittings with ends as required for application.

18.8.2.2 Traps

Traps on pipework shall have the following diameter:
RECOMMENDED TRAP SIZES

<table>
<thead>
<tr>
<th>Type of fixture</th>
<th>Trap size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory</td>
<td>40</td>
</tr>
<tr>
<td>Floor drain</td>
<td>50 and 75</td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>50</td>
</tr>
</tbody>
</table>

Traps for use with ranges of wash basins shall have adjustable inlets.

Traps types, unless noted otherwise, shall be:

- Traps for wash basins - bottle type, P outlet
- Traps for sinks - tubular type, P outlet
- Floor Drain - deep seal trap; P outlet

18.8.2.3 Condensate drain pipes

A. Pressure PVC pipes, with 9mm flexible elastomeric insulation.

18.8.2.4 HDPE non pressure corrugated pipes

A. High Density Polyethylene (HDPE) Corrugated and Smooth Lined Pipe & Fittings shall be manufactured in accordance with requirements of ASTM F 2306, latest edition. Type S: This pipe shall have a full circular cross section, with an outer corrugated pipe wall and a smooth inner wall.

B. High Density Polyethylene (HDPE) Corrugated and Smooth Lined Pipe shall be manufactured from virgin PE compounds which conform with the requirements of cell class 435400C as defined and described in ASTM D 3350.

C. Minimum Pipe Stiffness (PS) at five percent deflection shall be as described in ASTM F 2306, Section 6.3 when tested in accordance with ASTM D 2412.

D. Installation shall be in accordance with ASTM D 2321, “Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications”.

E. All contractors and inspectors shall be trained and certified by the manufacturer prior to installing HDPE pipe. A copy of the training certification and proof of insurance shall be provided to the Supervisor before any work shall commence.

F. Infrastructure Outdoor Manholes material is HDPE fully compatible with corrugated pipes installation.

18.8.3 EXECUTION

18.8.3.1 Piping applications

A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.
B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.

C. Aboveground, Soil, Waste and Rain water Piping and under building sewer piping: Use Non Pressure UPVC piping with solvent cement joint for DN50 and push fit joint for DN75 and above.


E. Vent pipe: UPVC

F. Force Pipe: pressure pipe UPVC PN16.

18.8.3.2 Piping installation

A. Refer to Section "Basic Mechanical Materials and Methods" for basic piping installation.

B. Install cleanouts after every pipe bend. Make all pipe sections attainable through clean-outs.

C. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

D. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Refer to Section "Basic Mechanical Materials and Methods" for sleeves and mechanical sleeve seals.

E. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Section "Basic Mechanical Materials and Methods" for wall penetration systems.

F. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook, Installation of Cast Iron Soil Pipe and Fittings."

G. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not use straight tees. Do not change direction of flow using 90 degrees elbows. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

H. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer’s written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

I. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping DN 80 and smaller; 1 percent downward in direction of flow for piping DN 100 and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

J. Install force mains at elevations indicated.

K. Install engineered soil and waste drainage and vent piping systems in locations indicated and as follows:
   2. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

L. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

M. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

18.8.3.3 Valve installation

A. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
   1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
   3. Install backwater valves in accessible locations.
   4. Refer to Section "Plumbing Specialties" for backwater valves.

18.8.3.4 Hanger and support installation

A. Use Pre-fabricated hot-dip galvanized clamps with elastomeric rubber insert, according to manufacturer's recommendations.

B. Install supports according to Section "Hangers and Supports."

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced 1 size for double-rod hangers with 10-mm minimum rods.

E. Install hangers for UPVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. DN 40 and DN 50: 1200 mm with 10-mm rod.
   2. DN 80: 1200 mm with 13-mm rod.
   3. DN 100 and DN 125: 1200 mm with 16-mm rod.
   4. DN 150: 1200 mm with 19-mm rod.
   5. DN 200 to DN 300: 1200 mm with 22-mm rod.
F. Install supports for vertical UPVC piping every 1200 mm.

G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

18.8.3.5 Connections

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Section "Plumbing Fixtures."

2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.

3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Section "Plumbing Specialties."

4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections DN 65 and larger.

18.8.3.6 Field quality control

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 30 kPa. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 250 Pa. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 345 kPa above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

4. Prepare reports for tests and required corrective action.

18.8.3.7 Cleaning
A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

18.8.3.8 Protection
A. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.
18.9 SECTION 221319 — PLUMBING SPECIALTIES

18.9.1 GENERAL

18.9.1.1 Summary
A. This Section includes plumbing specialties for the Water distribution systems and Soil, waste, and vent systems:
   1. Backflow preventers.
   2. Outlet boxes.
   3. Floor drains.
   4. Trench drains.
   5. Plastic floor drains.
   6. Rain water surface drains.
   7. Grease interceptors.

18.9.1.2 Submittals
A. Product Data: For each plumbing specialty indicated. Include rated capacities of selected equipment and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping for all plumbing specialty products.
B. Reports: Specified in "Field Quality Control" Article.
C. Maintenance Data: For specialties to include in the maintenance manuals specified Include the following:
   1. Retain and edit list below if required to include in maintenance manuals.

18.9.1.3 Quality assurance
A. Product Options: Drawings indicate size, profiles, dimensional requirements, and characteristics of plumbing specialties and are based on the specific types and models indicated.
B. Provide listing/approval stamp, label, or other marking on plumbing specialties made to specified standards.
C. Listing and Labeling: Provide electrically operated plumbing specialties specified in this Section that are listed and labeled.
   1. Listing and Labeling Agency Qualifications: "Nationally Recognized Testing Laboratory".
D. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
18.9.1.4 Warranty
A. Refer to relevant section

18.9.2 PRODUCTS
18.9.2.1 Backflow preventers (anti-pollution valve)
A. General: Valve set designed to prevent contamination of water system from subsystems.
   1. Working Pressure: PN20 minimum, unless otherwise indicated.
   2. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.
   3. NPS 2-1/2 (DN 65) and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.
      a. Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.
   5. Strainer: On inlet.
B. Pipe-Applied, Atmospheric-Type Vacuum Breakers: ASSE 1001, with floating disc and atmospheric vent.
C. Double-Check-Valve Backflow Prevention Assemblies: UL 312, FM approved; with two bronze body spring loaded center guided check valves and two bronze ball valves, and four test cocks, 300-psig (2000-kPa) working-pressure gate valves.
   1. Maximum Pressure Loss: 5 psig (35 kPa)] through middle 1/3 of flow range.

18.9.2.2 Rain water surface drain
A. Roof drain: Consisting of the drain body, extension (to adjust to required finished height), grated cover, and outlet spigot.
   1. Body material: Cast iron surface drain consisting of lacquered cast iron body, with a large flanged membrane guard.
   2. Grate: galvanized cast iron or ductile iron flat grate.
   3. Outlet Spigot: threaded cast iron matching pipe size.
   5. The assembly shall be threaded (screwed) to a spigot /adaptor to match drain pipe size. The drain assembly shall be suitable for the insulated and waterproofed roof as detailed in the architectural drawings.
B. Approved Manufacturers: Wade, Pont-a-Mousson or equal.

18.9.2.3 Floor drain for toilet
A. PP Floor drain, installed on plastic pipes, shall conform to normal building European
Standard; body shall be of shallow type with 5cm minimum water trap with three possible inlet of not less than DN50 and one outlet of DN75.

B. Removable PVC water seal for possible maintenance and cleaning.

C. Mechanical properties of PVC at 23°C are:
   1. Tensile strength at yield of 53 Mpa stress at break 43 Mpa
   2. Residual elongation at break 150%
   3. All according to ISO 527 Bending modular of elasticity 3.000 Mpa
   4. PVC density 1.43 Kg/dm³ according ISO 1183
   5. Vicat softening under 5Kg: 80°C according to EN 727.

D. Cover to be adjustable, chrome plated bronze or heavy weight stainless steel cover, of not less than 4mm thick

18.9.2.4 Area drains

A. AD: Heavy duty top drain, for parking area, consisting of drain body with seepage pan, slotted grate, sediment bucket and membrane flashing clamp.
   1. Body: Dura-coated Cast iron.
   2. Grate: Heavy duty Dura-coated Cat iron slotted with suspended sediment bucket.
   3. Outlet spigot: bottom.
   5. The assembly shall be threaded (screwed) to a spigot /adaptor to match drain pipe size. The drain assembly shall be suitable for the insulated and waterproofed roof as detailed in the architectural drawings.

18.9.2.5 Gully trap (interceptor)

A. GT: In line trap interceptor, UPVC with rubber joint, with thickness and sockets according to EN1329 and EN1401.
   2. Water seal: minimum 3.5cm.
   3. Features: Double inspection by means of two plugs of same size as trap, vent access points.

18.9.2.6 GREASE INTERCEPTORS

A. Grease Interceptors: Comply with UPC and basic Plumbing Code. Enzymatic model, complete with extension, complete with deep integral trap, removable baffle assembly, non skid gasketed bolted covers and frame with access for adding enzyme, with automatic dosing until including all accessories.
   1. Delete features below if not required.
   2. Plumbing and Drainage Institute Seal: Required.
6. Rate is limited to 100 gpm (6.3 L/s).
7. Capacity is limited to 200 lb (90.7 kg).
8. Inlet and Outlet Size: 4” (100 mm).
11. Mounting: Recessed for the main cooking and dishwashing and above floor for pot wash.
12. Flow-Control Fitting: Required.

18.9.2.7 Miscellaneous piping specialties
A. Vent Caps: Aluminum body with threaded or hub inlet and vandal-proof design. Include vented hood and set-screws to secure to vent pipe.

18.9.3 EXECUTION
18.9.3.1 Plumbing specialty installation
A. General: Install plumbing specialty components, connections, and devices according to manufacturer’s written instructions.
B. Threaded Flanged or grooved end specialties to follow the pipes design and specified installation.
C. Install expansion joints on vertical risers, stacks, and conductors as indicated.
D. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.
E. Install vent flashing sleeves on stacks passing through roof. Secure over stack flashing according to manufacturer’s written instructions.
F. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor or as indicated. Size outlets as indicated.
G. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.
H. Fasten recessed, wall-mounting plumbing specialties to reinforcement built into walls.
I. Secure supplies to supports or substrate.
J. Install individual stop valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve is not indicated.
K. Install water-supply stop valves in accessible locations.
L. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

M. Locate drainage piping as close as possible to bottom of floor slab supporting fixtures and drains.

N. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

O. Include wood-blocking reinforcement for recessed and wall-mounting plumbing specialties.

18.9.3.2 Connections

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping connections between plumbing specialties and piping specified in other Sections.

2. Install piping connections indicated between appliances and equipment specified in other Sections; connect directly to plumbing piping systems.

3. Install piping connections indicated as indirect wastes from appliances and equipment specified in other Sections, to spill over receptors connected to plumbing piping systems.

B. Install hoses between plumbing specialties and appliances as required for connections.

C. Arrange for electric-power connections to plumbing specialties and devices that require power. Electric power is specified in Sections.

D. Supply Runouts to Plumbing Specialties: Install hot- and cold-water-supply piping of sizes indicated, but not smaller than required by authorities having jurisdiction.

E. Drainage Runouts to Plumbing Specialties: Install drainage and vent piping, with approved trap, of sizes indicated, but not smaller than required by authorities having jurisdiction.

F. Ground electric-powered plumbing specialties.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

G. Arrange for electric-power connections to plumbing specialties and devices that require power. Electric power, wiring, and disconnect switches are specified in Sections.

18.9.3.3 Commissioning

A. Before startup, perform the following checks:

1. System tests are complete.

2. Damaged and defective specialties and accessories have been replaced or repaired.
3. Clear space is provided for servicing specialties.

B. Before operating systems, perform the following steps:
   1. Close drain valves, hydrants, and hose bibbs.
   2. Open general-duty valves to fully open position.
   3. Remove and clean strainers.
   4. Verify that drainage and vent piping are clear of obstructions. Flush with water until clear.

C. Startup Procedures: Follow manufacturer's written instructions. If no procedures are prescribed by manufacturer, proceed as follows:
   1. Energize circuits for electrically operated units. Start and run units through complete sequence of operations.

D. Adjust operation and correct deficiencies discovered during commissioning.

18.9.3.4 Demonstration
A. Startup Services: Engage a factory-authorized service representative to perform startup services and train Owner's maintenance personnel as specified below:
   1. Train Owner's maintenance personnel on procedures and schedules related to startup of and servicing interceptors.
   2. Train Owner's maintenance personnel on procedures and schedules related to startup of and servicing grease recovery units.
   3. Review data in the maintenance manuals.
   4. Schedule training with Owner with at least 7 days' advance notice.

18.9.3.5 Protection
A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
B. Place plugs in ends of uncompleted piping at end of each day or when work stops.
18.10 SECTION 221329— SUBMERSIBLE SEWAGE PUMPS

18.10.1 GENERAL

18.10.1.1 Summary
A. This Section includes sewage pumps for the building sanitary drainage systems.

18.10.1.2 Submittals
A. Product Data: Include performance curves, motor curves for torque, current, power factor, input/output kW and efficiency, furnished specialties, and accessories for each type and size of pump indicated.
B. Shop Drawings: Show layout and connections for pumps. Include setting drawings with templates, directions for installing foundation and anchor bolts, and other anchorages.
   1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
C. Maintenance Data: For each type and size of pump specified to include in maintenance manuals specification.

18.10.1.3 Quality assurance
A. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on specific manufacturer types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

18.10.1.4 Delivery, storage, and handling
A. Retain shipping flange protective covers and protective coatings during storage.
B. Protect bearings and couplings against damage.
C. Comply with pump manufacturer's rigging instructions for handling.

18.10.1.5 Extra material
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Mechanical Seals: One mechanical seal for each pump.

18.10.1.6 Warranty
A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents
and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: A written warranty, signed by Contractor and manufacturer, agreeing to replace any water distribution pumping station or component that do not meet requirements or that fail within the specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion for any component of the pumping station.

18.10.2 PRODUCTS

18.10.2.1 Sewage pumps

A. Description: Factory-assembled and -tested, single-stage, centrifugal, end-suction sewage pump units. Include motor, operating controls, and construction for permanent installation.

B. Motors: Single speed, with grease-lubricated ball bearings, and non-overloading through full range of pump performance curves.

C. Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

18.10.2.2 Submersible sewage pumps

A. Description: Submersible, direct-connected non-clog wastewater pump(s), complying with (Hydraulic institute) HI 1.1-1.5 for submersible sewage pumps. The pump(s) shall be automatically and firmly connected to the discharge connection, guided by no less than two guide bars extending from the top of the station to the discharge connection. There shall be no need for the personnel to enter the wet-well. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal to metal watertight contact. No portion of the pump shall need any support directly on the sump floor.

B. Pump Arrangement: Duplex alternating (Normal operation: One pump ON, on high pit level: Two pumps ON).

C. PUMP CONSTRUCTION: Major pump components shall be of grey cast iron, ASTM A-48 Class 35B, BS 1452 Grade 260 or DIN 1691 GG25 with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts, bolts and washers shall be of AISI type 304 stainless steel or better. All metal surfaces coming in contact with the pumped liquid, other than stainless steel or brass, shall be protected by a factory applied spray coating of alkyd primer with oxiranesther (Duasolid) paint finish on the exterior of the pump. Sealing design of major pump components shall incorporate metal to metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton O-rings. Fittings will be the of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit.

D. COOLING SYSTEM: Each unit shall be provided with an adequately designed cooling system. Provisions for external cooling and seal flushing shall be provided. The cooling system shall provide for continuous pump operation in liquid temperature of up to 50o.
E. CABLE ENTRY SEAL: The cable entry seal design shall preclude specific torque requirements to ensure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomer grommet, flanked by washers. The assembly shall provide ease of changing the cable. The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

F. MOTOR: The pump motor shall be a squirrel cage induction motor, shell type design, housed in an air filled, watertight chamber. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 155°C. The motor shall be designed for continuous duty handling pumped media of 50°C and capable of up to 15 evenly spaced starts per hour. Thermal switches set to open at 125°C and close at a minimum of 70°C, shall be embedded in the stator lead coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board, shall be hermetically sealed from the motor by an elastomer o-ring seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. Wire nuts or crimping type connection devices are not acceptable.

G. The motor and pump shall be assembled by the same manufacturer. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15. The motor shall have a voltage tolerance of plus or minus 10%. The motor shall be designed for operation up to 50°C ambient temp. and with a temperature rise not to exceed 85°C. The motor and the cable shall be watertight according to protection class IP 68 (20 m). The rated power shall be adequate so that the pump is not over-loading throughout the entire indicated pump performance curve.

H. BEARINGS: The pump/motor shaft shall rotate on two permanently grease lubricated bearings. The upper bearing shall be a single row roller bearing. The lower bearing shall be a two row angular contact ball bearing to compensate for axial and radial forces.

I. MECHANICAL SEAL: Each pump shall be provided with a tandem mechanical shaft seal system consisting of two independent seal assemblies. The seals shall operate in an oil reservoir that hydrodynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, and upper, secondary seal unit, shall contain one stationary and one positively driven rotating corrosion resistant tungsten carbide ring. Each seal interface shall be held in contact by it’s own spring system. Each pump shall be provided with an oil chamber for the shaft sealing system, the drain and inspection plug, for the oil, shall be accessible from the outside.

J. PUMP SHAFT: The pump shaft shall be an extension of the motor shaft with no Couplings. The shaft material shall be AISI type 431 Stainless steel.

K. IMPELLER: The impeller(s) shall be of grey cast iron, ( ASTM A-48 Class 35B ), hydro dynamically balanced, double shrouded non-clogging design having a long through let without acute turns. The impeller shall be capable of handling solids, fibrous materials, heavy sludge and other matter found in normal wastewater. All impellers shall be coated with alkyd resin primer.

L. WEAR RINGS: between the volute and the suction inlet of the impeller, shall be stationary and made of brass or rubber-clad steel frame, which is drive fitted to the volute.
inlet. The pumps shall also have a stainless steel impeller wear ring heat-shrink fitted to the suction inlet of the impeller to mate the stationary wear ring.

M. VOLUTE: Pump volute(s) shall be single-piece grey cast iron (ASTM A-48 Class 35B) non-concentric design with smooth passages large enough to pass any solids that may enter the impeller. The volute shall have a mating flange machined, and provided with a blind flange, correct positioned for a flushing valve.

N. PROTECTION: All motors shall incorporate thermal switches in each phase winding, serial connected. The thermal switches shall open at the temp. 1250 C and stop the motor and activate an alarm.

O. Option that shall be available: Float leakage sensor to detect water in the stator housing. When activated, the sensor will stop the motor and activate an alarm. When using optional monitoring, the manufacturer shall provide a control and status relay to be mounted into any control panel.

P. FLUSHING DEVICE: A flush valve shall be able to be fitted to the pump volute at the indicated mating flange. The flush valve shall transform the pump into a jet stream mixer during the first 20-40 sec (adjustable) of a pumping period. The flush valve function shall be based on the ejector principle and the operation shall be automatic and induced by the pump flow and pressure.

Q. High-Water Alarm: Rod-mounted, with micropressure-switch alarm matching control and electric bell; with transformer and contacts for remote alarm bell, unless battery operation is indicated.

18.10.3 EXECUTION

18.10.3.1 Installation

A. Install pumps according to manufacturer's written instructions.

B. Install pumps and arrange to provide access for maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support piping so weight of piping is not supported by pumps.

D. Submersible Sewage Pumps: Set pumps on basin floor. Make direct connections to sanitary drainage piping.

1. Anchor quick-disconnect systems to bottom of basins and basin sidewalls or covers. Install pumps so pump and discharge pipe disconnecting flanges make positive seals when pumps are dropped into place.

18.10.3.2 Connections

A. Sanitary drainage and vent piping installation requirements are specified in Section "Drainage and Vent Piping." Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

1. Install discharge pipe sizes equal to or greater than diameter of pump nozzles, and connect to sanitary drainage piping.

2. Install swing check valve and gate or ball valve on each sewage pump
discharge. Include spring-loaded or weighted-lever check valves for piping DN65 (NPS 2-1/2) and larger.

B. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

18.10.3.3 Adjusting
A. Pump Controls: Set pump controls for automatic single start, stop, dual start (high level), pump alarm fault, and high pit level alarm operation, as required for system application.

18.10.3.4 Commissioning
A. Final Checks before Starting: Perform the following preventive maintenance operations:
   1. Lubricate bearings.
   2. Disconnect couplings and check motors for proper direction of rotation.
   3. Verify that each pump is free to rotate by hand. Do not operate pump if it is bound or drags, until cause of trouble is determined and corrected.
   4. Verify that pump controls are correct for required application.

B. Starting procedure for pumps with shutoff power not exceeding safe motor power is as follows:
   1. Start motors.
   2. Open discharge valves slowly.
   3. Check general mechanical operation of pumps and motors.
18.11 SECTION 223330 –DOMESTIC STORAGE WATER HEATERS

18.11.1 Related documents
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division of general Specification Sections, apply to this Section.

18.11.2 Summary
A. This Section includes the following for domestic water systems:
   1. Storage domestic water heaters.
   2. Accessories.

18.11.3 Submittals
A. Product Data: For each type and size of water heater. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
B. Shop Drawings: Detail water heater assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Piping Diagrams. Differentiate between manufacturer-installed and field-installed piping.
C. Product Certificates: Signed by manufacturers of water heaters certifying that products furnished comply with requirements.
D. Maintenance Data: For water heaters to include in maintenance manuals specified in the general specification
E. Warranties: Special warranties specified in this Section.

18.11.4 Quality assurance
A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.
B. ASME standards listed below can have equivalent European standards.
C. ASHRAE Standards: Comply with performance efficiencies prescribed for the following:

18.11.5 Warranty
A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of water heaters that fail in materials or workmanship within specified warranty period.
1. Failures include heating elements and storage tanks.

2. Warranty Period: From date of Substantial Completion:
   a. Heating Elements: 3 Years.
   b. Storage Tanks: 3 Years.

18.11.2 PRODUCTS

18.11.2.1 Manufacturers

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Storage, Electric Water Heaters:
   a. Viessmann
   b. Dedietrich.
   c. A. O. Smith Water Products Co.

18.11.2.2 Storage water heaters

A. Storage Tank Construction: Steel with minimum 600-kPa working-pressure rating.

1. Tapings: Factory fabricated of materials compatible with tank for piping connections, relief valve, drain, anode rod, and controls as required. Attach tapings to tank before testing and labeling. Include BS, pipe thread.

2. Interior Finish: Materials and thicknesses complying with NSF 61, barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets. Finishing to be glass lined inner tank. (not less than 2.5 microns)

   Insulation: Comply with ASHRAE 90.2. Low thermal loss through highly all round except connections and controls with 80mm injected polyurethane.

   a. Shape: Cylindrical.
   b. Color: White, unless otherwise indicated.

B. Anode Rods: Factory installed, magnesium, removable type.

C. Dip Tube: Stainless steel, Factory installed. Not required if cold-water inlet is near bottom of storage tank.

D. Drain Valve: corrosion-resistant metal, factory installed.

E. Thermometers dial type in double setting: operation and security.

F. Working Pressure: not less than 6 bars.

18.11.2.3 Tube tank heaters

A. Tank heating units are used for heating water and are specifically engineered for installation in water storage tanks with minimum 1000-kPa working-pressure rating. The
heating medium will be hot water and solar (where applicable). Solar heater shall be installed at lower part of the tank and boiler heater shall be installed at higher level.

B. Heating Elements (where applicable): electric, screw-in, immersion type.

C. Heating units are manufactured from 3/4" OD 20 gauge seamless deoxidized drawn copper tubing, formed into "U" shapes with ends expanded into a brass tube sheet. Where necessary, the assemblies are installed with tube bundle supports and with spacers to keep tubes in alignment. Heater heads are constructed of flanged hot deep galvanized steel, or optional methods, depending upon working pressure.

D. All accessories for heater removal to be non corroddible with stainless steel screws and nuts.

18.11.2.4 Water heater accessories

A. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than heat-exchanger working-pressure rating.

18.11.3 EXECUTION

18.11.3.1 Water heater installation

A. Install water heaters, level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

B. Anchor water heaters to substrate.

C. Install pressure relief valves. Extend relief valve outlet with water piping in continuous downward pitch and discharge onto closest floor drain.

D. Install water heater drain piping as indirect waste to spill into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Section "Plumbing Specialties" for drain valves.

E. Install water regulator, with integral bypass relief valve, in booster-heater inlet piping and water hammer arrester in booster-heater outlet piping.

F. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

G. Fill water heaters with water.

18.11.3.2 Connections

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect hot- and cold-water piping with shutoff valves and unions. Connect hot-water-circulating piping with shutoff valve, check valve, and union.

D. Make connections with dielectric fittings where piping is made of dissimilar metal.

E. Ground equipment.
18.11.3.3 Field quality control

A. Engage a factory-authorized service representative to perform startup service.

B. In addition to manufacturer's written installation and startup checks, perform the following:

1. Verify that piping system tests are complete.
2. Check for piping connection leaks.
3. Check for clear relief valve inlets, outlets, and drain piping.
4. Check the recovery time for heating the water inside the tank
5. Check operation of circulators.
6. Test operation of safety controls, relief valves, and devices.
7. Adjust hot-water-outlet temperature settings. Do not set above 60 deg C unless piping system application requires higher temperature.
8. Balance water flow through manifolds of multiple-unit installations.

18.11.3.4 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water heaters.

1. Train Owner's maintenance personnel on procedures for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Schedule training with Owner, through Architect/Supervisor, with at least seven days' advance notice.
18.12 SECTION 224100 — PLUMBING FIXTURES

18.12.1 GENERAL

18.12.1.1 Related documents
A. Specification sections apply to work of this section. All fixtures shall need prior approval from the Architect/Supervisor.

18.12.1.2 Scope of work
A. General: This Section specifies materials and methods required for providing accessories and installing plumbing fixtures and trim. The work to be performed shall include all materials and equipment required for a complete operating installation.

18.12.1.3 Standards and codes
A. General: The work shall comply with or exceed the referenced standards and codes.
B. Codes: The work shall comply with one of the following codes:
   1. BOCA

18.12.1.4 Work cleanliness
A. General: The Contractor shall proceed with all work in a clean and workmanlike manner. Contractor shall keep stored materials, storage areas, and installed systems free of dirt and debris.

18.12.1.5 Quality assurance
A. General: All materials shall be clearly stamped or tagged as required by the referenced standards. Any materials or workmanship which in the opinion of the Supervisor does not meet the referenced standards and codes shall be discarded and replaced at the Contractor’s expense.
   1. Heavy duty cast iron closet carrier to ANSI A112.6M with adjustable closet connection, pylon feet ABS extension with integral test cap, chrome plated trim coated accessories and no seep fixture gasket.

18.12.2 FIXTURES

18.12.2.1 Lavatory countertop
A. White vitreous china lavatory, as per Architect/Supervisor, with mixer, complete with fixing brackets.

Lavatory shall be complete with the following trim and accessories, or approved equal:
   1. Chrome plated Basin Mixer, similar to Architect/Supervisor selection and pop up waste
   2. Chrome plated 1“1/4 P-trap with wall tube and wall flange, adjustable type.
   3. Chrome plated 1/2“ angle supply and stop valve with 30 cm long tube, blue index.
   4. Chrome plated 1/2“ angle supply and stop valve with 30 cm long tube, red index.
5. Stainless steel soap dispenser as per Architect/Supervisor approval.

18.12.2.2 Water closet

A. Wall mounted or approved equal, with the following as general guidelines.

B. Water closet shall be white vitreous china washdown siphonal action hanged horizontal outlet with two (2) levels flushing tank shall be complete with the following:
   1. Chrome plated water supply valve.
   2. Stainless steel paper roll holder and as approved by the Architect/Supervisor.
   3. Supports and all pipe works and accessories required for its installation, connection to water supply and drainage, Outlet connector supports, fixing its satisfactory operation.
   4. White solid plastic seat and cover complete with chrome plated hinge, rubber washers and plastic screws and nuts.
   5. Cistern 6 liters with supply and internal overflow, freeflow plastic siphon fitting, micro valve HP/ LP, ball valve with whisperflo refill unit, including cistern cover fastener

18.12.2.2 Service sinks:
   1. Fixture Material: Stainless steel.
   2. Stainless-Steel Thickness: 2.0 mm.
   4. Rim Guard: Chrome plated, brass.
   5. Faucet: Widespread, cast brass with supplies on 203-mm centers.
   6. Faucet Mounting: Wall, centered on fixture.

18.12.2.3 Urinals

A. Urinals,: Wall-hanging, bottom-outlet, vitreous-china fixture with infrared electronic flushometer valve.
   1. Type: Siphon jet
   2. Strainer or Trapway: [Separate removable strainer] with integral trap.
   5. Supply Spud Size: [DN 25]
   6. Outlet Size: [DN 50]
   7. Infra red Flushometer:
18.12.2.4 Disabeled toilet

Installation of the Complete set of fixture units including all the accessories and fittings to meet M3 building, LANTAC approved, with left or right hand corner.

A. CENTRAL TAPHOLE WASHBASIN

B. White vitreous china lavatory (55 cm wide), as per Architect/Supervisor selection model, complete with fixing brackets.

Lavatory shall be complete with the following trim and accessories, or approved equal:

1. Chrome plated with lever action (Spraymixa tap, or by to Architect/Supervisor selection and pop up waste
2. Chrome plated 1"1/4 brass strainer waste, adjustable type, with chrome plated bottle trap
3. concealed hanger
4. Multisystem 60 cm Handrail, with multisystem fixed height hinged support
5. Chrome plated 1/2" angle supply and stop valve with 30 cm long tube, blue index.
6. Chrome plated 1/2" angle supply and stop valve with 30 cm long tube, red index.

C. WATER CLOSET

D. Wall mounted or approved equal, with the following as general guidelines.

E. Water closet shall be white vitreous china wash down siphonal action hanged horizontal outlet with two (2) levels flushing tank shall be complete with the following:

1. Chrome plated reversible spatula type lever, water supply valve.
2. Stainless steel paper roll holder and as approved by the Architect/Supervisor.
3. Supports and all pipe works and accessories required for its installation, connection to water supply and drainage, Outlet connector supports, fixing its satisfactory operation.
4. White solid plastic seat and cover complete with chrome plated hinge, rubber washers and plastic screws and nuts.
5. Cistern 6 liters with supply and internal overflow, freeflow plastic siphon fitting, micro valve HP/ LP, ball valve with whisperflo refill unit, including cistern cover fastener.

18.12.3 EXECUTION

18.12.3.1 Verification of conditions

A. Examine the substrates, adjoining construction, and conditions under which the work would be installed. Contractor shall correct unsatisfactory conditions detrimental to the timely and proper completion of the work. Do not proceed with installation until unsatisfactory
conditions have been corrected.

18.12.3.2 Installation

A. General: All wall-hung plumbing fixtures not supported on chair carriers shall be supported on wall hangers furnished with fixtures by the fixture manufacturer.
   1. Masonry Construction: Drill holes through tile walls for wall bolts.
      Punched holes will not be allowed. Bolts shall support wall hangers and extend through tile walls ad through strap iron on the opposite side. Nuts and washers shall be installed so they can be buried in plaster or tile finish.

18.12.3.3 Field quality control

A. After the piping has been pressure tested, and the fixtures have been set and trim piped, but prior to practical completion, each fixture supply and drain shall be flowed to observe proper dynamic action to the set.

B. Contractor shall notify the Supervisor in writing at such time as the potable water systems, drainage, waste and vent piping, and plumbing fixtures are complete and ready to be flow tested on an acceptable basis.

18.12.3.4 Equipment handling

A. The Contractor shall furnish all supervision, labor, tools and equipment to relieve, unload, uncrate, inspect, move, disassemble, store, assemble, set in place, align and secure all equipment including all auxiliary items and components.

B. Adequate weather protection of all equipment and equipment parts is to be furnished and maintained at all times by the Contractor.

C. Stored equipment shall be protected from the elements and physical damage. Installed equipment shall be protected from damage until final acceptance.

18.12.3.5 Approved manufacturers

A. Toilet fixtures:
   1. Approval of a manufacturer does not necessarily constitute approval of his plumbing fixtures as equal to those specified. The Contractor shall submit to the approval of the Supervisor a summary of the plumbing fixtures proposed indicating type, manufacturer and model number.
18.13 SECTION 230713 - DUCT INSULATION

18.13.1 GENERAL

18.13.1.1 Summary
A. This Section includes insulation for ducts, semi rigid and flexible duct, plenum, and breeching; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

18.13.1.2 Submittals
A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
B. Samples: For each type of insulation and field-applied jacket. Identify each Sample, describing product and intended use. Submit 300-mm- square sections of each sample material applied on material.
   1. Manufacturer's Color Charts: Show the full range of colors available for each type of field-applied finish material indicated.
C. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

18.13.1.3 Scheduling
A. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

18.13.2 PRODUCTS

18.13.2.1 Insulation materials
A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, NFPA 255, NFPA 90A, & NFPA 90B, Type IB, with aluminum foil facing and with all-service jacket manufactured from kraft paper, reinforcing scrim.
B. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
C. Fiber should be non combustible when tested to BS 476 (part 4), ASTM E 84, 136 and with a K value of 0.034W/mK.

18.13.2.2 Field-applied jackets
A. General: ASTM C 921, Type 1, unless otherwise indicated.

18.13.2.2 Accessories and attachments
A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for
tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 270 g/sq. m.

1. Tape Width: 100 mm.

B. Bands: 19 mm wide, in one of the following materials compatible with jacket:

1. Stainless Steel: ASTM A 666, Type 304; 0.5 mm thick.
2. Galvanized Steel: 0.13 mm thick.
3. Aluminum: 0.18 mm thick.
4. Brass: 0.25 mm thick.
5. Nickel-Copper Alloy: 0.13 mm thick.

C. Wire: 2.0-mm, nickel-copper alloy; 1.6-mm, soft-annealed, stainless steel; or

1.6-mm, soft-annealed, galvanized steel.

D. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

18.13.2.3 Vapor barriers

A. Special adhesive coating water repellant and weatherproof coating ultraviolet resisting. Ensuring mechanical protection too. It shall have a low water vapor permeance, 0.6 to 0.74 perms at 1 mm dry film thick (ASTM E 96 method A) non flammable, surface can be washed. Copolymer emulsion 40% solid content.

1. Surface burning characteristics, class 0 tested to BS 476 Part 6 and 7 (ASTM E 84)
2. Service temperature: -20 to 92 degree C. application to be recommended for outside or inside.

B. Sealant Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

18.13.2.4 Adhesives

A. Rapid setting water-based for bonding fiberglass insulation to steel ducting.

B. Material: Synthetic resin emulsion, non flammable, moisture and humidity resistant. Service temperature: 0 to 85 Deg. C.

18.13.3 EXECUTION

18.13.3.1 Preparation

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

18.13.3.2 General application requirements

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.
B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each type of duct system.

C. Apply adhesive to insulation before fixing to duct.

D. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

G. Keep insulation materials dry during application and finishing.

H. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

I. Apply insulation with the least number of joints practical.

J. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

K. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

L. Insulation Terminations: all type of insulation to be terminated by a stainless steel ring. For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

M. Apply insulation with integral jackets as follows:
   1. Pull jacket tight and smooth.
   2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
   3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.

N. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

O. Install vapor-retarder mastic on ducts and plenums scheduled to receive vapor retarders.
   1. Ducts with Vapor Retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
   2. Ducts without Vapor Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.

P. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.
Q. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

18.13.3.3 Mineral-fiber insulation application

A. Blanket Applications for Ducts and Plenums: Secure blanket insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 450 mm and smaller, along longitudinal centerline of duct. Space 75 mm maximum from insulation end joints, and 400 mm o.c.
   b. On duct sides with dimensions larger than 450 mm. Space 400 mm o.c. each way, and 75 mm maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
   c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not over compress insulation during installation.

4. Overlap unfaced blankets a minimum of 50 mm on longitudinal seams and end joints. Secure with steel band at end joints and spaced a maximum of 450 mm o.c.

5. Overlap by Aluminum foil tape to ensure fixing and preserve the vapour barrier.

6. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 150-mm- wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 150 mm o.c.

8. Cover insulation with impregnated canvas (open scrim mesh) as a reinforcement and better protection and apply 2 layers of vapor retardant coating, each in different colour.

18.13.3.4 Field-applied jacket application

18.13.3.5 Finishes

A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Section "Painting."

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two
coats of insulation manufacturer’s recommended protective coating.

C.  Color:  Final color as selected by Architect/Supervisor.  Vary first and second coats to allow visual inspection of the completed Work.

18.13.3.6  Duct system applications

A.  Insulation materials and thicknesses are specified in schedules at the end of this Section.

B.  Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.

C.  Insulate the following plenums and duct systems:

   1.  Indoor concealed supply-, return-, and outside-air ductwork.

   2.  Indoor exposed supply-, return-, and outside-air ductwork.

18.13.3.7  Duct systems insulation schedule

**INTERIOR CONCEALED HVAC SUPPLY AND RETURN DUCTS AND PLENUMS**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>FORM/ SPECIFIC VOLUME KG/M3</th>
<th>THICKNESS IN MM</th>
<th>ADDITIONAL VAPOR BARRIER REQ’D</th>
<th>FIELD-APPLIED JACKET</th>
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</thead>
<tbody>
<tr>
<td>MINERAL FIBER</td>
<td>BLANKET/25</td>
<td>25</td>
<td>One coat</td>
<td>NO</td>
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**INTERIOR EXPOSED HVAC SUPPLY AND RETURN DUCTS AND PLENUMS**

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<tr>
<th>MATERIAL</th>
<th>FORM/ SPECIFIC VOLUME KG/M3</th>
<th>THICKNESS IN MM</th>
<th>ADDITIONAL VAPOR BARRIER REQ’D</th>
<th>FIELD-APPLIED JACKET</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINERAL FIBER</td>
<td>BLANKET/25</td>
<td>25</td>
<td>2 COATS</td>
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</table>

**EXTERIOR CONCEALED HVAC SUPPLY AND RETURN DUCTS AND PLENUMS I**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>FORM / SPECIFIC VOLUME KG/M3</th>
<th>THICKNESS IN MM</th>
<th>ADDITIONAL VAPOR BARRIER REQ’D</th>
<th>FIELD-APPLIED JACKET</th>
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</thead>
<tbody>
<tr>
<td>MINERAL FIBER</td>
<td>BOARD/65</td>
<td>50</td>
<td>2 COATS</td>
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**EXTERIOR EXPOSED HVAC SUPPLY AND RETURN DUCTS AND PLENUMS**

<table>
<thead>
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<th>MATERIAL</th>
<th>FORM/ SPECIFIC VOLUME KG/M3</th>
<th>THICKNESS</th>
<th>ADDITIONAL VAPOR BARRIER REQ’D</th>
<th>FIELD-APPLIED JACKET</th>
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<tbody>
<tr>
<td>MINERAL FIBER</td>
<td>BOARD/65</td>
<td>75</td>
<td>2 COATS</td>
<td>Aluminum 0.6 mm</td>
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18.14 SECTION 231113 — FUEL PIPING AND ACCESSORIES

18.14.1 GENERAL

18.14.1.1 Summary
A. This Section includes piping, specialties, tanks, pumps and accessories for:
  1. Fuel oil systems within building and to point indicated.
B. Related Sections: The following Sections contain requirements that relate to this Section:
  1. Section "Meters and Gages" for thermometers, pressure gages, and vacuum gages.

18.14.1.2 System performance requirements
A. Minimum Working-Pressure Ratings: Except where otherwise indicated, minimum pressure requirements are as follows:
  1. Oil Piping: 10 Bars.

18.14.1.2 Submittals
A. General: Submit each item in this Article according to the Conditions of the Contract Specification Sections.
B. Product Data including size, dimensions, rated capacity, pressure rating, settings, and operating characteristics of selected models, for the following:
  1. Fuel tank construction detail.
  2. Each type and size of fuel oil transfer pump.
  3. Each fuel oil system specialty.
  4. Special-duty valves.
  5. Filling system.
  6. Leakage monitoring and level measurement.
C. Coordination Drawings for fuel oil piping, including required clearances and relationship to other services for same work areas.
D. Wiring diagrams detailing wiring for power, signal, and control systems for each item of equipment with electric power supply and differentiating between manufacturer-installed and field-installed wiring.

18.14.1.3 Quality assurance

18.14.2 PRODUCTS

18.14.2.1 Pipes and tubes
A. Fuel:
  1. Steel Pipe: DIN 2440 Medium gauge or ASTM A 53; Type S, seamless;
Grade B; black, epoxy coated.

18.14.2.2 Fuel pipe and tube fittings


B. Steel Fittings: ASTM A 234 (ASTM A 234M), seamless threaded or welded, for welded joints.

C. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

D. Transition Fittings: Type, material, and end connections to match piping being joined.

18.14.2.3 Joining materials

A. Common Joining Materials: Refer to Section “Basic Mechanical Materials and Methods” for joining materials not included in this Section.

18.14.2.4 Piping specialties

A. Pipe Connectors: UL 567, swivel or compression type for connection to equipment.

B. Strainers: Y pattern, full size of connecting piping. Include stainless-steel screens with 3/64-inch (1.2-mm) perforations, except where other screens are indicated.

1. Pressure Rating: 125-psig (860-kPa) minimum steam or 175-psig (1200-kPa) WOG working pressure, except where otherwise indicated.

2. (DN50) and Smaller: Bronze body, with threaded ends conforming to ASME B1.20.1.

3. (DN65) and Larger: Cast-iron body, with flanged ends.

4. Screwed screen retainer with centered blow-down and pipe plug.

C. Refer to Section “Vibration Control” for flexible pipe connectors.

18.14.2.5 Valves

A. Gate Valves, (DN50) and Smaller: MSS SP-80; ASTM B 61, cast bronze; Class 125; Type 2, solid wedge, and inside screw, rising stem.

1. End Connections for Steel Pipe: Threaded.

B. Ball Valves, (DN50) and Smaller: MSS SP-110; ASTM B 62, 3-piece, cast-bronze body; 400-psig (2760-kPa) cold working pressure (CWP) rating. Include full-port, cast-bronze, chrome-plated bronze ball; polytetrafluoroethylene (PTFE) seats; lever handle; and threaded ends.

C. Check Valves, (DN50) and Smaller: MSS SP-80; ASTM B 62, cast bronze; Class 125; Type 4, brass swing check with nonmetallic disc.

1. End Connections for Steel Pipe: Threaded.

D. Filling valve: Cast Bronze; class125, with lockable bronze cap and chain.

18.14.2.5 Fuel tanks

A. Construction: Welded steel sheets 4mm with corrosion protective paint with service
manhole, Threaded pipe connection fittings on for fill, supply, return, vent, sounding, and gaging, in locations and of sizes indicated.

B. Seating: concrete base pads

C. Manufacturer’s warranty: 20 years for specific application.

18.14.2.6 Specialty valves and instrumentation

A. Oil Safety Valves: UL listed for flammable or volatile liquids, 250-psig (1725-kPa) maximum working pressure, and (288 deg C) maximum operating temperature. Include ASTM B 61 bronze body, bronze bases and discs; and field-adjustable, cadmium-plated, carbon-steel springs; factory set at 20 percent above operating pressure; and threaded ends.

B. Leak-Detection And Monitoring Systems: Calibrated, leak-detection and -monitoring system complying with UL 1238 with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel oil piping. The Leak detectors shall be connected to the alarm panel of the fillguard system and the Central Control Panel in the Central Control Room in the Operation Building.

18.14.2.7 Filling and monitoring system

A. Complete system of level monitoring and control of fuel oil filling and storage, consisting of level sensors, probes, gauges, remote gauges, relays, high/low level alarms. All components are rated with IP65 protection level.

B. The system provides local level reading on the tanks, as well as remote reading on the filling valve connection. It also provides high/low level alarms audible and visible, and connection to the Central Control Panel in the Central Control Room in the Operation Building for transmitting all readings and alarms.

C. Sensor Probes: Slim line armored brass flexible probe for tank top installation, provided with sealed capillary for remote reading.

D. Liquid level sensor designed to work with the probe sensor. Provides 4-20mA or 0-10 volts output transmission signal. All electronics shall be housed in an IP65 die cast aluminum box. The liquid level sensor sends level signal to the Central Control Panel in the Central Control Room in the Operation Building.

E. High/ low level alarm with calibrating potentiometer and activates audible and visual alarm inside the room and to the remote indicator panel. Upon High level alarm, the device sends signal to the filling line solenoid valve to close, and sends alarm to the BMS.

F. Control panel: Designed for monitoring 2 groups of tank, located on the fuel room wall. Includes 2 level indicators and distinct alarm signals (LED) and horn.

G. Remote Indicator panel: Housed in an aluminum IP65 panel, and includes 2 remote level indicators and alarm signal.

18.14.2.8 Fuel oil transfer pumps

A. Description: UL 343, single-stage, internal-gear, positive-displacement, rotary type. Include foot-mounted, cast-iron housing; steel gears; bronze bearings; steel shaft; mechanical seals; built-in pressure relief bypass; steel base; and drive coupling.

1. Drive: Direct drive, close coupled.

18.14.3 EXECUTION

18.14.3.1 Concrete bases
A. Install concrete bases of dimensions indicated for storage tanks, daily tanks and fuel oil transfer pumps. Refer to Section "Cast-in-Place Concrete" and Section "Basic Mechanical Materials and Methods."

18.14.3.2 Service entrance piping
A. Extend fuel oil piping and connect to oil distribution system supply piping in the location and of the size indicated for supply entrance to building.

18.14.3.3 Piping applications
A. General: Flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating may be used in applications below, except where otherwise indicated.
B. Aboveground Piping, (DN50) and Smaller: Steel pipe, cast-iron and malleable-iron fittings, and threaded joints.

18.14.3.4 Valve applications
A. Drawings indicate valve types used. Where specific types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use gate, or ball.
   2. Throttling Duty: Use globe.

18.14.3.5 Piping installations
A. Refer to Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.
B. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
C. Install strainers on supply side of each control valve, pressure-regulating valve, oil burner connection, and elsewhere as indicated. Install (DN20) pipe nipple and ball valve in blow-down connection of strainers (DN50) and larger. Use same size nipple and valve as blow-off connection of strainer.
D. Install dielectric fittings (unions and flanges) with ferrous and brass or bronze end connections, separated by insulating material, where piping of dissimilar metals is joined.
E. Anchor piping to ensure proper direction of piping expansion and contraction. Install expansion joints, expansion loops, and pipe guides as indicated.
F. Prepare and paint outside of containment conduits with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.

18.14.3.6 Tank installation
A. Install each tank on five concrete bases of 15cm height. Allow for proper access on all sides and arrange in order to remove tank with minimum disruption to installation.
B. Daily Tank: Elevated installation inside retention tank.
C. All tanks shall be inside retention tanks capable of holding 110% of the initial tank capacity. When no such tanks can fit into room (for large tanks), provide containment of leaked fuel inside the room capable of containing 110% of largest tank inside the room and provided with leak detector.

18.14.3.7 Automatic tank gauging
A. Electronic tank gauging consists of a probe mounted in a tank opening and extending to the bottom with a remote indicator panel that is microprocessor controlled and can be programmable and connected to the Central Control Panel in the Central Control Room in the Operation Building.

18.14.3.8 Leak detection and system monitoring
A. System monitoring consists of product level gauging and leakage annunciating. It should be monitored electronically.

18.14.3.9 Valve installation
A. Install shutoff, drain, and check valves as indicated.
B. Install valves in accessible locations, protected from damage. Tag valves with metal tag indicating piping supplied. Attach tag to valve with metal chain.
   1. Refer to Section "Basic Mechanical Materials and Methods" for valve tags.
   2. Refer to Section "Mechanical Identification" for valve tags.
C. Install valves at each branch connection to supply mains and elsewhere as indicated.
D. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.
E. Refer to Section "Valves" for general installation requirements.

18.14.3.10 Connections
A. Install fuel oil piping next to equipment using fuel oil to allow service and maintenance.
B. Connect fuel oil piping to equipment using fuel oil with shutoff valves and unions. Install valves upstream from equipment. Install union or flanged connection downstream from valves. Include flexible connectors where indicated.
C. Sediment Traps: Install tee fitting with capped nipple in bottom forming drip, as close as practical to inlet of equipment using fuel oil. Fabricate drip leg with a minimum length of 3 pipe diameters.
D. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
E. Electrical Connections: Wiring is specified in Sections.

18.14.3.11 Demonstration
A. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
B. Review data in the operation and maintenance manuals.

C. Schedule training with Owner with at least 7 days’ advance notice.

18.14.3.12 Commissioning

A. Fuel tanks leak test: Perform leak test for each tank for 48hrs to ensure a leak proof container.

B. Perform these steps before activating system:
   1. Open valves to fully open position and close bypass valves.
   2. Remove and clean strainer screens.
   3. Energize pump and check for proper direction of rotation.
   4. Check operating controls of fuel burner units.
   5. Check operation at automatic bypass valves.
18.15 SECTION 233113 - METAL DUCTS

18.15.1 GENERAL

18.15.1.1 Summary
A. This Section includes rectangular and round metal ducts and plenums for ventilating, and air-conditioning systems.
B. Refer to Section "Duct Insulation" for insulation requirements.
C. Refer to Section "Duct Accessories" for dampers, sound-control devices, duct-mounted access doors and panels, turning vanes, and flexible ducts.

18.15.1.2 Submittals
A. Product Data:
   1. For sealing materials and duct liner.
   2. Mill certificate for galvanized steel sheets.
B. Shop Drawings:
   1. Duct layout indicating pressure classifications, sizes, invert levels and distances from walls and columns on plans.
   2. Reinforcement and spacing.
   3. Seam and joint construction.
   4. Penetrations through fire-rated and other partitions.
   5. Terminal unit and coil installations.
   6. Hangers and supports, including methods for building attachment, vibration isolation, seismic restraints, and duct attachment.
C. Field quality-control test reports: Indicate and intercept test results for compliance with performance requirements.

18.15.1.3 Quality assurance
B. Mockups: Before installing duct systems, erect mockups representing system. Build mockups to comply with the following requirements, using materials indicated for completed Work:
   1. Include the minimum number of each of the following features and fittings:
      a. Five transverse joints.
      b. One access door.
      c. Two typical branch connections, each with at least one elbow.
      d. Two typical flexible duct or flexible connector connections for each duct and apparatus.
2. Obtain Consultant's approval of mockups before starting Work.

3. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

18.15.1.4 Delivery, storage, and handling

A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multicomponent materials.

B. Store and handle sealant and firestopping materials according to manufacturer's written recommendations.

C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

18.15.2 PRODUCTS

18.15.2.1 Metal duct materials

A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, Z275 (G90) coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.

B. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

C. Tie Rods: Galvanized steel, 6-mm minimum diameter for 900-mm length or less; 10-mm minimum diameter for lengths longer than 900 mm.

18.15.2.2 Duct liner

A. General: Comply with NFPA 90A or NFPA 90B and NAIMA's "Fibrous Glass Duct Liner Standard."

B. Materials: Fiber glass ASTM C 1071 with coated surface exposed to air stream to prevent erosion of glass fibers.

1. Thickness: 1/2 inch (13 mm).

2. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.

3. Fire-Hazard Classification: Maximum flame-spread rating of 25 and smoke-developed rating of 50, when tested according to ASTM C 411.

4. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and ASTM C 916.

5. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

a. Tensile Strength: Indefinitely sustain a 50-lb- (23-kg-) tensile, dead-load test perpendicular to duct wall.

b. Fastener Pin Length: As required for thickness of insulation and
without projecting more than 1/8 inch (3 mm) into airstream.

c. Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

18.15.2.3 Sealing materials

A. Joint and Seam Tape: 50 mm wide; glass-fiber fabric reinforced.

B. Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant, formulated with a minimum of 75 percent solids.

18.15.2.4 Hangers and supports

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for building materials.

B. Hanger Materials: Galvanized, sheet steel or round, threaded steel rod.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

18.15.2.5 Duct fabrication

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction with galvanized, sheet steel, according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

B. Static-Pressure Classifications: According to SMACNA classification for each applicable duct static pressure.

C. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 480 mm and larger and 0.9 mm thick or less, with more than 0.93 sq. m of unbraced panel area, unless ducts are lined.

D. Round Supply And Exhaust Fitting Fabrication: Fabricate 90-degree tees and laterals and conical tees to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal seam straight duct.

1. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

2. Elbows: Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate bend radius of die-formed, gored, and pleated elbows one and one-half times elbow diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

3. 90-Degree, Two-Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material-handling Classes A and B; and only where space restrictions do not permit using 1.5 bend radius elbows. Fabricate with single-thickness turning vanes.

4. Round Elbows, 200 mm and Smaller: Fabricate die-formed elbows for 45- and 90-degrees elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.
5. Round Elbows, 225 and larger: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees, unless space restrictions require a mitered elbow. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.

18.15.2.6 Duct fire proof coating

A. Description: Fire proof coating shall be specifically made for sheet metal ducts application. The coating shall ensure 1 hr fire resistance at 400 deg C

B. Type: Mineral Fibre based or Calcium Silicate.

C. Application: BY pump injection. Application should be done by the approved manufacturer representative.

D. Compliance: Material should have test certificates from acknowledged certification bodies to be according to BS 476 (Part B) or equivalent European Norm.

18.15.3 EXECUTION

18.15.3.1 Installation

A. Duct installation requirements are specified in other Sections. Drawings indicate general arrangement of ducts, fittings, and accessories.

B. Construct and install each duct system according to SMACNA duct construction standards for the applicable duct pressure classification.

C. Install round ducts in lengths not less than 3.7 m, unless interrupted by fittings.

D. Install ducts with fewest possible joints.

E. Install fabricated fittings for changes in directions, changes in size and shape, and connections.

F. Install couplings tight to duct wall surface with a minimum of projections into duct.

G. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 25 mm, plus allowance for insulation thickness.

J. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

K. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

L. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Use wooden frame sleeve for all duct penetration through walls.

N. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct.
Overlap opening on four sides by at least 38 mm.

O. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire damper, sleeve, and firestopping sealant. Fire and smoke dampers are specified in Section "Duct Accessories." Firestopping materials and installation methods are specified in Section "Through-Penetration Firestop Systems."

18.15.3.2 Joint and seam sealing

A. Seam And Joint Sealing: Seal duct seams and joints according to the duct pressure class indicated and as described in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

1. Pressure Classification Less Than 500 Pa: Transverse joints.
2. Seal externally insulated ducts before insulation installation.

18.15.3.3 Hangers and supports

A. Install rigid round and rectangular metal ducts with support systems indicated in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Refer to drawings for construction and reinforcement schedule.

C. Support horizontal ducts within 600 mm of each elbow and within 1200 mm of each branch intersection.

D. Support vertical ducts at a maximum interval of 3 m and at each floor.

E. Install concrete inserts before placing concrete.

18.15.3.4 Connections

A. Connect equipment with flexible connectors according to Section "Duct Accessories."

B. For branch, outlet and inlet, and terminal unit connections, comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

18.15.3.5 Field quality control

A. Disassemble, reassemble, and seal segments of systems as required to accommodate leakage testing and as required for compliance with test requirements.

B. Conduct tests, in presence of Architect/Supervisor, at static pressures equal to maximum design pressure of system or section being tested. If pressure classifications are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

C. Determine leakage from entire system or section of system by relating leakage to surface area of test section.

D. Maximum Allowable Leakage: Comply with requirements for Leakage Classification 3 for round and flat-oval ducts, Leakage Classification 12 for rectangular ducts in pressure classifications less than and equal to 2-inch wg (500 Pa) (both positive and negative pressures), and Leakage Classification 6 for pressure classifications from 2- to 10-inch wg (500 to 2490 Pa).

E. Remake leaking joints and retest until leakage is less than maximum allowable.

F. Leakage Test: Perform tests according to SMACNA's "HVAC Air Duct Leakage Test
Manual."

18.15.3.5 Adjusting
A. Adjust volume-control dampers in ducts, outlets, and inlets to achieve design airflow.
B. Refer to Section "Testing, Adjusting, and Balancing" for detailed procedures.

18.15.3.6 Cleaning
A. After completing system installation, including outlet fittings and devices, inspect the system. Vacuum ducts before final acceptance to remove dust and debris.
18.16 SECTION 233300 - DUCT ACCESSORIES

18.16.1 GENERAL

18.16.1.1 Summary

A. This Section includes the following:

1. Backdraft dampers. On all extract and supply air fans
3. Fire and smoke dampers. On all fire zone separating the storage, or private tenants from common public zones.
4. Duct silencers. On fans, FCU and AHU all over the project to reduce the noise level up to the requested level
5. Turning vanes. On all elbows
6. Duct-mounted access doors and panels. As per SMACNA and Standards
7. Flexible ducts. On all diffusers, grilles and plenum boxes
8. Flexible connectors. Between duct and air equipment
9. Duct accessory hardware. To be applicable according to SMACNA standards

18.16.1.2 Submittals

A. Product Data: For the following:

1. Backdraft dampers.
3. Fire and smoke dampers.
4. Duct silencers.
5. Duct-mounted access doors and panels.
6. Flexible ducts.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, location, and size of each field connection. Detail the following:

2. Fire- and smoke-damper installations, including sleeves and duct-mounted access doors and panels.

C. Sound Absorbers (Duct Silencers): Submit acoustical design data based on selected fans and acceptable Noise rating (as required by acoustic designer)

D. Product Certificates: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static-pressure loss, dimensions, and weights.
18.16.1.3 Quality assurance
A. NFPA Compliance: Comply with the following NFPA standards:
   1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
   2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

18.16.1.4 Extra materials
A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

18.16.2 PRODUCTS
18.16.2.1 Sheet metal materials
A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, Z275 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
B. Aluminum Sheets: ASTM B 209M, Alloy 3003, Temper H14, sheet form; with standard, one-side bright finish for ducts exposed to view and mill finish for concealed ducts. If requested by the ID and or indicated in the description.
C. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
D. Tie Rods: Galvanized steel, 6-mm minimum diameter for 900-mm length or less; 10-mm minimum diameter for lengths longer than 900 mm.

18.16.2.2 Backdraft dampers
A. Description: Suitable for horizontal or vertical installations.
B. Frame: 1.3-mm thick, galvanized, sheet steel, with welded corners and mounting flange.
C. Blades: 0.6-mm thick, roll-formed aluminum.
D. Blade Seals: Felt.
E. Blade Axles: Galvanized steel.
F. Tie Bars and Brackets: Galvanized steel.
G. Return Spring: Adjustable tension.

18.16.2.3 Manual-volume dampers
A. General: Factory fabricated with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
   1. Pressure Classifications of 750 Pa or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
B. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, and suitable for horizontal or vertical applications.
   1. Steel Frames: Hat-shaped, galvanized, sheet steel channels, minimum of 1.62 mm thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
   2. Roll-Formed Steel Blades: 1.62-mm thick, galvanized, sheet steel.
   4. Tie Bars and Brackets: Aluminum.

18.16.2.4 Fire dampers
A. General: Labeled to UL 555.
B. Fire Rating: Two hours.
C. Frame: SMACNA Type A with blades in airstream; fabricated with roll-formed, 0.85-mm thick galvanized steel; with mitered and interlocking corners.
D. Frame: SMACNA Type B with blades out of airstream; fabricated with roll-formed, 0.85-mm thick galvanized steel; with mitered and interlocking corners.
E. Mounting Sleeve: Factory- or field-installed galvanized, sheet steel.
   1. Minimum Thickness: 1.3 mm or 3.5 mm thick as indicated, and length to suit application.
   2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.
F. Mounting Orientation: Vertical or horizontal as indicated.
G. Blades: Roll-formed, interlocking, 0.85-mm thick, galvanized, sheet steel. In place of interlocking blades, use full-length, 0.85-mm thick, galvanized steel blade connectors.
H. Fusible Link: Replaceable, 74 or 100 deg C rated as indicated.

18.16.2.5 Ceiling fire dampers
A. General: Labeled to UL 555C; comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."
B. Frame: 1.0-mm thick, galvanized, sheet steel; round or rectangular; style to suit ceiling construction.
C. Blades: 0.85-mm thick, galvanized, sheet steel with nonasbestos refractory insulation.
D. Volume Adjustment: UL-labeled, fusible volume-control adjustment.
E. Fusible Link: Replaceable, 74 deg C rated.

18.16.2.6 Motorized fire smoke dampers
A. General: Labeled to UL 555S. Combination fire and smoke dampers shall be labeled
for two hour rating to UL 555.

B. Fusible Link: Replaceable, 74 deg C rated as indicated.

C. Frame and Blades: 1.62-mm thick, galvanized, sheet steel.

D. Mounting Sleeve: Factory-installed, 1.3-mm thick, galvanized, sheet steel; length to suit wall or floor application.

E. Damper Motors: Provide for modulating or two-position action.
   1. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 17 N x m and breakaway torque rating of 17 N x m.
   2. Two-Position Motor: 230 V, single phase, 50 Hz.

18.16.2.7 Motorized smoke dampers

A. General: Labeled to UL 555S. Smoke dampers shall be labeled for two hour rating to UL 555.

B. Frame and Blades: 1.62-mm thick, galvanized, sheet steel.

C. Mounting Sleeve: Factory-installed, 1.3-mm thick, galvanized, sheet steel; length to suit wall or floor application.

D. Damper Motors: Provide for modulating or two-position action.
   1. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 17 N x m and breakaway torque rating of 17 N x m.
   2. Two-Position Motor: 230 V, single phase, 50 Hz.

18.16.2.8 Duct silencers

A. General: Factory-fabricated and -tested, round or rectangular silencer with performance characteristics and physical requirements as indicated.

B. Fire Performance: Adhesives, sealers, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame spread and 50 for smoke developed when tested according to ASTM E 84.

C. Rectangular Units: Fabricate casings with a minimum of 0.85-mm thick, solid sheet metal for outer casing and 0.55-mm thick, perforated sheet metal for inner casing.

D. Round Units: Casings with sheet metal thicknesses for diameters listed below:
   1. Up to 600 mm: 0.85 mm.
   2. 660 through 1000 mm: 1.0 mm.
   3. 1060 through 1300 mm: 1.3 mm.
   4. 1370 through 1500 mm: 1.62 mm.
   5. Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.
6. **Interior Partitions and Baffles:** At least 0.85 mm and designed for minimum aerodynamic losses.

E. **Sheet Metal Perforations:** 3-mm diameter for inner casing and baffle sheet metal.

F. **Fibrous Acoustic-Fill Material:** Inert and vermin-proof fibrous material, packed under not less than 5 percent compression.

G. **Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.**
   1. Do not use nuts, bolts, and sheet metal screws for unit assemblies.
   2. Lock form and seal or continuously weld joints.
   3. **Suspended Units:** Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   4. **Reinforcement:** Cross or trapeze angles for rigid suspension.

H. **Source Quality Control:** Perform the following factory tests:
   1. **Acoustic Performance:** Test according to ASTM E 477, with airflow in both directions through silencer.
   2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels, for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with an airflow of at least 10-m/s face velocity.
   3. **Leak Test:** Test units for airtightness at 200 percent of associated fan static pressure or 1500-Pa static pressure, whichever is greater.

18.16.2.9 **Turning vanes**

A. **Fabricate to comply with SMACNA’s “HVAC Duct Construction Standards--Metal and Flexible.”**

B. **Manufactured Turning Vanes:** Fabricate of 38-mm-wide, curved blades set 19 mm o.c.; support with bars perpendicular to blades set 50 mm o.c.; and set into side strips suitable for mounting in ducts.

C. **Acoustic Turning Vanes:** Fabricate of airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

18.16.2.10 **Duct-mounted access doors and panels**

A. **General:** Fabricate doors and panels airtight and suitable for duct pressure class.

B. **Frame:** Galvanized, sheet steel, with bend-over tabs and foam gaskets.

C. **Door:** Double-wall, galvanized, sheet metal construction with insulation fill and thickness, and number of hinges and locks as indicated for duct pressure class. Include vision panel where indicated. Include 25-by-25-mm butt or piano hinge and cam latches.

D. **Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

E. **Insulation:** 25-mm-thick, fibrous-glass or polystyrene-foam board.

18.16.2.10 **Flexible connectors**

A. **General:** Flame-retarded or noncombustible fabrics, coatings, and adhesives
complying with UL 181, Class 1.

B. Standard Metal-Edged Connectors: Factory fabricated with a strip of fabric 89 mm wide attached to two strips of 70-mm-wide, 0.7-mm-thick, galvanized, sheet steel or 0.8-mm aluminum sheets. Select metal compatible with connected ducts.

   1. Minimum Weight: 880 g/sq. m.
   2. Tensile Strength: 84 N/mm in the warp, and 63 N/mm in the filling.

D. Conventional, Outdoor System Flexible Connector Fabric: Glass fabric double coated with a synthetic-rubber, weatherproof coating resistant to the sun's ultraviolet rays and ozone environment.
   1. Minimum Weight: 880 g/sq. m.
   2. Tensile Strength: 93 N/mm in the warp, and 77 N/mm in the filling.

18.16.2.11 Flexible ducts

A. General: Comply with UL 181, Class 1.

B. Flexible Ducts, Uninsulated: Spiral-wound steel spring with flameproof vinyl sheathing use for ventilation only.

C. Flexible Ducts, Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 38-mm-thick, glass-fiber insulation around a continuous inner liner use for conditioned air.
   1. Reinforcement: Steel-wire helix encapsulated in inner liner.
   2. Outer Jacket: Glass-reinforced, silver Mylar with a continuous hanging tab, integral fibrous-glass tape, and nylon hanging cord.

D. Pressure Rating: 1500 Pa positive, 125 Pa negative.

18.16.2.12 Accessory hardware

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments, and length to suit duct insulation thickness.

B. Splitter Damper Accessories: Zinc-plated damper blade bracket; 6-mm, zinc-plated operating rod; and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.

C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 75 to 450 mm to suit duct size.

D. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.
18.16.3 EXECUTION

18.16.3.1 Installation

A. Install duct accessories according to applicable details shown in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.

B. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.

C. Provide test holes at fan inlet and outlet and elsewhere as indicated.

D. Install fire and smoke dampers according to manufacturer's UL-approved written instructions.
   1. Install fusible links in fire dampers (where applicable).

E. Install duct access panels for access to both sides of duct coils. Install duct access panels downstream from volume dampers, fire dampers, turning vanes, and equipment.
   1. Install duct access panels to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining accessories and terminal units.
   2. Install access panels on side of duct where adequate clearance is available.

F. Label access doors according to Section "Mechanical Identification."

18.16.3.2 Adjusting

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers.
18.17 SECTION 233413 — AXIAL FANS

18.17.1 GENERAL

18.17.1.1 Summary

A. This Section includes the following:
   1. Propeller fans.
   2. Axial fans.

18.17.1.2 Performance requirements

A. Project Altitude: Base air ratings on sea-level conditions.

B. Operating Limits: Classify according to AMCA 99 or as per Eurovent, corresponding classification.

C. Fan Unit Schedule: The following information is described in an equipment schedule on the Drawings.
   1. Fan performance data including capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
   2. Fan arrangement including wheel configuration, inlet and discharge configurations, and required accessories.

D. Smoke Exhaust: when specified as smoke exhaust fans should withstand continuous operation at 300°C for 1hr.

18.17.1.3 Submittals

A. Product Data including rated capacities of each unit including real static pressure after recalculation, weights (shipping, installed, and operating), furnished specialties, accessories, and the following:
   1. Motor ratings and electrical characteristics plus motor and electrical sound power rating accessories.
   2. Material gages and finishes, including color charts.
   3. Dampers, including housings, linkages, and operators.

B. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

C. Coordination Drawings, including floor plans and sections drawn accurately to scale. Submit with Shop Drawings. Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Wiring diagrams detailing wiring for power and control systems and differentiating clearly between manufacturer-installed and field-installed wiring.

E. Maintenance data for air-handling units to include in the operation and maintenance manual specified in Section "Basic Mechanical Requirements."
18.17.1.4 Quality assurance

A. Electrical Component Standard: Provide components that comply with IEC regulations.

B. Listing and Labeling: Provide electrically operated fixtures specified in this Section that are listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100, or as per "Avis Technique"

C. AMCA Compliance: Provide products that meet performance requirements and are licensed to use the AMCA Seal, NF and EN compliance to NF E 51-713 or ISO5801

D. Electrical Compliance: Motors and electrical accessories shall comply with BS5000 or as per EN and NF 15 100 and NF P 75-411-1 (DTU 67-1).

18.17.1.5 Project conditions

A. Field Measurements: Verify dimensions by field measurements. Verify clearances.

B. Do not operate fans until ductwork is clean, filters are in place, bearings are lubricated, and fans have been commissioned.

18.17.1.6 Delivery, storage, and handling

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

18.17.1.7 Coordination

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

18.17.1.8 Extra materials

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Belts: One set for each belt-driven unit.
   2. Fan motor: furnish one motor for the main toilets exhaust fans in order not to affect the operation in case of failure.

18.17.1.9 Warranty

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
B. Special Warranty: A written warranty, signed by Contractor and manufacturer, agreeing to replace any axial fan or component that do not meet requirements or that fail within the specified warranty period.
   1. Warranty Period: 5 years from date of Substantial Completion for any component of the axial fans.

18.17.2 PRODUCTS

18.17.2.1 Propeller fans
A. Direct-drive propeller fans, as indicated, consisting of fan blades, hub, housing, orifice ring, motor, drive, and accessories.
B. Housings: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat after assembly.
C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
D. Accessories: The following accessories are required as indicated:
   3. Wall Sleeve: Galvanized steel to match fan and accessory size.
   4. Weathershield Hood: Galvanized steel to match fan and accessory size.
   5. Louvres: Aluminum for outdoor side.
   6. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

18.17.2.2 Axial fans
A. Description: Axial fans consisting of aerofoil impeller, cylindrical casing, mounting arms, pad mounted motor directly coupled to the fan impeller, in-line with duct.
B. Casing: manufactured from hot dipped galvanized steel to BS 10142. integral inlet and outlet flanges with pre-drilled bolt holes. Fans shall be fitted with access doors to enable cleaning.
C. Impellers: high pressure die cast aluminum hub and clamp-plate, with equally spaced, fully adjustable high pressure die cast aerofoil section blades all balanced to ISO1940.
D. Accessories: provide the following:
   1. Disconnect switch: non fusible type, with thermal overload protection mounted on fan housing, factory wired.
   2. Sound absorbers: Provide absorber when fan exceeds required acceptable noise criteria from both sides.
   3. Factory supplied galvanized steel mounting brackets.
   4. Flexible connectors and vibration isolators.
5. External weather louver for free discharge “unducted” fans.
6. 300°C for 1 hours continuous operation for smoke exhaust application.

18.17.2.2 Roof-top axial fan
A. Description: Fan designed for roof mounting, including weatherproof casing, fan impellers, guards, directly mounted motor.
B. Casing: Weather proof low profile cowl from flame retardant GRP, directly fixed to galvanized steel base with backdraught shutters and bird guard.
C. Fan: high pressure die cast aluminum hub and clamp-plate, with equally spaced, fully adjustable high pressure die cast aerofoil section blades all balanced to ISO1940.
D. Accessories: provide the following:
   1. Disconnect switch: non fusible type, with thermal overload protection mounted on fan housing, factory wired.
   2. Factory supplied galvanized steel base.

18.17.2.3 Motors
A. Refer to Section "Motors" for general requirements for factory-installed motors.
B. Motor Construction: General purpose, continuous duty, fitted with sealed ball bearings, manufactured to comply with BS5000 and IEC34-1, and with class F insulation and IP W 55 with overheat protections, wye – delta motor starter.
C. Enclosure Type: The following features are required as indicated:
   1. Guarded dripproof motors where exposed to contact by employees or building occupants.

18.17.3 EXECUTION
18.17.3.1 Installation
A. Install fans according to manufacturer's written instructions.
B. Support units using the vibration-control devices indicated.
C. Suspend units from structure using threaded steel rods and vibration isolation springs.
D. Install units with clearances for service and maintenance.
E. Label fans according to requirements specified in Section "Mechanical Identification."

18.17.3.2 Connections
A. Duct installation and connection requirements are specified in other Sections. Drawings indicate the general arrangement of ducts and duct accessories. Make final duct connections with flexible connector.
B. Electrical: Conform to applicable requirements in Sections.
C. Ground equipment.
D. Tighten electrical connectors and terminals, including grounding connections,
according to manufacturer's published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

18.17.3.3 Commissioning

A. Final Checks before Startup: Perform the following operations and checks before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ducts, and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operation. Reconnect fan drive system.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in the fully open position.

B. Starting procedures for fans are as follows:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
2. Measure and record motor voltage and amperage.

18.17.3.4 Field quality control

A. Equipment Startup Checks:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm
proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Replace fan and motor pulleys as required to achieve design airflow.

G. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

18.17.3.5 Adjusting

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

18.17.3.6 Cleaning

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

18.17.3.7 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain axial fans.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

2. Review data in maintenance manuals. Refer to Section "Closeout Procedures."

3. Review data in maintenance manuals. Refer to Section "Operation and Maintenance Data."

4. Schedule training with Owner, through Architect/Supervisor, with at least seven days' advance notice.
18.18 SECTION 233416 - CENTRIFUGAL FANS

18.18.1 PART 1 - GENERAL

18.18.1.1 Summary

A. This Section includes:
   1. Centrifugal fans for indoor or outdoor installations.
   2. Centrifugal In-line fans

18.18.1.2 Performance requirements

A. Project Altitude: Base air ratings on sea-level conditions.
B. Operating Limits: Classify according to AMCA 99, or to Eurovent corresponding classification.
C. Fan Unit Schedule: The following information is described in an equipment schedule on the Drawings.
   1. Fan performance data including capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
   2. Fan arrangement including wheel configuration, inlet and discharge configurations, and required accessories.

18.18.1.3 Submittals

A. General: Submit each item in this Article according to the Conditions of the Contract and Specification Sections.
B. Product Data including rated capacities of each unit with static pressure after recalculation, sound pressure level, weights (shipping, installed, and operating), furnished specialties, accessories, and the following:
   1. Material gages and finishes, including color charts.
   2. Dampers, including housings, linkages, and operators.
   3. Motor ratings and electrical characteristics plus motor & electrical sound power rating accessories.
C. Coordination Drawings, including floor plans and sections drawn accurately to scale. Submit with Shop Drawings. Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements
D. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, location and size of each field connection.
E. Wiring diagrams detailing wiring for power and control systems and differentiating clearly between manufacturer-installed and field-installed wiring.
F. Maintenance data for fans to include in the operation and maintenance manual specified in and in Section "Basic Mechanical Requirements."
18.18.1.4 Quality assurance

A. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL where available, or as per NF 15100 and NF P 50-411-2.

B. Listing and Labeling: Provide electrically operated fixtures specified in this Section that are listed and labeled.

   1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100, or as per "Avis Technique"

C. AMCA Compliance: Provide products that meet performance requirements and are licensed to use the AMCA Seal, NF and EN compliance to NF E 51-713 or ISO5801

D. Electrical Compliance: Motors and electrical accessories shall comply with NEMA standards or as per EN and NF 15 100 and NF P 75-411-1 (DTU 67-1).

18.18.1.5 Coordination and scheduling

A. Coordinate the size and location of concrete housekeeping pads. Cast anchor-bolt inserts into pad. Concrete reinforcement and formwork requirements are specified.

B. Coordinate the installation of equipment supports, and roof/wall penetrations. Roof specialties are specified in corresponding Sections.

18.18.1.5 Extra materials

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Fan Belts: Furnish one set of spare fan belts for each unit installed.
   2. Fan motor: furnish one motor for the main toilets exhaust fans in order not to affect the operation in case of failure.

18.18.1.6 Warranty

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: A written warranty, signed by Contractor and manufacturer, agreeing to replace any centrifugal fan or component that do not meet requirements or that fail within the specified warranty period.

   1. Warranty Period: 5 years from date of Substantial Completion for any component of the centrifugal fans.

18.18.2 PRODUCTS

18.18.2.1 Centrifugal fans

A. Factory fabricated and assembled (including housing), factory tested, and factory finished, with indicated capacities and characteristics.

B. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
C. Housings
1. Materials and Fabrication: Factory prefabricated, formed- and reinforced-galvanized steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and doors or panels to allow access to internal parts and components.

2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.

3. Fabrication Class: AMCA 99 Class II or equivalent European class.


5. Tubular Centrifugal Fans: Fabricate tubular housing from formed- and reinforced-steel panels with welded seams and the following:
   a. Outlet guide vanes.
   b. Spun inlet cone with flange.
   c. Outlet flange.
   d. Brackets suitable for horizontal or vertical mounting.

D. Wheels
1. Forward/Backward Curved as indicated in the schedule: galvanized steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; cast-steel hub swaged to back plate and fastened to shaft with set screws.

2. Airfoil Wheel: Steel construction with smooth curved inlet flange; heavy back plate; hollow die-formed airfoil-shaped blades continuously welded at tip flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.

E. Shafts
1. Statically and dynamically balanced and selected for continuous operation at the maximum rated fan speed and motor horsepower (HP), with final alignment and belt adjustment made after installation.

2. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.

3. Designed to operate so that the first critical speed is at least 25% over the maximum operating speed for each pressure class.

F. Bearings
   Ball-Bearing Rated Life: AFBMA 9, L-10 of 50,000 hours for staircase pressurization fans and L-50 of 200,000 hours for other.

G. Belt Drives

1. Description: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor: 1.5.

2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at factory.

3. Motor Pulleys: Adjustable pitch for use with motors through 5 HP; fixed pitch for use with motors larger than 5 HP. Select pulley so pitch adjustment is at the middle of the adjustment range at fan design conditions.

4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   a. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements; 2.7-mm-thick, 20-mm diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.


H. Accessories

1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.

2. Companion Flanges: Galvanized steel, for duct connections.

3. Fixed Inlet Vanes: Steel, with fixed cantilevered vanes welded to inlet bell.


5. Scroll Drain Connection: DN25 steel pipe coupling welded to low point of fan scroll.

6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

8. Weather Cover: Heavy-gage steel sheet with ventilation slots, bolted to housing.

I. Motors

1. Refer to Section "Motors" for general requirements for factory-installed motors.

2. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B, or as per NF 15 100 class F insulation, IP W 55.

3. Enclosure Type: The following features are required as indicated:
   a. Guarded drip proof motors.
4. Select motor as non-overloading over the entire fan curve.

J. Factory Finishes
   1. Sheet Metal Parts: Enamel or prime coat before assembly. Do not prime coat aluminum parts.

18.18.2.2 Centrifugal in-line fans
A. Compact size low noise multi-speed fans.
B. CASINGS:
   1. For DN200 and smaller: Fire retardant Polyamide glass-fibre impregnated material.
   2. For larger than DN200: Galvanized sheet steel with built-in guide vanes and drilled flanges.
C. IMPELLER:
   1. For DN200 and smaller: Plastic incorporating metal black plates.
   2. For larger than DN200: Galvanized sheet steel.
D. MOTORS:
   1. Non-overloaded with built-in thermal overload protection.
   2. Factory tested with the impeller/casing assembly.
   3. IP44 class B insulation.

18.18.2.3 Source quality control
A. Testing Requirements: The following factory tests are required as indicated:
   1. Sound Power Level Ratings: Comply with NF E51-705, ISO 12499, or, AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans. Or as per the European Standards EN.
   2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210.

18.18.3 EXECUTION
18.18.3.1 Examination
A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the fans. Do not proceed with installation until unsatisfactory conditions have been corrected.
18.18.3.2 Installation
A. Install fans according to manufacturer's written instructions.
B. Support units using the vibration-control devices indicated. Vibration-control devices are specified in Section "Vibration Control."
1. Support floor-mounted units on concrete housekeeping bases using housed spring isolators. Secure units to anchor bolts installed in concrete housekeeping base.

C. Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.

D. Install units with clearances for service and maintenance.

E. Label fans according to requirements specified in Section "Mechanical Identification."

18.18.3.3 Housekeeping bases

A. Construct concrete housekeeping pads as follows:

1. Coordinate size of housekeeping bases with actual unit sizes provided. Construct base 100 mm larger, in both directions, than the overall dimensions of the supported unit.

2. Form concrete pads with framing lumber with form-release compounds. Chamfer top edge and corners of pad.

3. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.

4. Place concrete and allow to cure before installing units. Use portland cement conforming to ASTM C 150, 27 MPa compressive strength, and normal-weight aggregate.

5. Clean exposed steel form according to SSPC Surface Preparation Specifications SP 2 or SP 3 and apply 2 coats of rust-preventive metal primer.

18.18.3.4 Connections

A. Duct installation and connection requirements are specified in other Sections. Drawings indicate the general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

B. Electrical: Conform to applicable requirements in Sections.

C. Grounding: Ground equipment.

D. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

18.18.3.5 Adjusting

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

18.18.3.6 Cleaning

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction debris. Vacuum clean
fan wheel and cabinet.

18.18.3.7 Commissioning

A. Final Checks before Startup: Perform the following operations and checks before startup:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ducts, and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnects.
   3. Perform cleaning and adjusting specified in this Section.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Verify lubrication for bearings and other moving parts.
   6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in the fully open position.

B. Starting procedures for fans are as follows:
   1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
   2. Measure and record motor voltage and amperage.

C. Site engineer to prepare a complete schedule for his reception with complete information about the test he performed for the response of each fan to the requested test: complete air test on flow and velocity, noise level, amperage for running and inrush current.

D. Replace fan and motor pulleys as required to achieve design conditions.

18.18.3.8 Demonstration

A. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

B. Review data in the operation and maintenance manuals. Refer to Section "Contract Closeout."

C. Schedule training with Owner, through Architect/Supervisor, with at least 7 days' advance notice.

D. Demonstrate operation of fans. Conduct walking tour of the Project. Briefly identify location and describe function, operation, and maintenance of each fan.
18.19 SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

18.19.1 GENERAL

18.19.1.1 Summary
A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

18.19.1.2 Definitions
A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.
B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.
C. Register: A combination grille and damper assembly over an air opening.

18.19.1.3 Submittals
A. Product Data: For each model indicated, include the following:
   1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
   2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
   3. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.
B. Coordination Drawings: Reflected ceiling plans and wall elevations drawn to scale to show locations and coordination of diffusers, registers, and grilles with other items installed in ceilings and walls.
C. Samples for Verification: Of diffusers, registers, and grilles, in manufacturer's standard sizes, showing the full range of colors. Prepare Samples from the same material to be used for the Work.

18.19.1.4 Quality assurance
A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Section "Substitutions."

18.19.2 PRODUCTS

18.19.2.1 Diffusers
A. Square diffuser (supply and return):
   1. Material: Aluminum.
   2. Finish: Baked enamel, color approved by The Supervisor.
5. Pattern: 4-way. Square diffuser(supply and return)
6. Damper( for supply only): opposed blade .
7. Fixing : Screwed in the neck.

B. Round diffuser (supply and return) :
1. Material : Aluminium
2. Finish : Baked enamel, color approved by The Supervisor .
5. Pattern: radial discharge.
6. Damper ( for supply only): flap .
7. Fixing : Screwed in the neck.

C. Slot diffuser (Supply & return):
1. Material: Aluminum.
2. Finish: Baked enamel, color approved by The Supervisor.
4. Style: Linear.
5. Pattern: adjustable.
6. Damper: Volume & Pattern control (for supply only).
7. Frame: as per Architect/Supervisor requirement.

D. Exhaust Round diffuser (for toilets/Kitchens) :
1. Material : UPVC.
2. Finish : color approved by The Supervisor.
5. Damper: Disk valve with threaded spindle .

18.19.2.2 Registers, grilles and louvers.
A. Registers/Grilles:
1. Material: Aluminum.
2. Finish: Baked enamel, color approved by The Supervisor.
5. Frame: 1 inch (25 mm) wide.
6. Fixing: Countersunk screw.
7. Damper Type: Adjustable opposed-blade assembly (registers only).

B. Bar registers/Linear Grilles:
1. Material: Aluminum.
2. Finish: Baked enamel, color approved by The Supervisor.
4. Frame: As per Architect/Supervisor requirement.
5. Fixing: screwed in the neck.
6. Damper: Volume & Pattern control (for supply only).

C. Exhaust Grilles:
1. Material: Aluminum.
2. Finish: Anodized aluminium in parkings and mechanical rooms. Baked enamel, in decorative areas.
4. Frame: 1 inch (25 mm) wide.
5. Fixing: Countersunk screw.

D. Fresh air sand trap louvers:
1. Material: Aluminum 1.2 mm thick frame and blades.
2. Finish: Baked enamel, color to the choice of the Architect/Supervisor.
3. Face Blade Arrangement: Composed of sets of inverted U channels mounted vertically on two opposite rows.
4. Sand chute: Inclined tray made of aluminum 1.2 mm thick at the bottom of the louver with sand drain.
5. Wire mesh: 12x12mm spacing and 1.5mm diameter
6. Provided with air filter.

18.19.3 SOURCE QUALITY CONTROL
A. Testing: Test performance according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

18.19.4 EXECUTION
18.19.4.1 Examination
A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions
have been corrected.

18.19.4.2 Installation

A. Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of the panel. Where architectural features or other items conflict with installation, notify Architect/Supervisor for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

18.19.4.3 Adjusting

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

18.19.4.4 Cleaning

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.
18.20 SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONING UNITS

18.20.1 PART 1 - GENERAL

18.20.1.1 Related documents
Drawings and general provisions of the Contract, including General and Supplementary Conditions.

18.20.1.2 Summary
This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

18.20.1.3 Definitions
Evaporator-Fan Unit: The part of the split-system air-conditioning unit that contains a coil for cooling and a fan to circulate air to conditioned space.

Compressor-Condenser Unit: The part of the split-system air-conditioning unit that contains a refrigerant compressor and a coil for condensing refrigerant.

18.20.1.4 Submittals
Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

The refrigerant must be R407c or 410.

Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

Retain paragraph below if Drawings do not include detailed reflected ceiling plans or if Project involves unusual coordination requirements.

Maintenance Data: For split-system air-conditioning units to include in maintenance manuals.

Warranties: Special warranties specified in this Section.

18.20.1.5 Quality assurance
Retain paragraph below to allow Drawing details based on one manufacturer's product to establish requirements and still allow competition. Revise to identify specific proprietary system or indicate on Drawings.

Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Other manufacturers' systems with equal performance characteristics may be considered.

Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
18.20.1.6 Coordination
Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases.
Retain below for units with remote-mounted air-cooled condensers.
Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations.

18.20.1.7 Warranty
When warranties are required, verify with Owner's counsel that special warranties stated in this Article are not less than remedies available to Owner under prevailing local laws.
Coordinate with Section "Warranties."

General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

Verify available warranties on units and components and retain number below or insert other.

Warranty Period: one year (minimum) from date of substantial completion. Warranty against corrosion should be for a minimum of five years.

18.20.2 PART 2 - PRODUCTS
18.20.2.1 Concealed evaporator-fan components
A. All units shall be inverter type
B. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
   1. Insulation: Faced, glass-fiber duct liner.
   2. Drain Pans: Galvanized steel, with connection for drain; insulated.
C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
D. Fan: Forward-curved, double-width wheel of special plastic or galvanized steel, double inlet, with adjustable belt drive.
E. Fan Motor:
   1. General: Refer to Section "Motors" for general requirements.
   2. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
   3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range.
   4. Temperature Rating: 50 deg C maximum temperature rise at 40 deg C ambient for continuous duty at full load (Class A Insulation). Static pressure should be as scheduled with a minimum of 50 Pascal
5. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.

6. Motor Construction: NEMA MG-1, general purpose, continuous duty, Design B.


8. Bearings: The following features are required:

9. Ball or roller bearings with inner and outer shaft seals.


11. Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

12. Enclosure Type: The following features are required:

13. Open dripproof motors where satisfactorily housed or remotely located during operation.


16. Efficiency: Energy-efficient motors shall have a minimum efficiency as scheduled according to IEEE 112, Test Method B. If efficiency is not specified, motors shall have a higher efficiency than "average standard industry motors" according to IEEE 112, Test Method B.

17. Nameplate: Indicate full identification of manufacturer, ratings, characteristics, construction, and special features.

18. Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in relevant Sections.

F. Disposable Filters: 1 inch (25 mm) thick, in fiberboard frames.

G. Cleanable Filters: 1 inch (25 mm) thick, in aluminium wire mesh.

H. Wiring Terminations: Connect motor to chassis wiring with plug connection.

18.20.2.2 Air-cooled, compressor-condenser components

A. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing. Test certificate to show the adaptability of the unit to withstand the corrosive outdoor ambient conditions.

B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

a. Compressor Type: Reciprocating, or Scroll.

b. Refrigerant cooled compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.

E. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
H. Fan: Aluminum-propeller type, directly connected to motor.
I. Motor: Permanently lubricated, with integral thermal-overload protection.
J. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
K. The condenser coil should be protected by factory protection paint allowing a durable coil and fins for at least five years.

18.20.2.3 Accessories

A. Sight glass.
B. Automatic-reset timer to prevent rapid cycling of compressor.
C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

18.20.3 PART 3 - EXECUTION

18.20.3.1 Installation

A. Install units level and plumb.
B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
C. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit.
D. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
E. Modify static deflection in paragraph below to suit Project.
F. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch (25 mm).
G. Connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

18.20.3.2 Connections

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.
B. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
C. Install piping adjacent to unit to allow service and maintenance.
D. Unless otherwise indicated, connect piping with unions and shutoff valves to allow units to be disconnected without draining piping. Refer to piping system Sections for specific valve and specialty arrangements.
E. Ground equipment.
1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

18.20.3.3 Field quality control

A. Installation Inspection: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections, and to prepare a written report of inspection.

B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

18.20.3.4 Commissioning

A. Delete paragraph below if factory-authorized service representative is not required.

B. Engage a factory-authorized service representative to perform startup service.

C. Verify that units are installed and connected according to the Contract Documents.

D. Lubricate bearings, adjust belt tension, and change filters.

E. Perform startup checks according to manufacturer's written instructions and do the following:

   1. Fill out manufacturer's checklists.
   2. Check for unobstructed airflow over coils.
   3. Check operation of condenser capacity-control device.
   4. Verify that vibration isolation devices and flexible connectors dampen vibration transmission to structure.

18.20.3.5 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

   1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining units.
   2. Schedule training with Owner, through Architect/Supervisor, with at least seven days' advance notice.