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**Appendix B: Technical Specification**

**Republic of Yemen**

**Ministry of Water & Environment**

**Local Water and Sanitation Corporation**

**Dhamar Gov.**

**Rehabilitation and completion of water network and household connections for the Al-gadad area Dhamar city**

**( IUS-AF-UWS-DHAM-016)**

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**2023**

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**Republic of Yemen**

**Ministry of Water & Environment**

**Local Water and Sanitation Corporation – Dhamar Governorate**

**Rehabilitation and completion of water network**

**and household connections for the Al-gadad area**

**Dhamar City**

**Appendix B: Technical Specification**

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**2022**

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# SECTION 01010

# SCOPE OF WORK

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

The project comprises Rehabilitation and completion of water network

and household connections for the Al-gadad area Dhamar city

The work will include civil, supply, delivery and installation works of the Water distribution network according to the related drawings and BOQ which are:

Supply, deliver and install HDPE pipes different size (DN 63 to 200 mm) with total length of about 10.4 Km.

Supply and Installation of HDPE Fittings.

Supply and Installation of Valves, Air Valve, and Special Equipment.

Supply and construct of Concrete Valve Chambers.

Supply and Installation of Domestic Water Flow Meters.

Structural works for valve Surface Boxes

Pipeline cleaning and testing.

Reinstatement work. Paving or Asphalt reinstatement of the road to match existing levels using the same existing stones type colour, pattern, and dimensions.

A detailed site investigation study has been carried out for the project area, which forms part of the available information for tendering purposes. Any geotechnical investigations required during construction shall be at the Contractor expense and will be deemed to be included in his tendered rates.

**1.1-01 Coordination**

Contractor shall plan schedule and coordinate his operations in a manner, which will facilitate the simultaneous progress of the work under this Contract as well as operations being performed by the Employer and work included under other contracts outside the scope of these Contract Documents.

* + 1. **Work Included**

The required work is described by the Drawings and Contract Documents and may be defined as including but not limited to the following:

* Site Clearing and Grubbing.
* Earthworks (filling, excavation and backfilling).
* Supply and Installation of Pipes and fittings.
* Supply and Installation of valves, and special equipment.
* Construct of chambers, surface boxes.
* Reinstatement works (asphalt and Stone Pavement pavements).

**1.1-03 Occupancy and Operation of Existing Facilities.**

The Contractor may be permitted to use available land belonging to Employer, on or near the various sites of the work, for construction purposes and for the storage of materials and equipment. The location and extent of the areas so used shall be considered as an optional privilege and may be withdrawn any time by the Employer.

The Contractor shall immediately move stored material or equipment if any occasion arises, as determined by Employer, requiring access to the storage area. Materials or equipment shall not be placed on the property of the Employer until the Employer has agreed to the location to be used for storage.

**1.1-04 Abbreviations**

The following abbreviations as referenced in the Contract Documents are defined to mean the associated names. Both the names and addresses are subject to change, and are believed to be, but are not assured to be, accurate and up-to date as of the date of the Contract Documents.

AASHTO - American Assoc. of State High- way & Transportation Officials 341 National Press Building Washington, D.C. 20044 202/628-2438

ACI - American Concrete Institute Box 19150 Redford Station Detroit, Michigan 48219 313/532-2600

AISC - American Institute of Steel Construction, Inc.

1221 Avenue of the Americans New York, New York 10020 212/764-0440

AISI - American Iron and Steel Institute

1000 16the Street, N.W. Washington, D.C. 20036 202/223-9040

ANSI - American National Standards Institute (Successor to USASI and ASA)

1430 Broadway

New York, New York 10018

21/868-1220

APA - American Plywood Association

P. O. Box 11700

Tacoma, Washington 98411

ASCE - American society of Civil Engineers

345 East 42nd Street

New York, New York 10017

ASME - American Society of Mechanical Engineers

345 East 47the Street

New York, New York 10017

212/752-6800

AWG - American Wire Gauge

AWS - American Welding Society, Inc.

2501 N.W. 7the St.

Miami, Florida 3215

305/6427090

AWWA - American Water Works Association, Inc.

2501 West Quaincy Avenue

Denver, Colorado 80235

303/794 - 7711

BS - British Standards Institution

Two Park Street

London, WIA 285

01-629-9000

CISPI - Cast Iron Soil Pipe Institute 1499 Chain Bridge Road

McLean, Virginia 22101

CRSI - Concrete Reinforcing Steel Institute

180 North La Salle Street Chicago, Illinois 60601

CS - Commercial Standard

U.S. Department of Commerce/ National Bureau of Standards Washington, D.C. 20234

DIPRA - Ductile Iron Pipe Research Association

1301 West 22nd Street, Suite 509 Oak Brook, Illinois 60521 312/654-2945

ES - Egyptian Organization for Standardization

Two Latin America Street Garden City, Cairo, A.R.E.

Hyd Inst - The Hydraulic Institute

122 East 32nd Street

New York, New York 10017

IFI - Industrial Fasteners Institute 1717 East Ninth Street

Cleveland, Ohio 44114

ISO - International Organization for Standardization

1 Rue de Vermbe, Case Postale 56 Geneva 20, Switzerland

PCI - Prestressed Concrete Institute 20 North Wacker Drive

Chicago, Illinois 60606

PS - Product Standard

(See CS-Commercial Standard)

SSPC - Steel Structure Painting Council

4400 Fifth Avenue

Pittsburgh, Pennsylvania 15213 412/621-1100

TCA - Tile Council of America, Inc.

P. O. Box 326

Princeton, New Jersey 08540

609/921-7050

US - U. S. Bureau of Standards

(See CS-Commercial Standards)

The following abbreviations as referenced in the Contract Documents are defined to mean the following:

ac - Alternating current

CIF - Cost, Insurance and Freight

cu - Cubic

g - Gram

ga,GA - Gauge

g/cu cm - Grams per cubic centimeter

ha - Hectare

IPS - Iron pipe size

kg - Kilogram

kg/scm - Kilogram per square centimeter

kg/cm - Kilogram per cubic meter

kj - Kilojoule

KN - Kilonewton

KN/m2 - Kilonewton per square meter

kW - Kilowatt

l - Litre or liter

l/m - Litre per minute

l/s - Litres per second

m - Metre or meter

sq.m. - Square metre

cu.m. - Cubic metres

mm. - Millimetre

sq.mm. - Square Millimetre

mN - Meganewton

MPa - Megapascals

max - Maximum

min - Minimum

mg/l - Milligrams per liter

ml/d - Millilitres per day

NPT - National Pipe Thread

N - Newton

No. - Number

dia - Diameter

Pa - Pascal

RL - Reduced Level

rpm - Revolutions per minute

req'd - Required

TWL - Top Water Level

typ - Typical

MWL - Minimum Water Level

D.I - Ductile Iron

UPVC - Unplasticised polyvinyl chloride

MPVC - Modified polyvinyl chloride

GMS - Galvanized mild steel

**END OF SECTION**

# SECTION 01015

# GENERAL REQUIREMENTS

**1. UNIT OF MEASUREMENT**

Units of measurement used in this Contract shall be in accordance with the International System of Units, which generally referred to as the SI metric system.

**2. GENERAL OBLIGATIONS**

**a.** The Contractor shall attempt to decrease noise and environmental pollution as much as possible.

**b.** The Contractor shall not use the Site for purposes other than the execution of the works.

**c.** The Contractor shall drain floodwater and excess water by pumping to prevent damage to any third party.

**d.** The Contractor shall preserve trees, planted fields and fences in a suitable manner, and shall replant and replace those trees that were damaged or removed, and re-erect and restore fences to their original condition, in accordance with the Engineer's instructions.

1. In case of need to erect scaffolding on the property of any neighbor, then the Contractor shall contact the said neighbor and arrange for the proper execution, and for the removal of the scaffolding, and carry out all repairs at the completion of the work.
2. All referenced specifications, codes, and standards mentioned elsewhere (in other divisions and sections) refer to the most current issue available at the time of Bid.
3. The term Engineer's Representative refers to also engineer assistants which may include resident engineer and / or independent inspectors.

**3- MATERIALS AND MANUFACTURED ARTICLES**

All material and workmanship shall be subject to the acceptance of the Engineer and the Engineer's Representative and shall be in conformity with acceptable modern practice.

In general, whenever the Contract Documents show or specify a particular make of material, manufactured article, device or equipment, it shall be regarded merely as a standard.

When a reference is made in the Contract Documents to standards or specifications of associations such as DIN, ISO, AWWA, ASTM, BS or others, the provisions of the latest revision of the standards or specifications shall be applicable.

In general, if two or more makes of material, manufactured articles, devices or equipment are shown or specified, each shall be regarded as the equal of the other. Any other make of material, manufactured article, device or equipment which is recognized equal of that specified, and is suitable for the purpose intended and accepted in writing by the Engineer and Engineer's Representative, will be accepted. However, in cases in which provision is made for tendering alternative makes of equipment, the Employer will select the alternative make that it considers will be most advantageous under the conditions.

In all cases, new materials and equipment shall be used, unless this provision is waived by notice from the Employer through the Engineer in writing.

**4- ELEVATIONS**

All elevations shown on the Drawings and in the Specifications and other Contract Documents are shown in meters and all other Divisions in millimeter unless otherwise shown on the drawings.

**5- LINES AND GRADES**

The Contractor shall keep the Engineer informed, a reasonable time in advance, of the times and places at which he intends to do work, in order that lines and grades may be established and necessary measurements for record and payment made with a minimum of inconvenience to the Engineer or delay to the Contractor. The Contractor shall have no claim for damages or extension of time on account of delays in the giving of lines and grades, making record measurements or destruction of such marks and the consequent necessity for replacement.

The Engineer will furnish the Contractor with such basic lines and grades as he; the Engineer, deems necessary, but this shall not be construed to mean all lines, grades, elevations and measurements. It shall be the Contractor's responsibility before commencing any section of the Work to locate the permanent benchmarks to be used. The Contractor shall refer all temporary benchmarks thereto.

In general, basic lines and grades will be established on offset lines provided by the Contractor. The Contractor shall set batter boards and other facilities such as laser beams required for proper installation of the Work and shall transfer the lines and grades from the offset lines with suitable surveying equipment in good condition and adjustment.

The Contractor shall be responsible for the stakeout survey for construction purposes and the replacement of monuments and property markers disturbed by the Work. The Work shall proceed in advance of the construction at a rate satisfactory to the Engineer. The Contractor shall keep the Engineer fully informed as to the progress of the stakeout survey.

The exact position of all work shall be established from control points, which are given or modified by the Engineer. Any error, apparent discrepancy or omission in the data shown or required for accurately accomplishing the stakeout survey shall be referred to the Engineer who shall take whatever corrective measures he deems necessary.

The Contractor shall be responsible for the accuracy of his Work and shall maintain all reference points, stakes, etc., throughout the life of the Contract. Damaged, destroyed or inaccessible reference points, benchmarks or stakes shall be replaced by the Contractor. Existing or new control points that will be or are destroyed during construction shall be reestablished and all reference ties recorded therefore shall be furnished to the Engineer.

All computations necessary to establish the exact position of the Work from control points shall be made and preserved by the Contractor. All computations, survey notes and other records necessary to accomplish the Work shall be neatly prepared and made available to the Engineer upon request or furnished upon Contract completion.

All instruments, equipment, stakes and other material necessary to perform the Work shall be provided by the Contractor.

All stakes used shall be a type acceptable to the Engineer, clearly and permanently marked so as to be legible at all times. It shall be the Contractor's responsibility to maintain these stakes in their proper position and location at all times. Any existing stakes or markers defining property lines and survey monuments which may be disturbed during construction shall be properly tied in to fixed reference points before being disturbed and accurately reset in their proper position upon completion of the Work.

The Engineer may check all or any portion of the stakeout survey work or notes made by the Contractor and any necessary correction to the Work shall be immediately made. Such checking by the Engineer shall not relieve the Contractor of any responsibilities for the accuracy or completeness of his work.

**6. ACCESS AND TEMPORARY ROADS**

The Contractor shall be responsible for providing and maintaining such temporary access roads to and along the right-of-way as necessary for transportation of materials and equipment.

The Contractor shall furnish and install cross drains where necessary or as required by the Engineer to assure proper drainage across all access and temporary roadways to prevent pounding of water or interruption of natural surface drainage in any way.

Where such roads are on private property, the Contractor shall obtain permission for their construction, use and removal, and pay all costs pertaining thereto. Except as shown on the Drawings or specified elsewhere all temporary construction roads shall be removed upon completion of Work and the area restored to its original contours and original type of ground cover.

**7. CONTROL OF WORK MANAGEMENT**

**a.** The Contractor shall co-operate with the Engineer in arranging the times and dates of Site meetings, and in the preparation of Minutes of Meetings.

**b.** He shall co-operate with the Engineer in taking photographs for the presentation of the progress of the work, and in the preparation of the periodic progress reports.

**c.** He shall keep a special record, registering the climatic conditions of maximum and minimum temperatures, humidity, and the average rainfall in millimeters, and the number of hours of rainfall, for each day whenever possible.

**d.** He shall provide the Site with signs which show the name of the Project, Employer, Engineer, and the Contractor; in the number, size and shape which shall be agreed upon with the Engineer.

**e.** When he is required to provide the Site with laboratory materials, then he shall staff it with a qualified laboratory technician with the necessary experience to carry out the required duties.

**f.** In case of Engineer or Engineer’s Representatives rejection of any material or work, the Contractor shall, before starting to rectify such condition, submit his proposals for such rectification or repair to the Engineer or the Engineer’s Representative, to alleviate the repetition of the error.

**8. WORK NEAR HAZARDOUS EQUIPMENT**

Any permanent fencing or other safeguards required to be erected around electrical or potentially hazardous equipment shall be completed as far as practicable before the equipment is energized or brought into operation, but where this is not practicable the Engineer's Representative may permit the use of temporary fencing or other safeguards.

If work is to be carried out in the vicinity of live electrical equipment or of potentially hazardous equipment which is in operation, the Contractor shall put into operation a controlled access system to the approval of the Engineer's Representative. Such permission or approval shall not create any responsibility or liability on the part of the Engineer or the Engineer's Representative resulting from the use of such temporary safeguards.

The Contractor shall keep all traveled ways free of foreign object such as rocks, timber, and other items that may fall from transporting vehicles of workmen.

Spillage of material carried by or dropped from the under-carriage of any carrying vehicle or workmen resulting from the Contractor's hauling operations along or across any public traveled way shall be removed immediately and such traveled way, both within and outside of the Contract limits, shall be kept free of such spillage by the Contractor. The Contractor shall conduct the operations to keep job-related dust to a minimum.

**9. RESTORATION OF PRIVATE AND PUBLIC RIGHT-OF-WAY**

Where the Work is on right-of-way provided through private property, the Contractor shall exercise special care to avoid damage. He shall confine his operations to the limits of the right-of-way provided unless he makes special arrangements with the owners. All public and private properties shall be restored by the Contractor to at least as good a condition as existed prior to entry by the Contractor to perform the Work.

All damage caused to existing roadways, walkways, ground configuration, plantings, trees, waterways, or embankment areas, fences, walls and other structures and facilities through trucking operations, delivery of materials, the actual performance of the Work, or other causes, shall be fully restored by the Contractor at his own expense to its original condition by supplying surfacing, pavement, soil grading, plants, trees, grass, topsoil, fertilizer, fencing, structural methods and such other materials and methods as may be necessary.

**10. DISPOSAL OF SURPLUS MATERIAL**

The Contractor must submit for approval by the Engineer and local municipal authorities the location of all proposed surplus material disposal sites and copies of an agreement with the property owner noting conditions of such agreement. The minimum requirements by the Engineer would be that final grading blend aesthetically with the surrounding ground and that proper drainage of site be maintained.

**11. WORK CLEAR OF WATER**

The Contractor shall keep the Works well drained until the Engineer certifies that the whole of the Works is substantially complete and shall ensure that so far as is practicable all work is carried out in the dry. Excavated areas shall be kept well drained and free from standing water.

The Contractor shall construct, operate and maintain all temporary dams, watercourses and other works of all kinds including pumping and well point dewatering plant that may be necessary to exclude water from the Works while construction is in progress. Such temporary works and plant shall not be removed without the approval of the Engineer's Representative.

Notwithstanding any approval by the Engineer of the Contractor's arrangements for the exclusion of water, the Contractor shall be responsible for the sufficiency thereof and for keeping the Works safe at all times particularly during any floods and for making good at his own expense any damage to the Works including any that may be attributable of floods. Any loss of production of additional costs of any kind that may result from floods shall be at the Contractor's own risk.

**12. ASSISTANCE FOR ENGINEER'S STAFF**

The Contractor shall provide every assistance to the Engineer's Representative and his staff in carrying out their duties and shall provide a sufficient supply of surveying instrument pegs, poles, paint, and other materials and small tools for checking, setting out and the measurement of Work.

The Contractor shall also provide for the Engineer's Representative and his staff such waterproof clothing, safety helmets, rubber boots, lights and the like as may reasonably be required by them. These articles shall remain the property of the Contractor, and they shall be repaired or replaced by him to the extent necessitated by fair wear and tear.

**13. MEDICAL FACILITIES**

The Contractor shall arrange for medical attention to be available when necessary and shall provide dressing stations complete with all adequate first-aid equipment within easy access of each Works area on the site. The Contractor shall display in suitable places the names of his employees who are available from time to time to render First Aid. The Contractor shall provide for the transport of serious cases to the nearest hospital.

**14. CONTRACTOR’S PROFESSIONAL CONDUCT AND EXECUTION OF HIS DUTIES IN CONNECTION WITH THE CONTRACT**

**a. Good Practice**

If a full description of any material, product or workmanship was not specified, then it is nevertheless understood that this material or work shall be suitable for the propose of the Contract or what may be needed to execute the item in conformity with good practice and whatever is mentioned for the relevant item in the Bill of Quantities, the General Technical Specifications and the Standard Specifications being used.

**b.** **Standard Specifications**

If standard specifications such as ASTM or BS are specified, then the Contractor shall submit a Certificate of Origin certifying that the item purchased is in conformity with such standard specifications, and submit the same for the Engineer’s approval.

For road works the currently used local specifications shall be referred to.

**c. Specifications Prescribing a Product**

If a single source should be specified for any material or a product, then the Contractor shall be bound by the same, and shall not change the said source without the written approval of the Engineer.

**d.** The Contractor shall place sings wherever services are concealed, in order to facilitate relocation of the said services, during testing, maintenance, repair or operation of the same.

**15. CONTRACT DETAILS**

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

**16. PHOTOGRAPHS**

The contractor shall arrange for photographs of the works to be taken as required by the Engineers Representative for record purposes.

No separate payment will be made to the contractor for any photographic responsibilities.

**17. SUBMITTALS**

The Contractor shall submit construction drawings, shop drawings, details or samples as required by the Engineer for pipe work, valves, concrete mixes, all mechanical and electrical equipment, construction material, and other items as specified by the Engineer

**18. BOUNDARIES OF WORK AND REINSTATEMENT**

The Contractor shall not clear; store materials upon, or use any more land than is reasonable and necessary. Other Contractors and/or employees of the Employer, other governing bodies, and the public utility agencies may for all necessary purposes enter upon the Work and premises used by the Contractor, and public utility shall give the other governing bodies, and public utility companies, all reasonable facilities and assistance for the completion of adjoining work.

The Contractor shall make his own arrangements and bear all costs incurred in leasing or buying, maintaining, etc. of the necessary land areas storage or manufacture, equipment storage and maintenance, offices, housing, etc.,.

**19. MAINTENANCE AND PROTECTION OF TRAFFIC**

The Contractor shall maintain traffic and protect the public from damage to person and property, within the limits of and for the duration of the Contract. Traffic shall be maintained over a reasonable smooth traveled way, which shall be so marked by signs, delineation and/or other methods that a person who has no knowledge of conditions can safely, and with a minimum of discomfort and inconvenience, ride, drive or walk over all or any portion of the highway under construction where traffic is to be maintained.

The Contractor is placed on notice that the maintenance and protection of traffic over Project streets during construction is considered as important and necessary item of the Work as the actual construction work itself.

The Contractor shall at all times conduct his operation in a manner to ensure the safety of not only the motorist, but also the pedestrian and his own employees.

The Contractor shall so schedule his Work as to keep to a minimum the amount of the traveled way that is destroyed or substantially damaged at any one time. The Contractor shall coordinate the schedule of his Work with the local municipality officials.

The Contractor shall assure the safety of the public, especially children, by providing the necessary lights, beams, warning signs, flagmen, watchmen etc., required for the proper control of any and all pedestrian and vehicular traffic during the continuance of the Contract. This control shall be provided continuously during the day, night, holidays, and weekends.

On main streets, the Contractor shall generally provide a traveled way suitable for two or more lanes of traffic. This traveled way shall be kept well drained and reasonably smooth and hard at all times and free of potholes, bumps, irregularities and depressions that hold or retain water. He shall conduct his operation to ensure a minimum of delay to traffic. Stopping traffic for more than approximately ten minutes is considered unsatisfactory.

The necessary equipment and personnel to attain and maintain a satisfactory riding surface shall be available and used as needed at all times, both when the Work is under way and when the Work is temporarily suspended for any period of time. Special attention shall be given to maintenance of a satisfactory traveled way over weekend and holidays.

The Contractor shall keep all traveled ways free of foreign objects such as rocks, timber and other items that may fall from transporting vehicles or workmen.

Spillage of material carried by or dropped from the under-carriage of any carrying vehicle or workmen resulting from the Contractor's hauling operations along or across any public traveled way shall be removed immediately and such traveled way, both within and outside of the Contract limits, shall be kept free of such spillage by the Contractor. The Contractor shall conduct the operations to keep job-related dust to the minimum level.

All signs shall be kept clean, and so placed as to be effective both day and night. Signs, warnings, delineators and barricades shall be used to adequately inform the motorist and pedestrians of any unusual or unsafe condition and to safely and clearly guide him through the Contract Work areas. Such signs, warnings, or devices shall be so placed as to give timely warning and permit the motorist or pedestrian to take the necessary action to traverse the areas safely.

All existing street signs, markers, delineators and their supports within the Contract limits are to remain in place and are to be maintained for the duration of the Contract by the Contractor as required by the Engineer.

The cost of all such Work shall be included in the unit prices bid for various items of Work.

**20. SUBSURFACE STRUCTURES AND ALL UTILITIES**

Before beginning excavation operations, the Contractor shall contact the local municipalities and utilities and notify them of his intention to begin excavation operations.

It shall be the responsibility of the Contractor to determine the exact location of such pipelines, subsurface structures and/or utilities ahead of his work by exploratory excavation or other means and to take suitable precautions to prevent damage to them and to prevent interruption of the services. If they are broken or damaged, they shall be restored by the Contractor or the appropriated utility at the Contractor's expense.

The Contractor shall bear the costs for relocating, altering or reconstructing water mains, sewers, poles, pole lines, overhead wires and all the facilities above ground. The work shall conform to the requirements of the local authorities concerned.

**21. PUBLIC NOTIFICATION**

The Contractor shall have a notice placed in the daily newspapers advising the public of the location or area of construction and possible inconvenience to local residents. Where proposed construction is in populated areas, the Contractor shall provide all residents with advance notification in the form of a written notice delivered to the resident at least 48 hours in advance of construction. The notice shall briefly describe the schedule and scope of Work and inform residents that they may be affected by noise, dust, disturbance of utilities and detours resulting from construction operations.

All notifications should originate from the relative local authorities.

**22. DISCHARGE OF WATER**

The Contractor shall make provision for the discharge or disposal from the Works of all water and waste products howsoever arising, and the methods of disposal shall be to the satisfaction of the Engineer's Representative and of any authority or person having an interest in any land or watercourse over in which water and waste products may be so discharged. The requirements of this clause shall not limit any of the Contractor's obligations or liabilities.

**23. INSTRUMENTS TO BE PROVIDED**

The Contractor shall provide all survey and soil measuring instruments of every kind necessary for his own use in the execution of the Works.

**24. AS-BUILT DRAWINGS**

The Contractor shall, upon the completion of all works at the project site, submit the As-Built Drawings for the Engineer's review and approval. No separate payment shall be made for preparation of As-Built Drawings one hard copy and one on CDs AutoCAD format.

**25. TRAINING REQUIREMENTS**

The Contractor shall carry out on-the-job practical training of up to four members of the Employer’s staff and shall provide a program for this training within three months of signing the Contract Agreement. Each member of staff shall receive not less than one-month training during the course of the works on site.

The training courses shall cover all the activities of the Contractor, and shall concentrate especially on the field of polyethylene pipe works including installation, laying, connections, fittings, testing, sterilization as well as the adjustment, calibration and maintenance of pressure reducing valves, water meters, pressure relief valves, pressure gauges and sensors, connection and application of data logger and evaluation of recorded data.

**Operations and Maintenance**

**Operation and Maintenance Manuals**

Comprehensive, computerized, operation and maintenance manuals in the English language covering all items of plant and including all manufacturer's instructions, references, lists, etc. shall be produced.

The manuals shall include an outline of the general principles of operation and maintenance suitable for training purposes, and shall make specific reference to the particular equipment provided. Sales brochures may be included only as additional information.

The manuals shall be submitted in five copies, two copies original and three clear photo copies and shall cover the testing, operation, control, maintenance, dismantling and repair of all the motors, device, equipment and apparatus provided in the Works. All information shall be supported by:

All electrical and mechanical equipment shall have part lists in numbers according to exploded views of the same numbers.

Catalogues and brochures;

Dimension drawings;

Data sheets;

Descriptive text;

Comprehensive drawings, sketches, plans, sections as required and

All electrical power, control and electronic detailed drawings.

The greatest importance shall be drawn to the completeness and clearness of presentation.

It is emphasized that a collection of standard pamphlets of general nature unaccompanied by drawings and descriptive matter will not be acceptable. In particular, information supplied by sub-contractors and manufacturers employed by the Contractor shall be co-ordinate in the comprehensive manual. Cross-references of descriptive texts, drawings and spare part lists must be complete.

The Contractor shall deliver to the Engineer, in duplicate, loose-leaf copies of draft operation and maintenance manuals for the Plant at least two months before start-up of the Works. The text or accompanying diagrams shall in addition show the electrical wiring, handling and erection instructions. Draft manuals shall, during the testing and commissioning of the Works, be carefully checked by the Contractor and updated and modified to ensure that they are fully descriptive and applicable to the final layout of Plant and process under operational conditions.

The final approved manuals for the Works shall be submitted before the start of the defects liability period. They shall be securely bound in A4 sized loose-leaf binders, clearly titled, index linked and cross-referenced. If prepared on computer, a standard PC word processor software such as Word for Windows shall be used, and a copy of the data file for each volume on CD shall be supplied in order to facilitate searching for information.

The final manuals shall incorporate instructions, recommendations and advice for the operation of the entire process covering the full range of flow and water conditions and include advice on the joint operation and control of all the process units on site. No section of the Works will be certified by the Engineer as completed unless this requirement has been met.

If during the defects liability period, the Contractor or the Engineer has found that the manual requires modification or enlargement as a result of subsequent operational and maintenance experience in the Works, the Contractor shall provide the approved modification for each relevant manual.

The manuals shall include explanations of the function and purpose in tabular form with look up program for each site of each item supplied and the operational, mechanical and electrical procedures for:

Lubrication, checking, calibration (including charts), testing and adjustment;

Attention at daily, weekly, monthly or other maintenance intervals to ensure reliable trouble-free operation;

Complete overhaul, dismantling and reassemble, testing and recommissioning;

The identification and selection of suitable lubricants standardized throughout the Works, including identifying equivalents available from local manufacturers where possible;

Defect location decision charts to facilitate tracing of the cause of malfunction or breakdown from symptoms or tests;

Routine and emergency safety precautions, procedures and recommendations;

Cleaning of the Plant and its components;

Guidelines for protection of equipment in case of taking the equipment out of service;

**Maintenance Procedure**

The operation and maintenance instruction manual shall be supplemented by the submission of a comprehensive yearly maintenance programme for the operation and maintenance staff. A wall chart or charts shall be provided, covering a period of one year with coloured markers. It shall have vertical divisions in weeks and horizontal divisions for each item of Plant. A fitter's card system shall be provided with at least one card for each item of Plant. The cards shall detail maintenance required with the relevant space for work done and parts required. The cards will form the basis of a system to check that the mechanical and electrical maintenance staff is carrying out the necessary routine work. The markers shall be arranged with standard colours to indicate work required, parts outstanding, work completed and the like. The Scheme shall be capable of extension to include any further routine work, which may be required.

Draft proposals for the maintenance scheme shall be included in the training program. The basics of the electronic part of the manual are to be presented at the same time.

**Tests, Inspection and Trial Run**

**Works Testing**

Performance tests conducted by the manufacturer in his works shall be in accordance to DIN standard, ISO 2548 or equivalent. The Employer and the Engineer reserve the right to witness the tests.

Pumps and motors shall be tested with their own individual motors, unless otherwise approved by the Engineer. Triplicate copies of test certificates and characteristic curves for pumps and motors shall be provided prior to acceptance of the equipment by the Engineer. Basic data obtained during testing shall be stamped on nameplates affixed to the equipment. Data from manufacturer’s catalogues will not be acceptable in lieu of test certificates and characteristics for the particular items supplied. Any arrangement required for the works testing of pumps, motors and engines are deemed to be included in the bid.

All pipework, pressure vessels, valves etc. shall be pressure tested according to DIN standards. Valves shall be tested and certified as being leak-proof against differential pressure.

For motors acceptable to VDE 0530, mainly comprising one heat run test, overspeed test at 20% over speed for five minutes, momentary overload to 60% for 15 seconds for all sizes of motors.

**Site Testing – General**

After installation, the whole of the equipment shall be tested in the presence of the Engineer's Representative to demonstrate compliance with the requirements of the specifications in respect of performance, mode of operation and electrical and mechanical reliability. It shall be the responsibility of the Contractor to obtain any water required for test purposes and pipe it from the supply point to the filling point on the system, and to dispose of any such water after testing in a manner acceptable to the Engineer.

The Contractor shall submit a scheduled procedure and method of testing for approval of the Engineer, before proceeding with the tests.

The Contractor shall furnish all supervision, labor, service, tools, equipment, instruments, materials and supplies required for both the proper hydrostatic testing operation and running tests to the complete satisfaction of the Engineer. The Contractor shall also supply oils, greases, and spares required during the setting to work of the Plant.

The pipe work shall be hydrostatically tested to 1.5 times the working pressure and this pressure shall be sustained for a period of two hours. No visible sign of leakage will be accepted. The Contractor shall perform the hydrostatic test on all completed piping prior to field-coating of any welds and fittings, and prior to backfilling of any trenches associated with pipes under test. Any vent cocks used on tests shall be left in-situ after erection. Filling points shall be plugged.

In the event of any site tests indicating a reduction in standard of the Works or related to the performance of any equipment supplied, the Contractor shall take necessary steps to rectify the shortcoming.

After installation of pumps, acceptance tests shall be carried out according to DIN standard. Equipment not conforming to the bidding data shall be rejected and replaced or modified as directed by the Engineer and at the expense of the Contractor.

1. **COMMISSIONING & TAKING OVER TESTS**

All the fully assembled plant or equipments is to be tested again for commissioning and perfect operation after complete installation for the taking over, and all these shall be witnessed by the Engineer at site. The Contractor shall make all needed adjustments and calibrations for this purpose for all the equipments at this stage as approved by the Engineer. All testing instruments, gauges, tools used in this Taking Over tests as instructed by the Engineer shall be certified by a 3rd party (1st grade) authorized Firm approved by the Engineer. (Certificates validity is one year). The contractor shall pay all cost for the third party related to the previous mentioned tasks (taking over tests).

**END OF SECTION**

# SECTION 01040

# COORDINATION

**1- DESCRIPTION**

This section covers the Contractor's requirements for coordinating work of this Project.

**1-1 Project Coordination**

The Contractor shall be responsible for the coordination of all work performed under these Contract Documents; including scheduling of all work, delivery of equipment and materials, establishing the work sequence, and completion of the work in accordance with the construction schedule and the specified time of completion.

**2- COORDINATION WITH OTHER CONTRACTORS**

The Contractor shall inform the Engineer, and all other parties with an interest in this project concerning his construction schedule and shall coordinate his work with that performed by others. The Contractor shall make all necessary arrangements concerning the timing, methods, and division of work required by any connections between this work and other work to be performed by others.

**3- RELATIONS WITH OTHER CONTRACTORS**

The Contractor shall cooperate with all other contractors who may be performing work in behalf of the Employer and workmen who may be employed by the Employer on any work in the vicinity of the work to be done under this Contract, and he shall so conduct his operations as to interfere to the least possible extent with the work of such contractors or workmen. The Contractor shall promptly make good, at his own expense, any injury or damage that may be sustained by other contractors or employees of the Employer at his hands. Any difference or conflict which may arise between the Contractor and other contractors or between the Contractor and workmen of the Employer in regard to their work shall be adjusted and determined by the Engineer.

Whenever there is interference with work under other contracts, the Engineer shall decide the manner in which the work shall proceed under each contract.

**4- UNDERGROUND INSTALLATION**

Existing underground installations such as water mains, gas mains, sewers, telephone lines, power lines, and buried structures in the vicinity of the work to be done hereunder are indicated on the Drawings only to the extent such information has been made available by the Employer, or discovered by the Engineer in preparing the Drawings. There is no guarantee as to the accuracy or completeness of such information, and all responsibility for the accuracy and completeness thereof is expressly disclaimed.

The Contractor shall be solely responsible for locating all existing underground installations, including service connections, in advance of excavating or trenching. The Contractor shall use his own information and shall not rely upon any information indicated on the Drawings concerning existing underground installations.

**5- EXISTING STRUCTURES**

The dimensions and elevations and locations of existing pipelines, conduits, cables, and equipment so indicated on the Drawings (if any) were taken for the most part from the Employer's records of the existing plant and are not guaranteed for accuracy.

It shall be the responsibility of the Contractor to check all dimensions and elevations of existing structures, pipelines, conduits, cables, equipment, or other existing items, both above and below ground, affected by or affecting the work under this Contract, prior to the start of construction or ordering of materials and equipment affected thereby.

The Contractor's attention is directed to the General Conditions which requires that each tenderer visit the site of the work to familiarize himself with the arrangement and condition of the site.

The Contractor shall be solely responsible for determining the extent of the cost of all removal and salvage operations. Any delay or extra expense to the Contractor due to encountering construction, piping, or equipment not shown or in locations different from those indicated on the Drawings (if any) shall not constitute a claim for extra work, additional payment, or damages.

**6. OPERATION OF EXISTING FACILITIES**

The Contractor's attention is directed to the fact that all existing services must be kept in continuous operation.

**END OF SECTION**

# SECTION 01300

# SUBMITTALS

**PART 1 - DESCRIPTION**

This section covers the requirements for Contractor submittals of letters, data, samples, submittals for material shop drawings, as built drawings, operation and maintenance manuals, testing and commissioning reports and construction scheduling to the Engineer prior to starting of work.

All drawings, data and samples shall be submitted to the Engineer for review accompanied by acceptable transmittal form or letter.

**1.1 SCOPE OF WORK**

Individual specific requirements for submittals are described in other sections.

**1.2 SUBMITTALS SCHEDULE**

The sequence of submission of all drawings, data and samples shall follow logical progression, such that all information required for review shall be available. A letter of transmittal shall accompany each submittal.

The Contractor shall allow sufficient time for review by the Engineer unless otherwise stated in the Contract.

The following table summarizes the timing, quantity and type of submission of documents required at various stages of the Contract.

Abbreviation: P, print - R, reproducible;

C, copy

H, hard copy

N, photographic negative

|  |  |  |  |
| --- | --- | --- | --- |
| ***Submittal Description*** | ***Quantity Required for Review*** | | ***Submittal Timing*** |
|  | ***Draft*** | ***Final*** |  |
| 1. Drawings and data for review | 4P  1P | 5P+1R  1P+1R | 4 weeks prior to manufacture or construction |
| 1. Letters | Original |  |  |
| 1. Manufacturer's and supplier's test certificates | 4C |  | Upon completion of tests prior to shipping |
| 1. Operation and Maintenance manual | 4C | 2C+4H | Before first  unit is offered for acceptance |
| 1. As-built Drawings | 4P | 4P+1R | Upon acceptance  of final unit. |
| 1. Samples |  | As required | Upon request of the Engineer |
| 1. Photographs | 4P+1N |  | With application for monthly payment. |
| 1. Other submittals as may be required. |  |  |  |

**Construction Schedule**

Within twenty days after the notice in writing, the Contractor shall prepare and submit to the Engineer for review and acceptance an estimated construction progress schedule for the Work, with sub schedules of related activities which are essential to its progress. The schedule shall be in the form of a modified CPM (Critical Path Method) for project scheduling with arrow diagrams.

**A. Arrow Diagram**

The schedule shall be sufficiently detailed to indicate such activities as shop drawing submittal and review, equipment manufacture and delivery, installation of equipment, concrete pours, and Subcontractor's items of work. Construction activities of less than one day duration or more than five days duration shall be kept to a minimum. Each activity shall be labeled with the following information; description, duration, scheduled start date, latest completion date, and total float. The critical path of activities shall be indicated on the arrow diagram by a heavy line.

**B. Listings**

Two chronological listings of the information shall be prepared: one for scheduled start dates and one for latest completion dates. Each listing shall show activity node numbers, description, scheduled start date, duration in work days, latest completion date, and total float for each item in the arrow diagram.

**C. Submittals**

The initial critical path schedule and subsequent revisions shall reflect the actual progress of the Project to within five (5) days prior to submittal. Contractor and his representative who prepared the schedule shall meet with Engineer and Employer to review the initial schedule and each subsequent revision. The meeting will be held in the office of the Engineer.

At least five copies of the arrow diagram and listing shall be submitted. A revised arrow diagram and listing shall be prepared and submitted at least every 60 days.

If the initial schedule or any subsequent revision is not acceptable to the Engineer, Contractor shall revise the schedule and resubmit as many times as necessary until the schedule is acceptable to the Engineer. Acceptance of the schedule will not be unreasonably withheld.

**D. Shop Drawings Schedule**

At the time the initial critical path schedule is submitted, the Contractor shall submit, if needed a schedule of the items of materials and equipment for which shop drawings are required by the specifications. For each required shop drawing, the Contractor shall give the date he intends to submit the drawings to Engineer for review and the date he will require its return to avoid delay in any activity beyond the scheduled start date. Contractor shall allow sufficient time for initial review, correction and resubmission, and final review of all Shop Drawings. In no case will a schedule be acceptable which allows less than 20 working days for each review by the Engineer.

**E. Progress Reports**

At the end of each month, the Contractor shall submit to the Engineer the node numbers of the activities that have been completed with their actual start and completion dates, and a list of the activities on which Work is currently in progress and the number of working days required to complete each.

If at any time during the Project, the Contractor fails to complete any activity by its latest completion date, he shall within five days submit to the Engineer, in writing, his plans to reorganize his work force to return to the schedule and prevent delays on any other activity.

**1-3 SCHEDULE OF VALUES**

After review of the tentative schedule at a preconstruction conference, and before submission of the first application for payment, the Contractor shall prepare and submit, if needed to the Engineer a schedule of values covering each lump sum item. The schedule of values, showing the value of each kind of work, shall be acceptable to the Engineer before any partial estimate is prepared.

The sum of the items listed in the schedule of values shall equal the contract lump sum price. Such items as Bond premium, temporary construction facilities, and plant may be listed separately in the schedule of values, provided the costs can be substantiated. Overhead and profit shall not be listed as separate items.

An unbalanced schedule of values providing for overpayment to the Contractor on items of Work which would be performed first will not be accepted. The schedule of values shall be revised and resubmitted until acceptable to Engineer. Final acceptance by Engineer shall indicate only consent to the schedule of values as a basis for preparation of applications for progress payments, and shall not constitute an agreement as to the value of each indicated item.

**1-4 SHOP DRAWINGS**

The Contractor shall check all the designs and drawings coordinating all different discipline requirements and shall have all points amended to the satisfaction of the Engineer before commencing of works and also before presenting complete shop drawings. Engineering data covering all equipment and fabricated materials to be furnished shall include drawings and descriptive information in sufficient detail to show the kind, size, arrangement, and operation of component materials and devices; the external connections, anchorages, and supports required; performance characteristics; and dimensions needed for installation and correlation with other materials and equipment.

All submittals, regardless of origin, shall be stamped with the approval of the Contractor and identified with the name and number of this Contract, the Contractor's name, and references to applicable specification paragraphs and Contract Drawings. Equipment and materials descriptive literature not readily cross referenced with the drawings or specifications shall be identified by a suitable use of the item in the Work. When catalogue pages are submitted, applicable items shall be clearly identified and items not pertinent to this project shall be crossed out. The current revision, issue number, and date shall be indicated on all drawings and other descriptive data. Schematics and connection diagrams for all electrical equipment shall be submitted for review. A manufacturer's standard connection diagram or schematic showing more than one scheme of connection will NOT be accepted, unless it is clearly marked to show the intended connections.

The Contractor's stamp of approval is a representation to the Employer and Engineer that Contractor accepts full responsibility for determining and verifying all quantities, dimensions, field construction criteria, materials, catalogue numbers, and similar data, and that he has reviewed or coordinated each submittal with the requirements of the Work and the Contract Documents.

All deviations from the Contract Documents shall be identified on each submittal and shall be tabulated in the Contractor's letter of transmittal. Such submittals shall, as pertinent to the deviation, indicate essential details of all changes proposed by Contractor (including modifications to other facilities that may be a result of the deviation) and all required piping and wiring diagrams.

The Contractor shall accept full responsibility for the completeness of each submission, and, in the case of a resubmission, shall verify that all exceptions previously noted by the Engineer have been taken into account.

Any need for more than one resubmission, or any other delay in obtaining the Engineer's review or submittals, will not entitle the Contractor to extension of the Contract Time unless delay of the Work is directly caused by a change in the Work authorized by a Change Order or by failure of the Engineer to return any submittal within 20 working days after its receipt in the Engineer's office.

The Engineer's review of drawings and data submitted by Contractor will cover only general conformity to the drawings and specifications, external connections, and dimensions which affect the layout. The Engineer's review does not indicate a thorough review of all dimensions, quantities, and details of the material, equipment, device or item shown. The Engineer's review of submittals shall not relieve the Contractor from responsibility for errors, omissions, or deviations, nor responsibility for compliance with the Contract Documents.

The Engineer will not accept submittals from anyone but the Contractor. Submittals shall be consecutively numbered referenced by specification number in direct sequence of submittal and without division by subcontracts or trades. Resubmittals shall bear the number of the first submittal followed by a letter (A, B, etc.) to indicate the sequence of the resubmittal. Two marked copies of each drawing, marked to show the result of the Engineer's review shall be returned to the Contractor.

When the drawings and data are returned marked NOT ACCEPTABLE or RETURNED FOR CORRECTION, the corrections shall be made as noted thereon and as instructed by the Engineer and one corrected copy and one corrected reproducible copy shall be resubmitted. Fabrication shall not commence until the final drawings have been returned marked EXCEPTIONS NOTED or NO EXCEPTIONS NOTED by the Engineer. When corrected copies are resubmitted, Contractor shall in writing direct specific attention to all revisions and shall list separately any revision made other than those called for by Engineer on previous submissions.

When the drawings and data are returned marked EXCEPTIONS NOTED, NO EXCEPTIONS NOTED, or RECORD COPY, no additional copies need by furnished.

**A. Certificates**

Where certificates are required by the relevant technical specification section, four copies of each such certificate under manufacturer's letterhead shall be submitted by the Contractor.

Certificates shall be clearly identified by serial or reference number where possible to the material being certified and shall include, but not be limited to, providing the following information, Contractor's name, project name, name of the item, manufacturer's name, and reference to the appropriate drawing, technical specification section and paragraph number, control register reference all as applicable and required by the relevant quality standard or specification.

The timing for submittal, of certificates shall be as follows:

1. Manufacturer's and supplier's test certificates shall be submitted not less than forty-five (45) calendar days prior to the time that the materials represented by such certificates are needed for incorporation into any work. Material represented by such certificates shall not be manufactured, delivered to the site nor incorporated into any work without any such review.

2. Certificates of tests (certificate of compliance to the specification), carried out during the performance or on completion of parts of the Permanent Works shall be submitted as soon as the tests have been completed.

**1-5 ENGINEERING DATA**

**A. Survey Data**

All field books, notes, and other data developed by the Contractor in performing surveys required as part of the Work shall be available to the Engineer for examination throughout the construction period. All such data shall be submitted to the Engineer with the other documentation required for final acceptance of the Work.

**B. Layout Data**

Contractor shall keep neat and legible notes of measurements and calculations made by him in connection with the layout of the Work. Copies of such data shall be furnished to the Engineer for use in checking Contractor's layout as specified herein. All such data considered of value to the Employer will be transmitted to the Employer by the Engineer with other records upon completion of the Work.

**1-6 CONSTRUCTION PHOTOGRAPHS**

Contractor shall be responsible for the production of construction photographs as provided herein. The Engineer shall designate the subject of each photograph.

Photographs of the overall general site or pertinent features thereof and of each area of construction shall be taken before the commencement of Work at the sites and promptly submitted to the Engineer. The same views shall be rephotographed upon completion of all construction activities and submitted with Contractor's application for final payment. An additional set of photographs shall be made each month throughout the progress of the Work at such times as requested by the Engineer, and submitted with Contractor's application for progress payment.

All photographs shall be produced by a competent photographer, and shall be coloured photographs of commercial quality. All negatives and two 100 by 125 mm prints of each view shall be submitted. Negatives shall be individually mounted and identified with description of view and date. Prints shall be mounted on linen with flap for binding or enclosed in clear plastic binders approved by the Engineer. Included in each view shall be a board which clearly indicates the name and number of the contract, name of Contractor, description and location of view, and date photographed.

Engineer shall transmit one copy of each photograph to the Employer.

**1-7 OPERATION AND MAINTENANCE MANUALS**

Adequate operation and maintenance information shall be supplied for all equipment requiring maintenance or other attention. The equipment supplier shall prepare an operation and maintenance manual for each type of equipment indicated Equipment Schedule. Parts lists and operating and maintenance instructions shall be furnished for other equipment not listed in the Equipment Schedule.

Operation and maintenance manuals shall include the following:

1. Equipment function, normal operating characteristics, and limiting conditions.

2. Assembly, installation, alignment, adjustment, and checking instructions.

3. Operating instructions for startup, routine and normal operation, regulation and control, shutdown, and emergency conditions.

4. Lubrication and maintenance instructions.

5. Guide to "troubleshooting".

6. Parts Lists and predicted life of parts subject to wear.

7. Outline, cross section, and assembly drawings; engineering data; and wiring diagrams.

8. Test data and performance curves, where applicable.

The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered, or which may be required by Contractor.

Manuals and other data shall be printed on heavy, first quality paper, A4 size (210x297 mm) with standard 3-hole punching. Drawings and diagrams shall be reduced to A4 or B4 (210x297 mm or 254x365 mm). Where reduction is not practicable, larger drawings shall be folded separately and placed in envelopes which are bound into the manuals. Each envelope shall bear suitable identification on the outside.

Two preliminary copies of each manual, temporarily bound in heavy paper covers bearing suitable identification, shall be submitted to Engineer prior to the date of shipment of the equipment. After review by Engineer, four final copies of each operation and maintenance manual shall be prepared and delivered to Engineer not later than 30 days prior to placing the equipment in operation. Final manuals and all parts lists and information shall be assembled in substantial, permanent, three-ring or three-post binders. As much as possible, material shall be assembled and bound in the same order as specified, and each volume shall have a table of contents and suitable index tabs.

All material shall be marked with Project identification, and inapplicable information shall be marked out or deleted.

Shipment of equipment will not be considered complete until all required manuals and data have been received.

**END OF SECTION**

# SECTION 01410

# TESTING AND TESTING LABORATORY SERVICES

**PART I – GENERAL**

* 1. **GENERAL**

1. Contractor will employ and pay for the services of an Independent Testing Laboratory acceptable to the Engineer and Employer to perform testing specifically indicated in the Contract documents. Employer may at any other time elect to have materials and equipment tested at a laboratory of the Employer’s choice for conformity with the Contract Documents at the Employer’s cost. If the Employer’s laboratory test result does not generally conform to the Contractor’s test results the Contractor shall be responsible for payment to the Employer’s testing laboratory:
   1. Contractor shall coordinate with the laboratory together with Engineer’s Representative to facilitate the execution of its required testing services.
   2. Employment of the laboratory shall in no way relieve Contractor’s obligations to perform the Work of the Contract.
   3. **RELATED REQUIREMENTS**
2. Conditions of the Contract: Inspections and testing required by laws, ordinances, rules regulations, orders or approvals of public authorities.
3. Respective sections of specifications: Certification of products.
4. Each specification section listed: Laboratory tests required and standards for testing.
5. Testing Laboratory inspection, sampling and testing is required for but not limited to the following:
   1. Site Preparation is including in Section 02100.
   2. Pavement Repair and Resurfacing is included in Section 02512.
   3. Trenching, Backfilling and Compaction is included in Section 02220.
   4. Pipework included in Division 2 and Division 15.
   5. Concrete and Concrete Reinforcement is included in Division 3.
   6. Masonry is included in Division 4.
   7. **SUBMITTALS**
   8. Submit to the Engineer the following information regarding the Independent Testing Laboratory:
      1. Qualification of Independent Testing Laboratory included: number of years the laboratory has been in business, similar projects the laboratory has undertaken, verification of laboratory equipment to perform laboratory testing required by this project, and verification of field equipment to perform field testing required by this project.
      2. Qualifications of Project Manager and key staff whom will be responsible for the testing program.
   9. **LIMITATIONS OF AUTHORITY OF TESTING LABORATORY**
6. Laboratory is not authorized to:
   1. Release, revoke, alter or enlarge on requirements of Contract Documents.
   2. Approve or accept any portion of the Work.
   3. Perform any duties of the Contractor.
   4. **CONTRACTOR’S RESPONSIBILITIES**
7. Assure the prompt services of the testing laboratory to perform the specified inspections, sampling and testing of materials. Promptly notify the Engineer of all irregularities or deficiencies in the Work which are observed during the performance of the specified testing. The Engineer shall have the option to witness all testing. Submit to the Engineer, five copies of all certified test reports prepared by the independent testing laboratory. Include in each report:
   1. Date issued.
   2. Contract title and number.
   3. Testing Laboratory name and address.
   4. Name and signature of Inspector.
   5. Date of inspection or sampling.
   6. Record of temperature and weather.
   7. Date of test.
   8. Identification of product and specification section.
   9. Location of sample.
   10. Type of inspection or test.
   11. Observations regarding compliance with Contract Documents.
8. Materials and equipment used in the performance of work under this Contract are subject to inspection and testing at the point of manufacture or fabrication. Standard specifications for quality and workmanship are indicated in the Contract Documents. The Engineer may require the Contractor to provide statements or certificates from the manufacturers and fabricators that the materials and equipment provided by them are manufactured or fabricated in full accordance with the standard specifications for quality and workmanship indicated in the Contract Documents. All costs of this testing and providing statements and certificates shall be a subsidiary obligation of the contractor, and no extra charge to the Owner shall be allowed on account of such testing and certification.
   1. **INSPECTION**
9. Inspection of all materials and equipment incorporated into the Work will all be required. Any delay in the Work or additional cost occasioned by the failure of such material or equipment to meet the specifications shall be the Contractor’s responsibility.
10. Authorized representatives: The Employer shall have access to the Work wherever it is in preparation or progress. Provide proper facilities for such access and inspection.
11. Contractor shall furnish incidental labor and facilities:
    1. To obtain and handle samples at the Project site or at the source of the product to be tested.
    2. For storage of test samples.

**END OF SECTION**

# SECTION 01430

# QUALITY CONTROL PROGRAM

1. **GENERAL**

1-1 The Contractor shall be responsible for establishing and executing a Quality Control Program.

1-2 "Quality Control" is the process used to verify procurement, fabrication, and construction compliance with drawings and specifications. The program shall describe this process in sufficient detail and clarity so that those implementing the program are fully aware of their specific duties, and those monitoring the program are assured that the duties are being carried out and the finished work is in conformance with Contract Documents.

1. **POLICY**

2-1 The objective of the program is to ensure that a high-quality product is produced by the Contractor. Quality Control personnel cannot inspect "Quality" into completed work. They can only verify that good quality work is produced.

2-2 The Contractor should provide a Quality Control organization staffed by as many construction inspectors and equipped to the extent deemed necessary by the Engineer to support the program. Such support facilities shall include but shall not be limited to:

1. Adequate materials testing services.

2. Qualified personnel in adequate numbers and separate from construction line reporting, to inspect, and evaluate work performed.

3. Clearly defined acceptability criteria for all work performed.

4. Responsibility and authority of quality control and inspection personnel to reject unsatisfactory work and have it corrected.

5. System for identifying, reporting, controlling, processing, correcting and documenting of non-conformances and their resolution.

6. A system of reporting and recording to fully document inspections and tests made and quality levels attained.

2-3 The requirements of this specification are not intended to limit the scope of the Contractor's Quality Control Program.

1. **QUALITY STANDARDS**

3-1 Relevant codes and criteria setting for the required standards for materials and workmanship are given in the Contract Documents. The Contractor's Quality Control Program shall take full account of the requirements of such codes and criteria, together with the general requirements of Submittals Section.

3-2 The Contractor shall furnish to the Engineer a copy of each applicable code or standard given in these specifications and/or used by Contractor in his Quality Control Program.

1. **CONTROL OF MATERIALS**
   1. **Approval of Materials**
   2. Unless otherwise specified, only brand-new materials and equipment shall be incorporated in the work. Brand new materials means the newest up-date version and the newest manufactured from the factory. Refurbishment, repainted or old versions are rejected. All materials and equipment furnished by the Contractor shall be subject to the inspection and approval of the Engineer. No material shall be delivered to the work without prior approval of the Engineer.
   3. As specified in Section 01300, the Contractor shall submit to the Engineer data sheets and compliance sheets relating to materials and equipment he proposes to furnish for the work. The data sheets shall state in a table from all manufacturer’s part specification. The compliance sheet shall also show in a table form of 4 columns, the 1st for Tender Complete Specifications in detail, the 2nd for submitted specifications, the 3rd for deviation and the 4th for remarks. Such data shall be in sufficient detail to enable the Engineer to identify the particular product and to form an opinion as to its conformity to the specifications.

All submitted catalogues and brochures of materials shall be marked on every specific item in the catalogue clearly. The Contractor shall attach with the submittal a table showing every submitted item and its page location in the related catalogue.

All longitudinal items of all kinds which to be installed in the project, such as cables, wires, pipe, profiles, ropes of all kinds, shutters, hand or guard rails, trays, steel sections, safety grills … etc. shall be of maximum and / or standard length that could be manufactured locally and / or outside the country and to the approval of the Engineer.

* 1. Facilities and labor for handling and inspection of all materials and equipment shall be furnished by the Contractor. If the Engineer requires, either prior to beginning or during the progress of the work, the Contractor shall submit additional samples or materials as a specimens and / or for such special tests as may be necessary to demonstrate that they conform to the specifications. Such samples shall be furnished, stored, packed and shipped as directed at the Contractor’s expense.
  2. Any delay of approval resulting from the Contractor’s failure to submit samples, data sheets or compliance sheets promptly shall not be used as a basis of a claim for added time or cost.
  3. In order to demonstrate the proficiency of workmen or to facilitate the choice among several textures, types, finishes and surfaces, the Contractor shall provide such samples of workmanship or finish as may be required.
  4. The materials and equipment used on the work shall correspond to the approved samples or other data.
  5. **Handling and storage of Materials**

1. All materials and equipment to be incorporated in the work shall be handled and stored by the Manufacturer, Fabricator, Supplier and Contractor before, during and after shipment in the approved Contractor’s site stores in a manner to prevent warping, twisting, bending, breaking, chipping, rusting and any injury, theft or damage of any kind whatsoever to the material or equipment.
2. Cement and lime shall be stored under a roof and off the ground and shall be kept completely dry at all times. All structural, miscellaneous, reinforcing steel shall be stored off the ground or otherwise to prevent accumulations of dirt or grease and in a position to prevent accumulations of standing water and to minimize rusting. Beams shall be stored with the webs vertical. Precast concrete shall be handled and stored in a manner to prevent accumulations of dirt, standing water, staining, chipping or cracking. Brick, block and similar masonry products shall be handled and stored in a manner to reduce breakage, chipping, cracking and spalling to a minimum.
3. All electrical and mechanical equipment subject to environmental damage by the atmosphere if stored outdoors shall be stored under shelter cover to prevent injury. The protective cover may be a temporary structure on the site, but it must be approved and satisfactory to the Engineer.
4. All material which, in the opinion of the Engineer, have become so damaged as to be unfit for the use intended or specified shall be promptly removed from the site of the work and the Contractor shall receive no compensation for the damaged material or its removal.
5. All pipe and other materials delivered to the job shall be unloaded and placed in a manner, which will not hamper the normal operation of the existing plant or interfere with the flow of necessary traffic.
6. **ORGANIZATION**
   1. A typical Quality Control organization would be divided into two parts, On-Site and Off-Site. The Off-Site organization reports to a Manager of Procurement. The quality control of materials and equipment from Off-Site shall be the responsibility of the Quality Control Supervisor as they arrive On-Site for inspection, protection, storage, handling and installation in the Permanent Works. The On-Site organization reports to the Quality Control Supervisor, and is further divided into:

1. Testing - to include all laboratory and field materials testing services; and

2. Inspection - to include all construction inspection staff.

* 1. The Quality Control Supervisor in turn, would report directly to the Project Manager.
  2. The Contractor is required to submit his proposed organization complete with names and positions for acceptance.
  3. Contractor shall designate one of his key personnel as Quality Control Supervisor. It shall be the sole duty and responsibility of the Quality Control Supervisor and his staff to organize, coordinate, conduct and otherwise implement the Quality Control Program as submitted by the Contractor and acceptable to the Engineer. No other duties or responsibilities shall be assigned to the Quality Control Supervisor or his staff unless expressly authorized in writing by the Engineer. The Quality Control Supervisor, or his approved alternate, shall be on the Work Site at all times while work is in progress.

1. **SUBMITTALS**
   1. **Quality Control Program**
      1. Within 30 days after "Notice to Proceed" the Contractor shall submit for review to the Engineer a detailed outline of the Quality Control Program proposed. Completed procedures for each element of the outline will be submitted for review and shall be implemented before any new items of work begin.
      2. The Contractor shall be responsible both for the quality of all his manufactured and purchased items and for the construction work. As such, two basic plans will be submitted:

1. Off-Site:

Supplier Quality Control and Inspection Plan which covers all items intended for inspection at the Contractor's and/or supplier's plants and the procedures for carrying out same.

2. On-Site:

On-Site Quality Control and Inspection Plan which covers all aspects of control, inspection and testing of field activities and construction works.

* + 1. Each plan must contain the following key elements which shall be supplemented and updated with additional information from time to time to satisfy the client and the Contractor's internal requirements:
    2. Organization Chart for quality control.
    3. Samples of proposed quality control records, testing forms and reporting forms.
    4. List of proposed "Hold Points", defined as points at which specific inspection and documentation shall be performed by the Contractor and reviewed by the Engineer prior to proceeding.
    5. List of materials and operations which shall be inspected by the Contractor at the various stages of construction together with inspection procedures, test types, and frequencies.
    6. A list of purchased items requiring inspection at the supplier's plant with proposed quality control procedure identified.
    7. A description of the location, layout and capability of the materials laboratory with regard to the testing requirements of this Contract.
    8. Prior to requesting Engineer's review of inspection, the Contractor's inspection personnel will have accepted the work and prepared all necessary documentation for sign-off. The Authorized Representative or his designee should sign for the Engineer, and the Quality Control Supervisor or his designee should sign for the Contractor.
    9. Sign-off of a Hold Point on the pertinent quality control document will constitute removal of the hold and authorized further work to proceed.
    10. When Contractor's Quality Control Program has been reviewed and agreed upon with the Engineer, it shall become a part of the Contract.
  1. **Certificate of Test**

Daily records of On-Site and Off-Site testing and inspection shall be kept on forms of approved format. Test results shall be certified by the appropriate responsible person on the Contractor's quality control team. All test certificates and inspection records shall be clearly identified with the appropriate part of the Permanent Works to which they refer, and they shall be submitted to the Engineer as required.

Certificates of test from suppliers or other Off-Site testing agencies shall also be clearly identified with the appropriate part of the work to which they refer and shall be submitted to the Engineer as soon as they are available, and in any case not later than the date at which the materials to which they refer are delivered to the Work Site.

* 1. **Periodic Reporting**
     1. Daily records of inspection and testing will be prepared and copies submitted to the Engineer daily or as often as directed by the Engineer.
     2. The daily records of inspection and testing will be used as the basis for a Quality Control Weekly Report to be submitted to the Engineer in an acceptable form. This report will summarize all quality control inspections and tests performed over the previous seven days.
     3. The Weekly Quality Control Report shall include all work performed by the quality control organization with all sample numbers assigned in a sequential and consecutive order and details of the sample or test to which each number has been assigned. The Weekly Quality Control Report shall also summarize all inspection reports and any Certificates of Non-Compliance issued or remedied that week for the Permanent Works (i.e.: Off-Site and On-Site).
     4. On a monthly basis, all test data shall be summarized in tabular and/or graphical form in a manner which best illustrates the trends, specific results, and specification requirements and shall be submitted to the Engineer. Where tests do not meet specification requirements, full explanations shall be provided to show what action was taken (i.e. rejection of the work, retest, etc.). On a monthly basis, and from the inspection and testing reports, the Quality Control Supervisor shall clearly indicate what elements of work are completed and recommended by the Contractor for acceptance by the Engineer.
     5. A separate report shall contain a forecast of work to be performed during the next seven days and a description of planned inspection and testing. Hold points shall be identified.
  2. **Inventory Records**

The Contractor shall keep detailed and up-to-date records (in an acceptable form) of all materials and equipment which are on order, delivered, found faulty, lost during the work or found to be surplus to requirements. The Engineer shall have access to these records at all times. Summary inventory records shall be submitted to the Engineer once a month.

* 1. **Additional Quality control Submittals**

Additional submittals will be made as required in the Contract Documents and the approved Quality Control Programs.

* 1. **Submittal Standards** 
     1. Contractor's drawings and data submittals shall be in accordance with other applicable sections of the Contract Documents.
     2. On all Contractor's drawings, the title block must be completed, including the Arabic translation, before being submitted to the Engineer for review.
     3. Where appropriate, all submittals shall be summarized on a cover sheet against the specified requirements so that compliance or exceptions are clearly stated. If proposed for Engineer acceptance, the Contractor shall comment on compliance and recommend accordingly.

1. **MATERIALS AND EQUIPMENT**

The Contractor shall supply all samples for testing and transport necessary for carrying out the Quality Control Program acceptable to the Engineer.

1. **EXECUTION**
   1. The Quality Control Program acceptable to the Engineer shall be followed throughout the performance of the Contract, unless specific acceptance or instructions to the contrary are received from the Engineer in writing.
   2. The Contractor's quality control personnel shall maintain close liaison with the Engineer at all times.
   3. The Contractor shall establish an efficient, comprehensive records facility and library. Drawings, books, publications and manuals shall be indexed and their distribution controlled.
2. **INSPECTION**
   1. The Contractor shall carry out all inspection testing and surveys both in supplier's shops and at the Work Site necessary to ensure that the works is executed in accordance with the Drawings and Specifications. Inspectors shall be qualified and experienced for the work they have to undertake.
   2. Access shall be provided for inspection of the work by the Engineer at all times, but such inspections shall not relieve the Contractor of his responsibilities for performing inspections and tests. The Contractor shall cooperate with the Engineer if any test is performed simultaneously with the Engineer inspection time.
3. **NON-COMPLIANCE**
   1. In the event of non-compliance with specified requirements, the Quality Control Supervisor shall issue a Certificate of Non-Compliance to his Project Manager for immediate remedial action. The Certificate of Non-Compliance shall indicate the following:

1. Date and section of work affected.

2. Description of Non-Compliance (with inspection report on test result attached).

3. Suggested remedial action.

* 1. It shall be endorsed by the Quality Control Supervisor and made immediately available to the Engineer as required. The Certificate of Non-Compliance shall further be used to record the date and nature of successful remedial action which shall again be endorsed by the Quality Control Supervisor. All Certificates of Non-Compliance shall be included in the Weekly Quality Control Report.

1. **ELEMENTS OF A QUALITY CONTROL PROGRAM (OFF-SITE AND ON-SITE)**

The following provides a guideline format for the types of elements that must be included in a Quality Control Program. It is not intended to be all inclusive but rather to give the Contractor a clear picture of the types of elements to be covered. Contractor may use his own format and grouping as long as the required elements are covered.

* 1. **General Items**

1. Scope

2. Organization (Positions, Authority, Responsibilities)

3. Drawing Submittal and Specification Control.

4. Procurement, Manufacturing and Shipping Control.

a. Control of:

(1) Manufacturing

(2) Material and equipment supplies

(3) Subcontractors

b. Receiving control

c. Inventory control

d. storage and maintenance during construction.

5. Survey Control

6. Testing Laboratory Control

7. Calibration of Construction Tools and Equipment.

8. Documentation and Record Storage.

9. Safety.

* 1. **Detailed Items (Off Site)**

1. Wastewater System

a. Gravity pipe and fittings.

b. Pressure pipe, valves and fittings.

c. Wastewater pumps and control panels.

d. Precast manholes/structures, if any.

f. Miscellaneous fabricated steel items, castings, access covers, etc.

2. Portable water system and irrigation

a. Pressure pipe and fittings.

b. Fire hydrants.

c. Meters.

d. Miscellaneous air valves, precast concrete items, fabricated steel items, castings, etc.

3. Storm Drainage System

a. Manhole and inlet castings.

b. Precast manholes and structures.

c. Gravity pipe and fittings.

4. Electrical System

a. High voltage cable transformers and switchgear.

b. Street lights, pedestals, etc.

5. Roads and Streets

a. Signs and hardware.

b. Traffic stripping paint.

c. Concrete batch plant.

d. Asphalt batch plant.

e. Miscellaneous aggregates.

6. Special Architectural Features and Landscape.

a. Plant nursery.

b. Street furniture.

* 1. **Detailed Items (On Site)**

1. Civil

a. Earthwork

(1) General excavation

(2) Backfill/compaction

(3) Trenching

(4) Materials testing and inspections.

b. Concrete

(1) Batch plant inspection and testing.

(2) Formwork

(3) Reinforcement in-place

(4) Concrete inspections

c. Road Work

(1) Sub-grade, sub-base, and base courses.

(2) Impermeable membrane.

(3) Bituminous surface treatment.

(4) Bituminous base and wearing courses.

(5) Road markings.

d. Structural and Miscellaneous Steel

(1) Receiving.

(2) Pre-Erection.

(3) Welding.

(4) Bolted connections.

(5) Erection complete.

(6) Painting.

e. Other Civil

(1) Precast concrete.

(2) Masonry.

(3) Manholes.

(4) Others.

f. Asphalt

(1) Batch Plant.

(2) In-place inspections.

(3) Material testing and inspection.

g. Architectural

(1) Fare face wall panels.

(2) Roofs.

(3) Doors, windows, louvers, vents, etc.

(4) Rendering.

(5) Internal/external finishes.

2. Mechanical/Piping

a. Pipe

(1) Materials.

(2) Supports, hangers.

(3) Coatings.

(4) Installation inspections.

(5) Testing.

b. Valves

c. Mechanical Equipment

(1) Storage and Maintenance.

(2) Installation and inspections.

(3) Testing.

d. Tanks and Vessels

(1) Installation inspections.

(2) Testing.

e. Welding

(1) Procedure qualification.

(2) Welder qualification.

(3) Testing and inspections.

f. Insulation

3. Instrumentation

4. Electrical

a. Equipment

(1) Storage and maintenance.

(2) Installation inspections.

(3) Testing.

b. Conduit

c. Cable

d. Connections

e. Ducts

f. Manholes

5. Protective Coatings and Painting Systems.

1. **AS-BUILT DRAWINGS**

The Contractor is required to prepare and furnish to the Engineer a complete set of "As-Built" drawings of the constructed works. To achieve this, the Contractor must collect and maintain the necessary data as the work progresses. He shall incorporate this requirement into his Quality Control Program and shall prepare "As-Built" drawings of portions of the works as completed. The as-built information shall be submitted to the Engineer progressively on a monthly basis, in a format proposed by the Contractor and acceptable to the Engineer.

Upon completion, the as-built drawings shall show accurately the entire works as and where constructed including all changes and deviations from the Contract Documents.

**12-1 As-Built Requirements**

"As-Built" drawings record field changes. The location in plan and elevation of buried utilities, the correct installation of piping and equipment, the addition of complete electrical information on single line and schematic diagram, and other deviations from the design are to be shown. As a minimum the following information (where applicable) is required on "As-Built" drawings:

**CIVIL:**

\* Facility limits and centerlines by coordinates and/or stationing based on coordinate points, by survey.

\* Plan location for buried utilities, culverts and drains, by coordinates or dimensions from centerline of roads, building, etc.

\* Elevation of changes in slope or direction, by survey. Manholes elevation by survey.

\* Location and elevation of existing utilities exposed during excavation.

\* Deviation from design drawings by dimensions, plan location and elevations.

\* Location of encased utility services and embedded metal if different from design.

\* Ditch and roadway centerline elevations by survey. Spot elevation on grade by survey.

\* Changes and substitutions in structural steel members.

**ARCHITECTURAL:**

\* Locations and identifying numbers referring to schedules.

**MECHANICAL:**

\* Locations of equipment, pipe, etc., referenced to equipment lists with identifying numbers.

\* Process piping and instrumentation diagrams as installed.

\* Equipment and instrumentation data sheets with identifying descriptions, numbers and settings.

\* Variations in location or arrangement of mechanical equipment or systems.

\* Any deviation from design drawings.

**ELECTRICAL:**

\* Plan location and elevations for underground and under floor conduit and cable routings.

\* Underground splice locations by survey or locating measurements.

\* Ground cables and rods by locating measurements.

\* Pole numbers on layout drawings for power and telecommunication pole lines.

\* Show equipment ratings and device/equipment numbers; power transformer impedances; C.T. ratios; cable size, conductors and cable numbers; system phasing, where differing from design.

\* Schematics with equipment/device numbers, wire and cable numbers, terminal numbers, and special sequencing or logic descriptions, where differing from design.

**TELECOMMUNICATION:** (addition to above applicable electrical)

\* Above grade cable routing with box and equipment numbers and location. Connections with trunk identification and assignment.

\* Cable pair loading coils.

The Engineer will provide the Contractor with reproducible sepia of each of the Contract Drawings for his use in preparation of the "As-Built" Drawings. The Contractor shall include any additional drawings, reproducible, or other information, which provide a clear, concise record of the Permanent Works.

The "As-Built" drawings shall be clearly labeled in large letters over the title block "As-Built". In addition, the drawings shall show the as-built revision in the title block as the last revision to the Contract Drawings.

The "As-Built" reproducible must be of good quality and totally legible in a reproduced form.

**END OF SECTION**

# SECTION 01510

# FIELD OFFICES AND TEMPORARY UTILITIES

**1- DESCRIPTION**

This section covers the construction services which the Contractor shall provide in the prosecution of work under this Contract.

**1-1 Related Work**

Other items of work that relate to and are referenced in this section include, but are not limited to, the following section:

Scope of Work

General Requirements.

Testing and Testing Laboratory Services

General Equipment and Material Stipulations

**2- REQUIREMENTS OF REGULATORY AGENCY**

Contractor shall comply with all local codes and regulations and with the requirements of the various utility’s companies.

1. **MATERIALS**

Materials shall be brand new and must be adequate in quality and capacity for the required usage, must not create unsafe conditions, and must not violate requirements of applicable codes and standards and must be approved by the Engineer.

1. **TEMPORARY OFFICES REQUIREMENTS**

Upon signature of construction Contract, the Contractor shall procure, install, complete and operate the field offices.

Buildings shall be structurally sound, watertight, with floors raised above ground. Walls and roof shall be constructed of materials providing a coefficient of heat transfer ("U" factor) of not more than 0.15. Up to the Engineer's option and approval, portable or mobile buildings that are modified for office use may be used, in case that permanent flat(s) or building is not available.

* 1. **Contractor's Office**

During the performance of this Contract, the Contractor shall maintain a suitable office at or near the site of the work which shall be the headquarters of a Contractor representative authorized to receive drawings, instructions, or other communication or articles. Any communication given to the said representative or delivered at the Contractor's office at the site of the work in his absence shall be deemed to have been delivered to the Contractor.

Copies of the drawings, specifications, and other Contract Documents shall be kept at the Contractor's office at the site of the work available for use at all times.

* 1. **Engineer's Offices**

1. Temporary offices shall be established on the job site where approved or directed by the Engineer, adequately furnished, and maintained in a clean, orderly condition by the Contractor. The Contractor or his authorized representative shall be present in the field office at all times while work is in progress. Instructions received there from the Engineer at the field office shall be considered as delivered to the Contractor.
2. Provide either a separate building or a rented area in an existing building of at least 120 square meters of floor space or as approved by the Engineer for the exclusive use of the Engineers and staff throughout the period of construction. The Contractor shall provide air-conditioned (cooling / heating) offices facility in addition to outer shed area for 6 car rooms for the Engineer. It shall be located at sites acceptable to the Engineer and the Client. The Employer’s representative will be provided a separate room at least 20 square meters.

In case of mobile or prefabricated offices, the temporary office shall be weather-tight, have a tight floor at least 60 cm off the ground and shall be insulated all around with rigid insulation board not less than 12 mm thick, and suitably ventilated. Each room of the office shall have at least two screened and barred aluminum / glass windows capable of being opened, a screen door and a solid door provided with cylinder lock and three keys. Floor coving with polyvinyl robust glued to floor mats shall be provided. The building walls shall be covered on the interior and the exterior surfaces with vain and humid proof sticking cover. The office shall be provided with janitorial service including for tea, coffee, Nescafe, coffee mate, milk and tea boy during all the working time, heating equipment, electrical wiring, outlets, and fixtures suitable to light the tables and desk adequately as directed. Office consumables such as stationary, pencils, copy paper, color markers, file folders…etc. are to be provided throughout the duration of the project. Separate toilet facilities shall be provided for the exclusive use of the Engineer and staff.

The offices shall be equipped by the Contractor with adequate lighting (minimum illumination value 400 Lux.), adequate ventilation and kitchen stove for which the Contractor shall provide all energy. Office shall have a telephone, facsimile and E-mail facilities in accordance with the Temporary Facilities Section. In addition, the office shall be equipped with air conditioning facilities.

Following is a minimum listing of furnishings required for six men occupancy. It is the intent that local purchased materials and manufactured items be used shall be brand new.

1. In addition to the requirements mentioned hereinbefore, the Contractor shall furnish and install the following furniture in the office, all to the approval of the Engineer:

Item Quantity

* + 1. Desk, `L' shaped 2 parts (2m x 1m + 1.5m x 0.5m) 1
    2. Desk, double pedestal, 1.0m x 1.5m 3
    3. Desk `L' shaped secretarial unit 2 parts (1.60m x 80m & 1.2m x 0.5m) 1
    4. Table plan, 1.5 x 2.0m 2
    5. Chairs, without arms (Lounge type-cloth upholstery) swivel

on castors, manual adjustable height 6

* + 1. Chairs, swivel on castors (cloth upholstery) with arms height by

Auto-arm 8

* + 1. Table, drafting board with parallel action as approved 1
    2. Storage cabinet, steel with adjustable shelves 0.75m x 0.45m x 2.0m

With manual & cylinder lock 2

* + 1. File cabinet, 4 drawer legal size (lockable) 2
    2. Straight chairs 6
    3. Table conference 1.2m x 3.0m 1
    4. Bulletin board 1.2m x 2.5m 1
    5. Bulletin board 1.2m x 3.5m 1
    6. Book shelf 1.0m x 1.0m, 3 shelves 4
    7. Filling trays, waste paper basket, ashtray 5 sets
    8. General office equipment-punch, stapler sharpener, etc. 5 sets
    9. Drafting equipment as specified by Eng. 1 set
    10. Plastic 5 liter insulated cooler 2
    11. Refrigerator (12 Cubic Feet)- no Frost 1
    12. Water container 3
    13. Fire extinguisher (5 kg.) 2
    14. First aid kit suitable for ten people with manuals similar to American

White Cross No. K10 or approved equal 5

* + 1. Six (6) sets of raingears, plastic safety helmets, rubber boots and

2-battery (D size, 1.5V) flashlights. 5

* + 1. Coat rack and hooks 3
    2. Photocopying machine, similar to Xerox Model 1025 I or approved equal
    3. Any other sundries required by the Engineer.

1. HARDWARE

The Contractor shall furnish, supply and maintain the following equipment for the offices of the Employer and the Employer’s Representative’s office. The costs for the supply and maintenance of the computers shall be borne by the Contractor and shall be deemed to be included in the Contract rates.

The computers and printers are to be of the latest model brand new, available in the local market of a reputable brands (Dell, Compaq or equivalent), totally assembled by the mother company and approved by the Engineer.

2 Nos. of each of the following hardware items are the minimum that are to be included by the mother company and of brands equivalent to those mentioned.

**D1. Computer 4 Sets (with all accessories)**

* + Intel Core I 7 3.65 GHz
  + 16 GB DD Ram 533/800 MHz
  + 500 SSD Hardisk drive.
* DVD writer
* Keyboard Deluxe
* Mouse Microsoft
* 64-bit PCI Ethernet card, 10/100 PCI Ethernet Adapter
* D-link Wireless card 150
* 19 “LG LCD Monitor
* Microsoft Windows 10 Arabic/English

**D2 Printer 2 Sets**

1 No. - HP Deskjet A3 / A4 Inkjet Printer

30 PPM B&W, 20 PPM CLR

1200 Dpi B& W, 4800 x 1200 dpi color resolution

1 No. – HP Laser, A3, A4, 40ppm, B & W printer

1200 Dpi, 4800 x 1200 dpi color resolution

**D3. Software**

* + Full equipped with full licensed software
  + Licensed Windows XP Pro.

**D4. Maintenance**

* The contractor shall provide for the maintenance of the computer and its equipments including printer ink and spare parts, for the whole duration of the Contract and the Engineers Offices.

**Notes:**

1. One of the PCs shall be 17”, other 2 (15”) and the 4th PC shall be Lap Top Complete with built in Floppy and CD facility.

2. Both PCs & Printers should be latest version of type at the year of submittals and approved by the Engineer.

1. The Contractor shall supply all fuel for heating and pay all electrical bills for the all field offices & Temporary utilities
2. LABORATORY TESTS:

All required tests, will be send to an approved laboratory accepted by the Engineer. Unless otherwise specified else were. All tests shall be performed under the supervision of the Engineer. All relevant costs will be borne by the Contractor.

* 1. **Preparation**

The Contractor shall fill, compact, and grade the site as required to provide proper surface drainage away from the structure.

Prior to installation of the office, Contractor shall obtain acceptance from the Engineer and Client on locations, access, and related facilities.

* 1. **Installation**

The Contractor shall construct the offices on proper foundation, provide steps and landings at all entrances doors and provide connections for utilities. When portable or mobile buildings are used for offices, they shall be secured to foundations to prevent uplift. The offices should be higher than the ground level by at least 60 cm.

* 1. **Maintenance and Cleaning**

The Contractor shall provide at his cost one office boy to work at the Engineer's office. All necessary maintenance shall be properly performed and supplied by the Contractor.

* 1. **Reconditioning**

Field offices furnished by the Contractor shall be the property of the Contractor and shall be removed from the site upon request by the Engineer, leaving the area clean and free of debris.

* 1. **Payment**

A. Engineer's Site office

All expenses for the provision of Engineer's site office facility, Maintenance and disposable supplies, shall be borne by the Contractor and shall be deemed to be included in the Contract rates.

Should the Contractor delay in the completion of the field offices beyond thirty (30) days after the signature of construction Contract, therefore, the Contractor will be penalized with (250) U. S. Dollars, per day of the delay period, in addition of payment for rented fully furnished office space as approved by the Engineer during the delay period and until the field offices completion.

1. **TEMPORARY SERVICES:**

**5-1 Electric Power**

The Contractor shall arrange with the utility company, to provide service required for power and lighting including that needed by the Engineer’s and Employer's temporary field offices.

In addition, the Contractor shall provide and install circuits and branch wiring, with area distribution boxes located so that power and lighting is available throughout the construction by the use of construction-type power cords.

The Contractor shall provide a standby generator of enough capacity to supply the temporary offices with power in case of the Utility power is off. All the cost of supply, installation and operation of this standby power shall be covered by the Contractor without any cost reimbursement by the Employer.

* 1. **Temporary Lighting**

The Contractor shall furnish and install all temporary lighting required for the prosecution of his work. Conductors shall be not less than 12 AWG and insulated for 600 volts. A CB. shall be provided for the protection of each circuit within the mcb panel for the whole facility.

* 1. **Temporary Heat and Ventilation**

The Contractor shall provide temporary heat and ventilation as required to maintain adequate environmental conditions to all temporary and permanent facilities through the progress of the work, to meet specified minimum conditions for the installation of materials and to protect materials and finishes from damage due to temperature or humidity.

The Contractor shall provide adequate forced ventilation of enclosed areas for curing of installed materials, to disperse humidity, and to prevent hazardous accumulations of dust, fumes, vapours or gases.

Heating equipment and fuels will be suitable for the particular purpose and include adequate safety devices. Combustion type heaters shall not be used without proper venting nor in areas where such equipment might introduce a hazard.

* 1. **Temporary Telephone Service**
     1. ***Land Lines:***

Contractor shall make all necessary arrangements and pay all installation charges for telephone lines in his offices at the site and a separate 2 (two) fixed telephone lines in the Engineer's offices; one telephone set in each office room connected to the exchange + 1 fixed line direct to the Project Manager Engineer’s Office + 1 fixed line to the exchange, and shall provide all telephone instruments of brand new sets.

The Contractor shall fulfill the followings for the Engineer’s Office:

1. Install private telephones in the field offices. Pay all bills charged against the private telephones (excluding only out-of-country calls), including installation charges and all monthly charges throughout the construction period. Monthly charges to be paid by the Contractor shall not exceed 200 US$ per each line.
2. Provide in conjunction with the telephone, an automatic telephone-answering device to record messages when the office is not manned.
3. Provide in conjunction with the telephone a fax machine for receiving correspondence. The fax machine shall be equivalent to Sharp UX-222 or approved equal. The Contractor shall provide all paper and ink for the fax machine for the duration the Contract.
   * 1. ***Mobile Lines:*** 
        1. Mobile Lines with Land Lines

In case of the presence of land line telephony and exchange supplied to the Engineer’s temporary offices, the Contractor shall install all of these land lines as illustrated in (5.4.1) above. In addition, the Contractor shall also supply to the Engineer (7) mobile phones with their lines. The usage of these sets shall be to the Engineers Staff and one of them to the Employer’s liaison Engineer.

* + - 1. Mobile Lines Only:

In case of absence of land lines due to very far distance which may be very costly or impossibility to install these lines and according to the Engineer’s approval, the Contractor shall supply the Engineer with minimum (8) sets of mobile phones and lines. The supply of these mobiles shall be in (1) week of the Engineer’s commencement’s date of his job either in his main office or in his temporary offices.

The usage of these sets shall be (6 sets) to the Engineer’s staff and one to the Employers liaison engineer. The fifth set shall be connected to a central exchange with land branches to all Engineers’ offices with the facility of automatic answering device and fax as detailed in (5.4.1-b & c above).

In both cases, the Contractor shall also pay all installation, maintenance (and substitute the malfunctioning set) costs, fees and monthly bills of all sets (Land lines and Mobile lines and their accessories), with calls charges not more than (60 US$) for each mobile line (excluding the international calls which shall not be paid by the Contractor).

* 1. **Temporary Communication System**

The Contractor shall provide his own temporary communications system, including all that for the Engineers offices.

The Contractor shall provide his Project Manager with a mobile set and line. The monthly charges for this mobile shall be paid by the Contractor and shall not exceed 250 US$.

The Contractor shall pay costs for installation, maintenance, and removal of temporary services, and restoration of existing or permanent facilities used.

* 1. **Temporary Water**

The Contractor shall provide the Engineer’s temporary offices with drinking water continuously throughout the Contract duration, including the provision and installation of all the required facilities (Water Tanks, Plumbing, Sinks, Drainage... etc). No separate payment for water and facilities shall be paid to the Contractor and all costs shall be deemed to be included in the Tender price.

All water required for and in connection with the work to be performed, and for any specified tests of piping, equipment, devices tightness of reservoirs, tanks, … etc., and for any other use as may be required for proper completion of the work shall meet drinking water standards or clean water of standards approved by the Engineer which shall be provided by and at the expense of the Contractor. No separate payment for water used or required for testing will be made and all costs in connection therewith shall be included in the Tender price.

* 1. **Temporary Sanitary Facilities**

The Contractor shall furnish temporary sanitary facilities at the sites, as provided herein, for the needs of all construction workers and others performing work or furnishing services on the Project.

Sanitary facilities shall be of reasonable capacity, properly cleaned and maintained daily throughout the construction period, and obscured from public view to the greatest practical extent. If toilets of the chemically treated type are used, at least one toilet shall be furnished for each 10 men.

For Engineer’s offices, toilets of normal type shall be one for 6 men but 3 minimum (two Euro type, one of them for the Project Manager / Engineer, the other Asian type).

* 1. **Compressed Air**

The Contractor shall provide all compressors, fuels, lubricants, hoses, piping, and other apparatus required for supplying compressed air required for prosecution of the work.

* 1. **First Aid**

The Contractor shall provide first aid facilities for his and subcontractor's employees, and one cupboard with sufficient First Aid inclusive for the Engineer offices

* 1. **Fire Extinguishers**

Wall mounted hand fire extinguishers shall be of the all-purpose, nitrogen-pressured, dry chemical type. Fire extinguishers shall be provided at each site during construction, 2 min. for Engineer offices. The fire extinguishers shall meet the new Underwriters' Laboratories Standards and shall carry the U.L. rating of 4A-40B.C. Capacity of the extinguishers shall be 6 kg and the color of the shell shall be red. Wall mounting brackets shall be furnished.

* 1. **Safety and Security Equipments**

The Contractor shall provide all safety equipment necessary for the safely and securely construction and completion. This equipment are, but not limited to barriers, barricades, temporary fence, safety helmets, safety boats, guardrails, handrails, scaffolding ladders, signs ... etc. No separate payment will be made for this item.

* 1. **Temporary Fence**

The Contractor shall provide adequate temporary security fences, access roads crossovers, gangways, gates, entrances barriers to surround the limit of works, shop drawings shall be made by the Contractor and approved by the Engineer. The security fence must be made in accordance with the Employer and Engineer requirements to ensure the securely of the working area.

* 1. **Temporary Storm water Drainage**

Allow for ensuring that the whole of the excavation and site are kept free from risk of stormwater flooding and providing such temporary ditches, gullies and the like as may be necessary and for subsequently backfilling such excavations. Any damage arising from noncompliance with this clause is to be made good at the Contractor's own expense.

* 1. **Scaffolding and Plant**

Allow for providing all scaffolding, hoists, tackle and other plants, profiles, templates, centering, and equipment generally required for the proper, safe and efficient execution of the works including sub-contractors works and providing all labor and things required by the Engineer for testing and measuring the works and for weighting, measuring or testing the efficiency of any portion of the work.

The Contractor is particularly to note that scaffolding, staging and the like is to be provided from the execution of his own work and that of sub-contractors employed under this Contract, including that required solely for the execution of work by sub-contractors.

Also allow for providing all gangways, walkways, planking, decking, ladders, temporary platforms, etc. necessary to construct and afford access to or between all parts of the works. All scaffolding and plant shall be erected and used in accordance with the applicable local laws and to the satisfaction of the Engineer.

* 1. **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 services shall only be made with the prior approval of the Engineer.

* 1. **Existing Installations**

Allow for protecting and maintenance all pipes, ducts and cables met in excavations, for keeping all ditches, gullies and channels clear and unobstructed and for making good any damaged caused to public or private roads, paths, curbs and drains and paying all costs and charges included.

* 1. **Clearing Rubbish**

Allow for clearing away all shavings, cuttings and other rubbish as it accumulates from time to time during the progress of the works (and at completion), including that of sub-contractors and specialist tradesmen and the disposal of all materials condemned by the Engineer. The Contractor is particularly to note that daily cleaning of rubbish may be asked by the Engineer where necessary.

The Contractor shall keep the construction site neat and cleaned up by continually removing surplus building materials, rubbish and temporary installation on the site to public dumping areas indicated by the local authority (Municipality). He shall also have to obtain a certificate from the local Authority certifying that the site is clean prior to taking over the works to the Employer.

* 1. **Temporary Works Generally**

The contractor shall ensure that all temporary electrical, water and other temporary installations are existed in accordance with the requirements of the authorities concerned. All temporary works are to be properly and adequately maintained and on completion of the Contract or when directed by the Engineer shall be cleaned away by the Contractor and all disturbed works made good. Any works damaged by failure to provide proper protection shall be removed and replaced with new work at the Contractor's expense.

1. **Ownership of Engineer’s Temporary Facilities after**

**Completion of Contract**

After the official completion (issuing the completion certificate by the Employer) of the Contract the Contractor shall hand over ownership and title to the Employer the following items specified in this section:

1. The computers.
2. The fax machine.
3. The photocopy machine.
4. All Furniture.

**END OF SECTION**

# SECTION 01515

# TRAFFIC CONTROL AND

# BARRICADING / CHANNELIZATION

**PART 1 - GENERAL**

* 1. **SCOPE OF WORK**

1. Furnish all labor, equipment, materials and all incidentals required to control and maintain traffic safely and efficiently at construction site locations as shown on the Drawings.
2. Abide by the requirements of the traffic and / or police authority.
   1. **RELATED WORK**
3. Pavement replacement is included under Section 02512.
4. Excavation, backfilling and compaction included under Section 02220.
   1. **REQUIREMENTS**
5. At least 15 days before doing any work in any job site notify said traffic and / or police authority and meet all requirements and conditions necessary.
6. In addition, comply with the following:
   1. At all times the main highways shall be open to two-way traffic unless approval to close a lane is obtained from the above-mentioned traffic and / or police authority.
   2. Make arrangements to the satisfaction of above authorities such that Fridays, holidays, or nighttime emergency work can be made immediately when and if necessary while the works is in progress.
   3. Do not store any materials on the roadway and shoulders that would interfere with the flow of traffic.
   4. Make every effort to accomplish the work as quickly and as efficiently as possible.
   5. Steel plates to cover trenches as directed by the Engineer shall be readily available at the site for use where necessary to protect the traveling public.
   6. Replace all traffic signs and pavement markings, which have been destroyed, disturbed or paved over.

**PART 2 - PRODUCTS**

* 1. **SIGNS**
  2. Contractor shall provide temporary (portable) traffic control signs (in the Arabic and English Languages) to alert, advise and guide the traveling motorist and pedestrians of upcoming traffic restrictions.
  3. Signs will have a minimum side dimension of 750mm, mounted so that the lowest part of the sign is 2.0 meter above the ground.



750mm x 750mm

Black letter, red background



750mm x 750mm

Black letters, orange background



750mm x 750mm

Black letters, orange background



750mm x 750mm

Black letters, orange background



750mm x 750mm

Black letters, orange background



750mm x 750mm

Black letters, orange background

### **STREET**

### **CLOSED**

750mm x 750mm

Black letters, orange background

### **SPEED**

### **LIMIT**

### **40**

600mm x 600mm

Black letters, orange background

* 1. **BARRICADES**

Contractor shall provide barricades and channelizing devices to protect workmen when working in the street. Barricades and channelizing devices shall be kept clean and fresh appearing at all times.

Marking for barricade panels shall be alternate orange and white stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass). Both stripes (orange and white) on all barricades panels shall be reflectorized with smooth surface weatherproof reflectorized sheeting.

sign road-1All barricades shall be constructed of suitable material to the dimensions shown herein. Barricade supports shall be substantial and white in color.

* 1. **BARRICADE WARNING LIGHTS**

The Contractor shall provide barricade warning lights for distant sighting, and marking unexpected hazards in the public right-of-way to alert the motorist that he is traveling in a construction area. They shall be mounted on all barricades, devices during hours of darkness. Barricade warning lights shall be in operation during hours of darkness.

Barricade warning lights shall be portable, battery operated, lens directed, and enclosed flashing lights.

Barricade warning lights used on signs, barricades and channelizing devices, except high level warning devices, shall be bi-directional. Barricade warning lights used on high level warning devices shall be unidirectional, incorporating the use of a parabolic reflector for increased intensity.

Barricade warning light lenses shall have a minimum effective diameter of 175mm. The color of the light emitted shall be yellow.

* 1. **HIGH LEVEL WARNING DEVICES**

The Contractor shall provide flag type high level warning devices to alert the motorist of an obstruction in the street. These are to be seen over the top of preceding vehicles. Height should be at least 2.4 m above ground to be effective in diverting traffic around obstructions.

sign road-2

* 1. Flag type high level warning devices shall display three flags so that the lowest point of all three flags is 2.4m or more above the street. The flag shall be 400mm square or larger. Flags shall be orange of fluorescent red-orange in color. The flag support shall be substantial to resist overturning by wind.
  2. During hours of darkness, each flag type high level warning device must be equipped with a minimum of one operating flasher with lens mounted more than 2.4m above the street.
  3. **CHANNELIZING DEVICES**

1. The Contractor shall provide traffic cones for daytime channelization of traffic and to delineate minor construction / maintenance areas. Traffic cones shall only be used during the daylight hours; and, if channelization is needed at night, they should be replaced with vertical panel channelizing device with warning lights.

Traffic cones may be conical or tubular devices generally with square weighted bases. The conical devices shall be a minimum of 0.5m high. The tubular devices shall be a minimum of 0.7m high shall be orange or fluorescent red-orange.

Traffic cones shall be used to channel traffic, divide opposing traffic lanes, and delineate minor construction operations in the street.

Cones should be placed in accordance with taper lengths. Spacing of cones shall exceed 7.5 meters.

1. Vertical Panel Channelizing Devices.

The Contractor shall provide vertical panel channelizing devices for 24-hours channelization, using flashing warning lights mounted at the top.

Markings for all vertical panel channelizing devices shall be alternate 200mm orange and white stripes sloping down at an angle of 45 degrees to the side of which traffic must pass.

Vertical panel channelizing devices shall be constructed of suitable material to the dimensions shown. The base and panel support shall be substantial and white in color.

sign road-3All vertical panel channelizing devices used in the right – of – way during hours of darkness shall have a barricade warning light attached and in operation. The warning light shall be mounted above the marked panel.

**PART 3 - EXECUTION**

* 1. **FLAGMEN**

The Contractor shall provide flagmen at locations where equipment is intermittently blocking or crossing a traffic lane or where only one traffic lane is available for two directions of traffic. Absence of flagmen is critical construction locations is enough reason for the Engineer’s Representative to order the Contractor to stop work immediately, cover up open trenches and put the area back to a “safe” motorist and pedestrian environment.

Flagmen shall be trained, alert, courteous, neat and possess a sense of responsibility for the safety of the public and work crew. Flagmen shall wear orange or fluorescent red-orange vests when assisting with traffic control. The use of orange or fluorescent red-orange hats is desirable.

Flagmen shall use a 600mm square red or fluorescent red-orange flag on a 1-meter long staff to control traffic.

Flagmen shall be stationed at a readily visible location in advance of the restriction. Flagmen stations shall be marked with a high-level warning device. “Flagman Ahead” and “Be Prepared to Stop” signs shall be used in advance of each station.

During hours of darkness, flagman stations shall be illuminated. All traffic control devices shall be reflectorized and have barricade warning lights.

* 1. **PEDESTRIAN WALKWAYS**

Where deemed necessary by the Engineer, the Contractor shall provide a pedestrian walking area, whether it existed previously or not in active construction areas. The Contractor shall maintain it at all times at that active construction site.

All walkways shall be clearly identified, protected from motor vehicle traffic and free of pedestrian hazards (holes, debris, dust, mud, etc.). Pedestrians using temporary walkways shall be protected using traffic control devices, including barricades, cones, signs, etc.

* 1. **STREET CLOSURES**

The Engineers will not approve a street closure strictly for the convenience of the Contractor. A street closure will be approved only when the Engineer determines it is necessary for the safety of the motorist and pedestrian as well as the Contractor. The procedure for obtaining permission to close a road and to properly sign this road is as follows:

* + 1. **Permit**

A street closure permit shall be submitted for review five working days prior to requested closure date.

* + 1. **Signing**

***Major Street***

The “Street Closed To Thru Traffic” sign shall be used for all complete closures of main streets. When in use, the proper “Detour Arrow” and other detour instructions shall be displayed. “Street Closed Ahead” and “Detour Ahead” Signs shall be used in advance of the closure at the following distances:

|  |  |  |  |
| --- | --- | --- | --- |
| “Street Closed Ahead” | |  | “Detour Ahead” |
| 40 KPH | 180 m |  | 90 m |
| 75 KPH | 300 m |  | 150 m |

***Local Streets***

The “Street Closed” with the “Local Traffic Only” sign installed underneath shall be used. On local street closures, the Engineer requires five days advance notice for review. If the closure is approved, the Contractor is required to notify the home owners affected by the closure by mailings, door messages, or in person, of the street closure at least twenty-four hours prior to the closing of the street.



750mm x 750mm

Black letters on orange background

* 1. **BARRICADING ILLUSTRATION**

The traffic channelization and barricading illustration on the following page is presented to show typical application of sings, barricades and channelizing devices.

They illustrate the method for uniform application of standard traffic control devices. Specific situations not illustrated must be applied for by the Contractor and approved by the Engineer.

Barricades or vertical panel channelizing devices shall be used at all times to mark hazards (excavations, holes, equipment, construction materials, piles of dirt, sand, etc.), close streets and to protect workmen in the public right-of-way.

Channelization may include the use of traffic cones during daylight hours. Traffic cones must be replaced with barricades and / or vertical panel channelizing devices during hours of darkness.

All traffic control devices during hours of darkness must be reflectorized and equipped with barricade warning lights, all stripes (orange and white) on all vertical panels shall be reflectorized with smooth surface weatherproof sheeting.

* 1. **TRAFFIC CONTROL – WATER CONSTRUCTION**

As a general rule, waterlines are to be constructed on either side or both sides of a street. Dual water lines, when required, occur in streets with right-of-way 12 meters or larger.

To minimize traffic / neighborhood disruption, Contractor will be required to work on one line per street. Where dual lines are to be installed in the same street, Contractor will not be permitted to open both trench excavations simultaneously. The following guidelines are proposed.

1. For streets with right-of-way less than 8 meters:
   1. Street closure may be required.
   2. Should the Contractor elect not to close street, Contractor shall provide for restricted traffic condition and provide necessary barricading and flagman.
2. For streets with right-of way between 8 – 10 meters:
   1. Restricted traffic condition with necessary barricading. Flagman required where conditions indicate one lane flow of traffic only.
   2. Traffic flow to be controlled at 25 KPH (maximum).
3. For streets with right-of-way 12 meters:

Same as (2) above, except traffic flow can be 30 KPH (maximum). With careful attention to traffic barricading, and where two lanes of traffic can be maintained, flagman may be optional.

1. For streets with right-of-way between 14 – 16 meters:

Same as (2) above, except traffic flow can be 40 KPH (maximum). With careful attention to traffic barricading, and where two lanes of traffic can be maintained, flagman may be optional.

**END OF SECTION**

# SECTION 01530

# BARRIERS

**PART 1 – GENERAL**

* 1. **DESCRIPTION**

This section covers the requirements for providing, installing, and maintaining suitable barriers as required to prevent public entry, and to protect the work, existing facilities, trees and plants from construction operations.

* 1. **REQUIREMENTS OF REGULATORY AGENCY**

Contractor shall comply with all local codes and regulation within the Country.

**PART 2 – PRODUCTS**

**MATERIALS**

Materials may be new or used, but must be suitable for the required usage.

* 1. **FENCING**

Materials to be used in the construction of fencing may be chain link.

* 1. **BARRIERS**

It is the intent to provide all sites with suitable barriers to prevent entry of the general public and safeguard personnel from traffic dangers.

Barriers shall be of materials at the Contractor's option and as appropriate to serve the required purpose. The Contractor shall provide and maintain suitable and safe bridges, detours, or other temporary expedients for the accommodation of private travel and shall give reasonable notice before interfering with them.

**2.3.1 Barricades and Lights**

All roads, which partially or totally closed to traffic shall be protected by effective barricades on which shall be placed acceptable warning signs. Barricades shall be located at the nearest appropriate positions and shall comply with the requirements & procedures illustrated in section 01515.

All open trenches and other excavations shall have suitable barricades, signs, and lights to provide adequate protection to personnel. Obstructions such as material piles and equipment shall be provided with similar warning signs and lights.

**PART 3 – EXECUTION**

**INSTALLATION**

Fencing, barriers, and other facilities shall be located and installed as directed by the Engineer in a neat and reasonable uniform appearance, shall be structurally adequate for the required purpose.

The Contractor shall maintain the barriers during the entire construction period, relocating as required by the progress of construction.

* 1. **TREE AND PLANT PROTECTION**

The Contractor shall preserve and protect all existing trees and plants at the sites which are designated to remain, and those adjacent to the sites when directed by the Engineer.

All trees and other vegetation which must be removed to perform the Work shall be removed and disposed by the Contractor; however, no trees or cultured plants shall be unnecessarily removed unless directed so by the Engineer. All trees and plants not removed shall be protected against injury from construction operations.

Contractor shall take extra measures to protect trees designated to be preserved, such as erecting barricades, trimming to prevent damage from construction equipment, and installing pipe and other Work by means of hand excavation or tunneling methods.

Such trees shall not be endangered by stockpiling excavated material or storing equipment against the trunk.

When the injury or removal of trees designated to be preserved cannot be avoided, or when removal and replacement is indicated on the Drawings, each tree injured beyond repair or removed shall be replaced with a similar tree of the nearest size possible.

All trimming, repair, and replacement of trees and plants shall be performed by qualified nurserymen or horticulturists.

* 1. **REMOVAL**

The Contractor shall completely remove barricades, including foundations, when construction has progressed to the point that they are no longer needed, and when acceptable to the Engineer.

The Contractor shall clean and repair damage caused by installation of any barriers and fill and grade the areas of the site to required elevations and slopes, and clean the area to the satisfaction of the Engineer.

**END OF SECTION**

# SECTION 01580

# PROJECT IDENTIFICATION SIGNS

**PART 1 - GENERAL**

* 1. **REQUIREMENTS INCLUDED**

1. Furnish, install and maintain project identification sign(s).
2. Remove sign(s) on completion of construction.
   1. **MEASUREMENT AND PAYMENT**
3. Unit Prices: No separate payment will be made for the work included in this Section. Include the cost of the project identification signs in overhead cost.
4. Stipulated price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.
   1. **SUBMITTALS**
5. In accordance with the requirements of Section 01300.
   1. **SYSTEM DESCRIPTION**
6. Sign Constructions: Within seven (7) Calendar days after Date of Commencement, the Contractor shall furnish, erect a Project Identification Signs, of not less than 3 square meters area each, constructed of new material with painted graphic, content to include:
   1. Title of Project:
   2. Project No.:
   3. Owner:
   4. Funding Agency:
   5. Engineer:
   6. General Contractor:
7. Appearance: Project identification signs shall be maintained to present a clean and neat look throughout the project duration.
8. Sign Manufacturer / Maker: Experienced as a professional sign company.
9. Sign Placement: Place signs at locations as directed by Engineer. The Engineer will provide sign placement instructions at the pre-construction meeting.
   1. A linear project is one involving paving, overlay, sewer lines, storm drainage, or water mains that run in the right-of-way over a distance. A linear project requires a project identification sign at each end of the construction site.
   2. Single Site or Building Projects: Provide one project identification sign.
   3. Multiple Sites: Provide on project identification sign at each site.
   4. Sign Relocation: as work progresses at each site, it may be necessary to move and relocate project identification signs. Relocate signs as directed in writing by the Engineer.
10. Graphic design, style of lettering and colors: as approved by the Engineer and subject to the approval of the local authorities and applicable local regulations for signs.
11. Erect Signs: At a location of high public visibility, adjacent to the main entrances to the construction area, as approved by the Engineer and the Employer.
    1. **INFORMATIONAL SIGNS**
12. Painted signs with painted lettering, or standard products.
    1. Size of signs and lettering: as required by Engineer.
    2. Colors: as required by Engineer, otherwise of uniform colors throughout Project.
13. Erect at appropriate location with bottom of signs approximately 2.2 meters above ground.
    1. **QUALITY ASSURANCE**
14. Sign Painter: Professional Experience in type of work required.
15. Finishes, Painting: Adequate to resist weathering and fading for scheduled construction period.

**PART 2 – PRODUCTS**

* 1. **SIGN MATERIALS**

1. Structure and Framing: must be new, wood or metal, in sound condition structurally adequate and suitable for specified finish.
2. Sign Surfaces: Exterior superior grad plywood with medium density overlay, standard large sizes to minimize joints.
   1. Thickness: Minimum 25mm or as required to span framing members, to provide even, smooth surface without warping and buckling.
3. Posts shall be pressure treated lumber 100mm x 100mm minimum size.
4. Rough Hardware: Galvanized.
5. Paint: Exterior (outdoor) quality.
   1. Use Engineer – approved colors for graphics.
   2. Color for structure, framing, sign surfaces and graphics: As selected by the Engineer.

**PART 3 – EXCUTION**

* 1. **PROJECT IDENTIFICATION SIGN**

1. Paint exposed surfaces of supports, framing and surface material; one coat of primer and one coat of exterior paint.
2. Paint graphic in Engineer – approved styles, sizes and colors.
   1. **MAINTENANCE**
3. Maintain signs and supports in a neat, clean condition; repair damages to structure, framing or sign.
   1. **REMOVAL**

Remove signs, framing, supports and foundations at completion of project or when directed by Engineer.

**END OF SECTION**

# SECTION 01600

# GENERAL EQUIPMENT AND MATERIAL STIPULATIONS

**1. GENERAL**

These General Equipment and Material Stipulations apply, in general, to all equipment and material to be supplied and all work to be performed by the Contractor. These requirements supplement the detailed equipment and material specifications but, in case of conflict, the detailed equipment and material specifications shall govern.

**2. MATERIALS AND EQUIPMENT**

Unless specifically provided otherwise in each case, all materials and equipment furnished for permanent installation in the work shall conform to applicable standard specifications and shall be new, unused, and undamaged when installed or otherwise incorporated in the work. No such material or equipment shall be used by the Contractor for any purpose other than that intended or specified, unless such use is specifically authorized by the Engineer in each case.

**3. WORKMANSHIP**

All equipment shall be designed, fabricated, and assembled in accordance with the best modern engineering and shop practice. Individual parts shall be manufactured to standard sizes so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests.

**4. COORDINATION**

The Contractor shall assume full responsibility for coordination of the entire project, including verification that all structures, piping, valves materials, instrumentation, and equipment components are compatible. The Contractor shall start up each equipment system and shall make all adjustments and tests necessary to ensure that each equipment item, system, and the entire works are placed in proper operating condition to the satisfaction of the Engineer.

**5. QUALITY ASSURANCE**

**5.01 MANUFACTURER'S INSTRUCTIONS**

When the specifications require that installation of work shall comply with the manufacturer's printed instructions, the Contractor shall obtain and distribute copies of such instructions to parties involved in the installation, including two copies to the Engineer.

The Contractor shall maintain one set of complete instructions at the job site during installation and until completion.

The Contractor shall handle, install, connect, clean condition and adjust products in strict accord with such instructions and in conformity with specified requirements. Should job conditions or specified requirements conflict with manufacturer's instructions, consult with the Engineer for further instructions. The Contractor shall not proceed with work without clear instructions.

The Contractor shall perform work in accordance with manufacturer's instructions and not omit any preparatory step or installation procedure unless specifically modified or exempted by the specifications.

**5.02 PATENT ROYALTIES**

All royalties and fees for patents covering materials, apparatus, devices, or equipment (as distinguished from processes) shall be included in prices quoted by equipment suppliers.

**6. ADAPTATION OF EQUIPMENT**

Equipment shall be readily adaptable for installation and operation in the structures shown on the Drawings. No responsibility for alteration of a planned structure to accommodate other types of equipment will be assumed by the Employer. Equipment, which requires alteration of the structures, will be considered only if the Contractor assumes all responsibility for making and coordinating all necessary alterations. All such alterations shall be made at the Contractor's expense and acceptable to the Engineer.

**7. DELIVERY, STORAGE, AND HANDLING**

**7.01 DELIVERY**

1. Materials and equipment furnished under this Contract shall be delivered and stored at a location directed by the Contractor and acceptable to the Engineer.
2. The Contractor shall provide all materials and packing cases necessary for the safe conveyance and delivery of items.
3. Before an item is dispatched from a manufacturer's works it shall be properly prepared and packed and the Contractor shall give the Engineer at least fourteen days notice that these preparations are to begin.
4. The Contractor shall, either directly or through contractual arrangements with others, accept responsibility for the safe handling and protection of the equipment and materials furnished under this Contract before and after receipt at the place of entry. Acceptance of the equipment shall be made after it is installed, tested, placed in operation, and found to comply with all the specified requirements.
5. All items shall be checked against packing lists immediately on delivery to the Work Site and shall be inspected for damage and checked for shortages. Damage and shortages shall be remedied with the minimum of delay.

**7.02 PROTECTION**

1. All equipment shall be packed, crated, or otherwise completely enclosed and protected during shipment, handling, and storage. All equipment shall be kept thoroughly dry at all times. Pumps, motors, electrical equipment, and other equipment having antifriction or sleeve bearings shall be stored in weather tight warehouses, which are maintained at a temperature of at least 16° C.
2. Painted surfaces shall be protected against impact, abrasion, discoloration, and other damage. All painted surfaces, which are damaged prior to acceptance of equipment, shall be repainted to the satisfaction of the Engineer.
3. Electrical equipment, controls and insulation shall be protected against moisture or water damage.

**7.03 PACKING LISTS**

Every crate or package shall contain a packing list in a waterproof envelope. Two copies of the packing list shall be sent by mail to the Engineer when the packing is dispatched.

**7.04 MARKING**

Crates, packages and the like shall be clearly marked with a waterproof material to show the weight, where the slings should be attached, and shall also have an indelible identification mark relating them to the packing list.

All items shall be clearly marked for identification against the packing list.

**7.05 STORAGE**

a. Stored items shall be laid out to facilitate their retrieval for use in the programmed order.

b. Stacked items shall be suitably protected from damage by spacers or load distributing supports and shall be safely arranged. No metalwork shall be stored directly on the ground.

c. Items shall be handled and stored so that they are not subjected to excessive stresses and so that protective coatings and finishes are not damaged.

d. Masonry products shall be handled and stored in a manner to hold breakage, chipping, cracking, and spalling to a minimum.

e. Cement, lime and similar products shall be stored off the ground on pallets and shall be covered and kept completely dry at all times.

f. Pipefittings and valves may be stored out of doors but must be placed on wooden blocking.

g. Equipment having moving parts, such as gears, bearings and seals, shall be stored fully lubricated with oil, grease, etc., unless otherwise instructed by the manufacturer, Manufacturer's storage instruction shall be carefully followed by the Contractor.

h. Moving parts shall be rotated a minimum of once weekly to ensure proper lubrication and to avoid metal to metal "welding". Upon installation of the equipment, the Contractor shall at the discretion of the Engineer start the equipment, at one-half load, once weekly for and adequate period of time to ensure that the equipment does not deteriorate from lack of use.

i. Lubricants shall be changed upon completion of installation and as frequently as required thereafter during the period between installation and acceptance. New lubricants shall be put into the equipment by the Contractor at the time of acceptance.

**7.06 OFF-SITE STORAGE**

Off-site storage arrangements shall be acceptable to the Engineer for all materials and equipment not incorporated into the work but included in Applications for payments. Such off-site storage arrangements shall be presented in writing, and shall afford adequate and satisfactory security and protection. Off-site storage facilities shall be accessible to Engineer.

**7.07 SPARE PARTS**

Spare parts shall be accurately manufactured from the same materials and to the same dimensions and tolerances as the originals. They shall be new, unused and strictly interchangeable with the parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the Work Site. Each spare part shall be clearly marked or labeled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or containers, and a detailed list enclosed. Cases, containers, and other packages shall be marked and numbered in an acceptable manner for purposes of identification. Cases, containers, or other packages shall be designed to facilitate opening and thereafter repacking. Spare parts record should be kept in the work site.

**8. SUBSTITUTIONS AND PRODUCT OPTIONS**

**8.01 EQUIVALENT MATERIALS AND EQUIPMENT.**

Whenever a material or article is specified or described by using the name of a proprietary product or the name of a particular manufacturer or vendor, the specified item mentioned shall be understood as establishing the type, function, and quality desired.

Other manufacturer's products will be accepted provided sufficient information is submitted to allow the Engineer to determine that the products proposed are equivalent to those named. Such items shall be submitted for review by the procedure set forth in the submittals section and as specified herein.

**8.02 SUBSTITUTIONS**

Requests for review of equivalency will not be accepted from anyone except the Contractor, and such requests will not be considered until after the contract has been awarded.

The Contractor shall submit a separate request for each item of material and/or equipment proposed for substitution, supported with data, drawings and samples as appropriate. Request for substitution shall include the following.

- Comparison of the qualities of the proposed substitution with that specified.

- Any changes required in other elements of the work because of the substitution.

- Effect on the construction schedule.

- Cost data comparing the proposed substitution with the equipment or material that is specified.

- Any required license fees or royalties.

The Contractor in requesting a substitution represents that he has investigated the proposed products and determines that they are equal to, or superior in, all respects to that specified. The Contractor shall provide the same warranties for the substitution as for the products specified. The Contractor will coordinate the installation of an accepted substitution into the project, and make all changes as may be required to make the work complete, waive ring all claims for additional costs, under his responsibility, which may subsequently become apparent.

The Engineer shall be the judge of the acceptability of all proposed substitutions.

**9. WARRANTIES**

The Contractor shall guarantee all equipment against (a) faulty or inadequate design, (b) improper assembly or erection, (c) defective workmanship or materials, and (d) leakage, breakage, or other failure. The guarantee period shall be as defined in the General Conditions-Period of Maintenance.

**10. JOB CONDITIONS.**

All equipment furnished shall be designed to meet stipulated conditions and to operate

Satisfactorily within the environment of the project area.

**11. SAFETY FEATURES**

a. The permanent works as installed, shall have no features that could be a hazard to operators, maintenance staff, visitors, or other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise suppression devices, written notices, safety colors, and the like shall be provided where needed.

b. Adequate safeguards shall be provided to prevent personnel accidentally coming into contact with dangerous machinery, mechanisms, hot surfaces, electrically live parts, and other hazardous components or contents. Guards shall be rigid, securely fixed and made so that they do not have to be removed during normal operation, running maintenance and routine inspection.

c. When the permanent works are operating at the normal conditions, the intensity of emitted noise in the working environment shall not constitute a health hazard to operators and other personnel or cause a nuisance to a community outside the boundary of the work site. The anticipated noise characteristics of all items of permanent works and systems which have a high noise potential shall be submitted to the Engineer early in the Contract.

The Contractor shall ensure that all pollutants are discharged in a controlled manner to satisfy the environmental protection requirements of the Employer.

**12. ANCHOR BOLTS**

Equipment suppliers shall furnish suitable anchor bolts for each item of equipment. Anchor bolts, together with templates or setting drawings, shall be delivered sufficiently early to permit setting the anchor bolts when the structural concrete is placed. Two nuts shall be furnished for each bolt.

**13. FABRICATION AND MANUFACTURER**

All equipment shall be designed, fabricated, and assembled in accordance with the best engineering practice. Individual parts shall be manufactured to standard sizes and gauges so that repair parts furnished at any time, can be installed in the field like parts of duplicate units shall be interchangeable.

Equipment shall not have been in service at any time prior to delivery, except as required by tests.

Materials shall be suitable for service conditions. Iron castings shall be tough, close-grained gray iron free from blowholes, flaws, or excessive shrinkage and shall conform to ASTM A48.

**14. LUBRICATION.**

a. Equipment shall be adequately lubricated by systems, which require attention no more frequently than weekly during continuous operation. Lubrication systems shall not require attention during startup or shutdown and shall not waste lubricants.

b. Lubricants of the type recommended by the equipment manufacturer shall be provided in sufficient quantity to fill all lubricant reservoirs and to replace all consumption during testing, startup, and operating prior to acceptance of equipment by the Employer. In addition, Contractor shall provide quantities of required lubricants to permit continuous operation of all items of equipment for a period of six (6) months from the date of Initial Acceptance.

c. A complete schedule of recommended lubricants which are readily available in the Republic of Yemen and the names and manufacturers and suppliers shall be submitted to the Engineer for acceptance.

d. Lubrication facilities shall be convenient and accessible. Oil drains and fill openings shall be easily accessible from the normal operating area or platform.

Drains shall allow for convenient collection of waste oil in containers, from the normal operating area or platform without removing the unit from its normal installed position.

e. Lubricating equipment shall be positioned so that it is not subject to damage during installation, operation, or maintenance of plant. Centralized lubrication systems shall conform to BS 4807. Recommendations for Centralized Lubrication as Applied to Plant and Machinery.

f. Grease lubrication systems shall preferably be the pressure type where no adjustment or recharging is needed more than once a week under normal continuous operating conditions. Grease application points shall be easily accessible and where needed, extension piping shall be provided. Where a number of greasing points can be grouped, they shall be routed to a battery plate of rigid construction and each application point shall be clearly labeled. Two grease applicators shall be supplied for each type of lubricant required and type of application nipple. Each applicator shall be clearly and permanently labeled.

g. Oil lubrication shall preferably be supplied by a recirculating reservoir type lubricator, which automatically maintains the correct level of oil and is sized to function for a long period under normal continuous operating conditions. A sight glass level indicator shall be fitted on all oil reservoirs, or where this is not practicable, a dipstick shall be fitted. Level indicators shall be easy to read over the maximum working range, simple to dismantle for cleaning, marked clearly with minimum/normal/maximum oil levels at normal running temperature and speed and marked to show the normal filling level at design ambient temperature. Sight glasses shall be protected against mechanical damage.

h. Water lubrication shall either be a recirculating or freely discharging system. Facilities shall be provided for visually observing both the flow and temperature of the inflowing and out flowing lubricating water where practicable. Freely discharging water from each lubricating point shall be separately piped to an open tundish, which shall be piped neatly to an acceptable surface water drainage system.

**15. DISSIMILAR MATERIALS**

Where the use of dissimilar materials in contact or proximity can be bridged by an electrolyte producing a corrosive condition, the Contractor shall demonstrate to the satisfaction of the Engineer that adequate precautions have been taken to prevent unacceptable corrosion.

**16. NAMEPLATES, RATING PLATES, AND LABELS**

a. Each item of the project comprising the permanent works shall have permanently attached, in a conspicuous position, a label or labels detailing its design performance, function, manufacturer's identification, and system identification shall be separately labeled. Script on all labels shall be English language.

b. Inscriptions shall be permanently engraved and, in general, a dark inscription on a light background shall be provided.

c. The proposed style, label material, inscription, location, and fixing shall be scheduled and submitted to the Engineer for review.

d. Embossed materials and techniques will not be accepted.

e. Labels provided for panels shall describe the duty and identify every instrument, relay circuit, circuit component, and item of equipment mounted externally and internally.

f. Multi section/circuit panels shall be fitted with a main designation label, and labels identifying each individual section/circuit shall be located at both the front and rear of the panel.

g. Where withdrawal or detachable equipment is provided both the fixed and moving or detachable portions shall be similarly labeled.

H. Externally fitted labels on panels shall be acceptable transparent plastic with rear engraved inscriptions filled with black. The back surface of these labels shall be painted in an acceptable color.

i. Labels shall be provided to warn of dangerous or potentially dangerous circumstances or substances.

j. Inscriptions on danger labels shall start with the word "DANGER" and be white on a red background.

k. Inscriptions on caution labels shall start with the word "CAUTION" and be red on a white background.

l. Instruction labels shall be provided where safety procedures are essential to protect operating and maintenance personnel from hazardous or potentially hazardous conditions such as advising the isolation or earthing of electrical circuits or the wearing of protective gear.

m. Each valve, pump, and unit of equipment which has been assigned a designation code number including existing items shall be provided with a number plate. Numerals shall not be less than 50 mm high. Number plates shall be anodized aluminum and shall have a number corresponding to the designation code number indicated on the Drawings or listed in the specifications. The location of number plates and the method of attachment to the equipment shall be acceptable to the Engineer.

n. Labeling and color-coding of pipe work, tanks and ducting shall be as specified in the Painting Section and as indicated on the Drawings.

**17. MARKER OR WARNING TAPE FOR BURIED SERVICES**

a. Wherever pipes, and similar services are buried in the ground a warning tape with Aluminum Strip Conductor shall be laid 300 mm above each and every service in the trench. The marker tape shall be 200 mm wide and 100 micrometers nominal thickness. In case of ductile iron pipes, Plastic warning tape can be accepted instead of the aluminum one.

**18. EQUIPMENT BASES**

Unless otherwise indicated on the Drawings or specified, all equipment shall be installed on concrete bases at least 150 mm high. Cast iron or welded steel base plates shall be provided for pumps, compressors, and other equipment. Each unit and its drive assembly shall be supported on a single base plate of neat design. Base plates shall have peds for anchoring all components and adequate grout holes. Base plates for pumps shall be a means for collecting leakage and a threaded drain connection. Base plates shall be anchored to the concrete base with suitable anchor bolts and the space beneath filled with grout as specified in the Grouting Section.

**19. SHOP PAINTING**

a. All steel and iron surfaces shall be protected by suitable paint or coatings applied in the shop. Surfaces, which will be inaccessible after assembly, shall be protected for the life of the equipment. Exposed surfaces shall be finished smooth, thoroughly cleaned, and filled as necessary to provide a smooth uniform base for painting. Surfaces to be painted after installation shall be shop painted with one or more coats of a primer which will adequately protect the equipment until finish coats are applied.

Shop primer shall be fully compatible with finish paint systems specified in the painting section. Electric motors, speed reducers, starters, and other self-contained or enclosed components shall be shop finished with at least one primer coat and one finish coat of high-grade oil-resistant enamel or equivalent system. Coatings shall be suitable for the environment where the equipment is installed.

b. Machined, polished, and nonferrous surfaces, which are not to be painted, shall be coated with rust-preventive compound.

**20. INSTALLATION AND OPERATION**

a. Equipment shall not be installed or operated except by, or with the guidance of, qualified personnel having the knowledge and experience necessary for proper results. When so specified, or when employees of Contractor or his Subcontractors are not qualified, such personnel shall be field representatives of the manufacturer of the equipment or materials being installed.

b. All equipment installed under this Contract shall be placed in successful operation according to the written instructions of the manufacturer's field representative. All required adjustments, tests, operation checks, and other startup activities shall be provided.

**21. OPERATION AND MAINTENANCE MANUALS**

The Contractor shall provide Operation and Maintenance Manuals for each item of equipment for which manuals are required by the Equipment Schedule Section. Manuals shall be provided in accordance with the Submittals Section (01300).

**END OF SECTION**

# SECTION 01702

# OPERATION, MAINTENANCE AND TRAINING SERVICES

# PRE-COMMISSIONING, COMMISSIONING, ADVISE AND ASSIST

**PART I – GENERAL**

* 1. **BRIEF DESCRIPTION**

To ensure successful project implementation, the construction of the Project / Plant must be completed with the proper running in operation by the Contractor start-up period before the plant will be handed over to the Client. In addition, the Contractor shall train the Client’s personnel prior, during and after the plant start-up and testing. Operation and training services have to be considered as an integral part of the complete construction and delivery contract.

(Operation, Maintenance and Training) services shall be rendered during the construction period and start-up of operation period and the last six months after the date of handing over the plant to the Client.

The Contractor shall in general provide the following services: -

1. Starting operation of the plant
2. Operation advisory services
3. Maintenance advisory services
4. Training services

**PART 2– CONTRACTOR SCOPE OF WORK**

* 1. **TERM AND SERVICES**
     1. **Term**

1. The Pre-Commissioning Period shall be a minimum of three months duration. Begin the Pre-Commissioning Period not less than three months prior to the expected date of certificate of Completion. The Contractor shall advise the Engineer at least five months before the expected date of Certificate Completion and the Engineer will issue a notice to proceed at least one month prior to agreed start of Pre-Commissioning. The Contractor’s OM&T personnel (except Operations Engineers) shall be fully mobilized at the commencement of the Pre-Commissioning Period.
2. The Commissioning Period shall commence on the date of the certificate of completion, and continue without interruption for three months.
3. Advise and assist the CLIENT management and supervisory staffing the Operation and Maintenance of the PROJECT / PLANT. During the Advice and Assist period, all processes shall be stabilized and refined so that the facility can produce an effluent quality acceptable to the Engineer. During this period continue to monitor and refine the development work on practices, procedures and management system that were initiated during the plant commissioning until they become fully functional plant processes.
   * 1. **Services to be provided during Pre-Commissioning Period**
4. **Pre-Commissioning services**
   1. A complete plan of operation showing the schedule of events and dates for all tasks involved with OM&T shall be prepared and submitted to the Engineer for review, a minimum of four months prior to the certificated of completion.
   2. Prepare a commissioning Work Plan. The Work Plan shall include the training plan, start-up plan and a safety program. The commissioning Work Plan shall be submitted to the Engineer for acceptance 30 days prior to Commissioning Period.
   3. Observe the final testing of plant structures and equipment. Adjust the Commissioning Work Plan for Plant start-up in accordance with the demonstrated operation and performance of plant and equipment.
   4. Establish and begin to implement the laboratory methods and procedures, which will be required to monitor and control the PROJECT / PLANT start-up, commissioning, running trials, and operations.

Collect a series of samples prior to start-up and conduct analyses to establish plant influent quality as base data for plant start-up.

* 1. Prepare an inventory of all plant facilities and equipment, spare parts, consumables, supplies and other resources, and identify equipment or supplies found deficient.

Collect and prepare data and information on maintenance and inventory; set-up workstations; design and train CLIENT PROJECT / PLANT staff in all phases of data entry and use of Maintenance Management System (MMS) and Inventory Control.

* 1. Make an initial review of the PROJECT / PLANT operations budget and comment on any areas that appear deficient or excessive.
  2. Prepare and initiate a preliminary safety program, encourage the participation of all plant personnel, and stress the need for safety awareness at all times.
  3. Compile the manufacturer’s O&M Manuals and begin to assemble from the approved reference list all literature required for use during the commissioning Period. Continue to refine and revise the O&M manual draft during this period to achieve milestones specified in Section 0703.
  4. Conduct preliminary needs assessments of all CLIENT personnel assigned to the PROJECT / PLANT and prepare and implement a preliminary training plan for the Pre-Commissioning Period. Interview CLIENT PROJECT / PLANT staff and develop and prepare initial duty assignments, organization charts, shift schedules and reporting responsibilities of implementation at the start of the Commissioning Period.

1. **Pre-Commissioning Training of Client Staff**

The training activities shall be designed to improve the quality of work performance rather than training based on the understanding of theoretical knowledge.

* 1. Training shall consist of on-site instruction and on-the-job training focusing on the establishment of the required work and duties for plant start-up and operation and maintenance of the Project equipment.
  2. Training records shall be maintained and a summary report on Pre-Commissioning training shall be provided during this period.
  3. A Training Plan as required shall be submitted to the Engineer for review no later than 30 days prior to completion of the Pre-Commissioning Period.
  4. Personnel training records on all assigned CLIENT PROJECT / PLANT staff shall be developed as a basis for staff development during the OM&T. These records shall be computerized and updated and maintained so that individual information and statistics show performance and progress.
     1. **Service to be provided during Commissioned Period**

**Start-up and Commissioning**

* 1. Conduct the start-up of the Project in accordance with the Commissioning Work Plan approved by the Engineer.
  2. Advise and assist the CLIENT management and supervisory plant personnel under a series of selected routine and non-routine process modes and conditions to determine the performance of individual elements and provide a base record of the capabilities of the plant for future reference. The process trials shall include but not be limited to the following:
     + operation at 148,500 cmd (average flow)
     + operation at 327,000 cmd (peak flow)
     + operation under standby power generation.
     + Operation with various process elements out of service.

In addition, advise and assist in supervising the operation and maintenance of the plant using various operating and maintenance procedures to test alternatives and determine optimum methods of operation. The operating trials shall include but not be limited to the following:

* 1. Monitor, report and refer problems which cannot be resolved on-site to the Engineer and recommend alternatives to correct the problems.
  2. Refine the initial review of the PROJECT / PLANT Operating budget based on the OM&T Contractors on-site experience and provide a more detailed analysis of the operating budget and report to the Engineer regarding any anticipated deficiencies.
  3. Refine in the initial appraisal of CLIENT personnel assigned to the PROJECT / PLANT regarding performance capabilities and identify to CLIENT and the Engineer, candidates for positions of increased responsibility and authority.
  4. Prepare the Advice and Assist Plan and submit it to the Engineer for acceptance 30 days prior to the conclusion of the Commissioning Period. The Work Plan shall include an activity / time-based schedule which can be updated and modified as agreed by the Engineer.

1. **Training During Commissioning Period**
   1. The Training Plan for the 3-month Commissioning Period shall consist of refining skills required for routine and non0routine operation and maintenance of the PROJECT / PLANT. This training shall include but not limited to the following categories:
      * Plant operation and process control
      * Plant maintenance procedure
      * Laboratory control – sampling and analysis
      * Records and reports
      * Emergency Operating Procedures (EOP)
      * Plant management and administration
      * Maintenance Management System (MMS)
      * Inventory and stores control system
      * Building and grounds maintenance
      * Budgeting and cost accounting
      * Chlorination
      * Plant electrical systems
      * Safety

Training shall be viewed as a continuous process and monitoring of PROJECT / PLANT staff performance shall be used as the basis for determining additional in-service training requirements.

Review and revise, as required, the Training Plan prepared during the pre-commissioning period as specified. This Training Plan shall be based on the Contractor’s continuous assessment of PROJECT / PLANT staff, progress and performance resulting from training accomplished during the Pre-commissioning and commissioning Period. And the training records prepared and maintained on all CLIENT staff assigned to the PROJECT / PLANT.

* + 1. **Services to be provided during advice and assist period**

1. **Operational Parameters / Performance Requirements**
   1. Determine, refine and continue to implement the process control management system and data management system. The process parameters to be monitored shall include those parameters necessary to assure continuous efficient and effective operation of each individual unit process in a manner that meets the effluent quality acceptable to the Engineer.
   2. Advise and assist CLIENT and CLIENT personnel to Operate the plant in accordance with the Facility Description and Design Data provide in the IFB. If it is determined that the facility is not capable of meeting the design parameters for any reason, determine the specific cause for the failure and report in writing to the Engineer of action to correct the deficiency.
   3. Report in writing to the Engineer regarding operational progress and update monthly during the term of the project.
2. **Maintenance Management Requirements**
   1. Develop and implement a computerized maintenance management system (MMS) during the first year of the OM&T. the MMS shall have Arabic & English Capability and shall include provision for preventive maintenance schedules, emergency maintenance activities, work orders, manufacturers references, maintenance forecasts, accountability, maintenance cost analysis, inventory control, vendor information, purchase order lag timer and other items. The computerized MMS program shall be selected prior to start-up of the OM&T and approved CLIENT and the Engineer. The MMS program shall be fully, implemented with all data input to the system completed within one year from the start of the Advice and Assist period.
   2. Establish a fully supported and implemented manual card file system for preventive maintenance in addition of the computerized MMS. The card file system shall be maintained in a current status, as a backup program until such time that in the opinion of the Engineer, it is no longer required.
   3. The computerized MMS program shall be provided on software designed for IBM or compatible computer. Provide the computers and peripheral equipment as specified herein which will become the property of the Employer upon completion of the OM&T.
   4. Inventory management will be an important element of the MMS program described above. Organize the plant spare parts, equipment, supplies and consumable such that stock items can be located quickly and easily. Inventory stock numbers shall be assigned based on utilization and location. Consumables shall be readily available.
3. **Laboratory Operation**
   1. Establish proper operating procedures in the PROJECT / PLANT Laboratory so that analytical results are reliable, repeatable, consistent and accurate. All laboratory analyses shall be performed in accordance with the latest edition of Standard Method for the Examination of Water and Wastewater, published by the American Public Health Association and the Water Pollution control Federation. The Contractor shall be responsible for the following laboratory functions:
      1. Advise and assist in the organization of CLIENT laboratory staff so that sufficient staff with appropriate capabilities are on duty as required to complete procedures and to assure reliability of results.
      2. Train all laboratory personnel in proper techniques and methods for all analytical procedures required. The training should be provided at the technical, professional and managerial levels.
      3. Prepare and establish a sampling and analysis plan including a sample collection program in accordance with the schedule of tests required.
      4. Develop and implement a Laboratory Quality Assurance / Quality Control (LAB QA/QC) program to include split sampling, parallel testing and verification of results.
   2. The minimum schedule of analyses to be included in the plan and performed during the services shall consist of the following:
      1. Suspended Solids (mg/1): Plant influent, primary effluent. Plant influent and effluent samples to be 24-hour composites.
      2. Biochemical Oxygen Demand (BOD) (mg/1): Plant influent, primary effluent. Plant influent, and effluent samples to be24 hours composites.
      3. Settleable Solids (m1/1): Plant influent, primary effluent – daily grab samples.
      4. Dissolved Oxygen (DO) (mg/1): Plant influent, primary effluent – daily grab samples.
      5. Coliform bacteria (MF plate count / colonies per 100 ml): Chlorine contact tank effluent – daily.
      6. Chlorine residual (mg/l): Chlorine contact tank effluent – 4 times daily; final drain discharge daily.
      7. pH : Plant influent, primary effluent – daily grab samples.
      8. Temperature (degree C): Plant influent, primary effluent, performed when Dissolved Oxygen (DO) analysis is performed.
      9. Meteorological data: Maximum, minimum and average temperature, relative humidity, wind speed, and rainfall to be related to plant performance.
      10. DO, BOD, Suspended Solids: simultaneous grab samples taken 10 meters upstream of PROJECT / PLANT outfall, at the outfall, 10 meters and 100 meters downstream of outfall; weekly.

The schedule shown above in items a through j shall be modified and expanded based on actual operating experience to the satisfaction of the Engineer.

1. **Training Program**
   1. Provide a training program, as sequence to the pre-commissioning and commissioning training, to improve and develop the managerial and the technical operation and maintenance capabilities of the personnel provided by CLIENT for the PROJECT / PLANT. The training shall be geared to the level of the CLIENT assigned personnel with a specific two-year objective of developing a capable O&M staff. The training shall be sequential, in accordance with an acceptable plan and shall include assumable performance objectives. The training shall be specific to the PROJECT / PLANT rather than general principles of plant operations and shall be coordinated with the day-to-day hands-on operation of the plant.
   2. A preliminary Training Plan, agreed to during the pre-Commissioning Period shall form the basis of the first stages of the training delivery. The Training Plan shall be reviewed and updated and submitted to the Engineer in its final form within 60 days after the end of the Commissioning Period. It shall provide the basis for all plant training and demonstration training throughout the OM&T.
   3. The Training Plan shall be based on a thorough needs assessment prepared through interviews and capability evaluations for all CLIENT personnel assigned to the PROJECT / PLANT. The Training Plan shall present a summary of the results of the needs assessment and then develop a philosophy; strategy and action plan for implementation. The Training Plan shall also include the following components:
      1. Course outlines with overall objectives for each Section. Training shall be sequential with successful completion of each Section required before moving to the next.
      2. Lesson plans without lines of material to be presented and containing measurable performance objectives. Each lesson plan should have an introduction, presentation, application and testing element.
      3. The course outline and lesson plans should be segregated by major areas of activity such as Operations, Maintenance, Laboratory and Sludge Disposal. The Employees shall be cross trained to greatest practical extent based on their ability so that they can be moved from area to area within the plant.
   4. Establish an evaluation system and evaluate the effectiveness of the training throughout the OM&T period and relate training results with improvements in the plant O&M performance.
   5. During the training program identify personnel with potential to become trainers or to become area or shift managers. For the personnel so identified, provide specialized training in topic related to their assignment.
   6. Use visual aids to the greatest practical extent, including: 35mm slides, audio/ visual transparencies, other graphic and audio/video cassette recording. Training is to be provided in Arabic & English through the use of bilingual instructors or through the use of translators. OM&T personnel shall assist in the training program in their specialty areas. Audio-visual equipment agreed to by the Engineer shall be paid from the Provisional Sum and shall become property of the Employer.
   7. Provide training in budgetary procedures, financial monitoring and financial management to those personnel who will have responsibilities in the accounting and budgeting departments.
2. **Safety Provisions**
   1. Utilize safety awareness procedures in every element of the OM&T work.
   2. Emphasis on site shall include:
      1. Safe working procedures.
      2. Cleanliness and care of the PROJECT / PLANT
      3. Accident and hazardous conditions reporting.
      4. Safe practice in sewers and sewage Project / Plants.
   3. The safety program prepared during the pre-commissioning phase shall be fully implemented during the advice and assist period. CLIENT management, supervisors, and personnel shall implement safe working and reporting procedures and give safety due emphasis in all plant operation and maintenance activities.
   4. Safe practices training and awareness shall be an important element of the Training Plan. In addition, informal safety discussions should be held at least weekly at various points throughout the plant. Also, the OM&T personnel shall take a lead role in the formation of a CLIENT safety committee that will meet monthly to discuss safety issues and procedures to improve safety. The committee should include a representative from the Contractor OM&T team, CLIENT, the Engineer and two members of the plant staff. Minutes of the meetings shall be kept for distribution, as appropriate.
3. **Standard Operating Procedures (SOP)**
   1. Provide site-tested and final version SOPs for each major component of the project / Plant by the end of the first full year of the OM&T. The SOPs shall be prepared for:
   2. Each SOP shall contain the following elements:
      1. A component numbering identification system.
      2. A description of normal settings, flow diversions and operational requirements.
      3. A description of routine operation procedures including visual observations and record keeping.
      4. A descriptive of routine safety procedures and potential danger area.
   3. The SOPs shall be printed on durable, A4 international size paper in English and Arabic & English and shall be simple and easy to read. Graphics, photos and illustrations should be used to the greatest practical extent. The English version of the SOPs shall be written for a specified and measurable readability level acceptable to the Engineer. The SOPs shall be nor more than 10 pages in length and shall be spiral bound with a plastic protective cover.
   4. **RELATED WORK**
      1. **Services of Manufacturers’ Representative**
4. Equipment furnished under Division (11, 13, 14, 15 and 16) shall include the cost of a competent representative of the manufacturers of all equipment to supervise the installation, adjustment, and testing of the equipment and to instruct the Owner’s operation personnel on operation and maintenance. This supervision may be divided into two or more time periods as required by the installation program or as directed by the Engineer.
5. See the detailed Specification for additional requirements for furnishing the services of manufacturer’s representatives.
6. A certificate in the form attached to this Section, from the manufacturer and signed by Owner’s representative stating that the installation of the equipment is satisfactory, that the unit has been satisfactorily tested, is ready for operation, and that the operating personnel have been suitably instructed in the operation, lubrication, and care of the unit shall be submitted for each piece of equipment indicated above.
7. For equipment furnished under other Divisions, the Contractor shall furnish the services of accredited representatives of the manufacturer only when some evident malfunction or over-heating makes such services necessary in the opinion of the Engineer.
   * 1. **Operating Manuals**
8. Four complete sets (1 original & 3 Copies) of operation and maintenance instructions covering all equipment furnished under Divisions (11, 13, 14, 15 and 16), shall be delivered directly to the Office of the Consulting engineers.
   1. The manual for each piece of equipment shall be a separate document with the following specific requirements:
      1. Contents:

Table of contents and index

Brief description of each system and components

Starting and stopping procedures

Special operating instructions

Routine maintenance procedures

Emergency procedures

Manufacturer’s printed operating and maintenance instruction, parts list, illustrations, and diagram

One copy of each wiring diagram

One copy of each approved shop drawing and each Contractor’s coordination and layout drawing

List of spare parts, manufacturer’s price, and recommended quantity

Name address and telephone numbers of local service representatives.

* + 1. Material:
       1. Loose leaf on heavy duty paper
       2. Page size, A4
       3. Diagram, illustrations, and attached foldouts as required, of original quality, reproduced by dry copy method.
       4. Covers: oil, moisture and wear resistant A4 size in a two-ring binder.
    2. Submittals to the Engineer.
       1. Three preliminary copies of manuals shall be submitted to the office of the Consulting Engineer Attention: Project Manager no later than 30 days following approval of the shop drawings for each piece of equipment. Provide four final copies of complete manuals prior to testing.
    3. **Contents, Each Volume**

1. Table of Contents: Provide title of Project, names, addresses, and telephone numbers of Engineer, sub-consultants, and Contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.
2. For Each Product or System: List names, addresses and telephone numbers of Sub-Contractors and suppliers; including local source of supplies and replacement parts.
3. Product Data: Mark each sheet to clearly identify specific products and components parts, and data applicable to installation. Delete inapplicable information.
4. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams, do not use Project Record Documents as maintenance drawings.
5. Type Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer’s instructions specified.
6. Warranties and Bonds where pertinent.
   * 1. **Manual for Material and Finishes**
7. Building Products, Applied Materials, and Finishes: Include product data, with catalog number, size, composition, and color and texture designations. Provide information for re-ordering custom manufactured products.
8. Instructions for Care and Maintenance: Include manufacturer’s recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
9. Moisture Protection and weather Exposed Products: Include product data listing, applicable reference standards, chemical composition, and details of installation. Provide recommendations for inspections, maintenance, and repair
   * 1. **Manual for Equipment and Systems**
10. For each Item of Equipment and Each System provide the following:
    1. Overview of System and description of unit or system, and component parts. Identify function, normal operating characteristics and limiting conditions. Include performance curves, with Engineering data and tests and complete nomenclature and commercial number or replaceable parts.
    2. Panel board Circuit Directories including electrical service characteristics, controls and communications, and color-coded wiring diagrams as installed.
    3. Operating Procedures: Include start-up, break-in, and routine normal operating instructions and sequences; regulation, control, stopping, shutdown, and emergency instructions; and summer, winter, and any special operating instructions.
    4. Maintenance Requirements:
       1. Routine procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.
       2. Servicing and lubrication schedule, and list of lubricants required.
       3. Manufacturer’s printed operation and maintenance instructions.
       4. Sequence of operation by controls manufacturer.
       5. Original manufacturer’s parts list, illustrations, assembly drawings, and diagrams required for maintenance.
    5. Control diagrams by controls manufacturer as installed.
    6. Contractor’s coordination drawings, with color-coded piping diagrams as installed.
    7. Charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
    8. List of original manufacturer’s spare parts, current prices, and recommended quantities to be maintained in storage.
    9. Test and balancing reports as specified.
    10. Additional Requirements: As specified in individual product specification Sections.
        1. **Instruction of Owner Personnel**
11. Before final inspection, instruct Owner’s designated personnel in operation, adjustment, and maintenance of products, equipment, and systems, at agreed upon times.
12. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.
13. Prepare and insert additional data in Operation and Maintenance Manual when need for such data becomes apparent during instruction.

**END OF SECTION**

# SECTION 01710

# CONTRACT CLOSEOUT

1. **GENERAL**

This Section covers Contract closeout requirements in addition to those described in the Conditions of Contract.

1. **FINAL INSPECTION OF CONSTRUCTION WORK**
   1. When the Contractor considers that all stage of the works are complete, the Contractor shall submit the following written certifications to the Engineer prior to final inspection of this work:
      1. Contract Documents have been reviewed.
      2. All stages of the works have been inspected for compliance with the Contract Documents.
      3. All stages of the works have been completed in accordance with the Contract Documents.
      4. Equipment and systems have been tested in the presence of the Engineer and are operational.
      5. Performance tests specified in the Contract Documents have been satisfactorily completed.
      6. All stages of the works are completed and ready for final inspection.
   2. When the construction work is ready for final inspection, the Contractor shall submit certifications to the Engineer that the works are ready for final inspection. The Contractor along with the Employer, and the Engineer shall make a final inspection to verify the status of completion. The Contractor shall notify the Engineer at least 14 days prior to proposed inspection. The engineer shall establish the actual date of the completion inspection after consulting the Employer. During the inspection, the Contractor shall develop a “punch list” of items, which do not conform to the Contract Documents.
   3. If the Engineer determines the work are incomplete or defective, the engineer will promptly notify the Contractor in writing, listing the incomplete or defective work. The Contractor shall then take immediate steps to correct the stated deficiencies and shall send a second written certification to the Engineer when all stages of the construction work are completed. Upon receipt of the second certification, the Engineer shall then reinspect the Works. After all deficiencies have been corrected, a final inspection of the Work in company with the Contractor, the Engineer, and the Employer shall be constructed. The Engineer shall establish the actual date of the final completion inspection after consulting with Employer.
   4. The completion inspection and any deficiency corrections required by this paragraph shall be accomplished within the time stated for completion of the entire task or any particular increment thereof.
   5. When the Engineer determines that all stages of the Works are acceptable under the Contract Documents, and the Engineer has received the closeout submittal from the Contractor, the Engineer shall issue a Certificate of Completion for the Works.
   6. Before the Engineer issues a certificate of Completion for the Works, the Contractor shall submit As Build documents for the Project which accurately reflect the Works as constructed.
2. **PROJECT AS BUILT DOCUMENTS**
   1. Documents Required: The Contractor shall prepare and submit As Built documents for the Project, which accurately reflect the Works as constructed. To facilitate the production of As-Built Drawings. The Employer will provide the Contractor with electronic files containing details of all Contract Drawings. The original electronic files and the As-Built Drawing electronic files (produced in a format acceptable to the Engineer) are to be submitted to the Engineer on completion. Documents shall be submitted to the Engineer for review prior to issuance of the certificate of partial completion of all construction work.

Documents that shall be maintained at the Works site and submitted to the Engineer include, but are not limited to, the following:

* + 1. Specifications.
    2. Hard Copies of the As Built Drawings and as electronic files produced in a format acceptable to the Engineer.
    3. Addenda.
    4. Change Orders and other modifications of the Contract.
    5. Engineer’s field orders and other written instructions.
    6. Reviewed Shop Drawings, product data, and samples.
    7. Field test records.
    8. Correspondence.
    9. Operation and Maintenance Manuals.
  1. Upon completion of the work and after review and approval of the As Built Drawings by the Engineer, the Contractor shall submit the final record documents as follows unless otherwise stated:
     1. One transparent copy of all drawings.
     2. Three hard copies of all drawings.
     3. One Soft copy, according to the Software type, format and version specified by the Employer on CD.
  2. As Built drawings: Each document shall be labeled “As Built Drawing” in neat large printed letters. As built documents shall be legibly marked and shall show actual construction conditions including, but not limited to, the following information:
     1. As Built, piping works, elements that shall be produced, and electrical works.
     2. Depths of various elements of foundation in relation to finished first floor datum.
     3. Horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
     4. Location of internal utilities and appurtenances referenced to visible and accessible features of the structure.
     5. Field changes in dimension and details.
     6. Changes made by field order or Change Order.
     7. Details not on original Contract Documents.
     8. Any other utilities, structures, piping works, cables …etc, that have been found or identified through out project period.
  3. Specifications and Addenda shall be legibly marked and shall include the following information:
     1. Manufacturer, complete Address including fax, e-mail, Tel etc. trade name, catalogue number, and supplier of each product and item of equipment installed as tables of beginning of each section (electrical, Mechanical… etc.).
     2. Complete list of subcontractors, manufacturers, and suppliers who furnished labor, materials, or equipment. The address of each firm shall be included together with type of materials or work performed.
  4. Document Submittal: As built documents shall be delivered to the Engineer prior to the commissioning (startup) period. All letter-sized material shall be neatly indexed and placed in a two or three ring binder. Drawings shall be bound in sets of convenient size for ease of handling. A transmittal letter, in duplicate, shall accompany the submittal of record documents. The transmittal letter shall contain the following information:
     1. Date.
     2. Project title and number.
     3. Contractor’s name and address.
     4. Title and number of each record document.
     5. Certification that each record document as submitted is complete and accurate.
     6. Signature of Contractor or his authorized representative.

1. **CLOSEOUT SUBMITTAL**

The Contractor’s closeout submittal shall include the project record documents, as specified, and the following certificates and affidavits:

* + 1. Manufacturer’s 1-year (minimum) warranties and bonds for all equipment and plant.
    2. Certificates of insurance for products’ liability.
    3. Affidavit of payment of all taxes.
    4. Affidavit of payment of Debts and Claims.
    5. Affidavit of Release of Liens.
    6. Consent of Surety.

1. **FINAL FEES**

The final account shall be completed prior to final inspection.

Final adjustment of Account shall be submitted within the period prescribed in the Conditions of Contract, Clause 60, and shall include but not be limited to the following information:

1. The original Contract Price including original authorized cost of the work and listing of the Provisional Sums.
2. Additions and deductions resulting from:
   1. Previous Change Orders.
   2. Deductions for uncorrected work.
   3. Deductions for liquidated damages.
   4. Other adjustments.
3. Total authorized cost of the Works, as adjusted.
4. Previous payments.
5. Final Payment due

Upon receipt of the final statement of accounting, the Engineer will prepare a final change Order reflecting approved adjustments to the authorized cost of the works which were not previously made by Change Orders.

1. **TEMPORARY UTILITIES**

The Contractor shall submit the final application for payment in accordance with procedures and requirements stated in Clause 60 of Conditions of Contract.

**END OF SECTION**

# SECTION 02050

# DEMOLITION AND MODIFICATIONS

**PART 1 - GENERAL**

**1-1 DESCRIPTION**

This section covers the demolition, and modifications of existing structures, materials and equipment as indicated on the Drawings, as specified, or as required to complete the work.

**1-1.01 Related Work**

Other items that relate to and are referenced in this section include, but are not limited to, the following sections: -

Submittals

Excavation and Backfilling

Cast-in-Place Concrete

Grouting

Epoxy Grout

Masonry

Fasteners

Painting

**1-2 APPLICABLE CODES AND STANDARDS**

The codes and standards generally applicable to the work of this section are listed. Codes and Standards current at the time of bid shall be used.

**1-2.01 ASTM - American Society for Testing and Materials**

C881 Epoxy-Resin-Base Bonding Systems for Concrete, and Standard Specification.

**PART 2 - PRODUCTS**

**2-1 PERFORMANCE AND DESIGN REQUIREMENTS**

**2-1.01** All facilities of the existing system which are not to be removed from service or modified must continue in use during the work with an absolute minimum of interference and inconvenience to the Owner. The existing plant, distribution systems and pump station shall be kept in continuous operation throughout the progress of the work, as required by the project requirements and in keeping with the established schedule of construction operations.

The Contractor shall visit the Work Site and thoroughly inspect all existing facilities, and shall take into account, in the preparation of his bid, how such conditions will affect the work required by the Drawings and specifications. Failure to do so will in no way relieve the Contractor of the responsibility for furnishing all labor, materials, and equipment required.

Any delay or extra expense caused by encountering construction or materials other than anticipated different from those indicated shall not constitute grounds for claims for additional payments or damages.

The Contractor shall assume full responsibility for any and all damages, resulting from his Work, to the existing facilities which are to remain in place. He shall take any necessary photographs of existing construction to verify existing conditions, and he shall file a report with the Engineer listing any existing damaged construction before the Work started.

All repairs and modifications except as modified herein shall be made using epoxy mortar or grout. Epoxy mortar shall be one-part epoxy adhesive and one-part oven-dried sand by volume.

Concrete repairs shall be formed wherever possible or necessary to hold epoxy grout in place. When the repair work is formed, the grout mix shall be one-part epoxy adhesive with two parts of sand and one part of pea gravel.

Epoxy adhesive shall conform to ASTM C881, Type II and shall be used to bond plastic concrete to hardened concrete in accordance with the manufacturer's recommendations.

Epoxy adhesive for the mortar and grout mixes for horizontal applications shall have a low viscosity and shall conform to ASTM C881, Type II, Grade 1. Epoxy adhesive for vertical applications shall have a nonsagging consistency and shall conform to ASTM C881, Type II, Grade 3.

The clean, dried, and graded sand shall be as specified for fine aggregate in the Cast-in-Place Concrete Section, and pea gravel shall conform to the Cast-in-Place Concrete Section with a 10 mm maximum size.

**2-1.02 Pressure-Injected Epoxy Resin**

The pressure-injected epoxy resin shall repair all cracks and crack networks to (2) mils. wide and larger. The pressure-injected epoxy resin shall consist of a two component epoxy system.

The pressure-injected epoxy resin shall meet or exceed the following requirements: -

Final cure, days (material at 24 C) 7

Tensile strength at cure, minimum. MPa (ASTM D-638) 39.5

Elongation at cure, per cent (ASTM D-638) 2

Compressive modulus, minimum, MPa (ASTM D-695) 1585

Minimum application temperature , C 6

**PART 3 - EXECUTION**

**3-1 DEMOLITION**

All demolition work shall be carried out in a manner which will prevent injury to workmen and damage to existing facilities or construction. Blasting will not be permitted. Demolition work shall be performed in accordance with all applicable laws and ordinances. Open burning is prohibited.

Certain items of demolition are set out by the Drawings and specifications; however, the demolition work shall not be confined to those items, but shall include all such work required to complete the project. An itemized list of the necessary demolition work shall be incorporated into the schedule of construction operations required by the Submittals Section.

The general area in which the demolition work is to be performed shall be left clean and free of debris and, in addition, shall be graded as required to provide a uniform appearance.

All backfilling required in the demolition area shall conform to the governing requirements of the Excavation and Backfilling Section.

**3-1.01 Concrete Structure**s

Existing concrete structures, as noted, shall be removed to the limits indicated, and to a point not less than one metre below finished grade, unless such remaining portions will interfere with new construction in which event they shall be entirely removed. The remaining bottom slab of any structure or manhole, specified or noted to be abandoned and filled, shall be broken out as required before any filling is begun, to permit the escape of ground water.

**3-1.02 Pipelines**

Existing underground and above grade piping shall be cut, removed, abandoned, disconnected, and/or salvaged as specified, shown on the Drawings, and required. The open ends of abandoned piping shall be tightly sealed with a minimum of 300 mm thick cast-in-place concrete plugs.

Piping shall be disconnected, dismantled and removed as required and in such a manner as to minimize disturbing water supply to customers or damaging adjacent construction. At any point or location where new work is to be connected or installed, the removal of existing work shall be done so as to facilitate the new installation work to the maximum possible extent.

**3-1.03 Pavement Removal**

Concrete or asphalt pavement in streets, in parking lots, sidewalks and curbs shall be removed to existing joints or sawed to the lines indicated on the Drawings. The lines shall be sawed to a depth sufficient to remove the material without disturbing the pavement to remain and shall be such as to provide a true butt line between new and existing pavements. No jagged, rough, or uneven exposed removal lines will be allowed.

The Contractor shall remove only sufficient existing concrete or asphalt pavement at entrances or at curb lines as necessary to complete the transition from new construction to existing surface elevations. Lines indicating the limits of entrance or parking lot adjustments are indicated on the Drawings but are subject to refinement by the Engineer in the field.

**3-2 MODIFICATIONS**

**3-2.01 Concrete Modifications**

All existing concrete shall be removed where indicated in the Drawings or as directed by the Quality Control Supervisor. All dust, laitance, grease, curing compounds, impregnations, waxes, foreign particles and disintegrated material shall be removed. If chipping is necessary, the edges shall be perpendicular to the surface or slightly undercut. Feather edges will not be permitted.

All defective existing concrete shall be removed down to sound concrete where indicated on the Drawings or as directed by the Quality Control Supervisor. Where existing concrete is to be removed, the Contractor shall fill, repair, and finish the surface smooth and flush with adjacent undisturbed surfaces.

Existing reinforcing exposed during removal operations shall be cleaned and remain in the new construction unless otherwise indicated on the Drawings or acceptable to the Engineer.

**3-2.02 Anchor Bolt Grouting**

Anchor bolts shall be provided in existing concrete where indicated on the Drawings. Anchor bolt grouting shall be epoxy grouted as specified in the Epoxy Grouting Section.

**3-2.03 Floor and Wall Sleeves**

Where new conduits or piping are to be installed through existing concrete floors or walls, holes of minimum size shall be made using a rotary core type drill except that jackhammers may be used for large holes and in other locations where the use of a core drill is impractical. Piping and sleeves shall be grouted in the holes where and as indicated on the Drawings and the concrete surfaces shall be finished smooth and flush with adjacent surfaces as indicated on the Drawings. Grouting shall conform to the requirements of the epoxy Grouting Section.

**3-3 CLEANUP**

The various areas of structure and piping removal shall be left clean, free of debris, and ready for backfill and grading.

**3-4 BACKFILL**

Any holes or excavations resulting from demolition or removal operations and not within areas to be occupied by new construction shall be backfilled in conformity with the requirements of the Excavation and Backfilling Section.

**3-5 DISPOSAL**

All materials and debris resulting from the removal and demolition work, which are not noted to be salvaged or reused in the new construction, and are not suitable for backfill in the opinion of the Quality Control Supervisor, shall become the property of the Contractor and shall be removed from the site to the Contractor's own place of disposal at his expense. Credit for the salvage value, if any, of such removed material shall have been reflected in the Contractor's bid price.

**END OF SECTION**

# SECTION 02100

# SITE PREPARATION

**PART 1 GENERAL**

**1.1 SCOPE OF WORK**

1. Furnish all labor, materials, and equipment required and perform all site preparation, complete as shown on the Drawings and as specified herein.
2. Obtain all permits required for site preparation work prior to proceeding with the work.
3. The areas to be cleared, grubbed, and stripped within public rights-of-way and utility easements shall be minimized to the extent possible for the scope of sewer line work and in consideration of the actual means and methods of construction used. No unnecessary site preparation within these areas shall be performed.
4. If during construction the contractor's excavations reveal remains and artifacts of archaeological interest, he shall immediately inform the Engineer and abide by the Engineer's directions, and shall coordinate and modify the sequence of the execution of the Work at no additional cost to the Employer.
   1. **RELATED WORK**

Earthwork is included in Section 02200.

* 1. **SUBMITTALS**

Submit to the Engineer copies of all permits required prior to clearing, grubbing, and stripping works.

**PART 2 EXECUTION**

* 1. **CLEARING**

1. Cut and remove all trees, stumps, brush, shrubs, roots, grass, weeds, rubbish, and any other objectionable material resting on or protruding through the surface of the ground.
2. Trees and other vegetation designated on the Drawings, if any, or directed by the Engineer to remain shall be preserved and protected as specified below.
   1. **GRUBBING**
3. Grub and remove all stumps, roots in excess of 35mm in diameter, matted roots, brush, logs, concrete rubble, and other debris encountered to a depth of 300 mm below original grade or 300 mm beneath the bottom of foundations.
4. All grubbing holes and depressions excavated below the original ground surface shall be refilled with suitable materials and compacted to a density conforming to the surrounding ground surface in accordance with Section 02200.
   1. **STRIPPING**
5. Strip topsoil if any and as directed by the Engineer from all areas to be occupied by buildings, structures, and roadways, and all areas to be excavated or filled.
6. Topsoil shall be free from brush, trash, large stones and other extraneous material. Avoid mixing topsoil with subsoil.
7. Stockpile and protect topsoil if it is to be used in landscaping operations. Dispose of surplus topsoil after all work is completed.
   1. **DISPOSAL**
8. Material and debris from site preparation operations shall be disposed of by hauling such materials and debris to an approved offsite disposal area. No rubbish or debris of any kind shall be permitted to be buried on the project site.
9. Burning of cleared and grubbed materials, or other fires for any reason will not be permitted.
   1. **PROTECTION**
10. Trees and other vegetation designated on the Drawings or directed by the Engineer to remain, shall be protected from damage by all construction operations by erecting suitable barriers, guards, and enclosures, or by other approved means. Clearing operations shall be conducted in a manner to prevent falling trees from damaging trees and vegetation designated to remain and to work being constructed and so as to provide for the safety of employees and others.
11. Protection shall be maintained until all work in the Vicinity of the work being protected has been completed.
12. Heavy equipment operation or stockpiling of materials shall not be permitted within the branch spread of existing trees.
13. Any damage to existing tree branches, trunks, or root systems shall be repaired immediately. Roots exposed and / or damaged during the work shall immediately be cut off cleanly inside the exposed or damaged area. Cut surfaces shall be treated with an acceptable tree wound paint, and topsoil spread over the exposed root area.
14. When work is completed, all dead and downed trees shall be removed. Live trees shall be trimmed of all damaged limbs and branches. All cuts shall be cleanly made at their juncture with the trunk or preceding branch without injury to the trunk or remaining branches. Cuts over 25 mm in diameter shall be treated with an acceptable tree wound paint.
15. Construction activities shall be restricted to those areas within the limits of construction designated on the Drawings, within public rights-of-way, and within easements provided by the Owner. Adjacent properties and improvements thereon, public rights-of-way, and within easements provided by the Owner. Adjacent properties and improvements thereon, public or private, which become damaged by construction operations shall be promptly restored to their original condition, to the full satisfaction of the property owner by the Contractor on his own expense.

**END OF SECTION**

# SECTION 02220

# EXCAVATION AND BACKFILLING

**PART 1 GENERAL**

**1.1 SCOPE**

The work covered by this section consists of providing all plant, labour and materials, and of performing all operations in connection with clearing and grubbing of the job site from young growth, roots, from old building, fences and debris.

Stripping of topsoil, excavation of soil and rock for buildings, general placing of soil and refilling of the working spaces and trenches including compaction. Preparation of the final grade and topsoil. The work shall include disposal of surplus material, all necessary sheeting, shoring, protection of work and dewatering as required.

* + 1. **Related Works**

A. Granular Material is included in Section 02230.

**1.2 APPLICABLE CODES AND STANDARDS**

The codes and standards generally applicable to the work under this section are listed. Codes and standards current at the time of bid shall be used.

* + 1. **ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)**

C33 Standard Specification for Concrete Aggregates.

C117 Materials finer than No. 200 (75 Micron) Sieve in Mineral Aggregates by Washing.

C136 Sieve or Screen Analysis of Fine and Coarse Aggregates.

C 75 Sampling Aggregates.

D 423 Test for Liquid Limit of Soils.

D 424 Test for Plastic Limit and Plasticity Index of Soils.

D 1556 Density of Soil-in-Place by the Sand-Cone Method.

D 1557 Moisture-Density Relations of Soils, Using 10-pound Rammer and 18-inch Drop.

D 2049 Relative Density of Cohesion less Soils.

D 2167 Density of Soil-in-Place by the Rubber-Balloon Method.

D 2487 Classification of Soils for Engineering Purposes.

**1.2-2 BS (BRITISH STANDARDS)**

BS 812 Methods for sampling and testing of mineral aggregates, sands and filters.

BS 1377 Methods of testing soils for engineering purposes.

BS 1924 Methods of testing for stabilized soils.

**1.2-3 AASHTO: AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS**

Any equivalent codes and standards may be accepted subject to the approval of the Engineer.

**1.3 QUALITY ASSURANCE**

**1.3-1 Governing Standards**

Soil tests, when required, shall be governed by ASTM, AASHTO & BS standards.

**Test Standard(S)**

Liquid Limit BS 1377-2A/ASTM D423

Plastic Limit BS 1877-3 /ASTM D424

Plasticity Index BS 1877-4 /ASTM D424

Particle Gradation BS 1377-7 /ASTM D422

In Situ Density BS 1377-15B/ASTM D1556

Moisture Content BS 1377-1A

Apparent Specific Gravity BS 1377-6A X 6B

Modified Proctor Test BS 1377-13&14/ASTM 1557

Los Angle Abrasion Loss ASTM C131

California Bearing Ratio BS 1377-16/ASTM D 1883

Soundness Na2 SO4 AASHTO T 104

Relative Density of soil D 2049

**1.3-2 Testing**

All testing of materials as required to determine the characteristics and suitability of material that may be encountered in excavations for fill material beneath structures, and tests to determine moisture and compaction and density of the materials used, shall be performed by the Contractor on site or by authorized laboratory subject to the approval of the engineer.

**PART 2 PRODUCTS**

**2.1 BASIC MATERIALS**

**2.1-1 Material to be Excavated**

Soil and rock to be excavated is classified in the following Clauses 2.1.1.1 through 2.1.1.6. The soil class applicable will be determined from the state of the soil when loosened.

**2.1-1/ 1 Topsoil**

The top layer of soil is called topsoil. Here, only such soil will be taken as topsoil which, in a loosened state, besides the normal inorganic components also contains mineral elements in adequate quantity to serve as a nutrient medium for vegetation when watered. Soil that has already been used for such purposes shall, as a basic rule, always be classified as topsoil.

**2.1-1/2 Easily Loosened Soils**

Easily loosened soils are non-cohesive sands, sand-gravel mix, and gravel containing less than 15% of clay. This class of soil should not contain more than 30% by weight of stones of gradation exceeding 63 mm and should not contain any stones of more than 0.01 m3 volume.

**2.1-1/3 Moderately Loosened Soils**

These are mixtures of sand, gravel and clay showing more than 15% by weight of clay, as well as all cohesive soils with a water content permitting the classification of "soft-plastic". Maximum content of stones as in Clause 2.1.1.2.

**2.1-1/4 Soils Loosened With Difficulty**

All soils as per Clauses 2.1.1/2 and 2.1.1/3 containing more than 30% by weight of stones exceeding a gradation of 63 mm up to a volume of 0.01 m3, and soils containing a maximum of 30% by weight of stones up to a volume of 0.1 m3. This class also includes all cohesive soils with a low moisture content permitting the classification "stiff-plastic" up to "dense".

**2.1-1/5 Soft Rock (Readily Loosenable)**

Rock types having an inner, mineral bound cohesion, but being heavily fissured, crumbly, friable, slatey, soft or weathered, as well as comparable consolidated, non-cohesive and cohesive types of soil. Non-cohesive and cohesive soil types with more than 30% by weight of stones of more than 0.01 m3 up to 0.1 m3 volume.

**2.1-1/6 Hard Rock (Loosenable with Difficulty)**

Rock types having an inner, mineral bound cohesion and high structural strength, and which are only slightly fissured and weathered. Material cannot be removed without the use of pneumatic impactors, heavy rock excavation machinery, or by blasting.

**2.1-2 Material to be Filled or Backfilled**

The selection of the fill material depends on the future purpose of the areas to be filled. The letters in brackets shown in the specification of soils below refer to the applicable ASTM D 2487.

**2.1-2/1 Non-Cohesive Soils**

(GW) Well-graded gravels or gravel-sand mixtures, little to no fines

(GP) Poorly graded gravels or gravel-sand mixtures, little to no fines.

(SW) Well-graded sands or gravelly sands, little to no fines.

(SP) Poorly graded sands or gravelly sands, little or no fines.

The compressibility of the soils of groups GW, GP, SW and SP is almost none.

(SM) Silty sand, sand-silt mixture.

**2.1-2/2 Cohesive Soils**

(MH) Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.

(CH) Inorganic clays of high plasticity, fat clays.

(OH) Organic clays of medium to high plasticity, organic silts.

(OL) Organic silts and organic silty clays of low plasticity.

**2.1-2/3 Rock**

Where rock is required as fill material, it shall, prior to placing, be crushed by adequate equipment to have a maximum stone size of 250 mm. For filling immediately adjacent to structures or surfaces the material shall be crushed to smaller sizes so as not to damage structures or damp-proof membranes.

**2.1-2/4 Characteristics of Principal Soil Types Pertinent to Building Foundations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***MAJOR DIVISIONS*** | ***LETTER*** | ***NAME*** | ***POTENTIAL FROST ACTION*** | ***COMPRESSIBILITY AND EXPANSION*** |
|  | GW | Well-graded gravels or gravel-sand mixtures, little to no fines. | None to Very  Slight | Almost  None |
| Gravel and  Gravely Soils | GP | Poorly graded gravels or gravel- sand mixtures, little to no fines | None to very  Slight | Almost  none` |
|  | GM | Silty gravel, gravel-sand-silt mixtures | Slight to medium | Slight |
|  | GC | Clayey gravel, gravel-sand - clay mixtures | Slight to medium | Slight |
| Coarse Grained Soils | SW | Well-graded sands or gravely sands, little or no fines | None to very slight | Almost none |
|  | SP | Poorly graded sands or gravely sands, little or no fines | None to very slight | Almost none |
| Sand and Sandy Soils | SP | Poorly graded sands or gravely sands, little or no fines | None to  Very slight | Almost none |
|  | SM | Silty sand, sand -silt mixtures | Slight to high | Very slight to medium |
|  | SC | Clayey sands, sand-clay mixtures | Slight to high | Slight to medium |
|  | ML | Inorganic silts and very fine sands, rock flour silty or clayey fine sands or clayey silts with slight plasticity | Medium to very high | Slight to medium |
| Silts and clays LL above 50 | CL | Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, clean clays, | Medium to high | Medium |
|  | OL | Organic silts and organic silty clays of low plasticity | Medium to high | Medium to high |
| Fine Grained Soils |  |  |  |  |
|  | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts | Medium to high | Medium |
| Silts and Clays LL below 50 | CH | Inorganic clays or high plasticity, fat clays | Medium | High |
|  | OH | Organic clays of medium to high plasticity, organic silts | Medium | High |
| Highly Organic Oils | Pt | Peat and other highly organic soils | Slight | Very high |

**2.1-3 SPECIAL FILL**

Unless otherwise indicated on the contract drawings, the followings specifications shall be adopted.

**2.1-3/1 Hardcore**

Hardcore shall consist of broken stone, concrete or acceptable local material, of a size not greater than 100 mm. It shall consist of clean, durable sharp fragments mixed with a binder and shall be free of clay, soft chalk and all deleterious matter, as well as being chemically inert.

The material to be crushed has first to be screened in such a manner that not less than ninety percent of the uncrushed material is retained on a 63,5 mm square sieve. The amount of crushing shall be regulated so that at least eighty percent, by weight, of the pieces retained on the 63,5 mm sieve have at least one mechanically fractured face. After crushing, the portion retained by 44,5 mm square sieve shall be 0 to 10% by weight.

This crushed material forms basic material as coarse aggregate e.g. for base courses, and shall meet the following gradation with a square sieve.

|  |  |
| --- | --- |
| **Sieve Size** | **Percent Passing** |
| 37.5 mm | 100 |
| 25.0 mm | 60 - 100 |
| 19.0mm | 65 - 85 |
| 4.75 mm | 30 - 60 |
| 2.00 mm | 25 - 50 |
| 0.425mm | 15 - 30 |
| 0.075mm | 8 - 15 |

**2.1-3/2 Filler Material or Granular Material**

Filler material used for dewatering of excavation or used as a backfill shall be clean, crushed stone or gravel or a mixture of clean sand and gravel, which shall comply with the following gradation; with a square sieve:

|  |  |
| --- | --- |
| **Sieve Size** | **Percent Passing** |
| 9.50 mm | 100 |
| 4.75 mm | 80 - 95 |
| 2.36 mm | 50 - 80 |
| 1.18 mm | 30 - 50 |
| 0.60 mm | 5 - 25 |

**2.2 ACCESSORIES**

**2.2-1 Planks for Shoring**

Planks for shoring of excavation pits shall have the same form over the entire length. Deformed planks shall not be used. If wooden planks are used, they must have a minimum thickness of 50 mm.

**2.2-2 Wales and Struts for Shoring**

If wooden struts and wales are used, they shall have a minimum diameter of 100 mm. In case of extensible metal pipes (trench braces) they shall have a minimum diameter of 40 mm with a minimum wall thickness of 3 mm. The supporting plates of the trench plates shall have a minimum size of 70 x 70 mm.

**2.2-3 Sheet Piling**

In case the contractor intends to use other materials or methods for shoring and bracing than described above in 2.02-1 and 2.02-2 he must provide proof to the Engineer that the intended materials or methods conform with all safety requirements.

**PART 3 EXECUTION**

**3.1 SITE PREPARATION**

Site preparation includes the clearing of the project area from aboveground obstacles, the removal of vegetation, stripping of topsoil and marking fixed points for controlling the levels and location of the structures, as well as surveying the surface.

**3.1-1 Demolition Work**

Prior to all demolition work a written notice shall be prepared between the Engineer and the Contractor specifying all salvageable materials resulting from the demolition work. The contractor shall store this material on site and hand it over to the Client as agreed upon.

Careful co-ordination with other work executed at the site must be obtained to perform the demolition work involved. Before starting any demolition work, the contractor shall inspect the structures to be demolished and he shall take all necessary precautions to ensure that those parts to be retained will remain undamaged. All damage to retained parts shall be repaired by the Contractor at his expense.

It shall be the Contractor's responsibility to secure all load-bearing parts by adequate supports, in case the demolition will change the load-bearing behavior, or when higher loads will have to be taken either for temporary purposes or permanent use.

When executing the demolition work, the surrounding areas must only be affected to the absolutely necessary minimum. In the event that demolition work might cause damage to surrounding structures, the contractor shall, in conjunction with the Engineer and the owners of such structures, determine their present condition and the contractor shall, if required, take appropriate measures before demolition work commences.

All debris, rubbish and other materials resulting from demolition operations shall be removed from the site to an authorized dumping area. Storage or sale of removed materials will not be permitted on the site.

**3.1-2 Clearing**

Clearing includes the removal of existing obstacles above ground, except for buildings, for instance the removal of loose boulders up to 0.3 m3 volume, fences, trees and vegetation. Trees must only be removed upon approval by the Engineer.

When removing trees and other growth, stubs and roots of more than 80 mm diameter trunk size, they shall be removed down to a minimum depth of 500 mm below ground level. Where required, depressions caused by the removal of boulders, trees or other obstacles shall be filled with adequate soil and compacted at no extra cost. Burning of removed materials will not be permitted on the site. All unsalvageable materials shall be disposed of by removing them from the site at the contractor's expense.

**3.1-3 Surveying**

Prior to starting any earthwork the contractor shall make a land survey of the area where such work shall be carried out, establish permanent bench marks, take and record all data for reference and measurement, as well as mark boundary lines.

After completion of the finish grading, the elevations of the cut and fill areas shall be controlled in the presence of the Engineer. The contractor shall prepare a signed statement on the results of this surveying work, certifying the correct location and level within the tolerances of +/-30 mm. Deviations shall be shown in the statements.

**3.1-4 Removal of Topsoil**

When topsoil is to be excavated and separated from the bulk excavation material, it must be removed by stripping. The stripped topsoil shall carefully be stockpiled until re-used. Stockpiles shall have a clean shape to allow for measuring. The thickness of the layer to be stripped depends on local conditions and shall be determined in agreement with the Engineer.

**3.1-5 Rough Grading**

After the site preparation has been completed, general cutting and all types of excavation as described in the Project Documents, regardless of the material encountered, shall be performed within the specified grading limits for the project. Satisfactory materials for fill and backfill, i.e. all non-cohesive soils, shall be obtained from the required excavation at site. It shall be transported to and placed in fill areas. Cohesive soils must only be placed as fill material where future settlements cause no harm, i.e. for future vegetational areas.

All excavated materials not required or unsatisfactory for fill or backfill shall be hauled off site to an authorized general garbage area designated by the Engineer at the Contractor's expense. Material required for fill in excess of that produced by excavation within the grading limits shall be obtained from borrow excavation. The material shall be selected to meet the requirements for the particular fill with written approval from the Engineer.

Excavation and filling shall be performed in a manner and sequences that will provide drainage for surface water at all times.

**3.1-6 Finish Grading**

Lines and grades shown in the Project Documents shall be established and maintained by means of line and grade stakes placed at the site by the Contractor.

The contractor will be responsible for exact location and level of the control devices including the bench marks. The finished grading must not deviate from the designed level by more than +/-30 mm.

Excessive excavations shall be filled with compactable material and be compacted as encountered with the natural soil. Excessive heights shall be reworked. This work shall be performed at the contractor's expense.

**3.2 EXCAVATION**

**3.2-1 (a) General**

Excavation shall be in accordance with the dimensions shown in the Project drawings and according to the arrangement specified in the structural remarks drawing. If no slope inclinations have been shown, the contractor shall select an adequate slope at his option. However, he will be responsible for the stability of the ground. Excavation shall extend to a sufficient distance from walls or footings to allow for placing and removal of forms and for inspection.

A 500 mm wide usable working space lateral to the exterior edge of the formwork including posts shall be provided. In the case of sloped excavation this clearance is measured from the slope base to the exterior edge of the formwork including posts.

The classification of the soil depends on its state when loosened and shall be classified as indicated in Clauses 2.01-1/1 through 2.01-1/6. In the event that the contractor should encounter soil classes deviating from those shown in the Project Documents, the Engineer shall be informed in writing. If not otherwise permitted in the Project Documents or approved by the soils investigation report, any excavation performed near buildings should be started with a distance of at least 2 m from any structure and a slope inclination of 1:1 (vertical: horizontal) shall be maintained. Any deviation from such limits shall require appropriate safety measures such as shoring or sheet piling. If such precautionary measures have not been specified in the Project Documents, agreement shall be obtained thereon from the Engineer.

If not determined otherwise for specific reasons in the Project Documents, it will be the contractor's option to select the machinery and the excavation method. Over excavations shall be filled with satisfactory soil and compacted to obtain the stability of the existing soils. This work will be at the contractor's expense.

The collection of water in the pit during excavation shall be avoided as much as possible. When necessary, the pit shall be dewatered by laying drain lines and using pumps or by other adequate measures which will prevent soaking of the foundation bottom. No structures or parts shall be permitted to the built on soaked soil. Soaked soils shall be removed and replaced by satisfactory material as specified above for over excavations. The contractor shall bear the responsibility thereof.

**Excavation in Private Property**

Before commencing any excavation work in private property, the Contactor shall prepare and agree with owner or occupier of such property, a record of the state of the surface with particular reference to any features that may require special care and reinstatement. The records shall be drawn up in collaboration with the Engineer, who shall be supplied with copies of all such agreements and records. No claim for extra work, delay, or stoppage will be entertained.

**(b) Road Excavation - Replace Soil by Selected Material**

The subgrade in cut, where the soil is unsuitable for retention as the subgrade layer; CBR > 25%, it shall be sub excavated to a depth of 200 mm below top of subgrade to allow for subsequent placing and compaction of the subgrade layer (topping). If the material of the subgrade is suitable for retention as subgrade layer it shall be scarified to the required depth, watered and compacted in accordance with Clause 3.02 of Section 02230 - “ Subgrade Surface Preparation”.

Where the subgrade is composed of rock as defined in Clause 3.02 of Section 02230 “ Subgrade Surface Preparation”, it shall be undercut to a depth of 200 mm below top of subgrade to allow for subsequent placing and compaction of the subgrade layer (topping) in accordance with Clause 3.02 of Section 02230 - “ Subgrade Surface Preparation”.

**3.2-2 Rock Excavation**

Loosening of rock shall be performed by means of pneumatic impactors, continuous rock mining excavators, or other heavy rock excavation machinery. Blasting for loosening purposes shall only be executed upon written approved by the Engineer or when specified in the Project Documents. Blasting shall be done in such a manner, that loosening will be completed nearly to the required grade. But care shall be taken not to loosen the surrounding rock. However, if such rock is loosened it shall be removed at the Contractor's expense.

Explosives shall not be used nor shall they be brought on the site unless approved by the Supervising Agency in writing. Such approval will only be given in exceptional circumstances. The use of explosives shall comply with the following Clauses.

The contractor shall employ his own specialists or an approved sub-contractor who is a specialist in the use of explosives. Having obtained the Engineer's written approval with the government regulations for the use of explosives and before starting operations, the contractor shall notify the Engineer and agree the times when blasting may take place. Due warning of the times of firing charges shall be given to all persons liable to be affected and watchman with red flags shall be deployed to warn persons and traffic, and generally the contractor must consider all rules and laws in the Republic of Yemen.

Explosives shall be stored in a locked building. Storage and use of explosives shall be in strict conformity with the Government Regulations. The contractor shall ensure that there is no unauthorized issue or improper use of explosives. Explosives shall be handled only by qualified shot firers.

Explosives shall be used in the quantities and manner recommended by the contractor's specialists. The size of the charge and its location for any one blast shall be subject to the approval of the Engineer. Such approval will not in any way relieve the contractor of his liabilities.

When blasting is carried out, the contractor will ensure, by adherence to proper safety distances and by the use of heavy blasting mats where necessary to prevent the dispersal of materials, that no damage is caused to persons, animals or properly on or off the site. Special care shall be taken when blasting in wet ground to ensure that individual explosions are reduced to such a size as to preclude damage to any buildings or structures.

All blasting operations shall be conducted by qualified persons and in full compliance with all laws, regulations, and local ordinances and with all possible care to avoid injury to persons and property. The rock shall be well covered and sufficient warning shall be given to all persons in the vicinity of the work before blasting. Care shall be taken to avoid injury to utilities or other structures above and below ground. Notify authorized representatives of all utilities which might be affected by blasting operations at least 24 hours before any blasting is performed.

In addition to observing all laws, regulations and ordinances relating to transporting, storage and handling of explosives, conform to any further regulation which the Engineer may deem necessary.

If rock below grade is shattered by blasting, caused by holes drilled too deep, or too heavy charges of explosives, or any other circumstance due to blasting, and if, in the opinion of the Engineer, the shattered rock is unfit for subgrade, the rock shall be removed and the excavation refilled with thoroughly compacted screened gravel at no additional cost.

**3.2-3 Trench Excavation**

Trenches for foundations and underground services shall be excavated to the required alignments and depths. Trenches that, as a result of existing soil conditions, might cave in or slide shall be shored or constructed with slopes. The inclination of the slopes will depend on the soil properties. Where no soil-mechanical characteristics have been provided, the following maximum angles of slope will be permitted:

non-cohesive or soft, cohesive soil 45 degrees

stiff, cohesive soil 60 degrees

soft rock 70 degrees

heavy rock 90 degrees

If not otherwise approved a strip of 600 mm minimum width shall be kept free of any loads at the upper edge of the trench. If the soil is sufficiently stable to use unshored vertical trench walls, trenches must not be deeper than 1.75 m. However, from a level 1.25 m from the bottom of the trench the sides must be sloped at an angle according to the above table or the sides above the 1.25 m level must be planked and braced.

Trenches which will be walked in must have a minimum width of 500 mm. Where pipes, foundations or other constructions are placed in the trenches, the width of the trench shall allow for adequate working space.

**3.2-3/1 Trenches for Foundations**

Where the trench base shall serve as foundation level for constructions, it must not be loosened.

**3.2-3/2 Trenches for Pipelines**

Trenches without planks and vertical or sloped walls of an angle exceeding 60 degrees shall at least be the exterior pipe diameter +0.40 m wide, if the exterior pipe diameter is 400 mm or less; where the diameter exceeds 400 mm, the trench width shall have a minimum of the exterior pipe diameter +0.70 m.

The same will apply to planked trenches. In this case the trench width is measured as the clear spacing between the planks. In pipeline trenches depressions shall be excavated at the pipe ends so that the bells and joints are absolutely free and the remaining pipe may rest uniformly over its entire length. These depressions must only be excavated after the construction of the trench base.

Where rock is encountered, the base shall be excavated to exceed the foundation bottom by 150 mm and the over depth shall be filled with load-bearing material. The same applies where non-supportive soil is found to exist in the bottom. It shall then be removed and replaced by load-bearing material.

**3.2-4 Planking and Strutting**

Where, as described in Clause 3.2-3, shoring is required the upper edge shall project above the ground level by at least 50 mm. The planks must be in tight contact with the ground over their whole surface. Cavities which might occur shall be filled and compacted immediately. All struts must be flush with the areas of contact. They shall be secured against sliding away or shifting. Where timber struts are used, they shall be held with wooden wedges to allow for renewed driving of the wedges. The wedges shall be secured against unintentional loosening.

Planks and struts must only be removed when the fill is placed. It will be the contractor's responsibility to make sure that the shoring remains in a safe and proper state during the whole construction period.

Shoring with horizontal planks shall be placed as the excavation progresses. The first planks shall be placed at least when an excavation depth of 1.25 m has been reached. Only planks of the same length shall be installed in the individual sections. Staggered joints will not be permitted.

Where shoring is constructed, the struts shall have a minimum diameter of 100 mm and/or 120 mm, the spacing of the braces as shown in the following table may be used. For different types of construction, the contractor shall provide structural evidence at his expense and to the approval of the Engineer.

**Horizontal shoring with vertical scantlings 80 mm x 160 mm**

**and circular strutting, diameter: 100 mm**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plank-Thickness 60 mm** | | | | |
| 1 | Max. wall height m | 3.00 | 4.00 | 5.00 |
| 2 | Max. blank span m | 1.90 | 1.90 | 1.90 |
| 3 | Max. cantilever m | 0.50 | 0.50 | 0.50 |
| 4 | Max. scanting span m | 0.70 | 0.65 | 0.60 |
| 5 | Max. cantilever of the scantlings m | 0.30 | 0.30 | 0.30 |
| 6 | Max. cantilever of the scantlings m | 0.60 | 0.55 | 0.50 |
| 7 | Max. length of the struts | 1.45 | 1.40 | 1.35 |

**Horizontal shoring with vertical scantlings 120 mm x 160 mm and**

**circular strutting, diameter: 120 mm**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plank-Thickness 60 mm** | | | | |
| 1 | Max. wall height m | 3.00 | 4.00 | 5.00 |
| 2 | Max. blank span m | 1.90 | 1.90 | 1.90 |
| 3 | Max. cantilever m | 0.50 | 0.50 | 0.50 |
| 4 | Max. scanting span m | 1.00 | 0.95 | 0.9 |
| 5 | Max. cantilever of the scantlings m | 0.40 | 0.40 | 0.40 |
| 6 | Max. cantilever of the scantlings m | 0.80 | 0.75 | 0.70 |
| 7 | Max. length of the struts | 1.80 | 1.70 | 1.60 |

**Appropriate Procedures for Laying Water Pipes and Sewers in Trenches**

1. As a general rule, water pipes and sewers should not be laid in the same trench. They should be laid in separate trenches at least 3 m apart in a horizontal direction; the distance being measured edge-to-edge

2. But if local conditions do not permit the horizontal minimum separation of 3 m (e.g. in very narrow streets) this distance could be decreased but the bottom of the water pipe must be kept at least 50 cm above the top of the sewer.

3. But if the vertical separation of not less than 50 cm cannot be obtained, sewer material and joints should be ductile iron type (pressure pipes) and should be pressure tested to ensure water tightness before back-filling. The least pressure shall be 1.5 times working pressure of the water pipe.

4. In cases where there is no alternative but to lay both water pipes and sewers in same trench, the following should be observed:

a. The water main should be offset of an undisturbed earth shelf

b. The bottom of the water main should be at least 30 cm above the top of the sewer lines

c. Both water and sewer lines should be cast iron with mechanical joints or equal construction

5. In situations where water pipes are in close proximity of sewers and no adequate horizontal or vertical separations can be provided, considerations should perhaps be given to encasing sewer lines with reinforced concrete in addition to using pressure types for sewers.

6. where sewers cross water pipes (4 inches in diameter or more) and the vertical projected distance between them is equal or less than 1.5 m then sewers for a distance at least 3 m on each side of the water line should be constructed of materials and joints shall be ductile iron type and shall be pressure tested to 1.5 times the working pressure of the water pipe to assure water tightness before backfilling

A vertical separation of at least 50 cm between the bottom of the water pipe and the top of the sewer should be provided, whenever possible

7. If sewers have to pass over water pipes whatever the diameter and whatever the vertical separation is, the following should be considered:

a. Vertical separation of at least 50 cm between the bottom of the sewer and the top of the water main

b. Sewers should be constructed of materials described in above item 3, i.e. a pressure-type pipe tested to 1.5 times the working pressure of the water pipe

c. Adequate structural support for the sewers to prevent excessive deflection of joints and settling on and breaking the water mains, i.e. full reinforced concrete encasement

d. The length of water pipe should be centered at the point of crossing so that the joints shall be equidistant and as far as possible from the sewer

e. Consideration should also be given to encasing the sewer line with concrete as specified in item 6 above.

8. This Clause (1- through -7) applies for sewer lines. For house connection and for the cases mentioned in item 1-6 it is not necessary to change the sewer pipe to ductile but full reinforced concrete encasement should be added to the house connection only when vertical separation is less than 50 cm.

For sewerage house connections passing over water pipes of any diameter, full concrete encasement should be added to the house connection and at least 50 cm vertical separation should be provided.

**3.3 BACKFILLING**

**3.3-1 (a) General**

Satisfactory material shall be used in bringing fill to the required lines and grades. The material shall be free from roots and other organic matter, trash, debris and stones larger than 80 mm in any dimension. Material as specified above for fill and backfill shall be obtained from the required excavation on site, if acceptable, (Liquid limit less than 40 and maximum dry density greater than 1.7 ton/cu m. (Modified Proctor) provide that the backfill material A1,A2,A3 acceptable to the Engineer). Unsatisfactory material on surfaces or in excavated areas to receive fill shall be removed and replaced with satisfactory material. No fill material shall be placed on muddy areas or on surfaces which have not been approved and comply with the following:

1. Maximum dry density not less than 1.7 gm/cm3 (AAHSTO T-180D)
2. Organic matter not more than 5% (AAHSTO T-267)
3. No use of A-6, A-7 soil (AAHSTO M-145)
4. Maximum size not more than 2/3 of the layer thickness
5. Plasticity Index (PI) less than 15%
6. 4-day soaked CBR should not be less than 10% (AAHSTO T-193) when compacted at 90% maximum dry density in accordance with AASHTO T - 180D.
7. No use of high to medium expansive soils.

**3.3-1 (b) Embankment – Topping (Selected Material)**

The 200 mm depth of embankment subgrade layer immediately below the bottom of sub base or base (in the absence of sub base layer) shall consist of selected topping material having a 4-day soaked CBR of at least 25% when tested in accordance with AASHTO T 193 and with a gradation and PI as specified under Clause 3.02 of Section 02230 - “ Subgrade Surface Preparation”.

The 600 mm depth of embankment immediately below the topping layer shall consist of material having a 4-day soaked CBR of at least 15% when tested in accordance with AASHTO T 193 and with PI not more than 15 and the material passing sieve #200 shall not exceed 35%, If not rock fill. If rock fill material is used for the bottom 400 mm then those requirement shall apply to the top 200 mm.

The contractor shall provide a properly compacted selected soil material in accordance with the specification shown on Drawings and indicated in the Contract Documents.

**3.3-2 Trench Backfilling**

Trenches shall not be backfilled until all required tests are performed and until the installed systems comply with all requirements.

The trenches shall be carefully backfilled with the excavated material approved for backfilling. The fill materials shall consist of sand or gravel, free from large clods of earth and free from stones larger than 25 mm, deposited in 150 mm layers and thoroughly and carefully tamped by hand until the pipe has a cover of not less than 300 mm, care being taken not to disturb the pipe or drain. Backfilling above this level can be carried out using mechanical means. Trenches improperly backfilled shall be reopened to the depth required for proper compaction, then refilled and compacted as specified at the contractor's expense.

**3.4 COMPACTION**

**3.4-1 (a) Soil Compaction (General)**

Prior to constructing the select-material layer, the previously constructed subgrade shall be cleaned of all foreign substances. Surfaces of subgrades shall meet the specified compaction and surface tolerances. Ruts or soft yielding spots that may appear in the subgrade, areas having inadequate compaction, and deviations of the surface from specified requirements shall be corrected by loosening, removing and by adding approved material, reshaping to line and grade, and re-compacting to specified density requirements.

Alternative blading and rolling shall be performed until a smooth, even and uniformly compacted finish is obtained.

Approved materials shall be placed along the edges of each layer in sufficient quantity to allow at least 0.60 meter of the shoulder to be rolled and compacted simultaneously with the rolling and compacting of the layer.

The surface shall show no deviations in excess of +/-30 mm when tested with a 3 m straight-edge applied parallel with and at right angles to the center line of the area to be paved. Deviations exceeding this amount shall be corrected by loosening, adding or removing material, reshaping, and compacting as directed. When the course is constructed in more than one layer, the smoothness requirements specified above shall apply to the top layer. The surface of underlying layers shall be finished to a reasonably even contour.

The completed thickness of the layer shall be within 10% of the thickness shown in the Project Documents, but must not deviate more than 30 mm, whatever is less. Where the measured thickness of the layer deviates from the smaller value, the contractor shall correct such areas by scarifying, adding mixture of proper gradation, reblading, and re-compacting as directed.

Roadway embankment consisting of soil or granular material shall be placed in horizontal layers not exceeding 250 mm thickness (Before compaction), shall be compacted as specified (200mm layer thickness after compaction) and shall be approved prior to placing the next layer.

**3.4-1 (b) Standards of Compaction for Soil and Granular Materials**

* + The following compaction standards shall apply to embankment materials other than predominantly rock materials. The “ maximum density” of soil type materials shall be the modified maximum density determined in accordance with AASHTO T 180 (Method D). The “relative density” shall be the relative density determined in accordance with ASTM D 2049, which identifies the state of compactness of material with respect to its loosest and densest state. The relative density shall be the standard to which the field density is referred for comparison in the case of cohesion less, free draining granular materials.
  + Soil type materials shall be compacted to at least 90% modified maximum density for the full depth of embankment. The 600 mm of embankment material immediately below the topping layer shall be compacted to at least 95% modified maximum density. Topping layer shall be compacted to 100% modified maximum density. Moisture content shall be within plus or minus 2% of optimum at the time of compaction.
  + Minimum soil tests required during the construction of embankment are listed as follows:

1. One sample for CBR, Classification (AASHTO M 145), and laboratory (Moisture-density) or relative density compaction form each source prior to use. Each sample shall represent not more than 2,000 m3.
2. One sample for Soil Classification representing not more than 1,500 cubic meters of the materials in use.
3. For every completed layer, one field density shall be determined each 1500 m2 or 100 linear meters whichever is less. Testing shall be in accordance with ASTM D 1556 or ASTM D 2167.

**PART 4 ANCILLARY WORK**

Ancillary work as stated in - General Requirements - includes the following:

**4.1 COST ITEMS TO BE INCLUDED**

**4.1-1** Securing of works against such surface water as may normally be expected and removal of this where necessary up to the time of acceptance.

* + 1. Removal of individual bushes and individual trees up to a diameter of 80 mm as measured 1 m above the ground, together with the roots and stumps belonging to them.

**4.2 COST ITEMS TO BE SPECIFIED**

No special requirements.

**4.3 SETTLEMENT**

The contractor shall be responsible for all settlement & backfill, fills, and embankments which may occur within the maintenance period stipulated in the General conditions. The contractor shall make, or course to be made, all repairs or replacements made necessary by settlement within 30 days after notice from the Engineer or client.

**PART 5 QUANTITY SURVEY**

Quantity survey as stated in-General Requirements- includes the following:

**5.1 GENERAL**

**5.1-1** Bulk excavation is measured from the surface of the ground to the base of the pit or trench.

**5.1-2** The unit price for excavation shall include for excavating in any material.

**5.1-3** Excavation shall be measured vertical with the circumference of construction and the unit price shall include for excavating below the normal water level, in running sit or sand, keeping excavations free from water, upholding sides of excavation, for general working space and working space for leveling, grading or compacting where necessary, bulking of materials and all double or multiple handling.

**5.1-4** The minimum trench width shall be as detailed in Clause 3.2-3 of this section.

* + 1. The unit prices for hardcore filling or the like are to include for preparing formation, trimming, rolling, leveling, grading and blinding surfaces.

**5.2 UNITS OF MEASUREMENTS**

**5.2-1 Site Preparation**

**5.2-1/1** Site clearance, which shall include removing vegetation, undergrowth, buses, hedges, trees or the like, shall be measured by area (m2).

**5.2-2 Excavation**

Excavation shall be measured by L.M (m) as the void which is to be occupied by the permanent construction, or vertically above any part of the permanent construction.

Excavation should include, but not limited to, the following:

**5.2-2/1** Oversize excavation to remove top soil.

**5.2-2/2** Excavation to reduce levels.

**5.2-2/3** Excavation in cuttings.

**5.2-2/4** Basement excavation.

**5.2-2/5** Trench excavation to receive foundations, which shall include pile caps and ground beams.

**5.2-2/6** Pit excavation to receive foundation bases.

**5.2-2/7** Excavation for diaphragm walls.

**END OF SECTION**

# SECTION 02230

# GRANULAR MATERIAL

**PART 1 GENERAL**

* 1. **THE REQUIREMENT**

1. The Contractor shall furnish all labor, equipment and materials required to complete all work associated with the installation of aggregate material beneath foundations, as backfill and as roadway subgrade and other related and incidental work as required to complete the work shown on the Drawings and specified herein.
   1. **RELATED WORK**
2. Excavation and Backfilling is included in Section 02220
3. Aggregate Base Coarse is included in Section 02540
4. Paving is included in Section 02512
   1. **REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ASTM C 127 Test for Specific Gravity and Absorption of Coarse Aggregate.

2. ASTM C 136 Test for Sieve Analysis of Fine and Coarse Aggregates.

3. ASTM C 535 Test for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

1. ASTM C 88 Test for Soundness.

AASHTO: American Association of State Highway and Transportation Officials.

T11, T27, T88 Sieve Analysis, Standard Method of Test

T89 Determining the Liquid Limit of Soils, Standard Method of Test for

T90 Determining the Plastic Limit and Plasticity Index of Soils, Standard Method for

T96 Determining the Percentage of Wear of Aggregate, Standard Method of Test for

1. BS: British Standard.

Any codes proposed by the Contractor subject to the approval of the Engineer

**PART 2 PRODUCTS**

**2.01 CRUSHED STONE, SCREENED GRAVEL, AGGREGATE BASE COURSE (ABC) AND GRANULAR MATERIAL FOR SUB-BASE**

1. Crushed stone or screened gravel shall meet the requirements of Aggregate Standard Size as defined by Table 1 or Table 2, mentioned herein after.

**TABLE 1**

|  |  |
| --- | --- |
| **Sieve – square openings** | **Percent Passing by Weight** |
| 25-mm | 100 |
| 19-mm | 90-100 |
| 9.5-mm | 20-55 |
| No. 4 | 0-10 |
| No. 8 | 0-5 |

**TABLE 2**

|  |  |
| --- | --- |
| **Sieve – square openings** | **Percent Passing by Weight** |
| 37.5-mm | 100 |
| 25-mm | 95-100 |
| 12.5-mm | 25-60 |
| No. 4 | 0-10 |
| No. 8 | 0-5 |

1. ABC shall meet all requirements of aggregate for **base course** as specified hereunder:

California Bearing Ratio, Min.80

AASHTO T 193; percent

Min. at 100% compaction

Los Angeles abrasion, Max. 40%

AASHTO T 96; percent Fractured Faces, percent Min.80%

(For Aggregates retained on #4)

Liquid Limit, Max. 25%

(AASHTO T89) ; percent

Plasticity index, Range 2-6%

(AASHTO T90); percent

Max. Dry Density (gm/cm3) Min. 2.1

(AASHTO T 180-D);

Compaction ; percent 100%  
(AASHTO T 180-D);

Sand Equivalent, Max. 35%

(AASHTO T90); percent

Clay lumps and Friable particles Max. 3%

(AASHTO T112); percent

Flakness Index, Max. 25%

BS 812; percent

Elongation Index, Max. 25%

BS 812; percent

Soundness : Na Max. 12%

Mg Max. 18%

(AASHTO T104); percent

Gypsum Content (As SO3) Max. 2%

BS 1369; percent

Max. Tolerance in level ± 10mm

ABC gradation shall be as specified in Table 3.

**TABLE 3**

|  |  |
| --- | --- |
| **Sieve – square openings** | **Percent Passing by Weight** |
| 50-mm | 100 |
| 37.5-mm | 100 |
| 25-mm | 75-100 |
| 19-mm | 60-90 |
| 12.5-mm | 45-80 |
| 9.5-mm | 40-70 |
| No. 4 | 30-55 |
| No. 10 | 20-40 |
| N0. 40 | 8-20 |
| N0. 200 | 5-10 |

Note: The fractions passing the No. 200 sieve shall not be greater than two-thirds the fraction passing the No. 40 sieve.

1. Granular material for sub-base shall meet all requirements of granular material for **sub-base** as specified hereunder:

California Bearing Ratio, Min. 40

AASHTO T 193; percent

Min. at 100% compaction

Los Angeles abrasion, Max. 40%

AASHTO T 96; percent

Liquid Limit, Max. 30%

(AASHTO T89) ; percent

Plasticity index, Range 2-8%

(AASHTO T90); percent

Max. Dry Density (gm/cm3) Min. 2.05

(AASHTO T 180-D);

Compaction ; percent 100%  
(AASHTO T 180-D);

Sand Equivalent, Max. 25%

(AASHTO T90); percent

Clay lumps and Friable particles Max. 5%

(AASHTO T112); percent

Flakness Index, Max. 25%

BS 812; percent

Elongation Index, Max. 25%

BS 812; percent

Soundness : Na Max. 12%

Mg Max. 18%

(AASHTO T104); percent

Gypsum Content (As SO3) Max. 2%

BS 1369; percent

Max. Tolerance in level ± 10mm

Gradation for granular material for sub-base shall be as specified in Table 4.

**TABLE 4**

|  |  |
| --- | --- |
| **Sieve – square openings** | **Percent Passing by Weight** |
| 62.5-mm | 100 |
| 50-mm | 80-100 |
| 37.5-mm | 70-95 |
| 25-mm | 55-90 |
| 12.5-mm | 45-75 |
| No. 4 | 30-60 |
| No. 10 | 22-48 |
| N0. 40 | 10-30 |
| N0. 200 | 5-12 |

* 1. **SELECT SAND (FINE AGGREGATES)**

1. Select sand shall consist of natural or manufactured siliceous sand, clean and free from deleterious substances, and graded within the limits shown in Table 5, the sand shall meet all requirements of ASTM C33.

**TABLE 5**

|  |  |
| --- | --- |
| **Sieve – square openings** | **Percent Passing by Weight** |
| 12.5-mm | 100 |
| No. 4 | 95-100 |
| No. 8 | 80-100 |
| No. 16 | 50-85 |
| No.30 | 25-60 |
| No. 50 | 10-30 |
| No. 100 | 2-10 |
| N0. 200 | 0-5 |

\*For manufactured sand, the percent passing the No. 100 Sieve may be increased up to 15%.

**PART 3 EXECUTION**

* 1. **CRUSHED STONE, SCREENED GRAVEL, AGGREGATE BASE COURSE (ABC), AND GRANULAR MATERIAL FOR SUB-BASE**

A. The Contractor shall install crushed stone, screened gravel, ABC and granular material for sub-base in accordance with these Specifications and as shown on the Drawings and indicated in the Contract Documents.

1. Unless otherwise stated herein or shown on the Drawings, all mat foundations (bottom slabs) for the proposed structures shall have a blanket of crushed stone or ABC 150-mm thick minimum placed directly beneath the proposed mat. The blanket shall extend a minimum of 300-mm beyond the extremities of the mat.

2. For subgrade preparation at structures and structural fill, the foundation material shall be ABC where specifically specified on Drawings, otherwise, crushed stone or screened gravel shall be used.

1. For ground under drains, pipe bedding, and drainage layers beneath structures the coarse aggregate shall meet the requirements of aggregate standard Size as defined in Table 2 of this Section.
   1. **SUBGRADE SURFACE PREPARATION**

The subgrade (topping) shall have previously been constructed in accordance with the following requirements:

A. These works shall consist of furnishing materials, constructing the subgrade layer and preparing the subgrade surface (top of subgrade, P.G.L) ready to receive the pavement structure and shoulders, all as and where shown on the Drawings.

1. The subgrade layer is the 200 mm minimum depth of selected material (Topping) immediately below the subgrade surface (top of subgrade, PGL), or as defined in the drawings or directed by the Engineer.
2. Materials:
3. Topping material shall consist of selected material having a 4-day soaked CBR of not less than 25% when tested in accordance with AASHTO T 193 when compacted at 100% of modified proctor AASHTO (T-180-D) and having a maximum PI of 10%. Topping gradation shall be reasonably smooth without gap grading. All material shall pass 75 mm sieve and not more than 18% shall pass 0.075 mm (No. 200) sieve.
4. In situ material shall be deemed to be rock if it is natural solid mineral matter occurring in large masses; if it is non-rip able by D8 or equivalent; and if 100 mm diameter core specimens, when tested in accordance with ASTM D2938 have a crushing strength of at least 7 MN/sq.m (70 kg/sq. cm) when dry and at least 4 MN/sq.m (40 kg/sq. cm) when tested after soaking in water for 24 hours.
   1. **TESTING**

A. Sub-base and Base course material shall be tested in accordance with Table 7 after mixing with water at the mixing plant for source of material tests and in -situ after dry mixing prior to spreading and compaction for control on site tests and if satisfactory shall be approved for use. This approval shall not be deemed to constitute acceptance of the base course for full payment purposes.

B. Compaction shall be tested in accordance with AASHTO T 191, AASHTO T 205 or any acceptable method. If there is a significant delay between the construction of any layer and the following layer, the Engineer may require the compaction of the lower layer to be re-verified to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

**Table 7: Required Tests and Minimum Repetition for Base & Sub-base Course Material.**

|  |  |  |  |
| --- | --- | --- | --- |
| Source of Material | | Control on Site (The Road) | |
| Required Test (A) | Repetition Required for all Tests in (A) | Required Tests (B) | Repetition Required for all Tests in (B) |
| 1. Gradation of Materials | 1. Test of each source | 1. Proctor (modified) | 1. Test for every 500 Linear Meter and for each layer |
| 1. Plasticity Index | 1. For every 2000 cu m | 1. Gradation of Materials | 1. When materials changed |
| 1. Abrasion | 1. When Materials changed | 1. Plasticity Index |  |
| 1. CBR |  | 1. CBR |  |
| 1. Sand Equivalent |  | 1. Abrasion |  |
| 1. Percentage of fractured Grains/ |  | 1. Sand equivalent |  |
| Base course |  |  |  |
|  |  | 1. Clay lumps & friable particles |  |
|  |  | 1. Field Density |  |
|  |  | 1. Any other |  |
|  |  | 1. Thickness | 1. Test for every 750 square meter and for each layer |

**END OF SECTION**

# SECTION 02401

# SURFACE AND GROUNDWATER CONTROL

**PART 1 GENERAL**

**1.1 SCOPE OF WORK**

1. Work to be done under this Section includes, but is not limited to, the following items including all labor, materials, equipment and services necessary and incidental to the proper execution of the Work as shown on the Drawings and as specified herein.
   1. Designing, furnishing, installing, operating maintaining and removing temporary groundwater and surface water control systems as necessary to:
      1. Lower and control water levels in all excavation areas, to 500 mm below subgrade levels such that excavation is conducted in-the-dry.
      2. Reduce hydrostatic pressures acting on excavation support system elements where necessary.
      3. Control and remove water seeping into excavations from perched aquifers or leaking utility pipes. Prevent migration of soil from outside the excavation limits to inside the excavation limits.
      4. Prevent flow of surface water into excavations.
      5. Maintain the water level at least 500 mm below the backfill surface during backfilling operations.
   2. Collecting and disposing of discharge water from the groundwater control systems as specified in this Section.
   3. **RELATED WORK NOT INCLUDED**
2. Excavation, trenching and backfill is included in Section 2220.
   1. **DESIGN CRITERIA**
3. The methods of controlling groundwater are to be the option of the Contractor who shall be solely responsible for the location, arrangement and depth of any system or systems selected to accomplish the Work. The primary purpose of groundwater control is to preserve the undisturbed bearing capacity of the subgrade soils. Dewatering in the project area may be required depending on soils conditions and groundwater levels at the time of construction relative to trench excavation subgrade levels, dewatering systems or combinations to be provided for pipe installation and backfill placement.
4. The Contractor shall take measures to prevent damage to properties buildings or structures, waterlines and other utility installations, pavements, sidewalks and other work. The contractor’s attention is directed to provisions of Local Corporation for Water & Sanitation in Hadramout Governorate – Coastal Areas (LCWSSHG-CA) Technical Specs for Sewerage Works and Water Mains and Distribution. Repair damage, disruption or interference resulting directly or indirectly from groundwater control system operations at no additional cost to the Employer.
5. Control groundwater seepage into excavation such that seepage water does not cause disturbance to the subgrade soils and do not adversely affect construction of the work. Seepage into the excavation which allows migration of soil particles is not allowed. If loss ground results from seepage, then stop the work and take whatever measures are necessary to cut off or control this groundwater such that further loss of ground is prevented.
   1. **SUBMITTALS**
6. Provide a written description and shop drawings showing the type of surface and groundwater control system to be implemented in the particular area where work will begin, including the following information:
   1. Arrangements, locations and depths of proposed groundwater control system elements.
   2. Description of pumping equipment to be used including manufacturer, rated capacity, performance curves, pertinent operating characteristics.
7. If for any reason the groundwater control system is found to be inadequate, make additions, changes and replacements as necessary, to provide a satisfactory system at no additional cost to the Employer.
   1. **QUALITY ASSURANCE**
8. The Contractor shall employ or retain the services of a recognized specialist in groundwater control system installation and operation, with a minimum of two (2) years experience in this field. The specialist shall be present initially when each new groundwater control system is installed and operated, and periodically thereafter, to consult on installation and equipment problems as the need arises, or as requested by the Engineer.
9. Adhere to the applicable requirements of all codes and regulations of authorities having jurisdiction over disposal of discharge waters.
   1. **JOB CONDITIONS**
10. Site investigation information has been collected and summarized in Volume 2 of the Contract Documents, Appendix A Geotechnical Information. Appendix A lists other information regarding subsurface conditions and the availability of such information. The Contractor’s groundwater control system design shall be coordinated with the excavation support system design and excavation procedures to accommodate perched groundwater levels and associated unstable ground conditions, if and when encountered.
11. The Engineer does not make any expressed or implied guarantee regarding the accuracy of site investigation information which is made available to the Contractor for his information and which is to be used at his own risk. The Contractor shall be responsible for obtaining all additional information he deems necessary for the design of the groundwater control system.

**PART 2 PRODUCTS**

* 1. **MATERIALS**

1. Piping, pumping equipment and all other materials required to provide control of groundwater in excavations shall be suitable for the intended purpose. Standby pumping systems and a source of standby power shall be maintained at all sites.

**PART 3 EXCUTION**

* 1. **GENERAL**

1. All work included in this Section shall be done in a manner which will protect existing structures and utilities and shall not cause loss of ground or disturbance to the pipe bearing soil or to soil supporting, overlaying or adjacent to structures. The Contractor shall be solely responsible for any damage to properties, buildings or structures, sewers and other utility installations, pavements, sidewalks and work that may result from his groundwater and surface water control operations.
2. If damage to any structure occurs as a result of groundwater control operations, Contractor shall take immediate measures to prevent further damage and revise methods or implement measures as necessary to prevent damage to other structures.
3. Surface water and groundwater shall be controlled to the extent that excavation to the required bottom of the excavation is made in-the-dry, the bearing soils are maintained firm and undisturbed, and softening and instability due to the presence or seepage of water does not occur. All construction and backfilling shall be done in-the-dry and flotation of completed portions of the Work shall be prevented.
   1. **SURFACE WATER CONTROL**
4. Surface water control measures, including dikes, ditches, diversions, sumps and other methods shall be constructed to positively prevent flow of surface water into any excavation.
   1. **SUBSURFACE WATER CONTROL**
5. At all times during construction, provide and maintain proper equipment and facilities to remove all water entering excavations. Excavations shall be kept dry so as to obtain a satisfactory undisturbed subgrade foundation condition until the fills, structures or pipes to be built thereon have been completed.
6. Prior to any trench excavation below groundwater levels, the groundwater control system shall be installed in the area of the proposed initial excavation and operated sufficiently to demonstrate to the satisfaction of the engineer that the system is capable of adequately maintaining the groundwater level as specified. The system shall be modified, if required, to maintain such capability, prior to any excavation-taking place below groundwater levels, at no additional cost to the Employer.
7. Operate the groundwater control system(s) to:
   1. Effectively lower and maintain the piezometric level in aquifers underlying and directly influencing stability of the subgrade soils to at least 500 mm below the bottom of any part of the excavation.
   2. Prevent damage to adjacent buildings, properties, structures, utilities, and completed Work.
   3. Collect and discharge surface water, seepage water from wadis, leaking utility pipes, ground water and drilling water which may enter excavations.
   4. Develop dry excavation subgrades for execution of subsequent construction operations in-the-dry.
   5. Maintain and control the water level in backfill to prevent flotation of the completed Work, and at a minimum of 500 mm below the top of backfill during backfill placement and compaction operations.
   6. **DISPOSAL OF WATER**
8. Water removed or diverted from excavations must not be allowed to cause nuisance or damage to traffic or any public or private property or service.
9. Dispose or drainage so that flow or seepage back into the excavated area will be prevented.

**END OF SECTION**

# SECTION 02512

# ASPHALT PAVING & SURFACING

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This Section covers furnishing labour, materials, and equipment for the construction of hot mix-hot laid asphaltic concrete binder (base) course, bituminous tack coat, and hot mix-hot laid asphaltic concrete surface (wearing) course for the roads, drives and parking areas at the locations indicated on the Drawings or required by the Project.

**1-1.01 Related Work**

**A. General Equipment and Material Stipulations**

The General Equipment and Material Stipulations shall apply to all materials furnished under this Section.

**B. Work Specified Elsewhere**

Other items of work that relate to and are referenced in this section include but are not limited to the following sections:

Submittals

Earthworks

Aggregate Base Course

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work of this Section are listed. Codes and Standards current at the time of bid shall be used.

**ASTM - American Society for Testing and Materials or equivalent.**

D1188 Test Method for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Parafin-Coated Specimens

D2172 Test Method for Quantitative Extraction of Bitumen from paving Mixtures

**1.3 QUALITY ASSURANCE**

**1.3.01 Governing Standards**

Except as otherwise specified or indicated on the Drawings or required by the Project, materials, equipment, details, and methods of construction shall conform to the latest edition of the Standard Specifications of the American Association of State Highway and Transportation Officials (AASHTO).

**1.3.02 Tolerances**

**A. Smoothness**

Asphalt concrete work shall be tested for surface smoothness by using a 3 meters straightedge applied parallel to the direction of drainage. The surface course shall have no deviation in excess of 5 mm from the nearest point of contact. No pockets or depressions which cause water to pool shall be permitted.

**B.** The finished surface levels of binder and wearing courses shall not vary by more than + 1 cm from the levels shown on the Drawings or required by the Project.

**1.4 SUBMITTALS**

**1.4.01 Samples and Data**

All submittals of samples and data shall be in accordance with the procedures of the applicable AASHTO specifications or equivalent.

**A. Test Reports**

Contractor shall submit laboratory test reports conforming to the applicable AASHTO requirements or equivalent for the following:

1. Aggregates, (coarse and fine) from each material source and each grading.
2. Asphalt cement for each penetration grade.
3. Uncompacted asphalt concrete mix.
4. Compacted asphaltic concrete mix.
5. Density and stability analysis of mix.
6. Plant sampling and testing of asphalt concrete mixes for quality control during paving operations.
7. Asphalt plant inspection.

**B. Design Mix Report**

The design mix report for the asphaltic cement base and for the surface course data, as submitted for review, shall include the following:

1. Percentage of asphalt cement per unit weight of dry aggregate.
2. Stability, all mixtures (Marshall).
3. Density
4. Number of compaction blows
5. Flow, all mixtures
6. Percent air voids: (Laboratory specimen)
7. Base
8. Surface
9. Percent voids in the mineral aggregate

**1.5 PRODUCT DELIVERY, STORAGE AND HANDLING**

**1.5.01 Handling**

Equipment and facilities for storage, measuring, mixing, heating, transporting, spreading, compacting, and other operations shall be in accordance with the applicable requirements of the governing standards. All equipment and facilities shall be acceptable to the Engineer.

**1.6 JOB CONDITIONS**

**1.6.01 Existing Conditions**

Aggregate base course receiving asphalt concrete paving will be compacted base course as specified in the AGGREGATE BASE COURSE Section.

**1.6.02 Environmental Requirements**

The following are environmental requirements including minimum temperatures under which asphaltic pavements may be constructed and marked. No materials shall be placed when the underlying surface is muddy, frozen, or has frost or water thereon.

The prime coat and asphaltic cement courses when placed with a spreading and finishing machine, shall not be placed when the ambient temperature is below 7 °C and falling; but may be placed when the ambient temperature is above 4 °C and rising. The asphaltic concrete courses shall not be placed when the ambient temperature is below 16 °C and falling but may be placed when the ambient temperature is above 10 °C and rising. The ambient temperature shall be taken in the shade.

**PART- 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Material List**

Materials for asphaltic concrete paving shall conform to the following requirements:

Bituminous Materials AASHTO M20

Prime Coat AASHTO M82, MC 70, medium curing cut-back asphalt.

The asphalt concrete shall consist of a mixture of crushed limestone aggregates and asphalt cement 60-70 for the binder and wearing courses.

The amount of crushing of aggregate shall be so regulated that at least 50% by weight of the material retained on AASHTO Sieve No. 4 shall consist of pieces with at least two fresh mechanically fractured faces.

The crushed aggregate shall be hard, durable, clean, free from dirt or any objectionable matter, and shall conform to the following requirements:

|  |  |
| --- | --- |
| Plasticity Index (from hot bins)  (AASHTO T-89, T-90). | NONE Plastic |
| Clay lumps and friable particles:  AASHTO T-112. | 0.25% max. |
| Gypsum Content for fine and course  aggregate corresponding to SO3  content BS 3681. | NONE |
| Chert in aggregate ASTM | 15% max. |
| Flaky particles (BS 812) | 25% max. |
| Elongated particles (BS 812) | 25% max. |
| Sand Equivalent, AASHTO T-176 | 50% min. |

The aggregate shall have a percentage of wear of not more than 40% in 500 revolutions as determined by AASHTO T96; moreover, the percentage of wear at 100 revolutions to that of 500 revolutions shall not exceed 0.25 for the same sample.

The soundness (ASTM C88) of coarse aggregate when tested by sodium sulfate method shall not exceed 12% loss, and when tested by magnesium sulfate shall not exceed 16% loss.

When the combined grading of the coarse and the fine aggregates is deficient in material passing Sieve No. 200, mineral filler shall be added. The mineral filler, if needed, shall consist of limestone dust, dolomite dust, portland cement, or other non-plastic mineral matter from sources approved by the Engineer.

The bituminous material for the binder and the wearing courses shall be petroleum asphalt cement grade 60-70 penetration as certified by the refinery and in conformity with the requirements of AASHTO M20 Table 1.

The temperature for mixing and compaction in the laboratory for Marshall Test, when the viscosity of bitumen is 170 +20 centistoke for mixing and 280 +30 centistokes for compaction, shall be 158 + 2 °C for 60/70 penetration and 156 + 3 °C for 80/100 penetration. Compaction temperature of the mix in the mould must be 134 + 2 °C.

Only automatically controlled batch mixing plant must be used conforming to ASTM D995. Necessary arrangements must be provided for calibrating scales of aggregate and bitumen.

When the aggregate is tested for soundness in accordance with AASHTO T104, the coarse aggregate (retained on No.4 seive) shall not show signs of disintegration, and the loss by weight after 5 cycles shall not exceed 9% in the case of sodium sulfate test, and 12% in the case of magnesium sulphate test.

When the aggregate is tested for resistance to stripping in accordance with the AASHTO T182, at least 95% coated particles should be achieved.

**2.1.02 Surface Course (Wearing)**

The asphaltic concrete surface course shall be fine graded. The coarse aggregate portion shall be crushed lime stone or crushed sieved wadi gravel; pea gravel shall not be acceptable. Asphalt materials shall form 4.5 to 7 percent of the mixture by weight.

The gradation shall be:

|  |  |
| --- | --- |
| Sieve Designation (square opening) | Percent Passing |
| 25.4 mm | 100 |
| 19.0 mm | 90 - 100 |
| 12.5 mm | 71 - 90 |
| 09.5 mm | 56 - 80 |
| No. 4 (4.8 mm) | 35 - 65 |
| No. 8 (2.4 mm) | 23 - 49 |
| No. 20 (1.18 mm) | 14 – 43 |
| No. 50 (0.300 mm) | 5 – 19 |
| No. 80 (0.150 mm) | 4 – 15 |
| No. 200 | 2 – 8 |

**2.1.03 Binder Course**

The grading of the asphaltic concrete binder course shall be :-

|  |  |
| --- | --- |
| Sieve Designation (square opening) | Percent Passing |
| 2.54 mm | 100 |
| 19.0 mm | 70 - 100 |
| 12.5 mm | 53 - 90 |
| 09.5 mm | 40 - 80 |
| No. 4 (4.75 mm) | 30 - 56 |
| No. 8 (2.36 mm) | 23 - 49 |
| No. 20 (1.18 mm) | 14 - 43 |
| No. 50 (0.3 mm) | 5 - 19 |
| No. 80 (0.15 mm) | 4 - 15 |
| No. 200 (0.075 mm) | 2 - 8 |

**2.1.04 Seal Coast.**

Cover aggregates for bituminous seal coats shall consist of screenings of crushed stone. Aggregate for slurry seals shall consist of crushed stone fines or natural sand blended with not less than 50% crushed stone fines. Wadi gravels shall not be used for seal coats.

Aggregates shall not contain crystalline or amorphous gypsum (expressed as SO3) more than 1%, and shall not contain more than 5% chert.

Aggregate particles shall be clean, hard, durable and sound. For particles retained on 4.75mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces and 100% by weight shall have one or more fractured faces.

Flakiness Index and Elongation Index tested in accordance with BS-812 shall not exceed 25% for each of flakiness and elongation indecies. The percentage by weight of Clay lumps & friable particles as determined by AASHTO T112 shall not exceed 3%. Light aggregate of specific gravity of 2 or less shall not exceed 3% as determined by AASHTO T113.

Cover aggregates and aggregate for slurry seals, when tested in accordance with AASHTO T27 and T11, shall conform to the gradations given below:

Gradation of Aggregates for Seal Coats

|  |  |  |  |
| --- | --- | --- | --- |
| **Sieve Designation (Square openings)** | **1st Application Grading B** | **2nd Application Grading C** | **Slurry Aggregate** |
|  |  |  |  |
| 25. mm (1 in.)  19.0mm (¾ in.)  12.5mm (½ in.)  9.50mm ( in.)  4.75mm ((No.4)  2.36mm (No8)  1.18mm (No.16)  0.60mm (No.30)  0.30mm (No.50)  0.15mm (No.100)  0.075mm (No.200) | 100  90 - 100  20 - 55  0 - 15  0 - 5  -  -  -  -  -  0 - 0.5 | 100  58 - 100  10 - 30  0 - 10  0 - 5  -  -  -  0 - 0.5 | 100  90 - 100  65 - 90  45 - 70  30 - 50  18 - 30  10 - 20  5 - 15 |

The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T96 (Los Angeles Test), shall not exceed 35%.

When tested for soundness in accordance with AASHTO T104, the aggregates shall not show signs of disintegration and the loss by weight shall not exceed 10% in the case of the sodium sulphate test or 12% in the case of the magnesium sulphate test.

When tested for resistance to stripping in accordance with AASHTO T182, at least 95% of the aggregate surface area shall remain coated with a bitumen film.

The material shall contain a minimum 50% of sand equivalent as determined by AASHTO T176.

**2.2 PERFORMANCE AND DESIGN REQUIREMENTS**

**2.2.01 Design Mix**

A design mix for the asphaltic concrete surface course, based upon the aggregates to be furnished, shall be determined by an independent testing laboratory at the expense of the Contractor and submitted to the Engineer for review. The grade of asphalt used will depend upon the ambient temperature at the time of application and shall be acceptable to the Engineer.

The design mix, upon acceptance, shall be the basis for the mix to be used in all asphaltic concrete pavement constructed under these specifications.

The job-mix formula shall combine the mineral aggregate and asphalt in such proportion as to produce a mixture conforming to the following composition limits by weight:

|  |  |
| --- | --- |
|  | Binder Wearing |
| - Total mineral  aggregate, % | 96.0 - 93.0 95.5 - 93.0 |
| - Asphalt content, % | 4.0 - 7.0 4.5 - 7.0 |

The Marshall Method or Hveem shall be used to determine the percentage of asphalt cement to be incorporated in the mixture.

When tested according to the Marshall Method and compacted at 50 blows at each end, the bituminous concrete shall conform to the following requirements:

|  |  |  |
| --- | --- | --- |
| **Property** | **Binder** | **Wearing** |
| Stability, kg. | 750 minimum. | 750 minimum |
| Flow (1/100 in.) | 8 to 16 | 8 to 16 |
| Voids in total mix, % | 3.0 to 5.0 | 3.0 to 5.0 |
| V.M.A., % using bulk Sp. Gr | 13 minimum-1 | 14 minimum-1 |
| Loss of stability (24 hours  soaking and compared with  30 minutes at 60 deg.C. for  all specimens in water bath). | 25% maximum | 25% maximum |

**PART 3 - EXECUTION**

**3.1 PREPARATION**

**3.1.01 Aggregate Base Course Preparation**

Preparation and compaction of the aggregate base course shall be as specified in the Aggregate Base Course Section. Prior to application of base course (binder), aggregate base course shall be checked for conformity with elevations and cross sections.

Preparation of the aggregate base course, including compaction thereof, shall be completed for the full width before the base (binder) material for roads, drives, and parking areas is placed thereon.

Ditches and drains along the aggregate base course shall be maintained as required for effective drainage. Whenever ruts of 50 mm or more in depth are formed, the aggregate base course shall be brought to grade, reshaped, and recompacted. Storage or stockpiling of base course materials on the aggregate base course will not be permitted.

Remove all foreign and loose material from aggregate base course surface immediately before application of paving by use of blades, power brooms, blowers, and hand brooming as required.

**3.1.02 Frame Adjustments**

The Contractor shall check the alignment and elevation of frames for subsurface structures including existing and new frames furnished under other work of this Specification.

Frames shall be set to elevation with a ring of compacted asphalt concrete prior to the paving operation. The asphalt concrete mix shall be placed to 25 mm below the top of the frame, sloped to grade, and compacted with a hand tamper.

The frame cover shall be set to grade, flush with surface of adjacent pavement. If permanent covers are not available, temporary covers shall be provided over openings until completion of rolling operations.

**3.2 PROPORTIONING AND MIXING**

**3.2.01 Binder and Surface (Wearing) Courses**

The asphaltic cement surface course shall be proportioned and mixed in accordance with AASHTO Designations. Temperature of both aggregate and asphalt shall be 170 + 5 °C and 155 + 5 °C respectively, before mixing in the plant.

**3.3 CONSTRUCTION**

**3.3.01 General**

Asphalt concrete paving shall consist of asphaltic concrete surface course of the depth indicated on the Drawings or required by the project.

The paving shall be compacted with two rollers, one being a pneumatic roller, the other a 2 or 3 wheel steel roller.

The asphalt concrete paving shall be placed and rolled as specified herein.

**3.3.02 Prime Coat**

A bituminous prime coat shall be applied to the aggregate base course. All loose or objectionable materials shall be broomed off the surface.

Prime coat material of MC 70 and tack coat of RC 250 or equal shall be provided on top of the aggregate base course and binder course respectively, and to be spread over at a rate of 0.7-1.50 ltr/sq m and 0.3 ltr/sq m respectively.

**3.3.03 Binder Course**

One layer of asphalt concrete (Binder) course shall be constructed on prepared base course and after the application of the prime coat.

The layer shall be compacted to the maximum density specified. The surface of the layer shall be smooth and shall be parallel to the grade and section shown for the finished paving surface. Placing, compaction and grading operations shall be carefully supervised.

The binder course mixture shall be hauled to the site of paving and placed as soon as possible after mixing. Temperature of the mix in the finisher should not be less than 130°C.

**3.3.04 Construction Joints**

Construction joints shall be made in such a manner as to ensure a neat junction, thorough compaction, and bond throughout. Construction joints shall be made as specified herein.

A transverse joint extending over the full width of the strip being laid and at right angles to its centerline shall be constructed at the end of each day's work and at any other times when the operations of placing the mixture are suspended for a period of time which will permit the mixture to chill. The forward end of a freshly laid strip shall be thoroughly compacted by rolling before the mixture has become chilled. When work is resumed, the end shall be cut vertically for the full depth of the layer, and the clean edge is to be primed before placing the new mix.

Longitudinal joints between strips shall be parallel to the centerline of the roadbed. The longitudinal joints between strips shall be not less than 150 mm distant transversely from like joints in the previously placed course or layer. When the wearing course is constructed in an even number of strips, one longitudinal joint shall be on the centerline of the roadbed, and when constructed in an odd number of strips, the centerline of one strip shall be on the centerline of the roadbed.

**3.4 FIELD QUALITY CONTROL**

**3.4.01 Asphaltic Concrete Tests**

One each of the following tests shall be made on each type of asphaltic concrete for each day's operation.

Density and stability test in accordance with the AASHTO designations.

Extraction and gradation test in accordance with ASTM D2172.

Field in-place density test in accordance with ASTM D1188.

Test samples shall be obtained, prepared, tested and paid for by the Contractor under the supervision of the Engineer.

**3.4.02 Thickness**

The pavement shall be examined to determine whether the specified total thickness of asphaltic concrete has been placed. A minimum of one thickness test shall be made for each 500 square meters of paving. The average thickness shall not be deficient by more than 6 mm, and no individual measurement shall be deficient by more than 16 mm. Deficient areas shall be defined, removed and replaced, or adjusted to design thickness by methods acceptable to the Engineer and moreover deductions will be carried on all deficient thickness areas. All adjustment expenses shall be borne by the Contractor.

**3.4.03 Density and Compaction**

Each course shall be uniformly compacted to not less than 98 percent of that density developed in the laboratory test. If additional compaction is required, rolling shall be done while surface temperature is ranging between 120-130 degrees Centigrade. Mixes with lower temperatures than 120 degrees Centigrade before rolling shall be rejected and replaced at the expense of the Contractor.

**3.5 ADJUST AND CLEAN**

**3.5.01 Cleaning**

After completion of paving operation, all areas are to be cleaned of excess spilled asphalt materials to the satisfaction of the Engineer.

**END OF SECTION**

# SECTION 02621

# GALVANIZED STEEL PIPE AND FITTINGS

**PART 1 : GENERAL**

* 1. **SCOPE OF WORK**

1. Furnish all labor, materials, tools and equipment and incidental required and install 13 mm to 25 mm exposed galvanized steel piping and appurtenances as shown on the drawings and as specified herein.
   1. **RELATED WORK**
2. Trenching, backfilling and compaction.
3. Concrete work.
4. Valves and appurtenances.
   1. **SUBMITTALS**
   2. Shop drawings and product data and shall include the following:
      1. Installation instruction and drawings of typical pipe joints and fitting assemblies.
      2. Description of proposed field testing and disinfecting methods, procedures and apparatus.
   3. **REFERENCE STANDARDS**
5. British Standards
   1. BS 1378, medium series, seam welded steel tubes, hot dip galvanized,
   2. BS 1740, fittings, galvanized
6. DIN or other Standards
   1. DIN 2440, medium weight
   2. ASTM A120
   3. JSS No. 137, medium class
   4. **QUALITY ASSURANCE**
   5. All galvanized steel pipe and fittings of each type shall be furnished by a single manufacturer who is experienced in the manufacture of the items to be furnished; however, it shall not be a requirement that the pipe and fittings be manufactured by the same manufacturer, provided that the pipe and fittings are compatible in both composition and size. The pipe and fittings shall be designed, constructed, and installed in accordance with the best practices and methods and shall be suitable for the intended service.
   6. **SYSTEM DESCRIPTION**
7. Piping shall be installed in those locations as shown on the Drawings.
8. The galvanized 13mm and 25mm exposed pipes are to be installed inside the property to rearrange for the water meter installation as shown on the design drawing details.
9. In general, new water house services will be constructed when new water mains are constructed in The length of galvanized steel pipe, fittings and required valves are based upon the Engineer’s best estimate of the number of house services require; however, the Contractor is advised that the number actually installed could vary from the number estimated.

**PART 2 : PRODUCTS**

* 1. **MATERIALS**
  2. Galvanized steel pipe shall be designed for a working pressure of 16bars (352 psi). It shall be equivalent to Schedule 40, per ASTM A-120 (test pressure, 48 bar or 700 psi).

**PART 3: EXECUTION**

* 1. **GENERAL**
  2. The Contractor shall furnish all labor, materials, tools and equipment necessary for installing the galvanized steel pipe, iron fittings and appurtenances which in general will be used for house services. Installation of the galvanized steel pipe, iron fittings and appurtenances shall be as shown on the Drawings, specified herein, directed by the Engineer’s Representative, and in accordance with the manufacturer’s instructions. Included hereunder are protection of existing structures and facilities; the removal and replacement of curbs, sidewalks, stairs, staircases, ramps, sidewalk tiles, driveways, guard rail, posts, markers, signs, walls, fences, and other structures and facilities which must be removed to carry out the work; the removal and / or relocation of underground pipe, structures and / or utilities, where required, which are not the responsibility of the owner of facilities; the removal and replacement of shrubs; installing, cleaning, testing and disinfecting the galvanized steel pipe and iron fittings or necessary tappings; and all other work necessary to complete the Contract as shown, specified or directed.
  3. **HANDLING AND STORAGE**

1. The pipe will be banded or fastened in lots weighting not less than one tonne or more than 10 tonnes with each lots consisting of one size of pipe. The fittings will be banded, boxed or skid-mounted in lots weighing not more than 10 tonnes with each lot consisting of one size and type of fitting.
2. All pipe, fittings and appurtenances shall be handled with every precaution to prevent damage. Pipe, fittings and appurtenances shall be loaded and unloaded by lifting with hoists or skidding in order to avoid shock or damage. Under no circumstances shall material be dropped. Pipe shall not be rolled or skidded against other pipe. All slings, hooks or other devices for lifting pipe, fittings and appurtenances shall be adequately padded to prevent damage to the pipe, fittings and appurtenances.
3. Pipe, fittings, and appurtenances shall be stored so as to ensure the preservation of their quality and fitness for the work, and where they will not interfere with excavation operations, public travel or access to private property. All pipe, fittings and appurtenances shall be kept free form dirt, rocks or other foreign matter.
4. Products cracked, gouged, chipped, dented or otherwise damaged will not be approved and shall be removed from the Project and replaced at the Contractor’s expense.
   1. **INSTALLATION**
5. Pipe, fittings ad appurtenances delivered to the job site shall be carefully inspected and any section found defective shall be removed from the site. Any pipe, fitting or appurtenance found to be broken or defective after it has been installed shall be removed and replaced at the Contractor’s expense. All pipe, fittings and appurtenances shall be laid true to the lines and grades specified herein, as directed by the Engineer’s Representative, or any that may be shown on the Drawings.
6. The galvanized steel pipe and iron fittings shall have threaded joints. The ends of the pipe and fittings shall be inspected prior to installation and all lumps, blisters and excess coatings shall be removed. The ends of pipe and fittings shall be wiped clean and dry of all dirt, sand and foreign matter. When joining the threaded pipes and fittings, the threads shall be painted with an approved lead-free jointing compound.
7. Prior to installation of pipe, fittings and appurtenances, the Contractor shall familiarize himself fully with all literature furnished by the manufacturer with respect to installation of galvanized steel pipe, iron fittings and appurtenances. All installation shall be in accordance with the manufacturer’s literature and recommendations, unless otherwise shown, specified or directed. Pipe, fitting and appurtenances shall be thoroughly cleaned before they are laid and shall be kept clean until acceptance of the completed work.
8. At the close of a day’s work or whenever pipe laying is not in progress, the open ends of the pipe or fittings shall be plugged, capped or otherwise made watertight to prevent the entry of foreign material of any nature. Care must be taken to prevent pipe or fitting floatation should the trench fill with water. The Contractor shall be responsible for all damage to the installed pipe, fittings, appurtenances and valves resulting from flotation or any other cause.
9. All pipe cutting required for the installation of fittings, appurtenances and valves shall be performed with abrasive wheel-type pipe cutters. Cutting shall be accomplished in such a manner as to prevent damage to the pipe or fitting.
10. Any section of pipe or fitting found to be laid at the wrong grade or to have settled shall be removed and relaid to the satisfaction of the Engineer’s Representative at the Contractor’s expense.
11. Field measurements shall be taken where required prior to installation to ensure proper fitting of the work. Where pipe is threaded in the field, the threading operation shall be performed in a manner approved by the Engineer’s Representative. All valves and fittings shown, specified or directed shall be incorporated into the piping systems as required.
    1. **FIELD TESTING**

The galvanized steel pipe and iron fittings shall be subjected to hydrostatic pressure testing as described in Section 02616-3.2. All visible leaks showing during pressure testing shall be repaired. All equipment, labor, materials, tools and water necessary for carrying out of these tests to the complete satisfaction of the Engineer’s Representative, shall be provided by the Contractor as part of the pertinent bid item.

* 1. **DISINFECTION**

When feasible, the galvanized steel pipe and iron fittings shall be included in the disinfection procedure described in Section 02616-3.04. Otherwise, the house services shall be flushed using the water in the distribution main for a period of 5 minutes. All necessary apparatus, water and chlorine required for disinfecting and flushing shall be provided by the Contractor.

The Contractor shall provide suitable means for disposal of water used for testing, disinfecting, and flushing, such that no damage results to facilities or waterways. These means shall be subject to the approval of the Engineer’s Representative, local governing authorities and regulatory agencies. Details shall be submitted to the Engineer’s Representative upon request. The Contractor shall be responsible for any damage caused by his filling, testing, disinfecting, flushing and water disposal operations.

* 1. **RESTORATION AND CLEAN UP**

All road and street improvements excavated or damaged and any damage to adjoining property including curbs, gutter and sidewalks or facilities caused by construction operations shall be restored or repaired by the Contractor to a condition equal to that which existed prior to commencement of the work. Materials used and work done in such restoration and repair shall be of the same kind and of a quality equal to the original construction, and shall conform to the requirements of the agency having jurisdiction.

* 1. **CONNECTION TO DUCTILE IRON WATER MAINS**

Connection of the galvanized steel pipe and iron fittings to the ductile iron distribution mains shall be made by using the corporation valves. Connection to the D.I.P. mains shall be made by drilling to pipe with the tapping machines.

Installation and use of the corporation valves and the tapping machines shall be in strict conformance with the valve and tapping machine manufacturer’s instructions.

1. Hardware adjustments
2. Adjust and lubricate hardware for proper operation after installation.
3. Set hinges on in-swing doors to hold open approximately 30 degrees from the closed position when unlatched.
4. Set hinges on out swing doors and entrance swing doors to return to the fully closed position.
5. Wall- mounted screens – Attach with heavy duty concealed anchoring devices as recommended by the manufacturer to suit the supporting wall construction. Set units in accordance with the manufacturer’s instruction to provide support for the units and to resist lateral impact.

**END OF SECTION**

# SECTION 02776

# POND AND RESERVOIR LINERS

**PART 1 GENERAL**

**1.1 DESCRIPTION**

This work consists of water Proofing membrane lining materials for lagoons as called for on the detail drawings, installed on prepared surfaces in accordance with the relevant specifications.

* 1. **APPLICABLE CODES AND STANDARD**

The codes and standard generally applicable to the work under this section are listed codes and standards current all the time of bid shall be used.

1.2-01 ASTM - American Society for testing and Materials.

D638 - Tensile strength at Break and yield.

D1603- CARBON Black content.

D1204- Dimensional Stability

D1693- Environmental stress Crack

* 1. **SUBMITTALS**

The following items shall be submitted in accordance with the submittals section No. 1300.

Complete specification for the materials furnished under this section.

Three samples of 300 x 300 mm size of each material to be furnished under this section.

**PART 2 – PRODUCT**

* 1. **MATERIALS**

The membrane liner shall consist of Unsupported Polyethylene liner manufactured of Domestic Virgin first quality Product.

All materials must be approved by the Engineer. The liner material shall be so produced as to be free of holes, Blisters, striation, Undisperel Raw material Raw material or any sign of contamination by foreign matter. Any such material shall be rejected.

The finished product shall be supplied, as prefabricated panels in Rolls Panel size shall be determined by approved plans. Panels are to be of 6.0m seamless widths, the membrane shall be of high quality high density Polyethylene sheet of nominal thickness 1.00mm.

The membrane shall have the following properties:

ASTM D638 - TENSILE STRENGTH AT BREAK 3800 PSI (266 KG/CM2)

ASTM D638 - TENSILE STRENGTH AT YIELD 2100 PSI (150KG/CM2)

ASTM D1603-CARBON BLACK CONTENT 2-3%.

ASTM D1204-DIMENSIONAL STABILITY + 2%.

ASTM D1693-ENVIRONMENTAL STRESS CRACK 1500 HOURS.

* 1. **PRODUCT HANDLING**
     1. **PACKING**

All materials shall be delivered in the original unopened package bearing the name of manufacturer and the brand.

* + 1. **STORAGE**

Material shall be stored under cover in dry place and shall be protected from the weather at all times.

* 1. **INSTRUCTIONS AND DRAWINGS REQUIRED**
     1. The Contractor shall furnish complete written instructions for the storage, handling, installation, and seaming of the liner in compliance with specification and the condition of warranty.
     2. The material supplier shall furnish complete written instruction for the repair of the lining materials.
     3. The manufacturer or his designated representative shall furnish panel with accessories layouts as required for the liner installation. Final lagoon configuration, attachment details, and survey information needed will be furnished by the end user or his designated representative.

**PART 3 - EXECUTION**

* 1. **INSTALLATION**

Furnish and install flexible membrane lining in the area shown on the drawings all work shall be done in strict accordance with Project drawings.

The liner shall be installed in a relaxed condition and shall be free of tension or stress upon completion of the installation. Stretching of the liner to fit will not be allowed installation. Contractor shall leave sufficient material to prevent “Trampolining” in cold weather conditions.

* 1. **QUALITY AND WELDING**
     1. All test on materials to be supplied are to be in accordance with ASTM D638-82, to ensure tensile properties.

A quality control certificate shall be issued.

* + 1. All welding material shall be of a type recommended and supplied by the manufacturer and shall be delivered in the original sealed containers, each with an index label bearing source and origin and complete direction as to proper storage.
    2. Welding of membrane on site (with minimum 10 cm overlaps) or as instructed by manufacturer shall be by the double-wedge fusion welding process testing of welded seams shall be by the air pressure process, and the vacuum box method as required by the Engineers.

Individual panels of liner material shall be laid out and over lapped extreme care shall be taken by the installer in the preparation of the areas to be welded. The area to be welded shall be cleaned and prepared according to the procedures laid down by the material manufacturer.

Surface to be lined shall be smooth and free of all rocks, stones, sticks, roots, sharp objects, or debris of any kind. The surface should provide a firm, unyielding foundation for the membrane with no sudden, sharp on abrupt changes or break in moisture shall be allowed. The installation Contractor shall certify in writing that the surface on which the membrane is to be installed in acceptable before commencing work.

* 1. **FIELD SEAM TESTING / QUALITY CONTROL**
     1. The installer shall employ on-site physical non-destructive testing on all welds to ensure watertight homogeneous seams.
     2. A quality control technician shall inspect each seam. Any area showing a defect shall be marked and repaired in accordance with the manufacturer procedures.
     3. A test weld 1.0 meter long from each welding machine shall be run each day prior to liner welding and under the same conditions as exist for the liner welding. The test weld shall be marked with date, ambient temperature, and welding machine number. Samples of weld 10 – 20 mm wide shall be cut from the test weld and tested in shear and peel. Seams should be stronger than the material. The weld sample shall be kept for subsequent testing on laboratory tensometer equipment in accordance with the applicable ASTM standard. Random weld samples may be removed from the installed welded sheeting at a frequency to be agreed.

**END OF SECTION**

# SECTION 02901

# MISCELLANEOUS WORK

**PART 1 GENERAL**

**1.1 SCOPE OF WORK**

1. Furnish all labor, materials, equipment and incidentals required to do the miscellaneous work specified in this Section.
2. When no applicable specification exists the Contractor shall perform the work in accordance with the best modern practice and / or as directed by the Engineer.
3. The work of this Section includes, but is not limited to, the following:
   1. Cleaning up.
   2. Job photographs,
   3. Restoring easement and right-of-ways.
   4. Temporary facilities.

**PART 2 PRODUCTS**

* 1. **MATERIALS**

Materials required for this Section shall be the same quality of materials that are to be restored. Where possible and with Engineer’s approval, the Contractor may re-use existing materials that are removed.

**PART 3 EXCUTION**

* 1. **CLEANING UP**

The Contractor shall remove all construction material, excess excavation, buildings, equipment and other debris remaining on the job as a result of construction operations and shall restore the site of the work to a neat and orderly condition.

* 1. **PHOTOGRAPHS OF PROJECT**

Prior to project beginning, the Contractor shall document existing conditions to the level accepted by the Engineer.

The photographs shall be retained in a secure location by the Contractor throughout the duration of the project and shall then be turned over to the Owner.

* 1. **RESTORING EASEMENTS AND RIGHT-OF-WAYS**

1. The work under this item shall include all protection and restoration of private property required within the limits of the easements and project area. All protection and restoration required outside the easement limits shall be at the Contractor’s own expense. All protection and restoration required within the project site shall be at the Contractors own expense unless otherwise stated.
2. The Contractor shall be responsible for all damage and shall restore all easement areas and affected private property to its original condition as existed prior to construction. He shall protect from injury all walls, ledges, fences, cultivated shrubbery and vegetables, fruit trees, pavement, underground facilities, such as water pipe, or all other utilities which may be encountered along the route. If removal and replacement are required, it shall be done in a workmanlike manner so that replacement is equivalent to that which existed prior to construction.
3. Lawn and grass surfaces if any, damaged by construction shall be replaced. The Contractor shall cut and replace the lawn and sod, or he may restore the areas with an equivalent depth and quality of loam, seed and fertilizer as necessary to produce a stand of grass at least equal to that existing prior to construction. These areas shall be maintained and reseeded, if necessary, until all work under this Contract has been completed and accepted. Any additional work required to restore property to the original condition shall be performed by the Contractor on his own expense.
4. Existing trees, shrubs, plants and bushes outside of easements that may be affected by the construction procedure shall be fully protected. When necessary, the work shall include removing and replacing those trees, shrubs and bushes. It shall include the careful excavation of the root ball which shall be wrapped with burlap while out of the ground. The Contractor shall replant them after backfilling the trench, stake them in an upright position and shall periodically water replanted trees, bushes and shrubs. The Contactor shall be fully responsible for ensuring that any and all trees, bushes and shrubs removed and replanted “take” and return to a viable state. Any replanted item that fails to “take” or that is so damaged as to be unsuitable for replanting shall be replaced by the Contractor, at no additional cost to the owner, with a tree, bush or shrub equal to the one removed.
5. The engineer will inspect all work for provisional acceptance upon the written request of the Contractor received at least ten days before the anticipated date of inspection.

After all necessary corrective work has been completed, the Engineer will certify in writing the provisional acceptance of the planting.

1. All plants shall be guaranteed by the Contractor for not less than one full year from the time of provisional acceptance.

At the end of this period, any plant that is missing, dead, or not in satisfactory growth, as determined by the Engineer, shall be replaced.

All replacements shall be plants of the same kind and size. They shall be furnished and planted as specified herein. The cost of replacement shall be borne by the Contractor except where it can be definitely shown that loss resulted from activities outside the contractor’s control such as vandalism.

At the end of the guarantee period, inspection will be made by the Engineer, to identify corrective work if any. After all necessary corrective work has been completed and tree staking has been removed, the Engineer will certify in writing the final acceptance of the planting.

* 1. **TEMPORARY FACILITIES**

The Contractor shall furnish, install, maintain and remove all temporary facilities required for construction or called for in the specifications.

**END OF SECTION**

# SECTION 03100

# CONCRETE FORMWORK

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers formwork for all concrete cast-in-place.

All forms shall be accurately and properly placed and finished, so that concrete cast-in-place may be placed as indicated on the Drawings, and as specified. The forms shall produce a smooth concrete finish, free from offsets, or irregularities. Special forms shall be used for fair face concrete.

**1.1.01 Coordination**

Work performed, and materials used, in conjunction with formwork, for concrete cast-in-place, shall be coordinated with work under the Cast-in-Place Concrete.

**1.1.02 Related Work**

Other items of work, that relate to, and are referenced in this section, include, but are not limited to the following section:

Section 03300: Cast-in-Place Concrete

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards, generally applicable to the work under this section, are listed. Codes and Standards current at the time of bid shall be used.

**ACI - American Concrete Institute**

**BS - British Standard**

Any equivalent, approved, codes and standards may be accepted, subject to the Engineer's approval.

**1.3 QUALITY ASSURANCE**

**1.3.01 Governing Standards**

Forms shall conform to ACI and BS requirements.

**1.3.02 Tolerances**

Tolerances for formed surfaces shall be as specified in BS and ACI. Manuals and code of practices.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Material List**

Materials used shall be:

Forms

Plywood Product Standard PS1, Waterproof, resin-bonded.

Lumber Straight, uniform width and thickness, and free from knots, offsets, holes, dents, and other surface defects.

Chamfer Strips Clear lumber, surface against concrete planed.

Form Coating Single component, pigmented copolymer resin type, applied in accordance with the manufacturer's recommendations.

Fiber Boards

Aluminum Parts of formwork are made of aluminum alloys type 6061-T6 or 6063-T6 as specified in ASTM – B 221.

Fiber-Glass-Reinforced Plastic As specified in ACI SP-4 and ACI 347.

Metal Forms As specified in BS and ACI.

**2.2 DESIGN CRITERIA**

Forms shall be designed to produce hardened concrete, having the shape, lines, and dimensions indicated on the Drawings. Forms, for surfaces, which will be exposed to view when constructed, shall be prefabricated plywood panel forms, job-built plywood forms, or forms that are lined with plywood or fiberboard. Forms for exposed surfaces, shall be laid out in a regular and uniform pattern, with the long dimension of panels vertical, and all joints aligned. The forms shall produce finished surfaces, that are free from offsets, ridges, waves, and concave, or convex areas. The maximum deviation from a true plane, shall not exceed 3 mm in 2 m. The use of proprietary forming systems is encouraged by the Engineer and should be used where possible.

Plywood or lined forms will not be required for surfaces, which are normally submerged, or not ordinarily exposed to view. Unlined wooden forms may be used for surfaces, which are not restricted to plywood, or lined forms, and may be used as backing for form linings. Concrete forms, are required above all extended footings.

Flat segmental forms, not more than 600 mm in width, may be used for forming curved surfaces, 7600 mm in diameter or larger.

Forms shall be substantial and sufficiently tight, to prevent leakage of mortar. Forms shall be braced, or tied, to maintain the desired position, shape, and alignment, during and after concrete placement. Walers, studs, internal ties, and other form supports, shall be sized, and spaced, so that acceptable working stresses are not exceeded.

Wherever the top of a wall will be exposed to weathering, the forms on at least one side, shall not extend above the top of the wall, and shall be brought to true line and grade. At other locations, forms for concrete, which is to be finished to a specified elevation, slope, or contour, shall be brought to a true line and grade, or a wooden guide strip, shall be provided at the proper location on the forms, so that the top surface can be finished with a screed, or template. At horizontal construction joints in walls, the forms on one side, shall not extend more than 0.6 meters, above the joint.

Temporary openings shall be provided, at the bottom of wall forms, and at other points, where necessary, to facilitate cleaning, and inspection.

**2.2.01 Form Ties**

Form ties, shall be of the removable end, permanently embedded body type, and shall have sufficient strength, and rigidity, to support and maintain the form in proper position, and alignment, without the use of auxiliary spreaders. Cones shall be provided, on the outer ends of each tie, and the permanently embedded portion, shall be at least 25 mm back from adjacent outer concrete faces. Form ties for water-bearing walls, shall be provided with water-seal washers, and located on the permanently embedded portions of form ties, approximately at the center of the wall. Permanently embedded portions of form ties, which are not provided with threaded ends, shall be constructed, so that the removable ends are readily broken off, without damage to the concrete. The type of form ties used shall be acceptable to the Engineer.

Form ties in exposed surfaces, shall be uniformly spaced, and aligned in horizontal and vertical rows.

**2.2.02 Edges and Corners**

Chamfer strips, shall be placed in forms, to bevel all salient edges, and corners, except the top edges of walls and slabs, which are to be tooled, and edges which are to be buried. Equipment bases shall have formed beveled salient edges, for all vertical and horizontal corners, unless specifically shown otherwise on the Drawings. Unless otherwise noted, bevels shall be 25 mm wide.

**2.3 FORMED SURFACES - CLASS OF FINISH**

Finishes to formed concrete surfaces, shall be classified as F1, F2, or F3. Where the class of finish is not specified, the concrete shall be finished to class F2. Concrete surfaces for the various classes of formed finishes specified, shall comply with the tolerances shown in Table1.

**Table 1**

**Maximum Tolerance (mm)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class of Finish** | **Line and Level** | **Abrupt**  **Irregularity** | **Gradual**  **Irregularity** | **Dimension** |
| F1 | -15 to +15 | 5 | 5 | +15,-5 |
| F2 | -5 to +5 | 5 | 5 | +15,-5 |
| F3 | -5 to +5 | 0 | 5 | -5 to +5 |

In the table, "line and level" and "dimension" shall mean the lines, levels, and cross-sectional dimensions indicated on the Drawings.

Surface irregularities, shall be classified as "abrupt" or "gradual". Abrupt irregularities shall be tested by direct measurement. They include, but are not limited to, offsets and fins caused by displaced or misplaced formwork, loose knots and other defects in formwork materials. Gradual irregularities shall be tested by means of a 1.5 meter length straight template, for plane surfaces, or its suitable equivalent for curved surfaces.

**2.3.01 Class F3**

Formwork for Class F3 finish shall be lined with panels of no staining material, with a smooth unblemished surface, such as sanded plywood, or hard compressed fiberboard. The panels shall be as large as possible, and shall be arranged in a uniform acceptable pattern, and fixed to back of formwork, by oval nails. Unfaced wrought boarding, or standard steel panels, shall not be permitted.

**2.3.02 Class F2**

Formwork for Class F2 finish shall be faced with wrought tongue and groove boards, plywood or metal panels arranged in a uniform acceptable pattern, free from defects likely to detract from the appearance of the surface.

**2.3.03 Class F1**

Formwork for Class F1 finish shall be constructed of timber, sheet metal, or any suitable material, which will prevent loss of grout when the concrete is vibrated. Surfaces, subsequently to be rendered, plastered, or tiled, shall be adequately scabbed, or roughened, as soon as the formwork is removed, to reduce the irregularities, to no more than half the thickness of such rendering, plastering, or bedding for tiles, and to provide a satisfactory key.

* 1. **FAIR FACE FORM WORK**
* Forms made of galvanized steel are forbidden to be used due to its adhesion ability.
* Steel forms shall be coated with rust resisting substance which will prevent concrete surfaces staining and will not stain concrete surfaces.
* Joints locations and details for structural or architectural purposes shall be specified in the Particular Conditions.
* Forms shall be substantial and sufficiently tight, to prevent leakage of mortar, rubber gaskets or wood backing which is approved by the Engineer may be used to tighten joints together.
* Ties made of abrasion and rust resisting material of the type which needs the least treatment when striking, and doesn't cause staining for concrete surfaces, approved by the Engineer, shall be used.
* It is forbidden to use forms of different materials, or shall new and used forms be used as a formwork for the same surface. Forms of the same material and same frequency of usage shall be used to prevent variations in appearance or color of the concrete surface.
* Large areas of fair face concrete shall be divided into smaller areas by architectural joints as specified in the Particular Conditions and as approved by the Engineer.
* All fair face concrete edges shall be 45 degrees bevels inclined to the concrete surface not less 20 mm width to prevent breaking the edges while striking formwork.
* Special Sleeve Ties approved by the Engineer shall be used. It is forbidden to use wire or reinforcing bars as ties.
* Formwork striking shall be gently and carefully taking into consideration to avoid breaking or indentation of concrete surfaces or edges.
* When ties are removed their places should be treated immediately according to the Engineer's instructions and approval.

**2.4.0****1 Classes of Finish Formed Surfaces (fair face)**

On formed surfaces the hereunder listed classes of finish shall be used where ordered:

**Class 1**

This finish is for surfaces of reservoirs inside and outside and prominently exposed to view where good appearance, uniform color and alignment are of special importance.

To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood or equivalent material in large sheets. The sheets shall be arranged in an approved, uniform pattern. All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets.

Concrete surfaces, which are described as fair face concrete, shall be finished free from honey combing and excessive air holes, fine grout loss, scaling, spalling, chipping, scoring, rust stains and projections arising from defective mixing, placing, or formwork.

The Contractor shall submit, for the approval of the Engineer, a sample panel of not less than 60x120 cm and a complete square column mock-up to demonstrate the quality of the exposed concrete to be produced by forms.

The quality of the finished Work shall be measured against the quality of the approved sample panel and any Work of inferior quality shall be repaired or replaced as directed by the Engineer, without any additional cost.

Construction joints, approved by the Engineer, shall be studied in detail ahead of time and the joints shall be grooved in a predetermined pattern.

**Class 2**

This finish is for surfaces of chambers where the highest standard of finish is not required. Forms to provide a Class 2 finish shall be faced with wrought and thick boards with square edges arranged in a uniform pattern. Alternatively, plywood or metal panels may be used if they are free from defects likely to detract from the general appearance of the finished surface. Joints between boards and panels shall be horizontal and vertical unless otherwise directed. This finish shall be such as to require no general filling of surface pitting, but fine surface discoloration and other minor defects shall be remedied by approved methods.

**3.1 INSPECTION**

**3.1.01 Replacement Inspection**

Before forms, reinforcement, water stops, anchor bolts, and embodiments are rigidly secured in proper position, all dirt, mud, water, and debris shall be removed from the space to be occupied by concrete, and all surfaces, encrusted with dried concrete from previous placement operations, shall be cleaned.

**3.2 INSTALLATION**

**3.2.01 Execution**

Installation of units, shall be in accordance with manufacturer's instructions and recommendations, as applicable, to ensure conformance with design and specifications requirements. Shop drawings, shall show details of installation. Forms shall be constructed, to ensure that the finished concrete members, will have true surfaces free of offset, waviness, or bulges, and will conform to the indicated shapes, dimensions, lines, elevations, and positions, within the specified tolerances. Form surfaces that will be in contact with concrete shall be thoroughly cleaned before each use.

**3.2.02 Form Removal**

Forms shall not be removed, or disturbed, until the concrete has attained a minimum of 70% of the required compressive crushing strength (but the period not less than that mentioned in the table below), to safely support all dead and live loads. Shoring beneath beams, or slabs, shall be left in place, and reinforced as necessary, to carry any construction equipment, or materials placed thereon. Forms shall be removed after the following conditions have been met: Where the structure as a whole is supported on shores, forms for beam and girder sides, columns, and similar vertical structural members, may be removed after 24 hours, provided concrete is sufficiently hard, not to be injured thereby. Supporting forms or shoring shall not be removed, until structural members have acquired sufficient strength to support safely their own weight, and any construction, and/or storage load, to which they may be subjected, but in no case shall they be removed in less than six days, nor shall forms used for curing be removed, before expiration of the curing period, except as specified. Care shall be taken to avoid spoiling the concrete surface, or damaging concrete edges. Wood forms shall be completely removed.

For ordinary structural concrete made with all types of Portland cement the minimum period before striking is given the table below as guidance unless otherwise directed by the Engineer:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Structural Concrete Element | Effective Span  m | Average Temperature ( º C ) | | | |
| ≥ 21 | 10 - 20 | 5 – 10 | ≤ 5 |
| Concrete Age ( Days ) | | | |
| Non Bearing Walls; Columns and Beams' sides |  | 2 | 3 | 5 | 7 |
| Walls; Columns and Only Vertical Loads Carrying Elements |  | 5 | 6 | 7 | 9 |
| Slabs | < 3.00 | 7 | 10 | 14 | 21 |
| 3.00 – 6.00 | 10 | 14 | 21 | 28 |
| > 6.00 | 14 | 21 | 28 | 28 |
| Beams | < 3.00 | 10 | 14 | 21 | 28 |
| 3.00 – 6.00 | 14 | 21 | 28 | 28 |
| > 6.00 | 21 | 28 | 28 | 28 |

**3.2.03 - A Control Tests**

Results of suitable control tests will be used as evidence that concrete has attained sufficient strength, to permit removal of supporting forms. Cylinders, required for control tests, shall be provided, in addition to those otherwise required by these specifications. Test specimens, shall be removed from molds 24 hours after casting, and stored in the structure as close to the points of sampling, as practicably possible, and shall receive, insofar as practicable, the same protection from the elements, during curing, as given those portions of the structure which they represent. Specimens shall not be removed from the structure for transmittal to the laboratory, prior to expiration of three-fourths of the proposed period before removal of forms. These cylinders shall be tested by, and at the expense of the Contractor. Supporting forms, or shoring, shall not be removed, until control test specimens have attained strength of at least 1,500 pounds per square inch (105 kg/sq cm) for all other work. The newly unsupported portions of the structure shall not be subjected to heavy construction, or material loading.

**3.2.03-B Tie Rods**

Tie rods, to be entirely removed from the wall, shall be loosened 24 hours after concrete is placed, and form ties, except for a sufficient number to hold forms in place, may be removed at that time. Ties wholly withdrawn from the wall, shall be pulled toward the face that will be concealed from view, in the permanent work.

Filling, or making right, of tie rod or boltholes, is specified in paragraph:

FINISHING FORMED SURFACES OF SECTION 03300: CAST-IN-PLACE CONCRETE OF THESE SPECIFICATIONS.

**END OF SECTION**

# SECTION 03110

# FORMWORK OF WATER RETAINING STRUCTURE

**GENERAL**

Formwork shall include all temporary or permanent forms required for forming the concrete, together with all temporary construction required for their support. Formwork shall be adequate to resist the pressure of the moist concrete without appreciable distortion, and shall be fixed in alignment and securely based so as to be able to withstand the weight of the construction and the movement of men, materials and plant without movement of any kind. All joints shall be tight enough to prevent leakage of liquid from the concrete.

Design and construction of the formwork shall be to the Engineer's approval. Drawings and calculations for the formwork shall, if required by the Engineer, be submitted as part of the method statement for concreting of any structure or group of structures.

The formwork shall be coated with an approved mould oil or release agent and all excess shall be carefully removed before the forms are erected. New timber or plywood formwork shall be given three coats of mould oil. These materials shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement or pre-stressing tendons and anchorage. Only one manufacturer's type of such material shall be used in formwork to concrete that will be visible in the finished Works.

Top formwork shall be used on any concrete face steeper than 15° to the horizontal.

All exposed arises shall be chamfered and shall be 12 mm by 12 mm unless specifically shown otherwise in the Drawings.

Rubbish, debris and water shall be removed from the interior of the forms before concrete is placed. Temporary openings shall have been provided in the formwork to facilitate its removal.

Permanent forms and formwork shall be of approved material and shall be fixed to the structure by approved means. Joints between them shall be made tight with mortar or other means of preventing loss of material from the concrete.

Ties passing through liquid retaining slabs / walls shall be approved by the Engineer and shall be of a type that will not form a potential drainage path through the concrete and will permit their removal or partial removal without damage to the concrete (water tight). All ties shall incorporate an anti-torsion bar or other device to ensure that they do not twist on striking. They shall be degreased before being placed in position and the use of grease on the outside of any end-former, later removed from the concrete, will not be allowed. The ties shall not foul or touch the reinforcement.

The use of through bolts will not be permitted. The surface of the concrete in all tie bolt holes shall be roughened by mechanical wire brushing or similar means after which the hole shall be sealed in an agreed manner with unapproved patent expanding mortar or filling compound. The local practice of using tie wire in place of she-bolts will not be permitted.

Where box-outs are required for pipes or ducts passing through concrete structures, the opening so formed shall be grouted up using the same concrete mix as in the main structure after fixing of the pipe work. Where directed by the Engineer the sides of the opening formed shall be squabbled prior to fixing of the equipment. Shuttering shall be provided as required.

Where box-outs are permitted below water level, the shuttering shall be provided with joggle joints and the sides of the opening formed shall be squabbled before the equipment is fixed. Where ordered by the Engineer, the box-out shuttering shall include a water bar and the concrete joint at the water face shall be provided with an approved sealer in a pre-formed sealing chase.

Expanded metal formwork to benching, specially profiled concrete and the like shall be heavy galvanized mild steel expanded metal mesh moulded approximately to the required profile and securely fixed after placing of the initial concrete filling so as to be approximately 20 mm below the final concrete surface. Concrete finishing screed shall be thoroughly worked into the mesh during lying.

**QUALITY OF FINISH AND DEFECTS OF CONCRETE**

The quality of finish shall be as indicated on the drawings, and shall not be inferior to that described herein.

If any portion of the face work should prove unsatisfactory on removal of the formwork it shall, without delay, be cut out and made good as directed. No plastering of concrete surfaces shall be allowed. At the discretion of the Engineer, board marks or minor discontinuities on exposed faces may be removed by rubbing down with carborundum, and pinholes, small voids or minor porosity of the surface, may be filled, by rubbing down with cement and sand mortar of the same richness as in the concrete. Such remedial works shall be carried out immediately after removing the formwork. The cement used shall consist of a mixture of white and grey Portland cement mixed in such proportions that the color of the mortar matches that of the surrounding hardened concrete. Specially approved admixtures and / or grouts to improve and repair the defected places shall be used upon the approval of the Engineer, cracks shall be inspected and identified in accordance with BS relevant standards of practice and shall be treated in an appropriate and approved manner .If in the opinion of the Engineer the defected areas are irreparable then upon his requested these elements should be removed from site and reconstructed properly on the cost of the Contractor.

Such remedial works shall be carried out as directed, and shall in no way relieve the Contractor from his obligation to cut out and reconstruct Work if, in the opinion of the Engineer, the required standard of surface finishes is not achieved. If the Contractor carries out remedial works to any surface without permission, that concrete shall be liable to rejection.

Wall shutter shall be well sealed at the kicker to prevent any loss of grout or possible bleeding.

The Contractor shall make proper compaction and vibration for the fresh laid concrete. Compaction of concrete shall be in layers. Over vibration shall be prevented.

If the concrete cube samples fail to meet the required strength, the contractor shall make (on his cost) further core tests to verify these requirements to approval of the Engineer. If core tests also fail to satisfy the requirements in the opinion of the Engineer then the Contractor shall demolish these related items and reconstruct them on his expense.

**Classes of Finish Formed Surfaces (fair face)**

On formed surfaces the hereunder listed classes of finish shall be used where ordered:

***Class 1***

This finish is for surfaces of reservoirs inside and outside and prominently exposed to view where good appearance, uniform colour and alignment are of special importance.

To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood or equivalent material in large sheets. The sheets shall be arranged in an approved, uniform pattern. All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets.

Concrete surfaces, which are described as fair face concrete, shall be finished free from honey combing and excessive air holes, fine grout loss, scaling, spalling, chipping, scoring, rust stains and projections arising from defective mixing, placing, or formwork.

The Contractor shall submit, for the approval of the Engineer, a sample panel of not less than 60x120 cm and a complete square column mock-up to demonstrate the quality of the exposed concrete to be produced by forms.

The quality of the finished Work shall be measured against the quality of the approved sample panel and any Work of inferior quality shall be repaired or replaced as directed by the Engineer, without any additional cost.

Construction joints, approved by the Engineer, shall be studied in detail ahead of time and the joints shall be grooved in a predetermined pattern.

***Class 2***

This finish is for surfaces of chambers where the highest standard of finish is not required. Forms to provide a Class 2 finish shall be faced with wrought and thick boards with square edges arranged in a uniform pattern. Alternatively, plywood or metal panels may be used if they are free from defects likely to detract from the general appearance of the finished surface. Joints between boards and panels shall be horizontal and vertical unless otherwise directed. This finish shall be such as to require no general filling of surface pitting, but fine surface discoloration and other minor defects shall be remedied by approved methods.

**Classes of Finish Unformed Surfaces**

On unformed surfaces the hereunder listed types of finish will be required.

***Class U/1***

This is a hard, smooth steel-trawled finish for surfaces of the reservoirs, water retaining structures and water towers bottom slab. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked to the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks.

***Class U/2***

This is a floated finish for surfaces of trenches and pumping house floors where a hard smooth steel-trawled surface is not required. Floating shall be done only after the concrete has hardened sufficiently and may be by hand or machine. Care shall be taken that the concrete is worked no more than is necessary to produce a uniform surface free from screed marks.

***Class U/3***

This is a screeded finish for surfaces of roofs, slabs and structural members to be covered by backfill, subsequent stages of construction, bonded concrete topping or cement mortar beds to receive paving, and on exposed surfaces of paving where a superior finish is not required. It is also the first stage for finishes U/1 and U/2. The finishing operations shall consist of levelling and screening the concrete to produce a uniform, plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

***Class U/4***

This is a non-slip surface for walkways and the like. Following initial trowelling the surface shall be brushed with marks parallel to the walkway, after which the edges shall be finished with an arising trowel.

**Striking of Formwork**

The Contractor shall give the Engineer not less than 24 hours notice of his intention to strike any formwork. The time at which the formwork is struck shall be the Contractor's responsibility, but the minimum periods between completion of concreting and the removal of forms, unless otherwise approved, shall be as given below.

Forms shall be removed without shock, vibration or other damage to the concrete. The Engineer may direct the manner in which the forms are struck.

Where the early concrete strengths are not accurately known, the minimum times in days elapsed before removal of formwork shall comply with the General Building Specifications of the Ministry of Public Works and Housing but shall also not be less than the following periods.

**Striking and Removal of shuttering periods**

The recommendations set out in Table 3.6 are given as minimum requirement for striking shuttering:

Table 3.6 Minimum requirement for striking shuttering

|  |  |  |
| --- | --- | --- |
| Item | Ordinary Portland Cement (Normal Weather 16 ºC days) | Rapid –Hardening Cement (Normal Weather 16 ºC days) |
| Beam sides, Wall columns | 1 | 1 |
| Slabs (props left under ) | 4 | 3 |
| Beam soffits (props left under) | 10 | 5 |
| Removal of props to slabs | 10 | 5 |
| Removal of props to beams | 16 | 8 |

The above striking times are for normal conditions and before deciding on the actual time for each case, the contractor shall consider and extend the period as tabled if

The span of the structural member under consideration exceeds 6 meters for beams and 3 meters for the slabs. An additional period of one day for each 500 mm of additional span shall then be allowed.

The dead load of the structural member under consideration forms a large proportion of the total design load.

Construction 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 load.

The setting of the concrete has been retarded for any reason.

The temperature falls below 8 ºC the striking time shall be extended by 12 hours for each occurrence. For temperatures falling below 3 ºC the additional period to be added shall be 1 day for each day on which the temperature falls below 3ºC.

Any combination of the above points and other consideration which would call for such a precaution to be taken.

If the temperature differs from those given in table (3.6), then periods shall be modified in accordance with BS 8110 clause 6.9.3.1

.

**TOLERANCES IN FINISHED CONCRETE**

The permissible tolerances in the finished faces of shuttered and un-shuttered concrete shall not exceed the values given in the following table.

Table 2.3.38-1 Permissible tolerances

|  |  |
| --- | --- |
| **Item** | **Tolerance in mm** |
| Overall dimensions and levels | ± 5 |
| Column sizes | ± 5 |
| Beam sizes | ± 5 |
| Wall sizes | ± 5 |
| Vertical lines out of plumb | 5 mm plus 5mm in every 5 m |

Otherwise measurements have to comply with BS standards or equivalent.

**END OF SECTION**

# SECTION 03200

# CONCRETE REINFORCEMENT

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers steel reinforcement, for all concrete cast-in-place.

The Contractor shall provide all bars, bar supports, ties, spacers, bolsters, inserts, screeds, and other accessories, required to maintain reinforcing in its proper position, and permit proper placement of concrete.

**1.1.01 Coordination**

All reinforcing material, and work, shall be coordinated with related work specified in the Cast-in-Place Concrete Section.

Work Specified Elsewhere

Other items of work, that relate to and are referenced in this section, include, but are not limited to the requirements shown in Section: Cast-in-Place Concrete Section.

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards, generally applicable, to the work under this section, are listed. Codes and Standards current at the time of bid shall be used.

**AASHTO American Association of State Highway and Transportation Officials.**

**ASTM American Society for Testing and Officials.**

**BS British Standards.**

Any equivalent, approved, codes and standards may be accepted subject to the Engineer's approval.

**1.3 QUALITY ASSURANCE**

**1.3.01 Tensile Tests**

Tensile tests on 10 mm through 36 mm bars, shall be performed in accordance with ASTM, AASHTO and BS.

**1.4 SUBMITTALS**

**1.4.01 Certification**

The Contractor shall furnish the Engineer, with a certification, that each delivery of reinforcing steel furnished, complies with the requirements specified under Materials. The certification shall be signed by the Contractor, and the reinforcing steel fabricator. The certificates shall show the name of the manufacturer, the country of origin, the type of steel, and all other pertinent data, and test results, of the physical and chemical properties, as required by the Specifications.

The Contractor shall also submit, welding procedure and welder qualification test results.

**1.5 PRODUCT HANDLING**

**1.5.01 Protection**

Reinforcing steel shall be carefully handled, and shall be stored on supports, which will prevent the steel from contacting the ground. Proper drainage, and protection from the elements, shall be provided, to minimize corrosion.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Material List**

Materials used shall be:

Reinforcing Steel Bars:

Except Weldable---------------------Grade 60, deformed (414 MPa min. yield strength)

Weldable------------------------------Grade 60, deformed, with maximum carbon equivalent of 0.55.

Beam Stirrups & Column Ties----- Grade 60, Deformed type bars.

Column Spirals-----------------------Cold drawn wire or cold- worked deformed wire.

Welded Wire Fabric----------------Spacing not greater than 400 mm in the direction of main reinforcement.

Bar Supports------------------------Plastic protected, or UPVC.

**2.1.02 Accessories**

The Contractor shall furnish all accessories, such as reinforcing steel supports, hold-downs, spreaders, hangers, tie wire, and all other incidentals, necessary to complete an acceptable installation of all concrete reinforcement. All accessories shall be of steel, with the exception of spacers, to maintain concrete cover to reinforcement against formed or blinded surfaces, which shall be of concrete of the same texture, color, and composition, as cast-in-place concrete. Alternatively, accessories may be PVC type, if so instructed, or accepted, by the Engineer. Concrete spacers, shall be in the form of a truncated cone, or pyramid, and shall be used with the larger face toward steel reinforcement. The smaller face of truncated cone, or pyramid, shall have a minimum dimension of 50 mm.

**2.1.03 Mechanical Splices**

Where mechanical couplings are indicated on the Drawings or in other locations which may be acceptable, such couplings, shall be supplied by an acceptable manufacturer, who shall also supply the equipment for making the couplings. Mechanical couplings (splices) shall be thermite type, welded tension splices. The Contractor shall demonstrate, by tensile tests on sample joints of all sizes required for use in the work, that the use of the couplings, does not reduce the strength of the parent bars, that completed couplings possess strength not less than that of the parent bars, and that there is no significant permanent set in the couplings as the bars are loaded.

**2.2 DESIGN CRITERIA**

Reinforcement shall be accurately formed, and shall be free from loose rust, scale, and contaminants.

**2.2.01 Special Coatings**

**A. Galvanizing**

Galvanizing of reinforcing steel, if required, shall be a minimum coating of 610 grams per square meter, and hot-dip applied, and safeguards against embrittlement. The Contractor shall submit copies of applicable test certificates, for coating and embrittlement safeguards, in accordance with Local Specifications if exist or international specifications.

**B. Epoxy Coatings**

Epoxy coatings, if required, shall be factory applied. Products may be of a proprietary type; however, products must be certified to meet all tests, which confirm that the bond value of the reinforcing steel, is not less than 95 per cent of the bond value for uncoated reinforcing steel. Field application, of epoxy coating, to the reinforcing steel, is prohibited and will only be allowed for touch-up work, as recommended by the Contractor, and accepted by the Engineer.

**C. Special Considerations**

Severe, and very severe exposure conditions may require the use of a factory-applied epoxy coated, or hot-dip, galvanized reinforcing steel. The use of the foregoing shall be in accordance with the drawings or as acceptable to the Engineer.

**D.** All reinforcing steel, with special coating, shall be handled, placed, and tied, using methods and materials that will not damage the coating.

**2.3 DETAILING AND FABRICATION**

**2.3.01 Detailing**

Steel reinforcement shall be as indicated on the Drawings. The Contractor shall be responsible for checking the Drawings, and preparing bending schedules for the Engineer's approval, before any cutting, and bending operations on the steel.

When any information relating to reinforcement is missing, or apparently incorrect, the Contractor shall not take upon himself any decision, but shall promptly request clarification from the Engineer.

Should the Contractor at any time, propose the introduction of alternative bar sizes, and/or lap (splice) locations, to those shown on the Drawings, the Contractor shall provide and submit fully detailed Drawings for the Engineer's approval.

With the exception of contact splices, the clear distance between parallel bars, shall not be less than 60 mm. Wherever beam reinforcement, is installed in two layers, or more, the bars in each layer, shall be placed exactly below those in the layer above. No eccentricity, between the centers, will be allowed.

The Contractor, shall be responsible for the design of all bar support systems.

**2.3.02 Splices**

Splices shall conform to the details indicated on the Drawings. Splices at locations, other than those indicated on the Drawings, shall be acceptable to the Engineer.

Except where indicated on the Drawings, welding, or tack welding, of reinforcement, is expressly prohibited. Reinforcement, upon which, unauthorized welding has been carried out, shall be removed, and replaced, conforming to all the applicable requirements.

Welded chairs, and supports may be used provided they are clamped, or wired to the reinforcement.

**2.3.03 Concrete Protection**

Unless otherwise indicated on Drawings, the minimum thickness of concrete cover to the reinforcement, measured from the surface of concrete, to the face of any bar, shall be 25 mm (1 inch) except as follows:

|  |  |
| --- | --- |
| * Footings, slabs, and walls in contact with ground. * Ditto as above over toping of blinding layer * Stirrups and ties at outside faces of columns and girders * Formed or top surfaces exposed to weather or saturated air, or sub- merged 16 mm bars or smaller * Formed or top surfaces in other locations 36 mm bars and smaller | 75 mm (3 inches)  50 mm (2 inches)  40 mm (1.5 inches)  40 mm (1.5 inches)  25 mm (1 inch) |

**2.3.04 Cutting and bending**

Bars shall be cut, and bent, in accordance with Drawings. All bending, shall be done cold, with the use of an approved bending machine. Rebending of bars shall not be permitted. Cut and bent bars, shall be bundled, and labeled for positive identification with the Drawings, and approved bending schedules, until they are incorporated into the work.

**2.3.05 Welding**

Welding of bars shall not be permitted, unless specifically authorized by the Engineer. When welding of reinforcement is employed, it shall strictly conform to ACI or BS Specifications.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

**3.1.01 Placement**

Reinforcement shall be accurately positioned, on supports, spacers, hangers, or other reinforcement, and shall be secured in place, with wire ties, or suitable clips. Wire ties, shall be cut as closely as possible, and bent into, or behind the bars, away from the finished concrete surface. Bare metal supports, shall not be used in contact with forms, for exposed surfaces.

**3.1.02 Concrete Cover**

Except as otherwise indicated on the Drawings, metal reinforcement for concrete, shall have the protective cover herein specified.

**3.1.03 Installation of Mechanical Couplings**

Mechanical couplings, shall only be used with equipment supplied by the coupling manufacturer, and shall be operated in accordance with the manufacturer's instructions.

**END OF SECTION**

# SECTION 03250

# CONCRETE ACCESSORIES

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers accessories including construction, expansion, and contraction joints for all concrete cast-in-place.

All construction, expansion, and contraction joints shall be accurately and properly constructed, so that concrete cast-in-place, can be placed as specified, and as indicated on the Drawings.

Dovetail anchor slots, shall be as specified in the Masonry Section, and located as indicated on the Drawings.

**1.1.01 Coordination.**

All reinforcing material and work shall be coordinated with work under the Concrete Formwork, Concrete Reinforcement, Cast-in-Place Concrete, and Sealant and Caulking Sections.

**1.1.02 Related Work**.

Work Specified Elsewhere.

Other items of work, that relate to, and are referenced in this section, include, but are not limited to the following sections:

Section 03100 : Concrete Formwork

Section 03200 : Concrete Reinforcement

Section 03300 : Cast-in-Place Concrete

Section 04220 : Masonry

Section 07920 : Sealant and Caulking.

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards, generally applicable to the work under this section, are listed. Codes and Standards current at the time of bid shall be used.

**ACI - American Concrete Institute**

**BS - British Standards**

Any equivalent, approved, codes and standards may be accepted, after the Engineer's approval.

**1.3 PRODUCT HANDLING**

**1.3.01 Protection**

Material shall be delivered, stored, and handled, in accordance with the General Equipment and Material Stipulations.

Rubber and plastic materials shall be stored in a cool place and shall not be exposed to direct sunlight.

**PART 2 - PRODUCTS**

Unless otherwise specified in other sections of these specifications, the following products shall be utilized: -

**2.1 MATERIALS**

Metal Water Stops Ungalvanized steel.

Rubber Water Stops "Dumbbell" type, 225 mm wide and 9.5 mm thick, with a 19 mm bead along each side. For concrete sections 200 mm or less in thickness, use 150 mm width.

Plastic Water Stops PVC ribbed, or serrated, 225 mm wide and 9.5 mm thick, with a "U" or "O" bulb closed center section. For concrete sections 200 mm or less, use 150 mm width.

Expansion Joint Filler Performed sponge rubber.

**2.2 PERFORMANCE AND DESIGN REQUIREMENTS**

**2.2.01 Construction Joints.**

Construction joints shall be made at locations indicated on the Drawings, or specified, or directed by the Engineer. Construction joints shall not be made at other locations, without the concurrence of the Engineer.

**A. Location.**

Construction joints, shall be located as follows:

1. In Columns and Walls.

At the under side of beams, girders, haunches, drop panels, and column capitals, and at floor levels. All haunches drop panels, and column capitals, shall be considered as parts of the supported floor and roof, and shall be placed monolithically therewith. Column bases will not be required to be monolithic with the floor beneath.

2. In Beams and Girders.

At the middle of the span, unless a beam intersects a girder at that point, in which case, the joint in the girder shall be offset a distance equal to twice the width of the beam. Provisions satisfactory to the Engineer shall be made for transfer of shear and other forces through the construction joint.

3. In Suspended Slabs.

At or near the center of the span in flat slab, or T-beam construction. No joint will be permitted between a slab and a concrete beam or girder, unless specifically required by the Drawings.

Construction joints in beams, girders, and slabs shall be perpendicular to the planes of their surfaces.

**B. Watertight Joints.**

Construction joints in the following locations, shall be watertight, and shall be provided with continuous metal water stops:

1. Walls and bottom slabs of dry pits, or rooms, where below finished grade, and in contact with backfill, or subgrade material on the opposite side.
2. Walls in contact with liquid, where the opposite face is above finish grade, or exposed in a dry pit, or room.
3. Slabs in contact with liquid, where the opposite face is exposed in a dry pit, or room.
4. Filters, and clear water reservoir, and floors.
5. Other locations, where specifically indicated on Drawings, or directed by the Engineer.

Metal water stops, shall be of the size, and thickness indicated on the Drawings, shall be made from ungalvanized steel, and shall be clean, and free from coatings that would weaken the bond with concrete. Each water stop, shall be continuous throughout the length of the construction joint, in which it is installed. Junctions between adjacent sections, shall be lapped 125 mm, and securely bolted, or welded together. All metal water stops, shall be maintained in proper position, until the surrounding concrete has been deposited, and compacted.

**2.2.02 Contraction Joints.**

Contraction joints, shall be provided at the locations indicated on the Drawings. Accessible edges of each contraction joint, shall be sealed as specified in the Sealants and Caulking Section.

Elastic water stops in contraction joints, shall be continuous and shall be of the rubber "dumbbell" type, or plastic (PVC) ribbed, or serrated type. Water stop embodiment, shall be equal on each side of the joint. Water stops, shall be spliced in strict conformity with the recommendations of the water stop manufacturer.

**2.2.03 Expansion Joints.**

Expansion joints shall be provided at the locations indicated on the Drawings. Expansion joint filler shall be firmly bonded to the previously poured joint face, with a suitable adhesive, and the new concrete, shall be poured directly against the joint filler. Accessible edges of each expansion joint, shall be sealed as specified in the Sealants and Caulking Section.

Expansion assemblies shall be furnished and installed, as indicated on Figures 1 through 4. Assemblies shall be two-way type, for floor-to-floor and floor-to-wall conditions, fabricated of 6063-T5 alloy aluminum, mill finish. Expansion assemblies shall be complete with all fasteners, concrete anchors, serrated floor plate, and extruded PVC filler strips.

Elastic water stops in expansion joints, shall be continuous, and shall be of the rubber "dumbbell" type, or plastic (PVC) ribbed, or serrated type. Water stop embodiment, shall be equal on each side of the joint. Water stops, shall be spliced, in strict conformity with the recommendations of the water stop manufacturer.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

**3.1.01 Placement Sequence.**

Construction joints, not indicated on the Drawings, shall be spaced at intervals for reducing, to a minimum, the effect of shrinkage in producing cracks, as recommended by the cement manufacturer, and acceptable to the Engineer. No two abutting sections shall be placed within a period of 72 hours, unless otherwise authorized by the Engineer.

**END OF SECTION**

# SECTION 03300

# CAST-IN-PLACE CONCRETE

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers all cast-in-place concrete, including materials, proportioning, batching, mixing, delivering, testing, receiving, placing, compacting, finishing, curing, and other appurtenant work.

Portland cement concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, sand and admixtures and shall be proportioned and mixed as specified herein.

All cast-in-place concrete shall be accurately formed and properly placed and finished as indicated on the Drawings and specified herein.

The Contractor shall inform the Engineer at least 24 hours in advance of the times and places at which he intends to place concrete.

**1.1.01 Related Work.**

Other items of work that relate to and are referenced to work specified in this section are included in the following sections:

Section 02220 : Excavation and Backfilling

Section 03100 : Concrete Formwork

Section 03200 : Concrete Reinforcement

Section 03250 : Concrete Accessories

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work under this section are listed. Codes and Standards current at the time of bid shall be used.

**ACI American Concrete Institute.**

**BS British Standards**

Any equivalent, approved, codes and Standards may be accepted, subject to the Engineer's approval.

**1.3 QUALITY ASSURANCE**

**1.3.01 Tolerances.**

Tolerances for formed surfaces shall be as specified in ACI and BS.

**1.4 SUBMITTALS**

**1.4.01 Materials Report**

At least 31 days prior to start of concrete delivery the following shall be submitted by the Contractor to the Engineer for review:

A. Recommended suppliers and sources of all ingredients for making concrete, including cement, water, fine and coarse aggregates, sand, and additives. (Item 1 Schedule 2 at the end of section 3300).

B. A supplier quality inspection plan to ensure continuing quality control of ingredients by periodic sampling, testing, and reporting to the Engineer on the quality of materials being supplied. (Item 2 Schedule 2).

C. All design mixes, using the "Standard Mix Design Presentation", Schedule 3, for each class of concrete, indicating that the concrete ingredients and proportions will result in a concrete mix meeting requirements specified. (Item 3 Schedule 2).

D. The name and location of the test laboratory to be used by the Contractor's concrete suppliers, as well as the proposed program, methods and details of plant, equipment, and personnel to be used in testing ingredients, mix design, and concrete samples. (Item 4 Schedule 2).

1. The proposed program, methods, and details of plant and equipment to be used for batching and mixing of concrete. (Item 5 Schedule 2).

The Contractor shall submit the mix design as a report with his recommendation to obtain Engineer acceptance prior to commencement of concreting work. This report shall compare the proposed mix design with specified requirements and shall be summarized on a form similar to that shown in Schedule 3 at the end of section 3300.

1. Materials

|  |  |
| --- | --- |
| **Cement** | ASTM C150, Type I, II, or III. |
| **Fly Ash** | ASTM C618, Class F, except loss on ignition shall not exceed 5 per cent. |
| **Fine Aggregate** | Clean natural sand, ASTM C33. Artificial or manufactured sand will not be acceptable. |
| **Coarse Aggregate** | Crushed rock, washed gravel, or other inert granular material conforming to ASTM C33, except that clay and shale particles shall not exceed one per cent. |
| **Water** | Clean and free from deleterious substances. |
| **Admixtures** |  |
| Accelerator | Calcium chloride, ASTM D98, dispensed as a solution |
| Retarder | ASTM C494, Type D; Grace “Daratard-HC”, Master Builders ”MB-HC”, Protex “Protard”, or Sika Chemical “ Plastiment. |
| Plasticizer | ASTM C494, Type A; Grace “WRDA-HC”, or Sika Chemical “Plastocrete 160”. |
| Air-Entraining Agent | ASTM C260; Grace “Darex AEA”, Master Builders “MB-AE10”, Protex “AES”, or Sika Chemical AER”. |
| **Reinforcing Steel** |  |
| Bars, Except Weldable | ASTM A615 (and Supplement S1) Grade 60, deformed. |
| Bars, Weldable | ASTM A706 or A615 (and Supplement S1) Grade 60, deformed, with maximum carbon equivalent of 0.55. |
| Beam Stirrups and Column Ties | ASTM A615 (and supplement S1) Grade 40, deformed |
| Column Spirals | ASTM A82, cold drawn wire. |
| Welded Wire Fabric | ASTM A185 or A497/ |

|  |  |
| --- | --- |
| Bar Supports | CRSI Class 1, Plastic protected, or Class 2, stainless steel protected. |
| **Forms** |  |
| Prefabricated | Simplex “Industrial Steel Frame Forms”, Symons “Steel Ply”, or Universal “Uni-form”. |
| Plywood | Product Standard PS1, waterproof, resin-bonded, exterior type Douglas fir; face adjacent to concrete Grade B or better. |
| Fiberboard | Fed Spec LLL-B-810, Type II tempered, waterproof, screenback, concrete form hardboard. |
| Lumber | Straight, uniform width and thickness, and free from knots, offsets, holes, dents, and other surface defects. |
| Chamfer Strips | Clear white pine, surface against concrete planed. |
| Form Coating | Nox-Crete “Form Coating” L&M “Debond”, Protex “Pro-Cote”, or Richmond “Rich cote”. |
| Wedge Inserts | Malleable iron, with galvanized askew-head bolts, nuts, and washers; Hohmann and Barnard “HW”, Richmond “Peerless”, or Weston “WC50”. |

**1.4.02 Hot Weather Concreting**

A report shall be submitted for proposed methods of compliance with hot weather concreting requirements. Providing chilling plant might be required. (Item 6 Schedule 2)

**1.4.03 Cold Weather Concreting**

A report shall be submitted for proposed methods of compliance with cold weather concreting requirements. (Item 7 of Schedule 2).

**1.4.04 Certificates**

Laboratory test reports and mill or manufacturer's certificates attesting to conformance of ingredients with the specifications shall be submitted with each mix design. (Item 8 Schedule 2)

In case the source, brand or characteristic properties of the ingredients need to be varied during the term of the Contract, a revised laboratory mix report shall be submitted. (Items 1, 2, & 3 of Schedule 2)

A certificate shall be submitted stating that each admixture used is identical in composition to the sample used for acceptance testing, and is compatible with all other material in the design mix. (Item 9 Schedule 2).

**1.4.05 Delivery Tickets**

A delivery ticket from the concrete supplier for each load delivered to the Work Site shall be submitted setting forth the following information:

Contract Number

Date

Name of Purchaser

Registration Number of Delivery Truck

Name of Driver

Class of Concrete

Slump Ordered

Air Content

Amount of Concrete in Truckload in Cubic Metres

Cement in Truckload in Kilograms

Total Water in Batch in Litres

Type of Additives Used

Type of Cement Used

Time of Mixing of Concrete (if Dry, Time Cement Added to Aggregates)

Temperature Specified (Maximum)

Temperature of Concrete (when Discharged at Place of Placement) \*

Time of Arrival at the Work Site\*

Time of Discharge at the Work Site\*

Amount of Extra Water Added in Litres (At Request of Recipient of Concrete, and His Signature) \*

\* To be completed by Contractor on the Work Site.

**1.4.06 Test Reports**

The Contractor shall obtain from his concrete supplier copies of the results of all tests which shall become part of the Contractor's Weekly Quality Control report to the Engineer.

**1.4.07 Summary of Submittals**

Schedule 2 is the complete list and frequency of reports which the Contractor shall obtain from his concrete supplier.

**1.4.08 Field Reports**

Field test reports shall be submitted as specified in this section, and in accordance with the Submittals and Quality Control Sections.

**1.4.09 Reinforcements**

Certifications and reports on reinforcements shall be submitted for review as specified in the Concrete Reinforcement Section.

**1.4.10 Layout of Joints and Lifts.**

The Contractor shall submit to the Engineer for review as soon as practicable after the Notice to Proceed and not less than three weeks before the commencement of concreting, detailed drawings showing his proposals for placing concrete on which the position of all construction joints and lifts shall be indicated. These shall take into account any specific requirements detailed on the Drawings and specified in the Concrete Accessories Section. No concreting shall be started until the Engineer has accepted the method of placing, the positions and form of the construction joints, and the lifts.

**1.4.11 Layout of Waterstops.**

The Contractor shall submit to the Engineer for review as soon as practicable after the Notice to Proceed and not less than three weeks before the commencement of concreting, detailed drawings showing his proposals for the installation of waterstops. These shall take into account the specific requirements detailed on the Drawings and specified in the Concrete Accessories Section. The Contractor's drawings shall show also where joints in the water stops are to be located and details of the intersections and changes of direction to a scale that shows the position of any joint and the shape of any molded section.

1. **Shop Drawings**

The contractor shall verify, check the contract drawings and designs in compliance with the specification, field measurements and shall wholly study and read the structural drawings in compliance with the Mechanical, Electrical and Architectural drawings, upon fulfilling the above , the contractor shall present for the approval of the Engineer a detailed structural shop drawings.

Shop drawings shall be submitted in 5 copies in which two copies will be returned to the contractor with (remarks/ approval) stamp. No. structural works are allowed before obtaining the approval on the shop drawings from the Engineer.

**1.5 DELIVERY, STORAGE AND HANDLING**

Materials shall be handled and stored as follows: -

**1.5.01 Aggregates**

Aggregates shall be transported and stockpiled separately according to their sources and gradations. Aggregates shall be handled in a manner which will prevent segregation and contamination with earth or foreign materials.

If aggregates show segregation, or if the different grades become mixed, the aggregates shall be re-screened before placing in the proportioning bins. Contaminated aggregates will not be used.

Aggregates shall not be transferred directly from trucks, railroad cars, or barges to the proportioning bins when moisture content and/or water absorption is such that it will affect the accuracy of the proportioning of the concrete mixture. In such cases, the aggregates shall be stockpiled until the excess moisture drains off.

Muddy or oil-leaking equipment shall not be allowed to operate on the stockpiles.

Reports on Aggregates shall include the following information:

1. Fine Aggregate:
   1. Source and type.
   2. Gradation.
   3. Deleterious Substances.
2. Coarse Aggregate
   1. Source and type
   2. Gradation and abrasion loss.
   3. Deleterious substances.
   4. Results of sodium or magnesium sulfate soundness test.

**Mix Design:**

Using concrete materials acceptable to the Engineer, a tentative concrete mix shall be designed and tested for each size and gradation of aggregates and for each consistency intended for use on the work. Design quantities and test results of each mix shall be submitted for review. Mixes shall be adjusted in the field as necessary to meet the requirements of these specifications.

The Report for each tentative concrete mix submitted shall contain the following information:

1. Slump on which design is based.
2. Total gallons of water per cubic yard.
3. Brand, type, composition, and quantity of cement.
4. Brand, type composition, and quantity of fly ash.
5. Specific gravity and gradation of each aggregate.
6. Ratio of fine to total aggregates.
7. Weight (surface dry) of each aggregate per cubic yard.
8. Brand, type, ASTM designation, active chemical ingredients, and quantity of each admixture.
9. Air content.
10. Compressive strength based on 7 day and 28 day compression tests.
11. Time of initial set.

**1.5.02 Packaged Cement**

When required, packaged cement shall be delivered to the mixing site in original moisture proof, sealed containers, which shall be labeled with the weight, name of manufacturer, brand, and type specified. Cement received in broken or damaged containers shall not be used.

Cement containers shall be stored in dry, weather-tight, and well ventilated enclosures.

Containers of cement which vary in weight by more than 3 per cent shall not be accepted.

**1.5.03 Bulk Cement**

Bulk cement shall be stored separately from packaged cement. Bulk cement shall be stored in dry, weather-tight, well-ventilated bins with provisions for prevention of moisture absorption or the intrusion of foreign matter.

Facilities for sampling of cement shall be provided at the weighing hopper, or at the feed line immediately before entering the hopper.

Different brands of cement, or the same brand of cement from different sources, shall not be used without prior notification by the Contractor.

**1.5.04 Admixtures**

Dry admixtures shall be stored in dry, weather-tight, well-ventilated housing or silos. Liquid admixtures shall be stored in clean, weather-tight tanks.

**1.5.05 Temperature Limits:**

TABLE 1.5.05

TEMPERATURE UPPER LIMITS AT POINT OF PLACEMENT

Temperature of Concrete

|  |  |
| --- | --- |
| **Concrete Thickness**  **(mm)** | **At time of Placement**  **(in ˚C)** |
| Not greater than 400 | 38 |
| Not greater than 750 | 32 |
| Greater than 750 | 25 |

**1.5.06 Temperature Control**

The concrete supplier shall provide procedures and facilities to control or reduce the temperature of all materials used in the concrete mix during "hot weather" as defined by air temperature over 32o C. Some hot weather concreting difficulties can be reduced by the use of concrete with up to 100 percent flaked ice in lieu of mixing water. The Contractor shall place concrete with as much ice as deemed necessary by the Engineer to surmount hot weather concreting difficulties. Separate payment shall not be made for any ice.

The following may also have to be used to assist in lowering the temperature of concrete to meet the temperature limits at the point of placement.

1. Exposed water tanks and piping, the roofs and vertical walls of cement storage silos or buildings, the tops and vertical walls of mixer discharge hoppers, and the sides of truck bodies carrying batched aggregate or mixed concrete may be painted white or silver.
2. Weighing hoppers, mixer drums, and tops of mixer discharge hoppers may be shaded from the rays of the sun when it is 30 C or more above the horizon, and may also be protected from drying winds by screens.
3. Water for concrete may be chilled by the use of heat exchanger coils, or by the addition of flaked ice.

4. Coarse aggregates may be cooled by misting, provided that any moisture retained be taken into account when determining the water-cement ratio for the mix.

5. Cooler aggregates may be used by reclaiming aggregate from stockpiles by the tunnel method so as to avoid using the surface layer of the stockpile.

Shade and wind protection may be used to protect the elevating conveyor to the batching plant.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Cement**

Cement shall be Portland cement or Portland - pozzolan cement (OPC), for the super structure and shall be sulphate resistant Portland cement (SRC) for sub-structure.

**2.1.02 Admixtures and Additives**

All concrete admixtures and additives shall conform to ACI and BS Specifications. Chemical admixtures are not to be used until the supplier has verified their use in accordance with ACI and BS Specifications and has also demonstrated by trial batches that two (2) times the admixture proposed can be used and still meet the specified concrete strength without noticeable deleterious effect.

Chemical admixtures may be:

1. Type A. Water reducing admixture

2. Type D. Water reducing and retarding admixture (Acceptance based on Contractor's report and recommendation shall be obtained from the Engineer before using.)

3. Type F. High range water reducer (superplasticizers) based upon sulfonated melamine or naphthalene formaldehyde condensates.

Calcium chloride or admixtures containing chloride from other than impurities from admixture ingredients shall not be used.

Cement colouring admixture shall be dry powder dust-on mineral oxide dye. Total colouring admixture shall not exceed 6 per cent by weight of the cement.

Corrosion-inhibiting admixtures shall not be used.

**2.1.03 Water**

Water to be used for cooling and washing aggregates, and for mixing and curing concrete shall be clean and free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances. Concreting water shall not be used until tested and until the report of testing has been reviewed by the Engineer.

Mixing water for use with cement shall be suitable to ensure that the salts content of the total concrete mix does not exceed the limitations set out in Table 2-2.04A .

**2.1.04 Fine Aggregate**

Fine aggregate shall consist of natural sand, and shall be composed of clean, hard, durable spherical particles in conformance with ASTM, AASHTO and BS Specifications.

The salt content of fine aggregate shall not exceed the limitations as set out in Table 2.2.04A.

**TABLE 2.2.04A**

**TOTAL ALLOWABLE SALTS CONTENT**

**MAXIMUM ALLOWABLE PERCENT BY MASS**

|  |  |  |  |
| --- | --- | --- | --- |
| **Salt** | **In Fine Aggregate by Weight of Fine Aggregate** | **In Coarse Aggregate by Weight of Coarse Aggregate** | **Total by Weight of Cement** |
| Chlorides | 0.06 | 0.10 | 0.20 for OPC\* |
| (NaCl) \*\* |  |  | 0.40 for SRC\* |
| Sulphates  (SO3) | 0.40 | 0.50 | 4.0 BS(8110)\* |

\* Includes salts in cement and water.

\*\* Equivalent determined by chloride ion x 1.6.

Deleterious substances shall be limited in fine aggregate to the amounts shown in Table 2.2.04B,

**TABLE 2.2.04B**

**ALLOWABLE DELETERIOUS SUBSTANCES IN**

**FINE AGGREGATE**

**Maximum Allowable**

**Item Percentage by Mass**

**---- ------------------**

Clay lump and friable particles 1.0

Other deleterious substances 5.0

(such as shale, alkali, mica,

coated grains, soft particles)

Material finer than 75 micron,

ASTM (No. 200) sieve 5.0

Fineness modulus for fine aggregate shall be between (2.3-3.1) + 0.2

Sand equivalent shall be 75% (min.).

The grading of fine aggregate shall be within the limits shown in Table 2.2.04C.

**TABLE 2-2.04C**

**GRADING LIMITS OF FINE AGGREGATES**

**FOR CONCRETE**

**Sieve Mass (percentage) Passing**

**----- -------------------------**

**(mm)**

9.5 (3/8 inch) 100

4.75 (No. 4) 95 -100

1.18 (No. 16) 45 - 95

0.30 (No. 50) 10 - 55

0.15 (No. 100) 5 - 35

0.075 (No. 200) 0 - 5

**2.1.05 Coarse Aggregate**

Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone or a combination of the two, and shall be composed of clean, hard, uncoated particles in conformance with ASTM, AASHTO and BS Specifications.

The salt content of coarse aggregate shall not exceed the limitations as set out in Table 2.2.04A.

Deleterious substances shall be limited in coarse aggregate to the amounts shown in Table 2.2.05A.

**TABLE 2.2.05A**

**ALLOWABLE DELETERIOUS SUBSTANCES IN**

**COARSE AND MEDIUM AGGREGATE**

**Maximum Allowable**

**Percent by Mass**

**Item (Coarse) (Medium)**

**------ ------------------------**

Opal Free Free

Clay lumps 2.00 1.5

Material passing 0.075 mm

(No. 200) sieve 1.50 4.0

Other deleterious substances 5.00

(such as shale, alkali, mica,

coated grains, soft particles)

Wearing Resistance of aggregate when tested in accordance with Los Angeles abrasion test, AASHTO (T96) should not exceed 40%.

Water absorption of aggregate should not exceed 6% when tested in accordance with AASHTO (T84).

Specific gravity of aggregate should be minimum of (2.5) when tested in accordance with AASHTO (T19).

Sodium and Magnisium Sulphate soundnesses, when tested according to AASHTO (T-104), should not exceed 10% and 16% respectively.

Flakiness and Elongation when determined according to BS 812 should not exceed 25% for each.

The grading of combined aggregate shall be within the limits as shown in TABLE 2-2.05B.

**TABLE 2.2.05B**

**GRADING LIMITS OF**

**COMBINED AGGREGATE FOR CONCRETE**

**Percentage Passing by Mass**

**Sieve mm & (Percent)**

**----- --------------------------**

38 (1.5 inch) 100

19 (3/4 inch) 60 - 100

9.5 (3/8 inch) 40 - 70

4.75 (No. 4) 28 - 50

2.36 (No. 8) 18 - 40

1.18 (No. 16) 14 - 33

0.6 (No. 30) 8 - 26

0.30 (No. 50) 3 - 18

0.15 (No. 100) 0 - 10

0.075(No. 200) 0 - 3

**2.2 PERFORMANCE AND DESIGN REQUIREMENTS**

**2.2.01 Classes of Concrete**

Classes of concrete are denoted by designations which consist of a letter followed by a numeral indicating the 28-day compressive strength in megapascals (MPa) as determined by BS 1881, and as shown in Schedule 1.

Each class of concrete may consist of one or more mixes determined by the maximum size of aggregate, slump and types of admixtures used.

Each mix within a class shall be considered a specific type, requiring acceptance of the design mix.

**2.2.02 Design Criteria**

Design concrete mixes shall have a minimum cement content per cubic meter of concrete consistent with the required slump, a water content corresponding to the appropriate water-cement ratio, the specified maximum size of coarse aggregate, and the required grading of aggregates, in accordance with those limits as set forth in Schedule 1, and in Tables 2-2.04C and 2-2.05B. Design mix proportions shall be as recommended by ACI & BS Specifications, unless otherwise specified herein. Trial mix water-cement ratio shall be used in accordance with ACI & BS Specifications, or the supplier's previously obtained field data for proportioning the design mix, as determined by the type of structure and exposure conditions, and shall be adjusted to meet specified design mix requirements. Design mixes shall be tested and reported on as specified herein.

The design mixes for each class of concrete shall be as determined by the Contractor through an acceptable design laboratory and accepted by the Engineer to produce the results as specified herein.

For each class of concrete there shall be as many mix designs as there are different combinations of ingredients anticipated to cover the requirements of the work. Mix design may vary to meet field conditions, particularly for hot weather and cold weather concreting, but after acceptance by the Engineer no change shall be made without notice to and acceptance by the Engineer based on the Contractor's report and recommendation.

Unless otherwise specified, design strength shall be based on 28 day tests.

A. **Design Mix**

When a design mix for any class of concrete has been accepted by the Engineer, it shall not be changed as to source, quality, proportioning, grading of materials, or in any other way that reduces durability.

All proposed changes shall be accomplished by preparing a new design mix as specified herein.

B. **Sampling and Testing**

Prior to use, all concrete ingredients shall be sampled and tested by a laboratory acceptable to the Engineer in accordance with the methods specified to determine compliance with this Section.

C. **Slump**

The slump range as specified shall be maintained for concrete at the point of delivery.

D. **Minimum Cement Content**

The minimum cement content per cubic meter shall be as specified in Schedule 1 for each class of concrete as determined by analysis of fresh concrete.

**Cement Content**

The quantity of Portland cement, expressed in pounds per cubic yard, shall be as shown in the following table. These minimum cement quantities shall apply only to concrete containing a specified water-reducing admixture. If, for any reason, the water-reducing admixture is omitted, the cement shall be increased 10 percent. At the option of the Contractor, fly ash may be substituted for up to 15 percent of the Portland cement quantity shown on the basis of 1.5 pounds of fly as for each pound reduction in cement

|  |  |  |  |
| --- | --- | --- | --- |
| **Concrete Slump** | **Coarse Aggregate Size**  **From No. 4 Sieve to** | | |
| **½”** | **¾”** | **1”** |
| 2 inches | 573 | 545 | 517 |
| 3 inches | 592 | 564 | 536 |
| 4 inches | 611 | 583 | 555 |
| 5 inches | 630 | 602 | 573 |
| 6 inches | 649 | 620 | 592 |

**Total Water Content**

Total water content of concrete shall not exceed 6.5 gallons of water per hundred pounds of cement in the mix, or equivalent cement weight if fly ash is added.

**Slump**

Concrete slump shall be kept as low as possible consistent with proper handling and thorough compaction. Unless otherwise authorized by the Engineer, slump shall not exceed 4 inches.

**Ratio of Fine to Total Aggregates**

The ratio of fine to total aggregates based on solid volumes (not weights) shall be:

|  |  |  |
| --- | --- | --- |
| **Coarse Aggregate**  **Size** | **Minimum**  **Ratio** | **Maximum**  **Ratio** |
| ½ inch | 0.40 | 0.55 |
| ¾ inch | 0.35 | 0.50 |
| 1 inch | 0.30 | 0.46 |
|  |  |  |

**Initial Set**

The initial set as determined by ASTM C403 shall be attained 5-1/12 hours plus or minus one hour after the water and cement are added to the aggregates. The quantity of retarding or accelerating admixture shall be adjusted to compensate for variations in temperature and job conditions.

**Total Air Content**

The total volumetric air content of concrete after placement shall be 6 per cent plus or minus one per cent. Air may be omitted from interior slabs which are to be trowel finished.

**Admixtures**

The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer’s recommendations for compliance with these specifications. A water-reducing admixture shall be included in all concrete.

Calcium chloride content shall not exceed 2 per cent of the cement content, by weight.

**Strength**

The minimum acceptable compressive shall be:

|  |  |
| --- | --- |
| Age | Minimum Strength |
| 7 days | 2/3 of design strength |
| 28 days | 100% of design strength |

**Storage of Materials**

**Cement and fly ash shall be stored in suitable moisture proof enclosures.** Cement and fly ash which have become caked or lumpy shall not be used.

Aggregate shall be stored so that segregation and the inclusion of foreign materials is prevented. The bottom 6 inches of aggregate piles in contact with the ground shall not be used.

Reinforcing steel shall be carefully handled and shall be stored on supports which will keep the steel from contact with the ground.

**Forms**

Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions shown on the drawings. Forms shall conform to ACI 347 and the following additional requirements.

Forms for surfaces which will be exposed to view when construction is completed shall be prefabricated playwood panel forms, job-built playwood forms, or forms that are lined with playwood or fiberboard. Forms for exposed surfaces shall be laid out in a regular and uniform pattern with the long dimension of panels vertical and all joints aligned. The forms shall produce finished surfaces that are free from offsets, ridges, waves, and concave or convex areas, within the tolerances specified herein.

Plywood or lined forms will not be required for surfaces which are normally submerged or not ordinarily exposed to view, such as the insides of manholes, basins, and reservoirs. Other types of forms, such as steel or unlined wooden forms, may be used for surfaces which are not restricted to playwood are lined forms and may be used as backing for form linings. Concrete forms are required above all extended footings.

Flat segmental forms not more than 24 inches wide may be used for forming curved surfaces 25 feet in diameter or larger.

Where concrete is placed against gravel or crushed rock, which does not contain at least 25 per cent material passing a No. 4 sieve, such surfaces shall be covered with polyethylene film to protect the concrete from loss of water. Joints in the film shall be lapped at least 4 inches.

Where concrete is placed against rock, all loose pieces of rock shall be removed and the exposed surface cleaned with a high-pressure hose.

Design

Forms shall be substantial and sufficiently tight to prevent leakage of mortar. Forms shall be braced or tied to maintain the desired position, shape and alignment during and after concrete placement. Walers, studs, internal ties, and other form supports shall be sized and spaced so that proper working stresses are not exceeded.

Beams and slabs supported by concrete columns shall be formed so the column forms may be removed without disturbing the supports for the beams or slabs.

Wherever the top of a wall will be exposed to weathering, the forms on at least one side shall not extend above the top of the wall and shall be brought to true line and grade. At other locations, forms shall be brought to a true line and grade, or a wooden guide strip shall be provided at the proper location on the forms so that the top surface can be finished to a specified elevation, slope, or contour. At horizontal construction joints in walls, the forms on one side shall not extend more than 2 feet above the joint.

Form Ties

Form ties shall be of the removable end, permanently embedded body type and shall have sufficient strength and rigidity to support and maintain the form in proper position and alignment without the use of auxiliary spreaders. Cones shall be provided on the outer ends of each tie and the permanently embedded portion shall be at least one inch back from the concrete face. Form ties for water bearing walls shall be provided with water seal washers located on the permanently embedded portions of the ties at the approximate center of the wall. Permanently embedded portions of form ties which are not provided with threaded ends shall be constructed so that the removable ends are readily broken off without damage to the concrete. The type of form ties used shall be acceptable to the Engineer.

Form ties in exposed surfaces shall be uniformly spaced and aligned in horizontal and vertical rows.

Edges and Corners

Chamfer strips shall be placed in forms to bevel all salient edges and corners, except the top edges of walls and slabs which are to be tooled and edges which are to be buried. Equipment bases shall have formed beveled salient edges for all vertical and horizontal corners unless specifically shown otherwise on the drawings. Unless otherwise noted, bevels shall be ¾ inch wide.

**Form Removal**

Form shall not be removed or disturbed until the concrete has attained sufficient strength to safely support all dead and live loads. Shoring beneath beams or slabs shall be left in place and reinforced as necessary to carry any construction equipment or materials placed thereon. Care shall be taken in form removal to avoid surface gouging, corner or edge breakage, and other damage to the concrete.

**Reinforcements**

Reinforcements shall be accurately formed and shall be free from loose rust, scale, and contaminants which reduce bond. Unless otherwise shown on the drawings or specified herein, the details of fabrication shall conform to ACI 315 and 318. Welded wire fabric will be acceptable in lieu of individually placed bars.

**Shop Drawings and Bar Lists**

Bar lists and drawings for the fabrication and placing of reinforcements shall be submitted for review.

**Placement**

Reinforcements shall be accurately positioned on supports, spacers, hangers, or other reinforcements and shall be secured in place with wire ties or suitable clips.

With the exception of contact splices, the clear distance between parallel bars shall be not less than 2- ½ inches. Where reinforcements in beams are placed in two or more layers, the bars in the upper layer shall be placed directly above the bars in the lower layer.

Reinforcements shall not be installed for beams or slabs which are supported by concrete columns until after the concrete for the column has been placed.

**Splices**

Splices shall conform to the details shown on the drawings. Splices at locations other than those shown on the drawings shall be acceptable to the Engineer.

**2.2.03 Structural Concrete**

Structural concrete shall be Class C30 for super structural concrete and class C35 for sub-structural concrete or as indicated on drawings and B.O.Q.

**2.2.04 Concrete Fill and Topping**

Concrete benching (concrete fill and concrete topping) shall be provided in the locations indicated on the Drawings and shall be Class C15 concrete.

**2.2.05 Cement Motar**

Cement mortar shall be composed of fine aggregate and cement in the proportions of 3 to 1 by volume.

The ingredients shall be thoroughly mixed while dry by machine or hand until the cement color can no longer be distinguished from the fine aggregate in any part of the mass and then shall be uniformly wetted by means of a hose while undergoing further thorough mixing.

The mortar shall be prepared and used in quantities such that no longer than 30 minutes shall elapse between the first wetting and complete use of the mortar in the Works and, if mixed by hand, no single batch shall exceed 1/4 cubic meter.

**2.2.06 Blinding Concrete**

Blinding concrete (mud mat) shall be Class C15 concrete and shall be as specified and not less than 50 mm thick.

**2.2.07 Concrete Embodiment and Encasement of Pipe**

Concrete for embodiment and encasement (concrete surround) shall be encasement concrete, Class C20 concrete, and shall be installed where and as indicated on the Drawings and at those locations where installation conditions require such pipe reinforcement because of unforeseen conditions encountered in the work.

**2.2.08 Architectural Concrete**

Architectural concrete shall be all exposed concrete on the buildings. Architectural concrete shall conform to the additional requirements set forth herein. Particular care shall be taken in forming, placing, and finishing architectural concrete.

**2.3 PROPORTIONING**

**2.3.01 Mix Design**

Mix design shall be determined by one of two methods:

1. Proportioning on the basis of field experience.

2. Proportioning by laboratory trial batches.

A. Proportioning on the Basis of Field Experience

1. Where a concrete production facility has a record, based on at least 30 consecutive strength test results that represent similar materials and conditions to those expected, required average compressive strength used as the basis for selecting concrete proportions shall exceed required design strength at designated test age by at least the following required margins based on standard deviation of existing strength test results:

**Required Margin Standard Deviation**

**MPa MPa**

**--------------- ------------------**

4.1 2.0 to 3

5.7 3.1 to 4

7.4 4.1 to 5

9.0 5.1 to 6

11.5 6.1 to 8

2. Strength test data for determining standard deviation shall be considered to comply with Subsection 2-3.01 A.1, if data represents a group of at least 30 consecutive results.

3. Strength test results used to establish standard deviation shall represent concrete produced to meet a specified strength or strengths within 5.0 MPa of that specified for the proposed class.

4. Variation of materials and proportions within the population of background test results used to establish standard deviation shall not have been more tightly controlled than for the proposed class.

B. Proportioning on the Basis of Laboratory Trial Batches.

1. When laboratory trial batches are used as the base for selecting concrete proportions, strength tests shall be made in accordance with BS 1881, on cubes prepared in accordance with BS 1881.

2. A curve shall be established showing the relationship between the water content and the compressive strength. The curve shall be based on at least three points, each point being the average of at least three cubes tested at 28 days, and representing batches which produce strengths above and below the required average compressive strength. The required average compressive strength shall be 30% greater than the design strength.

3. The minimum cement content for any concrete shall be that shown by the curve to produce the average compressive strength required for that class, unless a higher cement content is required by the values shown in Schedule 1 ( at the end of section 3300).

C. Reduction of Margin Based on Field Data

After sufficient test data becomes available from the job, the margin (the amount by which the average strength must exceed the design strength) can be reduced below those values indicated in Subsection 3.01, A.1, in accordance with ACI 214 "Recommended Practice for Evaluation of Compressive Test Results of Concrete", provided:

1. That the probable frequency of strength tests falling more than 3.5 MPa below the design strength will not exceed 1 in 100.

2. That the probable frequency of the average of three consecutive strength tests falling below the design strength will not exceed 1 in 100.

3. That the acceptance of the Engineer has been obtained for such reduction on the basis of the Contractor's report and recommendation.

**2.3.02 Plant and Mixture Trial Runs**

Prior to the delivery of any concrete to the Work Site, the Contractor shall demonstrate the suitability of its supplier and of the mix designs by plant trial mixes. The Contractor shall obtain appropriate notice from the supplier so that it may be present to witness the trial runs.

Trial batches of concrete shall be produced for all the classes of concrete proposed, and shall be designed in accordance with Subsection 2.3.01. Trial mixtures shall be designed for maximum permitted slump, air content, and ambient temperature range of use.

A minimum of six (6) test cubes shall be made and cured in accordance with BS1881, for each water-cement ratio, using mix materials all of which shall be in the same temperature range of the materials which will be used in the concrete to be delivered to the Work Site. Ambient temperatures and the temperature of each trial batch shall be recorded and made part of the test report.

Design mix shall be reworked and new test cubes shall be prepared as described in preceding paragraph when average ambient temperatures differ in excess of 15 ºC.

The report shall be submitted to the Engineer for acceptance based on the Contractor's recommendation (Item 9 Schedule 2).

**2.3.03 Batching and Mixing**

The Contractor's concrete supplier shall have radio communication between the mixing plant and the delivery vehicles.

Concrete shall be either batched and mixed at a central batching and mixing plant, or batched at a central batching plant and mixed in a truck mixer. The amount of concrete mixed in any one batch shall not be more than the rated capacity of the mixer, nor less than the mixer manufacturer's recommended minimum mix volume.

A. Batching

Batching of cement in any plant shall be by weight.

Batching of aggregates shall be by weight in any plant whose noted capacity is less than 100 cu m/hr, but may be by weight or volume in any plant of rated capacity greater than 100 cu m/hr.

Batching of water and of admixtures may be by weight or volume.

The accuracy of the measuring equipment shall be:

Cement + 1 percent

Water + 1 percent

Aggregates + 3 percent

Admixtures + 3 percent

Batching accuracy certificates shall be obtained from the supplier by the Contractor quarterly, comprising an account of weekly calibration tests and a record of adjustments made, and also accompanied by a statement as to the accuracy of all measuring devices. This record shall be maintained at all times by the Contractor, and shall be available for inspection by the Engineer at any time.

B. Mixing

(1) Central Mixing Plant:

Measuring tolerances, and mixing capability and time shall be as stated herein.

The fine and coarse aggregates and the cement shall be mixed for not less than four turns of the drum or paddle before the water is added. Water is to be added gradually while the drum or paddle remains in motion, and the concrete shall be mixed until a uniform consistency and colour have been obtained.

The quantity of water added to each batch shall be the net water, excluding moisture content of aggregate and free water, if any, but including water that will be absorbed by the aggregate, dependent on absorption and moisture content values determined daily and before any mixing takes place.

The water shall be added to the batch of concrete by means of a measuring device with an automatic cut-off of entry water while emptying into the mixer. All valves, etc. shall be regularly maintained to ensure there is no leakage of water into the mixing drum. The gagging receptacle shall be kept clean and must be completely emptied after each batch.

The whole of the mixed batch shall be removed before materials for a fresh batch enter the drum, unless the plant is designed for continuous mixing.

The retempering of concrete which has partially hardened by the addition of cement aggregate or water shall not be allowed. Concrete which has been over mixed to the extent that addition of water is necessary to preserve the required consistency during discharge shall not be used.

(2) Truck Mixers:

Truck mixers shall be of the revolving drum type, watertight.

Truck mixers shall be equipped with a tank containing water solely for making concrete. The addition of the prescribed quantity of water to the mix may either be at the central plant or at the site of concrete placement. Whichever method is adopted, the truck must be capable of producing a uniform concrete to the requirements of the specification.

The fine and coarse aggregates and the cement shall be mixed for not less than four turns of the drum or paddle before the water is added. Water is to be added gradually while the drum or paddle remains in motion, and the concrete shall be mixed until a uniform consistency and color have been obtained.

The maximum size of the batch or mix shall not exceed the maximum rated capacity of the truck mixer as stated by the manufacturer and stamped on the drum. Truck mixing shall be continued for not less than 50 revolutions, after all ingredients including water (but not necessarily additives) are in the drum. The speed shall not be less than 4 revolutions per minute or more than a speed resulting in a peripheral velocity of 70 meters per minute.

C. Transportation

Temperature of concrete leaving the mixing plant shall be such that at the time of placement the maximum temperature does not exceed that specified for its placement, in the Cast-in-Place Concrete Section.

Concrete shall be so transported and placed that contamination, segregation, or loss of the constituent materials does not occur.

The concrete shall be compacted in its final position within two (2) hours from the time of introduction of the cement into the aggregates, but in all cases at least ninety (90) minutes less than the certified initial set time of the cement.

When water is added to truck-mix concrete at the Work Site, it shall be done under the supervision of the Contractor's Quality Control Supervisor and shall be in quantities which will not exceed the water - cement ratio limits shown in Schedule 1.

The slump of delivered concrete shall be determined on-site and shall not exceed the working limit shown below :

**Working Limit Margin for Error Rejection Limit**

**------------- ---------------- ---------------**

100 mm 25 mm 125 mm

The margin for error can only be used for a maximum of one truckload out of ten consecutive truckloads of concrete.

Contractor is to assess slump at jobsite for acceptable workability. Special high slump easily worked mixes shall be used as required provided prior acceptance by the Engineer has been granted as based on the Contractor's report and recommendations.

Where the slump is deemed inappropriate for acceptable workability, the Contractor's Quality Control Supervisor can authorize adding additional water to the mix to obtain acceptable workability, but within the limitations of the water-cement ratio as required by this specification.

Upon arrival of concrete at the place of deposition, the Contractor shall receive from the driver, prior to acceptance, a delivery ticket for the concrete as specified in the submittals paragraph. The Contractor shall verify if concrete, as received, meets the requirements of the specification. The Contractor shall complete the delivery ticket and fill in those items for which he is responsible.

**PART 3 - EXECUTION**

**3.1 INSPECTION**

**3.1.01 Replacement Inspection.**

Before concrete is placed, forms, reinforcements, water stops, anchor bolts, and embodiments shall be rigidly secured in proper position; all dirt, sand, water, and debris shall be removed from the space to be occupied by concrete; all surfaces encrusted with dried concrete from previous placement operations shall be cleaned; and the entire installation shall be acceptable to the Engineer.

**3.2 PREPARATION**

**3.2.01 Limit of Pours.**

The limits of each concrete pour shall be predetermined by the Contractor and shall be acceptable to the Engineer. All concrete within such limits shall be placed in one continuous operation.

**3.2.02 Embodiments.**

Anchor bolts, castings, steel shapes, conduit, sleeves, masonry anchorage, and other materials that are to be embedded in the concrete shall be accurately positioned in the forms and securely anchored. Conduits shall be installed between the reinforcing steel in walls or slabs which have reinforcement in both faces. In slabs which have only a single layer of reinforcing steel, conduits shall be placed under the reinforcement.

Unless installed in pipe sleeves, anchor bolts shall have sufficient threads to permit a nut to be installed on the concrete side of the form or template. A second nut shall be installed on the other side of the form or template, and the two nuts shall be adjusted so that the bolt will be held rigidly in proper position.

Embodiments shall be clean when installed. After concrete placement, surfaces not in contact with concrete shall be cleaned of concrete spatter and other foreign substances.

**3.2.03 Bonding to Hardened Concrete.**

The surface of hardened concrete upon which fresh concrete is to be placed shall be rough, clean, and damp. Surface mortar shall be removed to expose the aggregate. The hardened surface shall be cleaned of all foreign substances (including curing compound), washed with clean water, and kept saturated during the 24 hour period preceding placement of fresh concrete.

Coarse aggregate shall be omitted from the first batch or batches of concrete placed on hardened concrete in wall or column forms. This mortar puddle shall cover the hardened area to a depth of at least 50 mm at every point.

**3.2.04 Concrete Embodiment and Encasement of Pipe.**

Embodiment and encasement of pipe shall be preceded by the following preliminary steps:

1. All loose material shall be removed from the trench prior to placing concrete. All concrete shall have a continuous contact with undisturbed soil on sides and bottom of trench.

2. Blinding concrete shall be accurately screeded to such grade and elevation that the pipe will be at specified grade when pipe bells are supported on, and in contact with, the top surface of the concrete.

3. Each length of pipe shall be rigidly held in alignment and anchored, to prevent flotation, in a manner acceptable to the Engineer.

**3.3 INSTALLATIONS**

**3.3.01 Placement.**

The limits of each concrete pour shall be predetermined by the Contractor and shall be acceptable to the Engineer. All concrete within such limits shall be placed in one continuous operation.

Before concrete is placed, forms, reinforcements, anchor bolts, and embodiments shall be rigidly secured in proper position; all dirt, mud, water, and debris shall be removed from the space to be occupied by concrete; all surfaces encrusted with dried concrete from previous placement operations shall be cleaned; and entire installation shall be acceptable to the Engineer.

All horizontal and sloping excavated surfaces on which concrete is to be placed and excavated surfaces as specified in the excavation sections shall be covered with blinding concrete immediately after completion of the final trimming of excavation.

A. Conveying Concrete.

Concrete shall be conveyed to the point of final deposit by methods which will prevent separation or loss of ingredients. Concrete shall be placed in final position without being moved laterally in the forms more than 1.5 m.

B. Placing Concrete.

Concrete shall be placed in approximately horizontal layers of proper depth for effective compaction; however, the depth of a layer shall not exceed 0.6 m. Each layer of concrete shall be plastic when covered with the following layer and the forms shall be filled at a rate of vertical rise of not more than 0.6 m per hour. Vertical construction joints shall be provided as necessary to comply with these requirements.

Concrete shall be thoroughly settled when top finished. All laitance, debris, and surplus water shall be removed from concrete surfaces at tops of forms by screeding, scraping, or other effective means. Wherever the top of a wall will be exposed to weathering, the forms shall be overfilled and after the concrete has settled, the excess shall be screeded off.

**3.3.02 Compaction.**

During and immediately after placement, concrete shall be thoroughly compacted and worked around all reinforcements and embodiments and into the corners of the forms. Mechanical vibrators shall be used which will maintain at least 9,000 cycles per minute when immersed in the concrete. Each vibrator shall be driven by a motor not smaller than 1.1 kW. Number and type of vibrators shall be acceptable to the Engineer.

**3.3.03 Hot Weather Concreting.**

Except as modified herein, hot weather concreting shall comply with ACI 305. At air temperature of the concrete when placed in the work shall be kept as cool as possible during placement and curing. The temperature of the concrete when placed in the work shall not exceed 32 ˚C.

Plastic shrinkage cracking, due to rapid evaporation of moisture, shall be prevented. Concrete shall not be placed when the evaporation rate (actual or anticipated) equals or exceeds 1 kg per square meter per hour.

To achieve the specified requirements, the Contractor shall provide sunshades over stockpiles of aggregate, cement silos, mixing water tanks, parked concrete trucks, and pipelines, and in addition shall carry out one or more of the following procedures which shall be submitted to the Engineer for review.

1. Cool the mixing water and/or replace part of the water by chipped ice. The ice shall be completely melted by the time mixing is completed.

2. Spray clean cool water over the aggregate stockpiles. The Contractor shall carry out regular tests on the aggregates to ensure that concentrations of sulphates or chlorides do not rise to unacceptable levels, and to ensure that moisture content determinations allow for such spraying.

3. Shade or wet the outside of the formwork.

4. Apply a fine moisture (fog) spray of clean cool water to shaded areas immediately prior to placing concrete.

5. Pour concrete at night.

Water used for cooling purposes shall be as specified.

**3.3.04 Cold Weather Concreting.**

Except as modified herein, cold weather concreting shall comply with ACI 306. The temperature of concrete at the time of mixing shall be not less than that shown in the following table for corresponding outdoor temperature (in shade) at the time of placement:

**Outdoor Temperature Concrete Temperature**

**------------------- --------------------**

Below -1 ˚C 21 ˚C

Between -1 ˚C and 7 ˚C 16 ˚C

Above 7 ˚C 7 ˚C

When placed, heated concrete shall not be warmer than 34oC.

When freezing temperatures may be expected during the curing period, the concrete shall be maintained at a temperature of at least 10 ˚C for 5 days or 21 ˚C for 3 days after placement. Concrete and adjacent form surfaces shall be kept continuously moist Sudden cooling of concrete shall not be permitted.

**3.3.05 Concrete Placement in Large Pours.**

Subject to the requirements for construction and movement joints and for preliminary test blocks specified herein, the Contractor shall not be limited to the size of individual pours of concrete. With large pours, defined as a pour where the least dimension is greater than or equal 1.5 meters, the following precautions shall be taken to limit thermal gradients and internal stresses:

1. The temperature of the concrete at the time of placinf shall not be more than 32 ˚C and, in any event, shall be such as to ensure that the maximum internal temperature attained during setting does not exceed 70 ˚C.

2. The final concrete in a large pour shall be a layer approximately 150 mm thick, the placing of which shall be completed within one hour of placing of the concrete at any point beneath it.

3. The concrete shall be protected as soon as practicable, after placing, by covering the surface with a minimum thickness of either 100 mm of water or 50 mm of sand (kept wet) and by shading from direct sunlight.

4. Sets of thermometers shall be provided in the concrete to measure the temperature at the center and near each face of the concrete, the sets being at centers not exceeding 5 m or as otherwise agreed with the Engineer.

5. The formwork shall be playwood 19 mm thick, or such other combination of materials having an equivalent insulation value, which shall not be removed until there has been sufficient time for the temperature difference between the center and any face of the concrete to drop to less than 20 ˚C.

**3.04 FINISHING UNFORMED SURFACES**

Buried concrete encasement will require no finishing except that necessary to obtain the required surface elevations or contours. The unformed surfaces of all other concrete shall be screeded and given an initial float finish followed by additional floating, and troweling where required. All tops of walls shall have a Class U3 finish.

**3.4.01 Class of Finish.**

Finishes to unformed surfaces of concrete shall be classified as U1, U2, U3, "spaded" or "bonded concrete". Where the class of finish is not specified or indicated on the Drawings the concrete shall be finished to Class U2.

A. Screeding (Class U1).

Screeding Class U1 shall provide a concrete surface conforming to the proper elevation and contour with all aggregates completely embedded in mortar. All screeded surfaces shall be free of surface irregularities with a height or depth in excess of 15 mm as measured from a 3 m straightedge.

B. Floating (Class U2).

Screeded (U1) surfaces shall be given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance with no unnecessary working of the surface.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a finish of uniform texture and colour.

Floating shall be performed with hand floats or suitable mechanical compactor-floats.

C. Troweling (Class U3).

Interior floor surfaces which will be exposed after construction is completed, surfaces to be covered with floor coverings, the exposed portion of the top of equipment bases, the top of interior curbs, and other surfaces designated on the Drawings shall be steel trowel finished. Troweling shall be performed after the second floating when the surface has hardened sufficiently to prevent an excess of fines being drawn to the surface. Troweling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

D. Finishing Surfaces for Bonding.

All surfaces to be covered with concrete or topping shall be float finished. All laitance, surface mortar, and unsound material shall be removed by brushing or air blasting at the time of initial set. Surfaces shall be rough, clean, and sound. Floors and other flatwork surfaces to receive topping shall be given a broom finish following the second floating.

E. Spaded Finish.

A spaded finish shall be a surface free from voids and brought to a uniform appearance by the use of shovels as it is placed in the work.

F. Edging.

Unless specified to be beveled, exposed edges of floated or troweled surfaces shall be edged with a tool having 6 mm corner radius.

G. Concrete Surface Tolerances.

Concrete surfaces for the various classes of unformed finishes specified shall comply with the tolerances shown in Table 3.4.01 except where different tolerances are expressly required by the specifications or indicated on the Drawings.

**TABLE 3.4.01**

**MAXIMUM TOLERANCE (mm)**

**Class of line Abrupt Gradual**

**Finish and level Irregularity**

**-------- --------- ------------ -----------**

U1 + 15 5 5

U2 + 5 0 5

U3 + 5 0 5

In Table 3.4.01, "line and level" shall mean the lines, and levels, indicated on the Drawings.

Surface irregularities shall be classified as "abrupt" or "gradual". Abrupt irregularities include, but shall not be limited to, offsets and fins caused by displaced or misplaced formwork materials, and shall be tested by direct measurement. Gradual irregularities shall be tested by means of a straight template for plane surfaces or it's suitable equivalent for curved surfaces, the template being 3.0 m long for unformed surfaces.

Defects in unformed surfaces shall be repaired in accordance with the relevant requirements of this section.

**3.4.02 Pavement Finishing.**

After the concrete has been consolidated, and surfaces screeded and given an initial floating, concrete pavement shall be finished by two applications of a soft, flexible belt 200-300 mm wide. The belt shall be moved forward with a combined transverse and longitudinal motion, the longitudinal advance being very slow for the first belting but with a sweeping motion for the final belting. Just before the concrete attains its initial set, the surface shall be given the final belting so as to produce a uniform surface of roughened texture. Before the initial belting or between the initial and final beltings, the surface shall be floated transversely with long handled wooden floats to eliminate any longitudinal or transverse waves indicated by a 3 meter straightedge. Excess water, laitance, or foreign materials brought to the surface during finishing operations shall not be reworked into the concrete, but shall be immediately removed.

**3.5 FINISHING FORMED SURFACES**

Fins and other surface projections shall be removed from all formed surfaces except exterior surfaces that will be in contact with sand backfill and surfaces not specified to be damp proofed. A power grinder shall be used, if necessary, to remove projections and provide a flush surface. Surfaces to be damp proofed shall have fins removed and tie holes filled, but no additional finishing will be required.

**3.5.01 Tie Holes.**

Tie holes in all formed surfaces shall be cleaned, wetted, and filled with patching mortar. Tie hole patches shall be finished flush and shall match the texture of the adjacent concrete.

**3-5.02 Special Surface Treatment.**

Surfaces listed below shall be finished by grout cleaning or by application of a cement-base coating.

Grout cleaning shall not result in an overall plastering of concrete surfaces, but shall produce a smooth, uniform surface free of marks, voids, surface glaze, and cement dust.

The cement base coating shall be a mill-formulated mixture of Portland cement, aggregate, and acrylic additives. The coating shall be applied in two coats. The coating shall comply with the Cement Base Coatings Section.

All interior concrete surfaces exposed to view in the permanent works except floor surfaces shall be grout cleaned or coated with cement base coating upon the contractor's choice.

All exterior concrete surfaces exposed to view in the Permanent Works except floor, paving, and sidewalk surfaces shall be coated with gray cement-base coating.

**3.5.03 Hardener:**

After the concrete surface has been thoroughly cured, and is perfectly dry, it shall be thoroughly cleaned, and one of the following surface hardeners shall be applied thereupon:

A. Chemical Hardener:

Floor hardener shall be a colourless aqueous solution of zinc and/or magnesium flu silicate, or flu sodium silicate. Flu silicate solution concentration shall not be less than 250 grams of crystal per liter . The sodium silicate solution shall be 32% by volume of 42 degrees Baume sodium silicate.

**A.1 Zinc and/or Magnesium Flu silicate:**

Shall be applied evenly using three coats, allowing 24 hours between consecutive coats. The first coat shall be 1/3 strength, the second coat 1/2 strength, and the third coat 2/3 strength. Each coat shall be allowed to remain wet on the concrete surface for a minimum of 15 minutes.

**A.2 Sodium Silicate:**

Shall be applied evenly using three coats, allowing 24 hours between consecutive coats. The sodium silicate shall be applied full strength at the rate of 1.25 liters for every 10 square meters (1/3 U.S. gallons per 100 square feet ) of concrete floor surface per coat.

After the final coat is in place and perfectly dry, any surplus hardener shall be removed from the floor surface by scrubbing and mopping with water.

B. Proprietary Hardener:

In lieu of the above, an approved proprietary hardener may be used, provided that the material is delivered, ready for use, in the manufacturer's original sealed containers. The Contractor shall furnish the Engineer, with manufacturer's descriptive data and application instructions for approval, prior to placing purchase orders for any proprietary hardeners. Metallic hardening compounds, may be used for areas subject to traffic, in accordance with the manufacturer's descriptive data for different rates of consumption and methods of application.

Proprietary hardeners shall be applied in strict conformity with the manufacturer's written instructions, and recommendations, and as approved by the Engineer.

**3.06 CURING**

Concrete shall be protected from loss of moisture for at least 7 days after placement. Curing of concrete shall be by methods which will keep the concrete surfaces adequately wet during the specified curing period.

**3.6.01 Water Curing.**

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete and shall be continuous for an initial curing period of 7 days. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water to walls may be interrupted for grout cleaning only over the areas being cleaned at the time, and the concrete surface shall not be permitted to become dry during such interruption.

**3.6.02 Membrane Curing**

Membrane curing compound may be used in lieu of water curing on concrete which will not be covered later with topping, mortar, or additional concrete.

Membrane curing compound shall be spray applied at a coverage of not more than 5.0 square meters per liter. A second coat shall be applied within 4 hours of initial coating or as recommended by the manufacturer. Unformed surfaces shall be covered with curing compound within 30 minutes after final finishing or following the initial 7 day water curing period. If forms are removed before the end of the specified curing period, curing compound shall be immediately applied to the formed surfaces before they dry out.

Curing compound shall be suitably protected against exposure to direct sunlight and abrasion during the curing period.

**3.07 FIELD QUALITY CONTROL**

**3.7.01 Testing.**

Field control tests, consisting of aggregate tests, slump tests, air content tests, water tests, and making compressive strength test cubes, shall be performed as directed by the Engineer.

All tests required for preliminary review shall be made at the expense of the Contractor. Tests required during the progress of the work shall also be made at the expense of the Contractor.

The frequency specified herein for each field control test is a minimum. If additional field control tests are necessary, in the opinion of the Engineer, all such tests shall be made.

1. Aggregate.

Aggregate tests shall be performed as specified by the Engineer.

1. Sampling Concrete.

Representative samples of fresh concrete shall be obtained in the field in accordance with BS 1881.

1. Slump.

A slump test shall be made for each 1 cu m of concrete or as directed by the Engineer. Slump shall be determined in accordance with ASTM, AASHTO and BS Specifications.

1. Air Content.

An air content test shall be made from one of the first three batches mixed each day, and form each batch of concrete from which concrete compressive strength test cubes are made. Air content shall be determined in accordance with ASTM, AASHTO and BS Specifications.

1. Water.

Water shall be tested as specified by the Engineer.

1. Compressive strength Tests.

Two sets of four concrete compressive strength test cubes shall be made each day when from 25 to 50 cubic meters of concrete are placed. Two additional sets shall be made from each additional 50 cubic meters or major fraction thereof, placed in any one day. Two cubes of each set shall be tested at an age of 7 days and the other cubes shall be tested at an age of 28 days. Compressive strength tests will be evaluated in accordance with BS1881.

Test specimens shall be made, cured and tested in accordance with BS1881. While still in the field, the test cubes shall be stored and cured as specified in BS1881. After transport to the laboratory, the cubes shall be cured in accordance with BS1881.

Each set of compression test specimens shall be marked or tagged with the date and time of day the specimens were made, the location in the work where the concrete represented by the specimens was placed, the delivery truck or batch number, the air content, and the slump.

**3-7.02 Test Reports.**

Test reports shall be prepared and distributed by the Contractor in accordance with the Quality Control Section.

**3-8 ADJUSTMENT AND CLEAN**

**3-8.01 Repairing Defective Concrete.**

Defects in formed concrete surfaces shall be repaired within 24 hours, to the satisfaction of the Engineer, and defective concrete shall be replaced within 48 hours after the adjacent forms have been removed. All Concrete which is honeycombed or otherwise defective shall be cut out and removed to sound concrete, with edges square cut to avoid feathering.

Concrete repair work shall be performed in a manner that will not interfere with thorough curing of surrounding concrete. Repair work shall be adequately cured.

**3-9 CRACKS**

All cracks over 0.25 mm wide in concrete surfaces of water filled structures shall be cut out and the groove filled with epoxy grout.

**SCHEDULE 1**

**CONCRETE MIX DESIGN STANDARD PARAMETERS**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CONCRETE CLASS DESIGNATIONS** | **28 DAYS MINIMUM COMPRESSIVE CEMENT STRENGTH MPA** | **MINIMUM CEMENT CONTENT**  **kg/cu m** | **MAXIMUM FREE WATER CEMENT RATIO**  **(BY WEIGHT)** | **MAXIMUM**  **SLUMP**  **mm** |  |
| C35A | 35 | 370 | 0.45 | 100 | (For water Retaining structures R.C.) |
| C30 | 30 | 350 | 0.50 | 100 | (For Normal R.C. structures.) |
| C30AA | 30 | 350 | 0.50 | 100 |  |
| C25 | 25 | 310 | 0.55 | 100 |  |
| C20 | 20 | 280 | 0.55 | 125 |  |
| C15 | 15 | 220 | 0.60 | 125 | (Blinding) |

\*\* Class AA mixes shall contain entrained air in accordance with 2-1.02.

1. Water-reducing admixtures shall be used as required to meet the limits specified in this table.

2. Special high slump easily worked mixes may be used, if required, provided the other limits of this table are not exceeded and prior Engineer acceptance has been granted, as based on the Contractor's report and recommendations.

**SCHEDULE 2**

**REPORTS CONTRACTOR IS TO OBTAIN FROM CONCRETE SUPPLIER AND SUBMIT**

**NO. TITLE REPORT FREQUENCY**

**SUBMITTED OF REPORT**

1 Sources of Materials a) 31 days prior to delivery a) One time

of concrete.

b) On apparent change b) As required

2 Supplier Quality a) 31 days prior to delivery a) One time

of concrete.

3 Mix design for all a) 31 days prior to a) One time

classes of concrete delivery of

(Referenced Schedule 3) concrete.

b) When mix is re- designed b) As required

for any purpose.

**SCHEDULE 2 (CONT'D)**

**REPORT CONTRACTOR IS TO OBTAIN FROM CONCRETE SUPPLIER AND SUBMIT**

**NO. TITLE REPORT SUBMITTED FREQUENCY OF REPORT**

4 Name, location, equip- a) 31 days prior to a) One time

ment & personnel of delivery of

test laboratory to be concrete.

used by supplier

(including own b) If changed b) As required

laboratory).

5 Program, methods and a) 31 days prior to a) One time

details of batching delivery of

plant & equipment concrete.

6 Proposed methods of a) 31 days prior to a) Each Summer

complying with hot delivery of

weather concreting. concrete.

7 Proposed methods of a) 31 days prior to a) Each Winter

complying with cold delivery of

weather concreting. concrete.

8 Certificate for cement a) 31 days prior to a) One time

from manufacturer. delivery of

concrete.

b) For each new b) As required

delivery from

manufacturer.

9 Certificate for a) 31 days prior to a) One time

admixtures from delivery of

manufacturer. concrete.

b) If any change b) As required.

occurs.

10 Report on plant trial a) 31 days prior to a) One time

mixes with 7 day & 28delivery of

day test results for concrete.

all classes of concrete

required for the Work. b) If changed b) As required.

11 Report of the following

tests on fine and coarse

aggregate:

1) Los Angeles abrasion a) 31 days prior to a) One time

at 100 & 500 revolu- delivery of

tions. concrete

2) Sieve analysis.

3) Clay, silt & dust

(passing 75 micron)

4) Clay lumps & b) During production b) Monthly

friable particlesof concrete. (with in-dependent

check report quarterly).

5) Water absorption

6) Percentage of sul- phates

(S03) Chlorides (NaCl).

**SCHEDULE 2 (CONT'D)**

**REPORT CONTRACTOR IS TO OBTAIN FROM CONCRETE SUPPLIER AND SUBMIT**

**NO. TITLE REPORT SUBMITTED FREQUENCY OF REPORT**

12 Reports of the follow- a) 31 days prior to a) One time

ing tests on water for delivery of

mixing concrete, wash- concrete.

ing and/or cooling

aggregates and curing: b) During production b)Monthly (with

of concrete. independent

1) Sulphates (as S03) check report

2) Chlorides (as NaCl) bi-monthly.)

13 Delivery ticket a) With delivery of a) Each delivery

each load of

concrete.

14 Calibration tests, and a) Submitted to Con- a) Quarterly

adjustments made to tractor who shall

concrete plant equip- also provide for

ment w/statement of inspection on

accuracy of all request by

measuring devices - Engineer.

for weekly tests.

**SCHEDULE 3**

**CONCRETE**

**STANDARD MIX DESIGN PRESENTATION**

Supplier and Class of Concrete :

Cement (Additive) Content and Type : (kg/ cu m)

Water - Cement Ratio :

Free Water : (liters/ cu m) or (kg/ cu m)

Specified Strength each 28 days : (MPa)

Current Mean Strength : (MPa)

Current Standard Deviation : (MPa)

Admixture Type :

Admixture Type : ( liters/cu m) or ( kg/cu m )

Slump each 30 minutes/Slump each 60

minutes (in laboratory) : (mm)/(mm)

Air Content : (%)

Chlorides (as NaCl)\* : (%)

**SCHEDULE 3 (CONT'D)**

**CONCRETE**

**STANDARD MIX DESIGN PRESENTATION**

Sulphates (as S03)\* : (%)

Method of Placement\*\*\* : Pump/Other

Aggregate Grading

Fine :

Medium :

Coarse :

Valid trial mix attached

Hot weather : Yes / No

Los Angeles abrasion each

500 revs/100 revs : (%)/(%)

Clay lumps : (%)

Friable particules : (%)

Coal and lignite : (%)

Other deleterious substances : (%)

Valid Hot Weather Trial Mix Report

Attached : Yes/No

Valid Cold Weather Trial Mix Report

Attached : Yes/No

\* Total in mix, expressed as a percentage by weight of cement.

\*\* Encircle as appropriate.

Fine Aggregate

Sieve Size 9.5 mm 4.8 mm 1.2 mm 0.30 mm 0.15 mm 0.075 mm

% passing by washing

Clay lumps : (%)

Friable particles : (%)

Coal and lignite : (%)

Other deleterious substances : (%)

Material finer than 75 micron, ASTM

(No. 300) sieve : (%)

Chloride salt content : (%)

Sulphate salt content : (%)

Coarse Aggregate

Sieve Size 38 mm 25 mm 13 mm 4.8 mm 2.4 mm

% passing by washing

Clay lumps : (%)

Other deleterious substances : (%)

Material passing 0.075 mm (No. 200)

sieve : (%)

**SCHEDULE 3 (CONT'D)**

**CONCRETE**

**STANDARD MIX DESIGN PRESENTATION**

Los Angeles abrasion at 500 revs/100 revs : (%)/(%)

Chlorides salt content : (%)

Sulphates salt content : (%)

\* Total in mix, expressed as a percentage by weight of cement.

\*\* Encircle as appropriate.

**END OF SECTION**

# SECTION 03350

# CONCRETE FINISHING

**PART 1 - GENERAL**

**1.1 SCOPE OF WORK**

1. Furnish all labor materials, equipment and incidentals required to finish cast – in – place concrete surface as shown on the Drawings and as specified herein.
   1. **RELATED WORK**

Concrete Formwork is included in Section 03100.

Cast – In – Place Concrete is included in Section 03300.

Grout is included in Section 03600.

* 1. **SUBMITTALS**

1. Submit shop drawings and product date, in accordance with section 01300 showing materials of construction and details of installation for:
   1. Floor hardener: the submittal shall also include documentation on the successful application of at least 50,000 square meters of the proposed hardener at an application rate equal to or greater than recommended for this project.
   2. Concrete Sealer: Confirmation that the sealer is compatible with additionally applied coatings shall also be submitted.
   3. **REFERENCED STANDARDS**
      1. American Society for Testing and Materials (ASTM)
      2. ASTM C33 – Concrete Aggregates.
      3. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.
   4. **QUALITY ASSURANCE**
2. Finishes
   1. For concrete which will receive additional applied finishes or materials, the surface finish specified is required for the proper application of the specified manufacturer’s products. Where alternate products are approved for use, determine if changes in finishes are required and provide the proper finishes to receive these products.
   2. Change in finishes made to accommodate products different from those specified shall be performed at no additional cost to the Owner. Submit the proposed new finishes and their construction methods to the Engineer for approval.
3. Services of Manufacturer’s Representative
   1. The Contractor shall make available at no extra cost to the Owner, upon 72 hours notification, the services of a qualified field representative of the manufacturer of curing compound, sealer or hardener to instruct the user on the proper application of the product under prevailing job conditions.

**PART 2 - MATERIALS**

* 1. **MATERIALS**

Floor hardener shall be non-metallic and consist of specially processed, natural aggregate, cementations binder, plasticizer and water reducing admixtures, formulated and processed under the stringent quality control of the manufacturer in their own facilities. The floor hardener shall be applied according to the manufacturers recommendations for heavy [or moderate] traffic areas [as designated on the Drawings]. (Manufacturer’s include Master Builders, Cleveland, OH Mastercron, or equal).

1. Concrete sealer shall be “kure – N – Seal”, by sonneborn, Minneapolis, MN; or equal.

**PART 3 - EXECUTION**

* 1. **FORMED SURFACES**

1. Form shall not be removed before the requirements of Section03300, have been satisfied.
2. Exercise care to prevent damaging edges of obliterating the lines of chamfers, rustications or corners when removing the forms or performing any other work adjacent thereto.
3. Clean all exposed concrete surface and adjoining work stained by leakage of concrete.

Rough – Form finish

* 1. Immediately after stripping forms and before concrete has changed color, carefully remove all fins and projections.
  2. Promptly fill holes left by tie cones and defects as specified in Section 03330,

1. Fair Faced (Rubbed) Finish
   1. Immediately upon stripping form and before concrete has changed color, carefully remove all fins. While the wall is still damp apply a thin coat of medium consistency neat cement slurry by means of bristle brushes to provide a bonding coat within all pits, air holes or blemishes in the parent concrete. Avoid coating large areas with the slurry at one time.
   2. Before the slurry has dried or changed color, apply a dry (almost crumbly) grout proportioned by volume and consisting of one part cement to 1 – ½ parts of clean masonry sand having a fineness modules of approximately 2.3 and complying with the gradation requirements of ASTM C33 for such a material. Grout shall be uniformly applied by means of damp pads of coarse burlap approximately 6-in in square used as a float. Scrub grout into the pits and air holes to provide a dense mortar in all imperfections.
   3. Allow the mortar to partially harden for one or two hours depending upon the weather. If the air is hot and dry, keep the wall damp during this period using a fine, fog spray. When the grout has hardened sufficiently so it can be scraped from the surface with the edge of a steel trowel without damaging the grout in the small pits or holes, cut off all that can be removed with a trowel. (Note: Grout allowed to remain on the wall too long will harden and will be difficult to remove.)
   4. Allow the surface to dry thoroughly and rub it vigorously with clean dry burlap to completely remove any dried grout. No visible film of grout shall remain after this rubbing. The entire cleaning operation for any area must be completed the day it is started. Do not have grout on surfaces overnight. Allow sufficient time or grout to dry after it has been cutoff with the trowel so it can be wiped off clean with the burlap.
   5. On the day following the repair of pits, air holes and blemishes, the walls shall again be wiped off clean with dry, used pieces of burlap containing old hardened mortar which will act as a mild abrasive. After this treatment, there shall be no built-up film remaining on the parent surface. If, however, such a film is present, a fine abrasive stone shall be used to remove all such material without breaking through the surface film of the original concrete. Such scrubbing shall be light and sufficient only to remove excess material without changing the texture of the concrete.
   6. A thorough was-down with stiff bristle brushes shall follow the final bagging or stoning operation. No extraneous materials shall remain on the surface of the wall. The wall shall be sprayed with a fine fog spray periodically to maintain a continually damp condition of the repair grout.
   7. **FLOORS AND SLABS**
2. Floated finish
   1. Machine Floating
      1. Screed floors and slabs with straightedges to the established grades shown on the Drawings. Immediately after final screening, a dry cement/ sand shake in the proportion of two sacks of Portland cement to 160 kg of coarse natural concrete sand shall be sprinkled evenly over the surface at the rate of approximately 2.5 kg per square meter of floor. Do not sprinkle neat, dry cement on the surface.
      2. The application of the cement / sand shake may be eliminated at the discretion of the Engineer if the base slab concrete exhibits adequate fattiness and homogeneity, and the need is not indicated. When the concrete has hardened sufficiently to support the weight of a power float without its digging into or disrupting the level surface, thoroughly float the shake into the surface with a heavy revolving disc type power compacting machine capable of providing a 90 kg compaction force distributed over a 60 mm diameter disc.
      3. Start floating along walls and around columns and then move systematically across the surface leaving a matte finish.
      4. The compacting machine shall be the “Kelly Power Float with compaction control” as manufactured by Kelly Industries of SSP Construction Equipment, Inc., Pomona, CA, or equal. Troweling machines equipped with normal trowel blades may be used for floating. Floating with a troweling machine equipped with normal trowel blades shall not be permitted. The use of any floating or troweling machine which has a water attachment for wetting the concrete surface during finishing shall not be permitted.
   2. Hand Floating
      1. In lieu of power floating, small areas may be compacted by hand floating. The dry cement / sand shake previously specified shall be used unless specifically eliminated by the Engineer. Screed the floors and slabs with straightedges to the established grades shown on the Drawings. While the concrete is still green, but sufficiently hardened to support a finisher and kneeboards with no more than 6 mm indentation, wood float to a true, even plane with no coarse aggregate visible. Use sufficient pressure on the wood floats to bring moisture to the surface.
   3. Finishing Tolerances
      1. Level floors and slabs to a tolerance of plus or minus 3 mm when checked with a 3 meter straightedge placed anywhere on the slab in any direction. Where drains occur, pitch floors to drains such that there are no low spots left undrained. Failure to meet either of the above requirements shall be cause for removal, grinding, or other correction as directed by the Engineer.
3. Broom Finish
   1. Screed slabs with straightedges to the established grades indicated on the Drawings. When the concrete has stiffened sufficiently to maintain small surface indentations, draw a stiff bristle broom lightly across the surfaces in the direction of drainage, or, in the case of walks and stairs, perpendicular to the direction of traffic to provide a non-slip surface.
4. Steel Trowel finish
   1. Finish concrete as specified in Paragraph 3.02 then hand steel trowel to a perfectly smooth hard even finish free from high or low spots or other defects.
5. Floor Hardener
   1. Floor slabs indicated on the room finish schedule to receive a hardener shall have the hardener applied as flows:
      1. Soak hardener in clean water for 10 minutes prior to application and allow to drain. After concrete placement, screening and floating as specified in Paragraph 3.02, make one steel trowel pass before dry shake. As soon as surface water disappears, sprinkle hardener uniformly over the surface in one application at a rate of 1.1 kg per square meter and embed it in concrete with the float.
      2. Compact the floor or slab to a non-slip surface by troweling, continuing until sufficient mortar is brought to the surface to fill all voids. Test the surfaces with a straight edge to detect high and low spots which shall be eliminated. After curing, if finish is too smooth, acid etch with diluted muratic acid and flush with clean water.
      3. Continue compaction only until thorough densification is attained and a small amount of mortar is brought to the surface. Avoid excessive floating.
6. Concrete Sealer
   1. Prepare and seal surfaces indicated on the room finish schedule to receive a sealer as follows:
      1. Finish concrete as specified in the preceding paragraphs and in accordance with the Schedule in Paragraph 3.04.
      2. Newly Placed Concrete: Surface must be sound and properly finished. Surface is application- ready when it is damp but not wet and can no longer be marred by walking workmen.
      3. Newly-Cured Bare Concrete: Level any spots gouged out by trades. Remove all dirt, dust, droppage, oil, grease, asphalt and foreign matter. Cleanse with caustics and detergents as required. Rinse thoroughly and allow to dry so that surface is no more than damp, and not we.
      4. Aged Concrete: Restore surface soundness by patching, grouting, filling cracks and holes, etc. Surface must also be free of any dust, dirt, and other foreign matter. Use power tools and / or strippers to remove any incompatible sealers or coatings. Cleanse as required, following the procedure indicated under cured concrete.
      5. Methods: Apply sealer so as to form a continuous, uniform film by spray, soft-bristle push broom, long –nap roller or lambs-wool applicator. Ordinary garden type sprayers, using neoprene hose, are recommended for best results.
      6. Applications: for curing only, apply first coat evenly and uniformly as soon as possible after final finishing at the average rate of 30 square meters per gallon. Apply second coat when all trades are completed and structure is ready for occupancy at the average rate of 50 square meters per gallon.
      7. To meet guarantee and to seal and dustproof, two coats are required. For sealing new concrete, both coats shall be applied full-strength. On aged concrete, when renovating, dust-proofing and sealing, the first coat should be thinned 10 to 15 percent with reducer per manufacturer’s directions.
   2. **APPROVAL OF FINISHES**
7. All concrete surfaces, when finished, will be inspected by the Engineer.
8. Surfaces which, in the opinion of the Engineer, are unsatisfactory shall be refinished or reworked.
9. After finishing horizontal surfaces, regardless of the finishing procedure specified, the concrete shall be cured in compliance with Section 03300 unless otherwise directed by the Engineer.
   1. **SCHEDULE OF FINISHES**
10. Concrete shall be finished as specified either to remain as natural concrete to receive an additional applied finish or material under another section.
11. Concrete for the following conditions shall be finished as noted on the Drawings and as further specified herein:
    1. Concrete to Receive Damp proofing: Rough-form finish See Paragraph 3.01D.
    2. Concrete Not exposed to View and Not Scheduled to Receive an Additional applied Finish or Material: Rough-form finish. See Paragraph 3.01D.
    3. Vertical concrete in Water containment Areas. Rubbed finish on exposed surface and extending to two feet below normal operating water level: rough-form finish on remainder of submerged areas. See Paragraphs 3.01 E and 3.01D.
    4. Interior and Exterior Underside of Concrete Exposed to View: Rubbed finish. See Paragraph 3.01E.
    5. Interior and Exterior Horizontal concrete not Requiring floor Hardener or Sealer: Floated finish. See Paragraph 3.02A.
    6. Concrete for Exterior Walks, Interior and Exterior Stairs: Broomed finish perpendicular to direction of traffic. See Paragraph 3.02B.
    7. Concrete slabs on which Process Liquids Flow or In Contact with Sludge: Steel trowel finish. See Paragraph 3.02C.
    8. Concrete to Receive Hardener: See Paragraph 3.02d.
    9. Concrete to Receive floor Sealer: See Paragraph 3.02E.
    10. Concrete tank bottoms to be covered with grout: See Section 03600.
    11. Concrete to receive terrazzo and seamless flooring – Once over steel trowel finish.
    12. Exposed interior concrete, including underside slabs beams and stairs of opening, beams and stairs – rubbed finish.
    13. Concrete to receive roof membrane – consolidate, screed, and wood float required grades.
    14. Concrete to receive rubber tile, carpet, and cleavage plane for ceramic tile bed – Steel trowel finish.
    15. Tops of curbs and pads – steel trowel finish.
    16. Concrete to receive bounded ceramic tile – steel trowel followed by light brooming.

**END OF SECTION**

# SECTION 03400

# LIGHTWEIGHT INSULATION CONCRETE

**PART 1 - GENERAL**

**1.1 SCOPE OF WORK**

Extent of Work: the extent of lightweight insulating concrete work is shown on drawings and includes the provision of proprietary lightweight concrete on roof decks.

* 1. **QUALITY ASSURANCE**

1. Material Evaluation Tests: perform material evaluation tests, for quality control and the design of concrete mixes.

Material and installed work may require testing and retesting at any times during the progress of the work. Allow free access to material stockpiles and facilities at all times. Test, including the retesting of rejected materials and installed work, are to be carried out at the Contractor’s expense.

1. Codes and Standards: comply with the requirements of the following Codes and Standards:

ASTM – American Society for Testing and Materials

C – 138 Test for Unit Weight. Yield and Air content of Concrete.

C – 150 Specification for Portland Cement.

C – 172 Sampling Fresh Concrete

C – 260 Specification for Air-Entraining Admixtures for Concrete.

C – 332 Specification for Lightweight Aggregates for Insulating Concrete.

C – 495 Test for Compressive Strength of Lightweight Insulating Concrete/

* 1. **SUBMITTALS**

1. General**:**

In addition to submittals listed below and prior to purchase, provide catalog cuts and manufacturer’s data for all items to be purchased, for review by the Engineer.

* 1. Samples of Materials as specified, including names, sources and descriptions as required.
  2. Laboratory test reports for materials mix design tests and quality control tests.

1. Reports:

Submit written report to the Engineer for review for each material sampled and tested, prior to the start of work. Provide the project identification name and number, date of report, name of Contractor, source of materials, manufacturers and brand names, values specified in the referenced specification for each material and test results. Indicate whether or not material is acceptable for intended use.

* 1. **PRODUCT DELIVERY, STORAGE AND HANDLING**

Deliver materials in manufacturer’s original undamaged packages and store off the ground and in covered sheds to protect them from damage and deterioration. Do not use materials, which show indications of moisture damage, caking or other signs of deterioration.

* 1. **JOB CONDITIONS**

Do not place lightweight insulating concrete during sandstorms or rain or when ambient temperature is above 32 degree C or below freezing. Do not place lightweight insulating concrete except in compliance with requirements of cold weather and hot weather concreting and as specified by the manufacturer and ordered by the Engineer.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

A. Proprietary Lightweight Insulation Material: Expanded ‘perlite’ as manufactured by Arab Insulating Materials Co., Amman, or approved equal.

B. Portland Cement ASTM C – 150 Type 1.

C. Aggregate ASTM C 332, GROUP 1.

D. Water Clean, fresh, potable

E. Expansion Joint Filler Refer to Section 07005 “CAULKING AND SEALANT”

**2.2 DESIGN MIX**

1. Design lightweight insulating concrete mix to produce the following physical properties.
   1. Oven Dry Density 120 kg/m3 plus or minus 20 kg/m3, when tested in accordance with ASTM C 495.
   2. Compressive Strength Minimum 0.90mpa when tested in accordance with ASTM C 495.
   3. Thermal Conductivity: 0.075W/m2 degree C.
2. Use only the minimum amount of water necessary to produce a workable mix.
3. Do not exceed air content recommended by manufacturer.

**PART 3 - EXECUTION**

* 1. **INSPECTION**

Contractor shall examine the areas and conditions under which lightweight insulating concrete is to be placed and correct all unsatisfactory conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

* 1. **PREPARATION**

Expansion Joint: Install expansion joints at perimeter of roof deck and at junctures with vertical surfaces, including up-stands, Krebs, walls, vents and wherever required, for the full depth of insulating concrete, as recommended by the manufacturer.

* 1. **INSTALLATION**

1. The manufacturer or his approved representative shall carry out installation of lightweight concrete.
2. Lightweight insulating concrete shall be places using equipment and procedures to avoid segregation of the mix and in strict accordance with the manufacturer’s instructions. Deposit and screed in a continuous operation until an entire panel or section of the roof area is completed. Do not vibrate or work the mix except for screeding or floating or as directed by the manufacturer. Place lightweight insulating concrete to the depth and slopes as indicated on the drawings, to produce the required degree of insulation.
3. Begin curing operations immediately after placement in accordance with weather and job conditions, strictly adhering to the manufacturer’s instructions.
4. Following curing operation, lightweight-insulating concrete shall receive a cement and sand (1: 4) screed having a 40mm minimum thickness. Screed shall be well finished and toweled smooth.
   1. **FIELD QUALITY CONTROL**
5. The Contractor is to take samples and conduct tests to evaluate lightweight insulating concrete.

Taking samples in accordance with ASTM C 172, except as modified by ASTM C 495.

* 1. Determine wet density in accordance with ASTM C 138.
  2. Determine compressive strength and oven dry density in accordance with ASTM C 495. Make at least 5 molds during each placement.

1. Report test results to the Engineer immediately after completion of each test.
   1. **DEFECTIVE WORK**

Refinish or remove and replace lightweight insulating concrete with objectionable thermal properties or with cracks and other defects which affect the performance of the lightweight insulating concrete or when physical properties do not meet specified requirements, as directed by the Engineer and in strict compliance with the manufacturer’s instructions.

**END OF SECTION**

# SECTION 03413

# PRECAST STRUCTURAL CONCRETE SECTIONS

**PART 1 - GENERAL**

**1.1 SCOPE OF WORK**

Furnish all labor materials, equipment and incidentals required to construct all precast structural concrete section work as shown on the Drawings and as specified herein.

The work under this section includes, but not necessarily limited to, the following:

1. Concrete Joists

* 1. **RELATED WORK**

Section 03200 : Concrete Reinforcement.

Section 03300 : Cast in place Concrete.

Section 03350: Concrete finishes

* 1. **SUBMITTALS**

**1.3.1** Shop Drawings:

1. Content:
   1. Dimensions and finishes.
   2. Estimated camber.
   3. Reinforcing and connection details.
   4. Anchors.
   5. Lifting and erection inserts.
   6. Other item cast into members.
2. Show location of unit by same identification mark placed on member.
3. Include design calculations.

**1.3.2** Manufacturer’s Literature: Manufacturers recommended installation instructions.

**1.3.3** Test Report: Reports of tests on concrete

**1.3.4** Shop drawings and design calculations Signed and Sealed by Professional Engineer, with a minimum of two years experience in prestressed concrete design.

* 1. **REFERENCED STANDARDS**

American Society for Testing and Materials (ASTM)

* 1. ASTM A36 – Standard Specification for Structural Steel.
  2. ASTM A416 – Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
  3. ASTM A663 – Standard Specification for Steel Bars, Carbon, merchant Quality, Mechanical properties.
  4. ASTM C31 – Standard Practice for Making and curing Concrete Test Specimens in the field.
  5. ASTM C33 – Standard specification for Concrete Aggregates.
  6. ASTM C150 – Standard Specification for Portland Cements

Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

* 1. **QUALITY ASSURANCE**

**1.5.1** Acceptable manufacturer

* 1. Minimum of two years experience in precast structural concrete work of quality and scope required on this project.

**1.5.2** Erector Qualifications

* 1. Regularly engaged for at least two years in erection of precast structural concrete similar to requirements of this project.

**1.5.3** Requirements of Regulatory Agencies

* 1. Construct and install precast structural concrete to meet requirements of the latest edition of the South Florida building Code.

**1.5.4** Allowable Tolerances

* 1. Width or thickness:
     1. Under 7-in (178 mm): plus or minus 1/8 –in (3.2 mm).
     2. 7-in (178 mm) to 16-in (406 mm) plus or minus 3/16-in (4.8 mm).
  2. Length
     1. 40 feet (12.2 m) to 50 feet (15.2 m): plus or minus 5/8-in (15.9 mm)
     2. Over 50 feet (15.2 m): plus or minus ¾ -in(19 mm).
  3. Chamber: Positive upward camber under full dead load.
  4. **DELIVERY, STORAGE AND HANDLING**

**1.6.1** Delivery and Handling

* 1. Transport and handle precast concrete units with equipment to protect from dirt and damage.
  2. Do not place units in position which will cause overstress, warp, or twist.
  3. Handle by means of lifting inserts.

**1.6.2** Storage

1. Store units off ground.

1. Place stored units so that identification marks are discernible.
2. Separate stacked members by battens across full width of each bearing point.
3. Stack so that lifting devices are accessible and undamaged.
4. Do not use upper member of stacked tier as storage area for shorter members or heavy equipment.
5. Do not place units in position which will cause overstress, warp, or twist.

**PART 2 - MATERIALS**

* 1. **MATERIALS**

**2.1.1** Portland Cement

* + 1. ASTM C150, Type V.
    2. Use same brand, type and source of supply throughout.
    3. Aggregates
  1. ASTM C33
     1. Water

1.Potable or free from foreign materials in amounts harmful to concrete.

* + 1. Tendons

1.Pretensioning:

a. Uncoated, stress-relived stand, ASTM A416, Grade 270.

* + 1. Anchors and Inserts
  1. Material
     1. Carbon Steel bars:
        1. ASTM A63, Grade 65
     2. Structural Steel:
        1. ASTM A36
     3. Grout

1.Cement grout:

One part Portland cement, 2-1/2 parts sand, sufficient water for placement and hydration.

2.Nonshrink grout:

Premixed, packaged ferrous aggregate shrink-resistant grout.

3.Epoxy – resin grout:

Two – component mineral filled epoxy-polysulfide, FS MMM-G0650-a, type I, Grade c.

* 1. **MIXES**
     1. Mixing Procedures

Same as for cast – in – place concrete: Section 03300.

* + 1. Concrete Properties

1. Water – cement ratio:

Maximum 40 pounds (18kg) of water to 100 pounds (45kg) of cement).

* 1. 28 day comprehensive strength:

Minimum of 30 Mpa (GRADE 30).

* 1. Do not use calcium chloride or other salts.

**2.3 FABRICATION**

**2.3.1** Formwork

* 1. Construct forms to withstand tensioning and detensioning operations.
  2. Construct forms to maintain units within their specified tolerances.
  3. Securely attach anchorage devices to formwork in locations not affecting position of main reinforcement or placing of concrete.
     1. Place concrete in continuous operations to prevent formation of seams.
     2. Provide permanent markings in precast units to identify pick-up points and location in structure.
     3. Finishes

1.Unexposed Area:

a) As cast

2.Remove irregularities, fins and other projections.

**2.4** **CONCRETE TESTING**

**2.4.1** Make one compression test for each day’s production of concrete.

**2.4.2** Specimens

* 1. Provide four test specimens for each compression test.
  2. Obtain concrete for specimens from actual production batch.
  3. 6 – in 12 – in (150 mm by 300 mm) molded concrete cylinder, ASTM C31.

**PART 3 - EXECUTION**

* 1. **INSPECTION**

- Before starting to erect precast concrete units verify that structure and anchorage inserts are within required tolerances.

- Check that bearing surfaces are smooth and level for installation of precast members.

- Determine field conditions by actual measurements.

* 1. **ERECTION**

- Fit and align precast concrete units straight, plum, level and square.

- Non-cumulative erection tolerance.

* 1. Joint dimension:

a) Nominal 3/8 – in (10 mm); to vary not more than plus 3/16 – in (5mm) or minus ¼ - in (6 mm).

- Adjust differential camber between units to within tolerance before final connection is made.

* 1. **CLEANING**

- After installation, clean precast concrete surfaces with detergent and water, using fiber brush and sponge and rinse thoroughly with clean water.

**END OF SECTION**

# SECTION 03600

# GROUTING

**1.** **GENERAL**

**1.1** **Description**

This Section covers nonmetallic, no shrinking grout to be used for the grouting of pump, motor, and equipment base-plates or bedplates; column base-plates; other miscellaneous base-plates; and other uses of grout as indicated on the Drawings or as required or specified. Unless otherwise specified, all grouting shall be done with no shrinking grout.

**1-1.01 Related Work**

**A. General Equipment and Material Stipulations**

The General Equipment and Material Stipulations shall apply to all materials furnished under this Section.

**B. Work Specified Elsewhere**

Other items of work that relate to and are referenced in this section include but are not limited to the following sections :

Cast-in-Place concrete

**1.2 APPLICABLE CODES AND STANDARDS**

The codes and standards generally applicable to the Work under this Section are listed. Codes and Standards current at the time of bid shall be used.

**1-2.01 CRD - U.S. Corp of Engineers, Handbook for Concrete and Cement**

C588 Nonshrink Grout Specification

**2. PRODUCTS**

* 1. **Materials**

**2.2.01. Material List**

Materials used shall be:

Nonshrinking Grout Premixed, nongassing, with nonmetallic aggregate, hardening and dispersing agents, binders, and oxidizing agents; minimum 28 day compressive strength 69 MPa.

Water Clean and free from deleterious substances.

Grout shall be furnished factory premixed so that only water is added at the job site.

* 1. **Performance and Design Requirements**

**2.2.1** **Mixing:** Grout shall be mixed in a mechanical mixer. No more water shall be used than is necessary to produce a flowable grout.

**3. EXECUTION**

**3.1** **Surface Preparation**

The concrete surface to receive grout shall be clean and free of all debris and shall be saturated with water for 24 hours prior to grouting.

**3.2 Placement**

Grout shall be placed in strict accordance with the directions of the Manufacturer so that all spaces and cavities below the top of base-plates and bedplates are completely filled without voids. Forms shall be provided where structural components of base plates or bedplates will not confine the grout.

**3.3 Edge Finishing**

In all locations where the edge of the grout will be exposed to view, the grout shall be finished smooth after it has reached initial set. Except where shown to be finished on a slope, the edges of grout shall be cut off flush at the base plate, bedplate, member, or piece of equipment.

**3.4 Curing**

Grout shall be protected against rapid loss of moisture by covering with wet rags or polyethylene sheets. After edge finishing is completed, the grout shall be wet cured for at least 7 days.

**END OF SECTION**

# SECTION 03603

# EPOXY GROUT

1. **GENERAL**

**1.1 Description**

This Section covers epoxy grout to be used for the grouting of dowels and anchor bolts into existing concrete, the patching of cavities in concrete, and other uses of epoxy grout as indicated on the Drawings or as required or specified.

**1-1.01 Related Work**

A. General Equipment and Material Stipulations.

The General Equipment and Material Stipulations shall apply to all materials furnished under this section.

**1.2 Applicable Codes and Standards**

The Codes and Standards generally applicable to the work of this Section are listed. Codes and Standards current at the time of bid shall be used.

**1.2.1 ASTM - American Society for Testing and Materials**

C881 Epoxy-Resin-Base Bonding Systems for Concrete, Standard Specification for.

* 1. **Product Handling**

**1.3.1 Storage**

Components of the epoxy grout shall be packaged in durable, moisture resistant containers and stored in such a manner as to prevent deterioration or contamination with foreign matter or moisture. Any material which has become damaged or contaminated shall not be used.

1. **PRODUCTS**
   1. **Materials**

**2.1.1 Material List.**

Materials used shall be:

Epoxy Grout

Adhesive - ASTM C881, Type 11b; Class and grade as required.

Aggregates - Clean, dry and graded sand.

**2.2 Performance and Design Requirements**

**2.2.1 Components**

Epoxy grout shall be a three-component epoxy resin system with two liquid epoxy components and one inert aggregate filler component. Components shall be furnished packaged separately from the factory and mixed on the Work Site.

**3. EXECUTION**

**3.1 Preparation**

**3.1.1 Surface Preparation**

The concrete surfaces to receive epoxy grout shall be clean, dry, and sound prior to grouting.

**3.1.2 Mixing**

Mixing of the epoxy grout components shall be in accordance with the Manufacturer's recommendations.

**3.2 Placement**

Grout shall be placed in strict accordance with the directions of the Manufacturer. The Contractor shall obtain field technical assistance from the epoxy grout Manufacturer, as required, to insure placement of the grout in compliance with the Manufacturer's recommendations and procedures.

**END OF SECTION**

# SECTION 03800

# CONCRETE AND REINFORCEMENT OF WATER RETAINING STRUCTURES

**GENERAL**

This section covers the requirements for concrete materials and production together with the construction of structures in concrete and reinforced concrete for the pumping stations, water reservoirs and for special concrete structures for the water, irrigation and sewer networks scheme.

The Contractor's attention is drawn to the prevailing climatic and geological conditions of the area. The Contractor shall take all necessary precautions to ensure that any material including cement, fine and coarse aggregates, water and concrete additives shall be capable of resisting the conditions caused by the aggressive nature of the soil.

Concrete production, testing, placing and control shall generally comply with the requirements of British Standard for concrete works, except where superseded by this specification.

Guideline for design, construction, inspection and testing of Water Retaining Structures is to be in compliance with BS 8007.

Concrete specification and materials for water retaining structures shall comply with the requirement of BS 8007 Section six.

**AGGREGATES FOR CONCRETE**

**Fine Aggregate Concrete**

Fine aggregate should be naturally occurring sand complying with BS 882. Very coarse or fine grading and gapped grading may cause finishing difficulties. Sand should be free from soft materials such as soft sandstone, limestone or coal. Crushed fines shall not be used. An aggregate that produces concrete with drying shrinkage exceeding 0.06% is not acceptable.

Except where otherwise approved on the basis of evidence of acceptable performance in concrete the grading of a fine aggregate, or of combined fine aggregate, shall comply with the grading limits for groups of 0/1, 0/2 and 0/4 as shown in Table2.3.2.1

The amount of material passing a 0.075 mm nominal sieve in each size of the single-sized aggregates shall not exceed the percentages by weight given in BS 812 and shall be within the unit of grading zone 2 green in BS 882.

Fine aggregates shall be free of clay lumps and friable particles.

The amount of hollow shells likely to form voids or remain partially unfilled and present in material retained on a 2 mm sieve, determined by direct visual separation, shall not exceed 3 % by weight of the entire sample.

Fine aggregate shall not contain appreciable amounts of flaky and or elongated particles.

The water absorption of fine aggregate shall not exceed 2.0% by weight.

The total acid soluble sulfate content of fine aggregate, expressed, as sulfur trioxide SO3, shall not exceed 0.40 % by weight.

The total acid soluble chloride ion (CL) content of fine aggregate, expressed as calculated equivalent (CL x 1.6 = Nalco) sodium chloride (Nalco), shall not exceed 0.05 % by weight.

**Grading of Fine Aggregates for Concrete to BS 882**

Where aggregates conforming to zones 2 or 3 of BS 882 are available, they should be used.

For standard mixes, zones 1, 2 or 3 aggregates only shall be used.

For nominal mixes, where permitted to be used, zone 2aggregates only shall be used, except for nonstructural concrete class 170 where all-in aggregated may be used.

**Coarse Aggregate for Concrete**

Coarse Aggregate shall be natural gravel complying with the requirements of BS 882, except where otherwise directed by the Engineer.

Coarse aggregates should be from naturally occurring wadi sources with grading complying with BS 882. Soft sandstone, limestone and aggregate giving drying shrinkage in concrete greater than 0.06% is not acceptable. The maximum size of course aggregate should be 20 mm in cases where pumping is required using machines locally available. Overall passing 200 mesh should not exceed 2.5%. Aggregates are to be chemically inert to alkali reaction.

The proportion of decomposed or weathered particles in the aggregates shall not exceed 0.5 % by weight. Aggregates shall be free of clay lumps and friable particles.

All coarse aggregates shall be produced, stockpiled and batched as single-sized material or as may be otherwise approved on the basis of evidence of acceptable performance in concrete.

The amount of materials passing a 0.063 mm nominal sieve in each size of single-sized aggregates shall not exceed the percentages by weight given in Table 1 in BS 882.

The proportion of flaky particles shall not exceed 20 % by weight, nor elongated particles exceed 35 % by weight in each of the fractions of single-sized aggregates.

The water absorption of each size of coarse aggregate, determined in accordance with BS 882, shall not exceed 2 % by weight.

The total acid soluble chloride ion (CL) contents of coarse aggregates, expressed as calculated equivalent (CL x 1.6 = NaCL) sodium chloride (Nalco), shall not exceed 0.02 % by weight. In the case of mass concrete this percentage may be increased at the Engineer's discretion.

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

They shall conform to the moisture absorption requirements of clause 2.02 (I) of BS 5337. Otherwise the Contractor shall prove the durability of the finished concrete by approved tests when used for making concrete required for liquid-retaining structures.

Aggregates of rounded shape or otherwise capable of producing concrete of good workability with the minimum addition of water shall be preferred.

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

Except where aggregates have been otherwise specified on the drawings, grading shall be as follows:

**Grading of Coarse Aggregates for Concrete to BS 882**

10 mm maximum size, graded, for all “fine” concrete.

20-mm maximum size, graded, for all reinforced concrete in beams and for walls and slabs not greater than 400 mm thick.

40 mm maximum size, graded, for all reinforced concrete walls and slabs in excess of 400 mm thick, subject to the approval of the Engineer.

Maximum aggregate size shall be consistent with the spacing of Reinforcement as provided in the Reinforcement detail.

**Aggregate Shrinkage and Reactivity**

The proportions of the aggregates shall be such that:

The drying shrinkage of concrete prepared and tested in an approved laboratory in accordance with the United Kingdom Building Research Station Digest No 35 (Second Series) shall not exceed 0.045 %;

The initial drying shrinkage of all the proposed concrete mixes prepared and tested in an approved laboratory in accordance with BS. 1881 shall not exceed 0.06 %.

It should be noted that the above involves a testing period of about eight weeks.

Aggregates shall not contain any materials that are deleteriously reactive with the alkalis in the cement, or any alkalis which may be additionally present in the aggregates and mixing water, or in water in contact with the concrete or mortar, in amounts sufficient to cause excessive localized or general expansion of concrete or mortar.

Coarse and fine aggregates shall be tested for potential reactivity by the methods listed in Table 2.3.4-1 and shall satisfy the various criteria given for innocuous aggregates in the relevant standard.

Aggregates shall not be composed of or contain any inclusions of materials likely to cause staining or otherwise disfigure finished concrete surfaces.

**Table 2.3.4‑1**

|  |  |
| --- | --- |
| The following tests shall be carried out: | |
| 1. | Pertrographic examination and description  (Including approximate composition; ASTM test C295.) |
| 2. | Partial chemical analysis  (including insoluble residue, chloride content, sulfate content, and calculated approximate composition, classical analytical test methods) |
| 3. | Potential Reactivity tests |
|  | Gel Pat test (National Building Studies Research Paper No. 14). |
|  | ASTM test C289 (Rapid Chemical Methods). |
|  | ASTM test C227 (Mortar Bar Method). |
| 4. | Soundness Tests |
|  | ASTM test C88, using sodium sulfate solution. |
|  | ASTM test C88, using magnesium sulfate solution. |

**Aggregate Sources**

The Contractor shall give details of his preliminary proposed sources of aggregate.

Sources of aggregate for concrete, extraction procedures and production methods shall be to the approval of the Engineer. Within eight weeks of the award of the Contract, a report on potential aggregate sources shall be submitted to the Engineer.

More than one source of supply shall be investigated for each type of aggregate required, and primary and secondary sources of supply for each type shall be proposed. The report shall contain the following information concerning the proposed sources:

Name, precise location/grid references, type of deposit, potential variability, and method/s of extraction in current use or proposed.

Methods and degree of extraction control being exercised or proposed.

Current or proposed processing method/s type/s of plant number processing stages (with flow diagram), standards of maintenance and process control, laboratory facilities and technical staffing.

Current or proposed stockpiling arrangements, loading and supply arrangements at the place of extraction.

Potential variations in end products due to variations inherent in the deposit and/or in the existing methods of extraction, processing and stockpiling.

Possible modifications to existing extraction, processing, storage and handling arrangements, and to supervision arrangements to reduce end product variations.

Possible requirements for supplementary processing, including washing of coarse and/or fine aggregates on site.

Photographs of each of the proposed sources close ups of working faces/areas and relating production and stockpiling arrangements.

Proposed method of transport/supply of aggregate from the place of extraction to the site of the Works.

Aggregate deposits or existing aggregate production at the proposed sources shall be sampled and tested to assess their potential suitability for use in the Works. The results of the sampling and testing shall be included in the report to the Engineer.

The method of sampling shall be by agreement with the Engineer and shall be carried out in the presence of the Engineer's Representative.

Composite samples of each size of aggregate shall be taken on two separate days' production:

directly from the production plant (discharge samples), and

From the producer's stockpiles or bins (stockpile samples).

The samples shall be subjected to the tests shown in Table 2.3.5-1. Testing shall be carried out in the Contractor's materials laboratory, or in an approved laboratory. The proposed program of testing shall be submitted for the approval of the Engineer prior to the commencement of work.

The report shall be produced by an experienced engineering geologist, or geologist, who shall be approved by the Engineer.

No aggregate for use in the permanent Works shall be brought onto the site until the proposed aggregate sources have been approved.

The report on aggregate sources shall be submitted at least four weeks in advance of the commencement of work on trial or site trial mixes.

Further testing and sampling according to Table 2.3.5-1 of aggregate from the approved sources shall be carried out regularly during the course of the Contract. Testing of the aggregates by other additional tests shall be carried out as required by the Engineer.

TABLE 2.3.5-1 Testing of Aggregates from Sources of Supply

|  |  |
| --- | --- |
| A | Tests on Composite Discharge Samples |
|  | On each sample: |
| 1. | Proportion of natural uncrushed material remaining |
| 2. | Grading |
| 3. | Decant able material (Silt, Clay and Dust) content (% by wt.) |
| 4. | Total acid soluble Chloride Content and total acid soluble Sulfate Content (% by wt.) |
| 5. | Flaky and elongated particles (% by wt.) |
| 6. | Shrinkage and Reactivity Tests as detailed in Clause 2.3.4. |
| 7. | Aggregate Crushing Value |
| 8. | Los Angeles Abrasion |
| 9. | Absorption test |
| B. | Tests on Stockpiled Samples: |
| 1. | Test No. 2 above |
| 2. | Test No. 3 above |
| 3. | Test No. 4 above |

**Aggregate Sampling and Testing at Site**

Aggregate delivered to site for use in the Works shall be sampled and tested at the frequencies shown in Table 2.3.6-1, or as directed by the Engineer.

Samples shall be taken from:

Loads at entry to site.

Discharge points from storage bins to the concrete mixer.

Storage bins or stockpiles.

Testing of the aggregates by the tests listed in Table 2.3.5-1, or other additional tests shall be carried out as required by the Engineer.

When ready mixed concrete is used, aggregate testing as above shall be carried out at the concrete supplier's premises.

TABLE 2.3.6-1 Minimum Testing Frequency of Aggregates and Mixing Water

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test | Grading | Decant able  Material | Chloride  Content | Sulfate Content | Flakiness  elongation | Absorption |
| Location: | (i) (ii) | (i) (ii) (iii) | (i) (ii) | (i) (ii) | (i) (ii) | (i) (ii) |
| Fine Aggregate: |  |  |  |  |  |  |
| Beach sand | fortnightly | Fortnightly | each load | each load | weekly | weekly |
| Wadi sand | fortnightly | Fortnightly | weekly | weekly | weekly | weekly |
| Coarse Aggregate | fortnightly | Fortnightly | weekly | weekly | weekly | weekly |
| Water | - | - | monthly | monthly | - | - |

**WATER FOR CONCRETE**

Water for use in mixing concrete and mortar and for curing shall be from an approved source and shall be clean, potable and free from deleterious material, silt, organic matter, alkali, salts or other impurities. The quality of water shall be such as not to affect the setting time, strength, durability of the concrete or mortar mixes nor the appearance of the hardened concrete or mortar by discoloration or efflorescence. In addition the water shall not in any way be deleterious to the reinforcement steel

The Contractor shall take samples of the water from the proposed source and shall carry out such tests as required. The results of the test shall be submitted to the Engineer in the form of a report on the proposed source of water.

Use of water whose physical or chemical characteristics lie outside the limits given in Table 2.3.7-1 will not be permitted.

In addition to the tests listed in Table 2.3.7-1 tests shall be carried out if directed to compare initial setting times and compressive strengths of cement pastes prepared with water from the proposed source, and with distilled water.

**TABLE 2.3.7-1 Chemical Analysis of Water for Concrete**

|  |  |
| --- | --- |
| **Chemical analysis required to determine:** | **Max. allowable concentration** |
| Sulfate content (as SO3) | 500 mg/l |
| Chloride content (as CL) | 500 mg/l |
| Bicarbonate content (as HCO3) | 1000 mg/l |
| Total dissolved solids | 1500 mg/l |

**CEMENT**

Unless specifically stated otherwise the cement used shall be Portland Cement complying with BS 12. Sources of cement supply shall be to the approval of the Engineer.

Within eight weeks of the award of the Contract a report on proposed cement sources shall be submitted to the Engineer.

The report shall propose primary and secondary sources of supply and shall give each manufacturer's full analysis of chemical composition and physical properties determined in accordance with BS 12 or equivalent.

The report on cement sources shall be submitted at least four weeks in advance of the commencement of work on trial concrete mixes.

In addition to the information called for under this clause, the Contractor shall complete the relevant schedule of particulars for each proposed source and type of cement. The information in this schedule shall be provided for every works from which a proposed manufacturer is likely to supply cement.

Cement shall be delivered to site in consignments of sufficient quantity to ensure that there is no suspension or interruption to the work of concreting at any time.

Unless approval is given in writing for the handling of cement in bulk, cement shall be packaged by the manufacturer in bags that are so designed as to prevent any contamination and to minimize the adverse effects off moisture and high humidity during transportation and storage.

The Contractor shall supply to the Engineer's Representative two unused sample bags for approval and retention. The bags shall be marked with the manufacturer's name, the brand name (if appropriate), the name of the producing works, the cement type, the standard to which it was made, and the date of manufacture, or date code. Consignments shall be used in the order in which they were delivered. Differing types or brands shall not be mixed together for use in the Works.

Where bulk cement deliveries are proposed the Contractor shall provide all information required by the Engineer's Representative concerning off site storage and loading arrangements and shall provide reasonable facilities for the Engineer's Representative to inspect these arrangements for approval purposes.

The Contractor shall obtain and provide to the Engineer's Representative a certificate for each consignment of cement that shall include the following information:

The manufacturer's bulk average test results for the manufacturing batch including chemical composition and physical properties determined in accordance with the approved relevant specification for the cement.

The date of manufacture, the date of original loading and the date of intended delivery to site.

All cement shall be used within 12 months of date of manufacture. Cement, which the Engineer’s Representative considers to have deteriorated in any way, shall be removed from site without delay.

Samples of cement shall be taken in the presence of the Engineer's Representative, on request, for testing in an approved independent laboratory and the Engineer's Representative shall have access to the cement store at all reasonable hours.

**STEEL REINFORCEMENT**

Steel reinforcement bars shall be hot rolled untreated bars conforming to the requirements of BS 4449 or equivalent ASTM specifications.

**TABLE 2.3.9-1**

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Code Reference** | **Minimum Yield Strength (N/mm2)** | **Tensile Strength (N/mm2)** |
| Ribbed Bars | High grade | 414 | 500 |

Steel bars shall be tested in accordance with required specification for every new Lot coming to the site and for every (100) tons in each lot. All bar sizes shall be lab tested. Mill certificates shall accompany each lot.

All reinforcement shall be delivered straight or bent to the required shape.

All reinforcement storage shall be on wooden supports on dense, impervious concrete slabs specially placed for this purpose. The slabs shall be kept swept clean at all times. These requirements shall apply equally to reinforcement bending and cleaning areas and to any prefabricated reinforcement storage area. The concrete slabs shall be constructed and fully completed to the approval of the Engineer before any reinforcement may be delivered to the Site.

Before being fixed and when not being handled, all reinforcement shall be protected from the corrosive effects of windblown dust and dew-fall by close wrapping with impervious sheeting or other approved method, and from any other detrimental effects.

At the time of fixing, reinforcement shall be free from loose mill scale, rust scale, and shall not be contaminated by grease, dirt, oil, paint, soil sulphates, chlorides, or any other agency which may impair the bond or initiate or accentuate any corrosion.

Where fixed reinforcement cannot be concreted for extended periods it shall be protected from windblown dust and dewfall by means of close wrapped polythene sheets or other approved method. Fixed reinforcement shall be protected from disturbance by foot or wheeled traffic while awaiting the placing of concrete.

The links connecting the ties or longitudinal bars in columns or other members shall be tightened so that the main bars shall be properly braced in every direction. The horizontal bars and the horizontal portions of bent bars in beams shall be straight and laid parallel to each other and the sides. The stirrups shall be kept tight to the bars that they embrace and such stirrups shall be kept from the face of the concrete at the distance shown on the working drawings.

The bending back of reinforcement into the formwork for subsequent bending out when the formwork is struck will not be allowed unless the Engineer's approval is given. When such a procedure is allowed the reinforcement shall be bent out over a suitably sized former to prevent damage or overstressing of the reinforcement.

No pieces of steel, blocks of wood or other materials other than approved concrete or plastic spacers shall be employed on the bottom of moulds or against the sides to keep the reinforcing bars in position. Concrete spacers shall not exceed 50 mm in length or breadth and shall be composed of one part cement and two parts fine aggregate.

If the Contractor wishes to use plastic spacers, these shall be of a pattern approved by the Engineer, which shall carry the loads imposed on them without significant distortion. They shall not lead to spalling of the concrete cover or to corrosion of the reinforcement.

No concrete or steel in the concrete work shall be cut in any way unless consent in writing has previously been obtained.

Unless otherwise shown upon the working drawings the Contractor shall ensure that the reinforcement bars are given cover in accordance with Table 2.3.39-1. All bending shall be done cold with a suitable machine.

No heating will be allowed for hooking the ends of the bars and no welds shall be made in any bar without permission in writing, and in such cases all precautions shall be taken to ensure that the physical properties of the steel are not changed.

The cutting, bending and development of bars shall be made in accordance with (clause 7.2 BS8110), BS446 and the related section 7 of BS 8007.

**TABLE 2.3.39-1 Minimum Concrete Cover in cm for Corrosion Protection and Bonding**

|  |  |  |
| --- | --- | --- |
| Environmental Conditions to which the members are exposed | Bar Diameter (mm) | Minimum Cover (mm) |
| Members to which outside air has constant or frequent access or remain permanently under water | 6 – 25 | 40 |
| Members, which remain permanently in soil | 6 - 25 | 50 |
| Members, in which concrete steel is exposed to particular corrosive action, e.g. due to the constant action of aggressive vapors or de-icing salts or to “aggressive” chemical attack. | 6 – 28 | 50 |
| Members , which are exposed to variable wetness | 6 - 28 | 50 |

**CONCRETE PRODUCTION METHOD STATEMENT**

The means of production of concrete for the works shall be to the approval of the Engineer. Within eight weeks of the award of the Contract a method statement shall be produced giving details of the proposed methods of concrete production.

The method statement shall include, but not necessarily be limited to the following:

Maker's name, model, capacity and details of the proposed batching plant.

Method of weigh batching, maker's name, model and details of weighing scales.

Method of addition of mixing water and details of the water measuring device.

Details of any apparatus for storage and feeding of concrete mix additives.

Number, type and capacity of aggregate cement and water feed bins or tanks.

Number, type, and capacity of aggregate stockpiles or storage bays.

Proposed layout of batching plant.

If the Contractor proposes to use ready mixed concrete, the method statement shall additionally include:

The names and addresses of the Contractor's proposed primary and secondary sources of ready mixed concrete.

The details required in part 1 (i - vii) of this clause, relating to the ready-mixed concrete suppliers' batching plants.

Make, capacity, and details of the suppliers' delivery vehicles and the number of such vehicles available to the Contractor.

Distances of the suppliers' batching plants from the site of the works, and the estimated travelling time required by the delivery vehicles.

The Contractor shall give preliminary information concerning his method of concrete production in the appropriate schedule of the schedule of particulars.

**Storage of Cement**

All bagged cement shall be stored in a weatherproof building having dense impervious bituminous or concrete floors, which shall be kept clean at all times. Cement shall not be stored in piles more than eight bags deep. The storage arrangements shall be fully completed and approved by the Engineer, before any cement is delivered to site. Cement shall be put into storage immediately upon delivery to site.

Each consignment of cement shall be separately stored for ease of access, identification, inspection, and sampling. The date of delivery shall be clearly marked on each consignment. Sufficient stocks shall be maintained on site to ensure the proper progress of the stockholding shall be to the approval of the Engineer. Consignments of cement shall be used in the Works in the order they are delivered.

Cement stored in silos shall be, in the opinion of the Engineer, adequately protected against rain, humidity and dewfall and all silos charging and discharging points shall be properly sealed. Silo aeration equipment shall, if required by the Engineer, incorporate de-humidifiers. If bagged cement is stored in silos it shall be charged into the silos through 6 mm mesh screens, welded or bolted to and covering the entire feed area of the silo-charging hopper.

Cement delivery in bulk shall be discharged only into an empty silo. Different batches of cement shall not be mixed in the same silo.

Cement which contains air-set or hardened lumps, re-powdered air-set material, foreign matter, or which has been contaminated or is in the opinion of the Engineer unsatisfactory shall be rejected and shall be removed from site without delay.

**Storage of Aggregates**

Separate stockpiles or storage bays shall be provided for each nominal size and type of aggregate. The storage bays shall be of sufficient size and sufficient stores of aggregates shall be maintained to allow for the progress of concreting works without interruption. Partitions between bays shall be substantially built and shall be sufficiently high to prevent mixing of different categories of aggregate through overspilling. The bays shall be provided with shades to protect the aggregates from over-heating from direct sunlight.

Dense concrete slabs shall be laid to cover the floor of all aggregate storage bays and shall extend to cover all surrounding areas where aggregates are likely to be discharged or handled. These areas shall be kept swept clean to ensure that the aggregates are not contaminated by the adjacent ground through trafficking or otherwise and shall be sufficiently stone to withstand all trafficking for the duration of use.

Sufficient windbreaks shall be provided to the storage bays and adjacent areas to prevent the contamination of the aggregate by wind-blown sand.

The generally localized build-up of fines in aggregate stockpiles shall not be allowed and any material which, in the opinion of the Engineer, is so affected will be rejected.

Any aggregates which have suffered segregation or contamination during processing, handling at source, transportation to site, stockpiling and handling on site, or which otherwise do not comply with the requirements of these specifications, either locally or generally, shall be rejected and shall be removed from site unless they are re-processed by the Contractor on site, or by the producer, and resubmitted for approval.

**WASHING OF AGGREGATES**

Effective washing or other supplementary processing of the aggregates shall be carried out on site if directed by the Engineer if:

In the opinion of the Engineer the aggregate produced at the Contractor's aggregate sources will not consistently comply with the Specification.

The aggregate suffers unacceptable physical or chemical contamination or other changes during handling, transportation or storage.

**STORAGE OF MIXING WATER**

Water for concreting shall be stored in covered tanks adequately sealed to prevent the ingress of dust, oil or other contaminants. The Tanks shall, when necessary, be shaded and insulated to prevent overheating of the water.

Provision for the storage and/or mixing of crushed ice with the water shall be made

**BATCHING PLANT**

An adequately drained dense concrete slab shall be provided under the batching plant and surrounding the whole area of the plant and aggregate delivery/storage areas. The foundations of the batching and weighing equipment shall be horizontal and securely fixed to allow accurate operation of the plant.

The batch shall be so charged into the mixer that some water will enter before cement and aggregate. Water shall continue to flow for a period that may extend to the end of the first quarter of the specified mixing time. Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed and that no additional water over the designated requirements can be added during mixing. The entire batch shall be discharged before the mixer is recharged. In no case shall the mixing time be less than 1½ minutes after all material are introduced.

The weighing equipment shall be maintained and calibrated by the Contractor to ensure continued accuracy. The weighing equipment shall batch the materials to an accuracy of not more than ± 2 % for aggregates and ± 1 % for cement. The equipment shall be maintained to conform to the above tolerances and checked at least once a month or at such times as the Engineer may require.

A tare adjustment, up to a maximum of 10 % of the nominal capacity weigh scale shall be provided on the weighing mechanism.

Dust seals shall be provided on hoppers used for cement between the loading mechanism and weigh hopper, and shall be fitted so as to prevent the emission of dust and not to affect weighing accuracy. The hopper shall be vented to permit escape of air without emission of excessive dust. Sufficient protection shall be provided to all weigh hoppers and weighing mechanisms to prevent interference with weighing accuracy by weather conditions or external build-up of materials. Fine and coarse aggregates shall be weighed individually into the weigh hopper and any build-up in the hopper during the day must be tarred out. At least once each day scales should be adjusted to zero by cleaning the plant.

**READY MIXED CONCRETE**

Concrete from the ready-mixed concrete source shall be carried in approved delivery vehicles. The concrete shall be compacted in its final position within 45 minutes of the introduction of water.

When truck-mixed concrete is used, water shall be added under supervision at the supplier's batching plant. Water shall only be added at the site with the prior approval of the Engineer. In no circumstance shall water be added in transit.

Each consignment of ready mixed concrete dispatched from the supplier's batching plant to the site must be accompanied by a certificate stating origin, time and date of mixing, temperature, slump and weight of constituents at the batching plant and proposed location of the concrete. Each certificate shall be countersigned by the Engineer's Representative or a member of his staff prior to incorporation of the concrete into the Works. Such signature shall not constitute acceptance of the concrete.

**Concrete Mixes - General**

Structural concrete shall be dense, durable and to the grades specified or shown on the drawings. Unless otherwise directed, Portland Cement shall be used. The quantity of water used shall not exceed that required to produce concrete with sufficient workability to be placed and compacted where required. In the case of water-retaining structures the Engineer may require the Contractor to provide concrete within minimum and. maximum water content limits. In such circumstances, the cement content must be so regulated to meet the requirements of strength and water cement ratio.

Concrete shall be mixed and tested according to BS.

Concrete is divided into Class CI concrete and Class CII concrete mixes for Class CI and Class CII shall be designed mixes.

The classes and grades of concrete to be used in the Works shall be as shown in Table 2.3.17-1.

Table 2.3.17-1 Concrete Strength Classes and their Application

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Concrete**  **Class** | **Strength**  **Grade** | **Characteristic Strength**  **\*N/mm2 (=MPa)** | **Application** | **W/C**  **Max.** | **Min**  **Cement**  **Content Kg/m2** |
| Concrete  CI | C20 | 20.0 | Plain concrete under Reservoirs and towers, benching for manholes and for blinding of buildings | 0.6 | 250 |
| Concrete  CII | C30 | 30 | Reinforced Concrete for pumping stations, manholes, chambers and earth retaining walls | 0.5 | 300 |
| C35A | 35.0 | Reinforced concrete for columns, walls, beams, slabs, foundations of reservoirs and water retaining structures | 0.5 | 350 |

The characteristic strength is the minimum value for the 28-day

Compressive strength of each cube based on the 5% fractal of the population.

Above concrete strength should comply with BS8007 clauses 6.3 and 6.6

**Concrete in Water Retaining Structures**

All water retaining structures shall be constructed in accordance with BS 8007/1987 for the design of “Concrete Structures for retaining Aqueous Liquids” and any other relevant BS standard.

Approved waterproof additive to be used.

Aggregate shall have a low drying shrinkage and absorption not greater than 3 percent measured in accordance with BS 812.

**Designed Mixes**

The Contractor in accordance with the methods given in BS see hereto attached list) shall carry out concrete mix design. The mix design shall be to the approval of the Engineer and approval shall be subject to the successful completion of suitability trials.

When the mix has been approved, no variations shall be made in the proportions and in the size and grading of the aggregate without the approval of the Engineer, who may require further tests to be made. Where subsequent analysis show grading to vary more than 5% from the approved values for the mix, the Engineer shall be at liberty to order new suitability trials to be carried out.

The water/cement ratio of the mix shall be consistent with the production of a workable mix, but shall in no case exceed 0.55.

The total sulphate content (as SO3) of any mix, excluding that present in the cement but including any present in the other materials, shall not exceed 2.5 % by weight of cement in the mix.

The total chloride content (as NaCL) of any mix, including any chloride present in the other materials, shall not exceed 0.45 % by weight of cement in the mix.

**Laboratory Suitability Trials for Designed Mixes**

The Contractor's mix design proposals for designed mixes shall be submitted to the Engineer's provisional agreement before test cubes are made.

Three sets of six 150 mm laboratory test cubes shall be cast and cured. Half of the cubes will be tested at 7 days and the other half at 28 days in accordance with BS1881. The mean strengths (or their converted equivalent) for each set of three cubes shall be not less than the value shown under "Series Strength" given in Table 2.3.17-1 plus the test margin given in Table 2.3.19-1.

The consistency of the concrete used for the suitability tests shall be at the upper limit of the desired consistency range.

Further tests shall be carried out if required by the Engineer to determine the properties of the concrete in regard to bleeding (ref. ASTM C232), free water cement ratio, and indirect tensile strength.

7-Day compressive strength results shall be converted in accordance with BS 1881.

The proposed designed mix may be approved on the basis of the compressive test results. If the results of the tests fail in any way to satisfy the Engineer, he may order a fresh mix design and/or set of test cubes to be made and tested.

TABLE 2.3.19-1 The test margin

|  |  |  |
| --- | --- | --- |
| **Concrete Class** | **Strength Grade** | **Test Margin N/mm³** |
| C I | C 20 | 5 |
| C II | C 30 | 8 |
| C 35A | 8 |

**SITE TRIAL MIXES**

Before concreting on permanent works commences, the Contractor shall carry out full-scale site trial mixes. All materials used in the site trials shall be those approved by the Engineer in accordance with the relevant clauses in these specifications and shall be delivered, stockpiled, stored, handled, batched and mixed by the method and with the plant the Contractor proposes to use for producing concrete for the permanent Works. Not less than three trial mixes shall be carried out and two sets of three cubes taken from each mix. The mix proportions shall be standard mix proportions or those approved by the Engineer as Designed Mixes.

The concrete shall be tested in the Contractor's materials laboratory in accordance with Clause 2.3.19 and the performance of the plant shall be to the satisfaction of the Engineer.

If, in the opinion of the Engineer, the results are unsatisfactory or inconsistent, other samples of fine and coarse aggregates, cement or water may have to be submitted for examination and testing, or the mix design may have to be varied. The difference between maximum and minimum values of cube results taken from one sample shall not exceed 20 % of the series strength plus test margin. The testing of trial mixes may be protracted and approval for the start of concreting for the permanent Works will not be given until the quality, grading and proportioning of the fine and coarse aggregates, cement and water have been satisfactorily determined by these tests and been approved by the Engineer.

If during the course of the Contract it becomes necessary for the Contractor to obtain fine or coarse aggregates, cement or water from a different source or sources other than those originally approved, or if the tests taken as specified hereafter indicate that an variation has taken place in the quality or proportioning of the aggregates, or if the plant is changed during construction, then the Contractor may be required to stop concreting and to make further site trial mixes or to repeat the concrete approval sequence before concreting resumes.

**Sampling and Testing Concrete**

All sampling, curing and testing of the fresh or hardened concrete shall be carried out strictly in accordance with BS 1881 under the supervision of a suitable competent representative of the Contractor.

Samples of concrete for testing shall be taken from the discharge chute of the mixer or transporters or from mixed concrete on the banker or stage immediately before the concrete is placed in the Work or as directed by the Engineer.

The Contractor shall make a set of six 150 mm cubes for each sample of concrete to be tested. The cubes shall be made in metal moulds of which twelve shall be supplied by the Contractor and kept on each site for the duration of concreting operations. The six cubes shall be taken from six different batches of the mixer.

The Contractor shall arrange for the sets of cubes to be cured and then tested, three at seven days and three at 28 days, or as directed by the Engineer and the results supplied directly to the Engineer. The Contractor shall supply adequate facilities for transporting of cubes without damage or deterioration from any cause.

Samples of concrete shall be taken for testing according to the frequency shown in Table 2.3.21-1, and such additional samples as are directed by the Engineer's Representative.

The strength requirements shall be regarded as fulfilled if the average compressive strength of each series of cubes attains at least the values shown in Table 2.3.17-1, plus the test margin given in Table 2.3.19-1 and if the compressive strength of each individual cube reaches the values shown in Table 2.3.17-1.

If more than three results out of forty individual cube results fall more than 15% below the value for series strength given in Table 2.3.17-1, or if any individual cube result falls below the nominal strength given in Table 2.3.17-1, the Engineer may order any of the following:

improvement to the standard of quality control or adjustment of the mix design and repetition of suitability and site trial mixes;

the cutting of test cylinders from the concrete and examination and testing of specimens prepared therefrom;

the carrying out of load tests on areas/structural members containing the suspect concrete;

the cutting out and replacement of such volumes of concrete as he considers to be defective;

The carrying out of non-destructive tests to assess the in-situ quality of the suspect concrete.

The Engineer may require other statistical control methods to be introduced for the control of concrete strengths if in his opinion the quality of concrete being produced is unsatisfactory.

TABLE 2.3.21-1 Frequency of Concrete Samples

|  |  |
| --- | --- |
| **Type of Concreting** | **Frequency of Sampling** |
| Floors, Walls of water retaining Structures | One sample per 50 m³ Concrete placed |
| Beams, Columns of buildings and other structures | One sample per 30 m³ Concrete placed  or \* |
| \* whichever is more frequent | One sample per structure for every three working days during which concrete is being placed on that structure |

**Concrete Admixtures**

Admixtures to concrete shall only be used with the approval in writing or at the direction of the Engineer.

If the Contractor proposes or is instructed to use admixtures, he shall submit full technical details and samples of the admixtures for testing and approval.3. Only concrete admixtures of the water-reducing or set-retarding type shall be permitted, and shall be of a lignosulphonate type base. The admixtures shall be of approved manufacture. Calcium chloride or admixtures containing chlorides shall not be permitted.

Admixtures shall be used in liquid or powder form and shall be measured by volume or weight in the case of liquids and by weight only if in powder form and shall be dispensed through equipment capable of measuring within the tolerance specified. Tanks or drums containing liquid admixtures shall be clearly labelled for identification purposes and stored in such a way as to avoid damage from contamination. Agitation shall be provided for liquid admixtures that are not stable solutions.

**APPROVALS**

The method of transporting and placing concrete shall be to the Engineer's approval. A method statement shall be submitted to the Engineer prior to the commencement of work on any structure or group of structures.

The method statement shall be submitted not less than 12 working days before the intended commencement date of the work concerned and shall cover:

The layout, arrangement and order of concreting bays.

The arrangement and design of construction joints.

The method of transporting the concrete from the batching plant to the point of placement.

The method of placement, including the use of any concrete pumps, spouts, chutes or lifts.

Any other relevant information which may be required by the engineer.

Concrete shall not be placed in any part of any structure without the approval of the Engineer's Representative. Application in writing for approval shall be made not less than 24 hours before the time the Contractor intends to commence placement of the concrete.

The Engineer's Representative will, where necessary, inspect the bay prepared for concreting. Approval to proceed will only be given after checking of the reinforcement, the alignment and cleanliness of the formwork and other surfaces.

If concreting is not started within 48 hours of approval being given, the approval procedure shall be carried out again.

**TRANSPORT AND PLACING OF CONCRETE**

Concrete shall be so transported and placed that contamination, segregation or loss of the constituent materials does not occur.

Concreting shall proceed continuously over the area between construction joints. Fresh concrete shall not be placed against in situ concrete that has been in position for more than 30 minutes unless a construction joint is formed. When in situ concrete has been in place for 4 hours no further concrete shall be placed against it for a further 20 hours.

Concrete shall be placed in the Work not later than fifteen minutes after it leaves the drum of the mixer of the batching plant. Exception for this is the use of an approved retarding admixtures , setting delay agent in the approved mix design such that maximum delay shall be approved by the Engineer .No concrete shall be used after it has developed initial set and any batch or pan of a batch that has commenced to set before being used shall be rejected. Concrete, when deposited, shall have a temperature of not less than 5° C and not more than 32° C.

Concrete shall be placed in such a manner that segregation does not occur and vibrated with approved immersion vibrators having a frequency of at least 8.000 cycles/minute. Once placing of concrete has commenced it shall proceed in one continuous operation between predetermined joints.

Vibration shall not be applied by way of the reinforcement. Where vibrators of the immersion type are used, contact with reinforcement and all inserts shall be avoided, so far as practicable.

Concrete shall be deposited in horizontal layers to a compacted depth not exceeding 450 mm where internal vibrators are used, or 300 mm in all other cases. Concrete floors and beams shall be cast in one layer except where otherwise shown on the drawings or when written approval has been obtained to an alternative construction method.

As soon as there is sufficient concrete within the formwork to immerse the vibrator, vibration shall commence and shall continue during the placing operation. A sufficient number of vibrators shall be provided and shall be kept constantly moving inside the formwork to effect maximum compaction and also to avoid over vibration and the consequent segregation of the concrete materials. Under no circumstances shall the vibrators be employed to move the concrete horizontally in the forms. Each vibrator shall be attended by one workman who shall have no other duty to perform while concreting is in progress.

The Contractor shall have available on site sufficient standby plant and equipment, such that in the event of breakdowns the placing of the concrete can continue unabated. Vibrators shall be tested to the satisfaction of the Engineer's Representative prior to the commencement of work on each pour of concrete.

Concrete shall not be dropped into place from a height exceeding two meters. Where the work requires the concrete to be deposited from a greater height, trenching and chutes, to the Engineer's approval, shall be used to prevent segregation of materials. The method of vibrating concrete in deep pours shall be to the Engineer's approval. Unless otherwise instructed the Contractor shall place concrete to the full depth of beams, slabs or similar members in one operation.

Concrete shall not be placed in flowing water. Underwater concrete shall be placed in position by tremies, or by pipeline from the mixer. Details of the method proposed shall be given in the method statement. During and after concreting under water, pumping or de-watering operations in the immediate vicinity shall be suspended until the Engineer permits them to be continued. Water shall not be allowed to flow over or exert any pressure against concrete until at least 48 hours after placing.

If for unforeseen reasons it is necessary to stop concreting before completion of the pour, then construction joints as specified shall be formed and further concreting shall be suspended for at least 24 hours. Construction joints shall be formed when the time between stopping and re-starting exceeds 30 minutes.

**CONCRETE PUMPING**

Where approved by the Engineer, the Contractor may use a suitable concrete pump for transporting the concrete from the batching plant or transport vehicle to the point where it is to be deposited, in which case the specified mix proportions shall be adjusted and agreed with the Engineer at the time of submission of the relevant method statement. The concrete shall be fed directly from the batching plant or transport vehicle into the hopper of the pump. The rate of the flow and mixing must be such as to ensure continuous movement of the concrete in the pipe work that shall have as few bends as possible. Frequent slump tests in accordance with BS 1881 shall be carried out at the delivery end to ensure the consistency and workability at the point of placing. All equipment shall be thoroughly cleaned at the end of each operation and the water used for this purpose shall be discharged outside the shuttering and clear of all other Works.

**ARRANGEMENT OF CONCRETING BAYS**

The chosen arrangement of concrete bays shall give consideration to the probable behaviour under load and under initial shrinkage of the members being formed.

The maximum horizontal length of wall or floor in any one direction shall be 7.5 m between construction joints. Construction joints between bays shall wherever possible form vertical or horizontal planes. In the case of floor slabs and similar, bays must be sized such that the whole bay can be poured in one continuous operation and that the sequence of pouring is such that no concrete has set hard before the next batch is placed against it.

Panels shall be constructed consecutively with a period of seven days allowed between adjacent bays. Alternatively, a gap not exceeding 1 m wide may be left between adjacent panels and filled not earlier than seven days after formation.

Where walls are designed to be monolithic with bottom slabs, a continuous up stand section (‘kicker’) not less than 75 mm high shall be cast at the same time as, and integrally with, the slab. Wall panels shall be poured not earlier than seven days after formation of the bottom slab panels on which they rest.

A record shall be kept on site of the time and date of placing of concrete in each section of the Works.

In the case of circular tanks having central hoppers in the floor, the hopper is to be cast first with the surrounding floor following in radial bays.

Corner sections and tee sections of walling in the case of rectangular structures shall be poured in such a manner that no vertical construction joint is formed within 1 m of the junction between the internal faces of walls.

**HOT WEATHER CONCRETING**

Concrete shall not be placed when the shade temperature exceeds 40° C. The temperature of batched concrete at time of placing shall not exceed 25° C.

Reference shall be made to the American Concrete Institute Standard ACI-305 “Recommended Practices for Hot Weather Concreting” and other standard publications on hot weather concreting practice which relate air temperature, concrete temperature, relative humidity and wind speeds to rate of water evaporation. Measures shall be taken to control evaporation rates to a level of 0.5 kg/m²/hour in order to limit the premature drying of the concrete.

Such measures must be described in the initial method statement and may include:

Painting white or silver all storage vessels, hoppers, pipes, walls or roofs which contain or convey aggregates, cement or mixing water.

Shading and/or watering of aggregates.

Removal of aggregates by tunnelling techniques to avoid the direct use of surface aggregate.

Use of iced mixing water or crushed ice.

Shading of concrete during and after placement.

Provision of wind breaks.

Placing of concrete at night.

These measures are in addition to those specified for the curing of concrete.

**COLD WEATHER CONCRETING**

When the ambient temperature is less than 2o C, all concreting operating shall stop and the freshly laid down concrete shall be protected against freezing, unless the Contractor uses adequate means to keep the temperature of mixed concrete above 13o C for thin sections and 7o C for massive sections.

Except as modified herein, cold weather concreting shall comply with (clause 6.7 –BS 8110) and ACI 306. The temperature of concrete at the time of mixing shall be not less than that shown in the following table for corresponding outdoor temperature

(in shade) at the time of placement:

Outdoor Temperature Concrete Temperature

Below -1o C 21o C

Between -1o C and 7 o C 16 o C

Above -1o C 7 o C

When placed, heated concrete shall not be warmer than 34 o C.

When freezing temperatures may be expected during the curing period, concrete shall be maintained at a temperature of at least 10 o C for 5 days or 21o C for 3 days after placement. Concrete and adjacent form surfaces shall be kept continuously moist. Sudden cooling of concrete shall not be permitted.

**WET WEATHER CONCRETING**

During rain fall concrete should not be commenced for open unprotected areas, if rain falls during concreting of unprotected or shuttered structures, the pouring should be stopped at the nearest approved position for a structural joint, the freshly laid exposed concrete shall be protected from rain and moist immediately.

**CONSTRUCTION JOINTS**

Reference is made to Cl 5.4 of BS 8007 Construction Joints

Where vertical construction joints are required, the joint face of the first cast concrete shall be finished against a stopping-off board, or vertical end shutter, and suitably notched to accommodate the reinforcement. Where horizontal or slightly inclined construction joints are required, the concrete shall be screened off.

Suitable keys shall be formed at all construction joints. The shape and positioning of keys shall be approved by the Engineer. Approved water stops shall be included in all construction joints in water retaining structures, below the water level construction joints in water retaining structures shall be water tight by the use of water stop bars and sealant.

The surface film (‘laitance’) of the first placed concrete shall be removed whilst the concrete is still green to expose the aggregate and leave a sound irregular surface.

Where concrete is to be deposited against or on top of previously executed work, the surface of the concrete shall be thoroughly wire brushed, hacked and cleaned with water and air under pressure to expose the surface of the aggregate and to remove laitance and contaminant. Immediately before placing concrete the surface shall be thoroughly wetted. Precautions shall be taken to avoid segregation along the joint plane and obtain thorough compaction

**JOINTS IN GROUND SLABS.**

Joints in ground slabs shall be in compliance with Cl 5.6 of BS 8007.

**JOINTS IN WALLS.**

Joints in walls shall be in compliance with Cl 5.7 of BS 8007

**JOINTS IN ROOFS.**

Joints in Roofs shall be in compliance with Cl 5.8 of BS 800

**MOVEMENT JOINTS**

Movement joints (e.g. expansion and contraction joints) shall be formed in the positions and in the forms shown on the drawings. Stopping-off boards or end shutters shall be used for vertical joints.

Where movement joints incorporate water bars, end shutters shall be so designed that adequate sealing exists between the water bar and the end shutters, and that the water bar is firmly held in position.

The two concrete faces of a sliding joint shall be plain and smooth. A rigid screening board or other suitable means shall be used to ensure that the top of the lower layer concrete is as flat as possible. The surface shall be finished with a steel float and after initial set, rubbed down with carborundum.

For further movement joints in formations reference is made to Clause 5.3 of BS 8007.

**JOINT MATERIALS**

Details of the types and makes of joint fillers, water stop bars, joint cover plates, joint sealing compounds and other proprietary materials shall be submitted for approval. These materials shall be used in compliance with the manufacturer's recommendations.

Water stop Bars shall be rubber or low modulus PVC and shall be used to positively stop leakage through all construction, contraction and expansion joints of water retaining structure. Rear fixed (external) type of water stops shall be used for floor joints while centre fixed type shall be used for the kicker and wall joints.

All water stop for construction joints shall have no central bulb while other contraction and expansion joints shall have a central bulb.

Centre fixed water stop shall be dumbbell type with 300mm minimum width and 10mm minimum web thickness with 2 solid edge bulbs of 23mm minimum thickness.

Rear fixed water stops shall be 250 mm wide and 5mm thick at web with a minimum of 4 edge bulbs of 20mm thickness.

The water stops shall be able to withstand the intended water pressure on it and shall be safe for use in potable water tanks by certification from WBS (Water Byelaws Scheme). PVC water stops shall comply with BS2571 and shall also comply with CRD – C 572 – 74.

It shall also be tested in accordance with BS2782 Part 3 and shall have a minimum tensile strength of 14N/mm2 and ultimate elongation in excess of 300% minimum.

Rubber water stops shall comply with BS5750 and CRD-C 513 and shall be tested in accordance with BS 903 and shall have a minimum tensile strength of 18 N/mm2 and a minimum ultimate elongation of 450%.

The contractor shall refer to the drawings for any special requirements and for the type of material required for the water stops and position.

Particularly for this project all water stops in water retaining structures shall be rubber water stops and all floor water stops shall be rear fixed.

All joints shall be factory fabricated and shall be tested on site using spark tester. All water stop materials shall be lab tested on selected samples to meet the specification. During concrete placing special precautionary action shall be made by the Contractor to make sure that the water bar alignment is not disturbed during concrete placing especially at the kicker. The concrete shall be evenly placed on both side of the water bar with proper compaction.

Joints shall be sealed using non – toxic two part polysulphide sealant, water Byelaws scheme approved product, and should comply with BS 4254 and BS6920, sealant shall be mixed and applied in accordance with the manufacturer’s current data sheet.

Chases shall be formed to the dimensions shown in the drawings and shall be primed using a primer recommended by the sealant manufacturer. Priming and filling of sealing chases shall be carried out to the manufacturer's recommendations. the sealant shall be health approval as non –toxic from a recognized international institute issuing such certificate to the approval of the Engineer.

Compressible material for expansion joint filler shall be self expanding cork filler complying with ASTM D 1752-67 (R73) Type III to the thickness shown on the drawings, or can be semi-rigid closed cell polyethylene sheet material which should be WRC (Water Research Counsel) approved with available compressibility of 50% and density 6 kg/cubic –meter, recovery should be 98% after 50% compression, minimum thickness 30 mm or as shown on the drawings. Reference should be made to the drawings for the joint filler type which if not specified shall be the semi-rigid closed cell polyethylene described above.

Bituminised fibreboard filler shall be of compressed bitumen impregnated blended wood fibersheet Plastic strip for sliding joints shall be non-compressible PVC membrane, in two layers each min. 1 mm thick. The lower layer shall be laminated on the underside with a 3 mm thick neoprene layer. The strips shall be affixed to the concrete surfaces of the joints using the manufacturer's recommended adhesive.

**CURING OF CONCRETE**

All concrete shall be cured for a minimum period of seven days commencing immediately after placing. Every effort shall be made to restrict the range of temperature changes to which it is subjected.

All vertical and horizontal faces of formwork and exposed concrete shall be covered as soon as possible after placing with saturated hessian or jute sacking which shall be kept thoroughly wet with water. Intermittent wetting of the coverings shall not be allowed. The water used for this purpose shall be near to but not colder than the temperature of the concrete.

All coverings shall be securely fixed down and positioned to prevent forced draughts of air blowing under the covering and across the new concrete or the formwork surface. When formwork is removed during the minimum curing period, the saturated protective coverings shall be replaced immediately in direct contact with the exposed surfaces of the concrete to prevent exposure.

When air temperatures exceed 30° C in any part of the day or when lower temperatures in combination with high wind speeds are likely to lead to excessive evaporation, the Engineer may approve the use of curing compounds, in conjunction with special wetting methods. The Engineer shall approve the curing compound and the manner of its application and use.

**EARLY LOADING**

Concrete shall not, within one month of the date of casting, be subjected to loading, including self weight, which will induce in it a compressive stress exceeding 33 % of its specified nominal strength at 28 days, unless the Engineer otherwise gives his approval. Such approval will not relieve the Contractor of any of his responsibilities under the Contract.

For the purpose of this clause, the assessment of the strength of the concrete and the stresses produced by the loads shall be subject to the agreement of the Engineer.

**END OF SECTION**

# SECTION 04 100

# MORTAR

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers mortar for masonry, Tiles, brick & block works and other uses, as indicated on the Drawings. The Contractor shall furnish all labour, materials, tools, and equipment, required by this part of the work.

**1.1.01 Related Work**

Work Specified Elsewhere.

Other items of work that relate to, and are referenced in this section, include, but are not limited to, the following section:

Brick & Block Works.

Plastering.

Tiles, Marble ...etc.

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards, generally applicable to the work under this section, shall conform with the latest revision of the applicable specifications of the BSI or ASTM.

Any other equivalent international standard may be accepted, subject to the Engineer's approval.

**1.3 SUBMITTALS**

**1.3.01 Samples and Data.**

All submittals of samples, and data, shall be in accordance with the Engineering Information and Requirements.

**1.3.02 Certifications.**

The Contractor shall submit certification, that all materials have been tested, and conform with the specified requirements.

**1.3.03 Proportions.**

The mortar proportions, proposed for the work, shall be submitted to the Engineer for review, before mortar work is started. Review of these proportions, shall be for general acceptability only, and continued compliance with all contract provisions will be required.

**1.4 PRODUCT HANDLING**

**1.4.01 Delivery.**

All package mortar ingredients, shall be delivered in their original unopened containers.

**1.4.02 Storage.**

All package mortar ingredients, shall be stored in weather tight enclosures, protected against contamination and warehouse set. All aggregates shall be stored, so that the inclusion of foreign materials is prevented. Whenever sand is piled directly on the ground, the surface beneath the sand, shall be smooth, well drained, and free from dust, mud, and debris. The bottom 150 mm of each pile, shall not be used in the mixing of mortar.

**1.5 JOB CONDITIONS**

**1.5.01 Environmental Requirements.**

The temperature of mortar, when being used, shall not be greater than 38 C, and all necessary action shall be taken, to ensure strict compliance with this condition. Cooling the mixing water, cooling the sand, and cooling the mixer, are appropriate methods for keeping the mortar temperature below the limit set herein. In addition to the protection specified for ordinary conditions, masonry materials shall also be kept from contact with dampness of any kind.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Material List.**

Materials used for mortar, shall conform to the following requirements:

Portland Type I and/or Type V.

Cement

Hydrated Standard Building Regulations

Lime

Quicklime Pulverized.

Lime Putty Quicklime, thoroughly slaked and stored for one day; kept moist until used.

Water Clean and free from deleterious substances.

Sand Natural sand, free from any organic, or other undesirable matter.

Gradation shall be as follows:

Sieve Percentage Passing

Number by Weight

1/8 95-100

7 80-100

14 60-100

25 30-100

52 5- 65

100 0- 15

Colouring Commercial pigments, suitably Agents compounded to give the required mortar colour.

**2.2 PERFORMANCE AND DESIGN REQUIREMENTS**

**2.2.01 Mortar.**

The method of measurement of all mortar ingredients, shall be accurate, and shall insure definite and uniform proportions.

Masonry mortar shall conform to Standard Building Regulations. Mortar shall be machine mixed, for at least 5 minutes, and shall be used within 90 minutes after mixing. Mortar left on hand, when work is stopped, shall be discarded. No remixing of mortar, more than 90 minutes old, with additional water, cement, or other materials, will be permitted. Mortar shall be mixed in volumetric proportions as follows:

Table (1)

|  |  |  |  |
| --- | --- | --- | --- |
| **Hydrated Lime** | | **Sand or (non-compacted)** | |
| **Service and Type** | **Portland Cement** | **Lime Putty** | **(Max)** |
| Rein- forced masonry (Type S) | 1 | ½ | 4 |
| All other building masonry (Type N) | 1 | 1 | 6 |

The sand content specified above, is a maximum non-compacted quantity.

Table (2)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Service and Type** | **Portland**  **Cement** | **White Cement** | **Hydrated Lime or Lime putty** | **Sand**  **(max.)** |
| Exterior masonry below grade | 1 | - | ¼ | 4 |
| Cut Stone | - | 1 | 1 | 6 |
| Marble | - | 1 | - | 3 |
| Reinforced masonry (type S) | 1 | - | ½ | 4 |
| All other building masonry (type N) | 1 | - | 1 | 6 |

The sand content specified above is maximum quantity. Intergral water proofing shall be added to each mortar mix.

* + 1. **Pointing Mortar**

Pointing mortar for glazed tile, glazed brick and glazed block shall be either prepared pointing mortar or Job-mixed in the volumetric proportions of one part white cement, 1/8 part lime of lime putty and 2 parts fine sand, integral water proofing shall be added to job-mixed pointing mortar.

Pointing mortar shall be mixed in volumetric proportions as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Service** | **Portland**  **Cement** | **White Cement** | **Hydrated Lime or Lime putty** | **Fine Sand** |
| Ceramic glazed tile | - | 1 | 1/8 | 2 |
| Glazed block | - | 1 | 1/8 | 2 |
| Glazed brick | - | 1 | 1/8 | 2 |
| Cut stone | - | 1 | 1/8 | 2 |
| Color lith | 1 | - | 1/8 | 2 |
| Marble | - | 1 | 1/8 | 2 |

* + 1. **Colouring Agents.**

Colouring agents are required in mortar, for use in pointing operations around stone units. Colouring agents shall be pre-blended, before being added to mortar, or pre-blended coloured masonry cement. Coloured mortar, shall be black, and shall be acceptable to the Engineer.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

**3.1.01 Application.**

See appropriate sections, as named in the "Work Specified Elsewhere" paragraph for application and use of mortar.

**END OF SECTION**

# SECTION 04150

# PLASTERING

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers internal and external plastering. The Contractor shall furnish all labour, materials, tools and equipment required by this part of the work.

**1.1.01 Related Work**

Other items of work that relate to, and are referenced in this section, include, but are not limited to, the following sections:-

- Mortar

- Masonry

- Cast-In-Place Concrete

- Damp proofing.

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards, generally applicable to the work under this section, shall conform to the latest revision of the applicable specifications of the BS.

Any other equivalent international standard may be accepted, subject to the Engineer's approval.

**1.3 SUBMITTALS**

**1.3.01 Samples & Data**

All submittals of samples and data shall be in accordance with the Engineering Information and Requirements.

**1.3.02 Certifications**

The Contractor shall submit certification that all materials have been tested, and conform to the specified requirements.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Materials List**

Mortar: see Section 04 100.

**2.1.02 Accessories**

The Contractor shall furnish all accessories, such as expanded metal lath (strip mesh, corner mesh, corner beads) ... etc., necessary to complete the works.

**2.1.03** **Shebreeze Plastering Material:**

1. The materials should fulfill the latest currently used specification. Fine Aggregate should be Quartz Sand only. It is forbidden to use broken stones fine aggregates.

1. The used coloring agent should confirm to BS (1014). Lead and Zink free component.

**2.1.04** **Shebreeze Mix Preparation**

* 1. When hydrated line is used it is mixed with the fine aggregator first until a homogeneous mix is formed, then cement is added while still mixing. Water is then added gradually until a suitable mortar consistency is reached.
  2. The volume of the hydrated lime does not affect the total volume of the mix.
  3. When plasticizers additives are used, it should be according to the manufacturing company instructions and the Engineer's approval. In this are hydrated lime is not used.
  4. Either Manual or mechanical mixing on special plats of metal or wood may be used. Provided that previously determined mixing proportions is used and approved by the Engineer.

**PART 3 - EXECUTION**

**General :** The work shall be executed in accordance with BS 5692, to the satisfaction of the Engineer. Any work rejected through non-compliance with the specification shall be removed and replaced at the contractor's expense.

* 1. **INSTALLATION**

**3.1.1 Ordinary plastering**

The surface to be plastered must be cleaned from dust, soot, grease and other materials damaging the plaster.

All electrical conduits, water and sanitary installations shall be covered by strip meshes. The width of the strip must be projected by 40 mm on both sides of the covered installations. Strips must be fixed by nails. All extruding corners must be protected by corner beads.

The plastering must be executed in three subsequent coats, as follows:-

a. First under coat: To provide rough surface (i.e. good bond) between the plastered surface and the second under coat.

b. Second under coat: This is the main plastering coat which gives the desired evenness, straightness and verticality to the plastering. The thickness of this coat ranges between (10-15) mm.

c. Top Coat: This is the final (smooth) coat of plastering. The thickness of this coat ranges between (3-5) mm.

Each coat must be cured for at least 24 hrs before the next coat is applied. The final coat must be cured for at least 3 days.

The plastering works should be started after the erection of all windows and doors frames, and after the completion of the electrical conduits and sanitary installations in the surfaces to be plastered.

**3.1.2 Shebreeze plastering**

It consists of 3 layers: 1st under coat (Rough surface), 2nd under coat, Top coat.

The Shebreeze plastering must be executed in three subsequent coats, as follows:

a. First under coat: To provide rough surface (i.e. good bond) between the plastered surface and the second under coat.

b. Second under coat: This is the main plastering coat which gives the desired evenness, straightness and verticality to the plastering. The thickness of this coat ranges between (10-15) mm.

c. The minimum thickness of Shebreeze layer should be 3 mm, the mortar is prepared from ordinary cement, or from white cement to which the required coloring agent and fine aggregate are adding according to requirements of the particular specification or the BOQ. The volumetric proportions of 1:3 is used coloring agent is used according to the manufacturing company directions, taking into consideration to get the same color all over the whole elevation.

**3.1.3 Provisions for the execution of Shebreeze plastering**

* 1. No ripple or prominence is allowed in the top or the Shebreeze layer.
  2. It is forbidden to start the Shebreeze layer work unless the curing period of the second under coat layer is completed.
  3. Dry mix of fine aggregate, cement and coloring agent according to pre specified proportions in a metal plate till a homogeneous mix is prepared, water is then added gradually, the amount of the prepared mortar should not be more then that required for half an hour work.
  4. Shebreeze layer is executed using a special mechanical machine pre calibrated to give the required layer.
  5. Work should go at a uniform regular speed from the top of the wall to the bottom Shebreeze layer consists of 2 coats; 4 hours should pass before starting the 2nd coat.
  6. Shebreeze layer should be cured and protected from wind and sunlight
  7. 30 mm frames on the vertical and horizontal straightedges are to be made and approved by the Engineer, wood ruler are used and placed over the 1st under coat layer then removed after Shebreeze layer.
  8. Samples of not less than 1 square meter area should be prepared according to the Engineer's regulation to enable him to choose the suitable color and texture.

**3.2 THICKNESS AND TOLERANCES**

**3.2.01 Thickness**

The minimum total thickness of plastering is (15+3) mm for the Internal plastering and (25+3) mm for the External plastering. The external plastering must be constructed of two-second under coats, 10 mm thick each.

The minimum thickness of Shebreeze layer should be 3 mm.

**3.2.02 Tolerance**

The following are the maximum permissible tolerances in the plastering works:-

Evenness + 8 mm measured over a length of 2.0 m

Thickness + 3 mm

Inclination + 0.3% of the height; max 2 cm.

**3.3 CLEANING AND PROTECTION**

All adjacent works (such as doors, windows, tiles, piping, ... etc.,) must be protected from splashes of mortar and must be cleaned immediately in any such case.

**END OF SECTION**

# SECTION 04200

# BRICKWORK AND BLOCKWORK

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This specification covers the work involved in the manufacture and construction of load bearing and non-load bearing brickwork and block work, and reinforced block work.

Except as otherwise required, materials and workmanship shall conform with the latest revision of the specification of the British Standards.

**1.2 REFERENCE STANDARDS**

The following publications of the British Standards listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

Any other equivalent international standard may be accepted, subject to the Engineer's approval.

BS 12 Specification for ordinary and rapid hardening Portland cement.

BS 729 Hot dip galvanized coatings on iron and steel articles.

BS 743 Materials for damp-proof courses, metric units.

BS 1198, 1199 & 1200: 1976

Building sands from natural sources.

BS 1243 Metal ties for cavity wall construction.

BS 3148 Methods of tests for water for making concrete.

(Including the suitability of water.)

BS 3416 Black bitumen coating solutions for cold application.

BS 3798 Coping units.

BS 3921 Clay Bricks & Blocks.

BS 4483 Steel fabric for the reinforcement of concrete.

BS 4721 Ready-mixed building mortars.

BS 4551 Methods of testing mortars, screeds and plasters.

BS 5642 Window sills of precast concrete, cast stone, clayware, slate and natural stone.

BS 6073 Part 1 and part 2. Precast concrete masonry units.

CP 111 Structural recommendations for load bearing walls.

CP 121 Brick and block masonry (walling).

**1.3 SAMPLES**

a) The Contractor shall construct test sections of brickwork as required by the Engineer in accordance with the Specifications, for review by the Engineer. Size of test sections to be 1500 mm X 1500 mm.

b) The Contractor shall submit samples of brick, block, masonry accessories and mortar if required by the Engineer before commencing work.

**1.4 PRODUCT HANDLING**

**a) DELIVERY AND STORAGE**

1) Masonry units shall be delivered and stored on site on pallets well away from roads. If this cannot be done, stack masonry units carefully and neatly on high ground and on solid planks. If not used immediately after delivery, cover with tarpaulins of 0.150 mm polyethylene adequately weighted or anchored down. Keep units protected from roofing bitumen, concrete, mortar and other work and materials which could stain them.

2) Store bagged products, such as lime, cement and metal accessories, in dry, waterproof sheds.

**b) PROTECTION**

1) The Contractor shall protect laid masonry from damage by weather. At end of each day or shutdown period, cover exposed tops of masonry with canvas or strong waterproof membrane securely clamped down and overhanging on each side of wall at least 600 mm.

**PART 2 - MATERIALS**

**2.1 AGGREGATE**

Aggregate used in making concrete blocks and concrete bricks shall conform to BS 1198, 1199 and 1200.

**2.2 ANCHORS, TIES, AND REINFORCEMENT**

Anchors and ties shall be of an approved design and except as otherwise specified herein, shall be zinc-coated ferrous metal of the types noted below. Zinc-coating of anchors and ties shall conform to BS 1243.

Wire mesh ties for anchorage of 120 mm thick partitions to exterior brick or block work walls shall be made of steel wire not lighter than 1.6 mm in diameter and shall be 80 mm wide, of an effective length for this purpose, and with 13 mm mesh.

Wire ties for anchoring concrete brick or block work partitions to exterior brick or block work walls shall be of bed joint segments with longitudinal wires bent as necessary to provide bond equivalent to a cross wire at each end.

Ties between concrete and brick or block work walls shall be as specified under Section: 03300, CAST-IN-PLACE CONCRETE.

Reinforcing steel for reinforced block work shall be as shown on the drawings and comply with the requirements of Section 03300 CAST IN PLACE CONCRETE.

**2.3 CONCRETE BLOCKS**

Concrete blocks (solid and hollow) shall conform to BS 6073, (7 N/mm2 on the gross area), sizes as indicated on the drawings and shall include all closers, jamb units, headers, and special shapes and sizes required to complete the work as indicated. Exposed to view or painted units in any one building shall be of the same appearance, and shall be cured by the same process. Units shall be free of any deleterious matter that will stain plaster or corrode metal. The surface of the concrete blocks, to which plaster and mortar setting beds or on which other materials are to be applied, shall be sufficiently rough to provide a good mechanical bond. Blocks shall be delivered to the jobsite in an air-dry condition and stored in an approved way that will protect them from contact with soil and exposure to the elements.

**2.4 MORTAR**

Mortar for all brickwork shall be composed of 1 part of Portland cement (BS 12, ordinary type) and 3 to 4 parts of sand (BS.1200. grading table 1). Mortar for block work shall be composed of 1 part Portland Cement to 4 parts sand. All parts measured by volume. The mortar shall comply with the specifications as given in BS 4551, while the average compressive strength at 28 days shall be not less than 12 N/mm2. When used in the work, mortar shall be mixed in the laboratory established proportions with as much as may be necessary to produce the workability desired regardless of initial flow. The Contractor shall furnish a certified copy of laboratory established proportions and tests as evidence that the mortar used in the work meets the requirements of the Specifications. No change in the laboratory established proportions shall be made nor shall materials with different physical or chemical characteristics be utilized in mortar used in the work unless the Contractor furnishes additional evidence that such mortar meets the requirements of the Specifications.

**2.5 DAMP-PROOF COURSES**

Damp-proof courses shall be laminated type, complying with BS 743.

**2.6 FACING BRICK**

Face or semi face bricks suitable for exterior use. Crushing strength 20 N/mm2. Water absorption 11.

Brickwork shall be laid in random range pattern using each colour of brick stated above. Acceptable percentages of each colour in range to be determined by the Engineer from sample panels as required by paragraph 1.3.

**PART 3 - EXECUTION**

**3.1 GENERAL**

Brick and block work shall not be erected when the ambient temperature is below 2o C, except by written permission of the Engineer. No frozen work shall be built on. No brick or block work unit having a film of water or frost on its surface shall be laid in the walls. Brick and block work shall be protected from freezing for 48 hours after being laid. Brick and block work erected during arid weather when the ambient air has a temperature of more than 37o C in the shade and a relative humidity of less than 50 percent shall be protected from direct exposure to wind and sun for 48 hours after installation.

**3.2 BRICKWORK AND BLOCKWORK**

Brick and block work shall be laid plumb, true to line, with level courses accurately spaced with a story pole, and unless otherwise shown, with each course breaking joints with the course next below. In stacked bond work, head joints shall be in accurate vertical alignment. Each block shall be adjusted to its final position in the wall while mortar is still soft and plastic. Any block that is disturbed after mortar has stiffened shall be removed and re-laid with fresh mortar. Bond pattern shall be kept plumb throughout. Corners and reveals shall be plumb and true. Courses shall be so spaced that backing masonry will level off flush with the face work at all joints where metal ties are used. Brickwork and block work shall be raised in a uniform manner so that nor portion of the work is more than one meter above another at any one time. Not more than sixteen courses of brickwork nor five courses of block work shall be built in any one day. Intersections between masonry walls shall be fully bonded in each alternate course. Walls or partitions abutting concrete columns or walls shall be anchored thereto with hoop iron anchors or ties spaced not more than 230 mm on centers vertically . Chases and raked-out joints shall be kept free from mortar or other debris. Spaces around metal door frames and other built-in items shall be solidly filled with mortar. Anchors, wall plugs, accessories, flashings, pipe sleeves, and other items required to be built in with the brick or block work shall be built as the brick and block work progresses. Walls and partitions shall be adequately reinforced for support of wall-hung plumbing fixtures when chair carriers are not specified. Openings shall be formed or otherwise neatly made for items indicated to be recessed in brick or block work, including access openings for recessed items to be concealed by cover plates, and for through-the-wall installation of ducts and cable trays. The openings shall be provided with structural steel or reinforced concrete lintels. Cutting and fitting required to accommodate the work of others shall be done by masonry mechanics with masonry saws. The sizes of any two adjacent units shall be within permitted tolerances so that the differences between the vertical faces of such units shall not exceed 3 mm in exposed to view or painted walls and partitions except in dead storage spaces, closets, and utility equipment rooms. Units in exposed to view or painted walls and partitions shall be free from chipped edges or other imperfections detracting from the appearance of the finished work. Cavity walls shall be built to the widths shown on the drawings. The two thicknesses of brickwork or block work shall be effectively tied with ties of an approved design. Cavity ties shall extend at least 50 mm into each of the sides forming the cavity wall. Cavities shall be kept clear of all debris. Cavities shall be cap sealed before brickwork, concrete, wooden or other construction is placed on the wall.

Cavity work below ground shall have the cavity filled with Grade 10 Concrete up to the levels indicated.

**3.3 DAMP-PROOF COURSES**

Damp-proof courses shall be installed in all brick and block walls.

Damp-proof courses shall be bedded in an even bed of the block work mortar and lapped a minimum of 150 mm at joints with projection of the damp-proof course beyond the mortar bed at the sides.

**3.4 JOINTS**

After the mortar has taken its initial set, joints shall be Concave tooled flush with the mortar thoroughly compacted and pressed against the edges of the units. The following joints on the weather side of exterior walls shall be raked out 20 mm and left ready for caulking.

a) Control Joints

b) Joints between metal frames and masonry

c) Other joints where so indicated.

**3.5 UNFINISHED WORK**

Unfinished work shall be stepped back for joining with new work. Toothing may be resorted to only when specifically approved. All loose mortar shall be removed and the exposed joint shall be thoroughly cleaned before laying new work. Surface of masonry not being worked on shall be properly protected at all times during construction operations. Adequate provisions shall be made during construction to prevent damage by wind and wind-blown sand.

**3.6 MORTAR**

Mortar that has stiffened because of chemical reaction due to hydration shall not be used. Except as specified below, mortar shall be used and placed in final position within 1 1/2 hours after mixing when air temperature is 27o C or higher and within 2 1/2 hours after mixing when air temperature is less than 27o C. Mortar not used within these time intervals shall be discarded. When cement or cements used in the mortar have been tested and the observed setting time as determined under BS 12 has been ascertained, the time interval during which the mortar must be placed in final position may be determined by an optional method as follows:

Air Temperature Time Interval

in Degrees Celsius after Mixing

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

27 or higher Setting time minus 1 hour

less than 27 Setting time minus 1/2 hour

In mixing mortar, the maximum amount of water shall be used as necessary to produce the best workable consistency possible. Mortars that have stiffened within the time interval as determined above, because of evaporation of moisture from the mortar, shall be retempered by adding water as frequently as needed to restore the specified consistency.

**3.7 ERECTION OF CONCRETE BRICKS AND BLOCKS**

a) Concrete bricks and blocks shall not be wetted before laying. Cutting of blocks shall be accomplished by masonry mechanics using masonry saws. Concrete blocks may be either dry or wet cut. Except as otherwise specified for stacked bond, blocks shall be set with vertical joints breaking not less than 100 mm over blocks in the course next below; head joints for stacked bond walls or partitions shall be plumb and in true alignment. Mortar joints shall be approximately 10 mm wide. Mortar joints in starting courses on footings, on solid foundation walls, and on beams shall be fully bedded under both shells and webs. Other joints shall have full mortar coverage on horizontal and vertical face shells, but mortar shall not extend through the blocks on the web edges. Each coarse shall be bonded at corners. Jamb blocks shall be of the shapes and sizes required to bond with wall blocks. No cells shall be left open in face surfaces. Sections of concrete brickwork shall be incorporated in the work where necessary to fill out at corners, gable slopes, and elsewhere as required. Brick and block walls or partitions supporting plumbing, heating or fixtures, and voids at door and window jambs, and other spaces requiring grout fill shall be full bedded in mortar to prevent leakage and filled solid with mortar mixed to pouring consistency.

b) The outside face of below ground level exterior concrete block walls enclosing usable rooms and spaces, except crawl spaces, shall be purged with mortar. Purging shall be not less than 13 mm thick, troweled to a smooth dense surface so as to provide a continuous unbroken shield from top of footings to a line 150 mm above adjacent finish grade, unless otherwise indicated. Purging shall be cured by dampening with a mist spray for 48 hours or more before fill or backfill is placed, the purging shall be painted twice with an approved bituminous paint.

c) Partitions shall be continuous from floor to underside of floor or roof construction above, unless otherwise shown on drawings.

Where suspended ceilings on sides of partitions are indicated, the partitions in spaces other than those mentioned above may be stopped approximately 100 mm above the ceiling level, unless otherwise indicated.

d) Lintels in concrete block partitions, unless otherwise indicated, shall be constructed of specifically formed lintels of 25N/mm2 concrete as specified under SECTION : 03300 CAST-IN-PLACE CONCRETE, using coarse aggregate of 13 mm to 4.76 mm nominal size, and shall be reinforced as indicated. However, not less than two 12 mm bars of the full length of the lintel shall be provided. Lintels shall extend at least 200 mm beyond each side of the opening. The bed joints of lintels at control joints shall be under laid with a sheet of 0.45 kg/m2 smooth copper with edges cut back 13 mm from face of wall below.

e) Where reinforced concrete block work is shown on two drawings, completely fill all holes in block work around reinforcing steel, with mortar.

1. Where Hollow Block partitions with horizontal span more than 4 meters, dummy R.C. columns shall be provided (with 4 ∅ 12 mm main bars and ∅ 8/200 mm ties).The dummy columns shall constructed along with the block wall doweled horizontally by ∅10/40 cm vertically into top and bottom slabs. The column shall have a cross section size of on side equal to the block wall thickness and the other side 20 to 30 cm and as the Engineer requirements.

**3.8 CONTROL JOINTS**

Control joints shall be provided where indicated on the drawings and shall be constructed by using either special control joint units, open-end stretcher units, or metal-sash jamb units on each side of joint, at the option of the Contractor. Sash jamb units shall have a 20 X 20 mm groove near the center at end of each unit.

Mortar in control joints shall be raked to a depth of 13 mm and left ready for sealing. Sealing of control joints as indicated is specified in SECTION 07-920 : CAULKING AND SEALING.

**3.9 EXPANSION JOINTS**

Expansion joints, size, details for construction shall be located as shown on the drawings.

Where flexible, joint filler strips are indicated, strips shall be installed for the entire story height and shall be sealed to the bricks or blocks on each contact surface with a full bed of plastic caulking compound. Expansion joint covers are specified in SECTION : 05990 MISCELLANEOUS METALS.

**3.10 POINTING AND CLEANING**

Before completion of the work, all defects in joints of exposed surfaces shall be raked out as necessary, filled with mortar, and retooled. All masonry surfaces shall be left clean, free from mortar daubs, dirt, stain and discoloration including lather from cleaning operation, and with tight mortar joints throughout.

**3.11 STABILITY UNDER LOAD**

Loads shall not be applied to a newly built wall until construction to the level of the loads has been completed and at least three days have elapsed since completion of the wall.

**END OF SECTION**

# SECTION 04220

# MASONRY

**PART 1 - GENERAL**

* 1. **DESCRIPTION**

This section covers unit masonry.

Unit masonry shall be constructed of units of the types, dimensions, arrangements, and coursing indicated on the Drawings and specified herein, complete with all materials, accessories, and appurtenances as indicated, specified, or required. All materials shall be from manufacturers and sources acceptable to the Engineer. The Contractor shall furnish all labor, materials, tools, and equipment required to complete the work.

* + 1. Related Work

1. Work specified Elsewhere

Other items of work relate to and are referenced in this section include but are not limited to the following Sections:

* 1. **APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work under this section are listed. Codes and Standards current at the time of bid shall be used.

* + 1. ASTM – American Society for Testing and Materials

A615 Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, Specification for

C67 Sampling and Testing Brick and Structural Clay Tile, Standard Methods of

C595 Blended Hydraulic Cements, Specification for

* + 1. MPWS – Ministry of Public Works Specifications, Hashemite Kingdome of Jordan. General Specifications for Buildings, 1871 (Arabic only).
    2. AASHTO – American Association of State Highway and Transportation Officials

M240 Blended Hydraulic Cements, Specification for

T96 Resistance to abrasion of Small Size Coarse Aggregate by Use of the Los Angles Machine

* 1. **QUALITY ASSURANCE**
     1. Governing Standards

Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the Local Specifications.

* + 1. Testing

The following tests shall be performed on blocks and ingredients:

Compressive Strength

Sieve analysis

Water absorption

Relative density

Abrasion – L.A. Abrasion Test for Stone and Aggregates (AASHTO T96)

* + 1. Tolerances

Acceptable tolerance for any block dimensions shall be +6 mm.

* 1. **SUBMITTALS**
     1. Samples and Data

Complete specifications, physical property test results, samples and data shall be submitted in accordance with the Engineering Information and Requirements Section.

* + 1. Sample Panel

Before the installation of any masonry, the Contractor shall erect at the building site a sample panel 2400 mm long by 1200 mm high showing proposed texture, color, bond, mortar joints, and workmanship for masonry.

The panel shall be laid in running bond and shall be representative of the typical wall construction indicated on the Drawings.

Masonry work shall not be started until the Engineer has examined and accepted the sample panel. The panel shall then become the standard of comparison for all masonry work. The panel shall not be destroyed or moved until masonry work is completed.

* + 1. Test Reports

Mix design reports, Aggregate and sand test reports shall be submitted before the use of Masonry and Mortar.

* 1. **PRODUCT HANDLING**
     1. Handling and Storage

All masonry units shall be handled in a manner which will prevent soiling, chipping, or damage of any kind. Broken, discolored, chipped, or otherwise damaged units will be rejected and shall be replaced with undamaged units.

Masonry units shall be stored on pallets and shall be protected against contamination and staining. Masonry units shall be kept covered at all times.

* 1. **JOB CONDITIONS**
     1. Environmental Requirements

When the ambient air temperature is 37 C or higher in the shade and the relative humidity is less than 50 percent, masonry construction shall be protected from direct exposure to sun and wind. Masonry mortar and brick shall be maintained at a temperature no greater than 38 C by methods specified in the Mortar Section.

**PART 2 - PRODUCTS**

* 1. **MATERIALS**
     1. Material List

Materials used shall be:

|  |  |  |  |
| --- | --- | --- | --- |
| Block materials | |  |  |
|  | Cement | Portlant Pozzolanic Cement, ASTM C 595 or AASHTO M240 | |
|  | Fine Aggregates and Sand Relative Density | 2.5 |  |
|  | Gradation | Sieve No. | Percentage passing by |
|  |  | 3/16 | 95 – 100 |
|  |  | 7 | 70 – 95 |
|  |  | 14 | 45 – 85 |
|  |  | 25 | 25 – 60 |
|  |  | 52 | 0 – 30 |
|  |  | 100 | 0 – 10 |
| Hollow blocks | |  |  |
|  | Sizes | 70 x 200 x 400 mm | Percentage of voids |
|  |  | 100 x 200 x 400 mm | Percentage of voids |
|  |  | 150 x 200 x 400 mm | Percentage of voids |
|  |  | 200 x 200 x 400 mm | Percentage of voids |
|  | Density, not less than | 2 gm/cu.cm |  |
|  | Min thickness | 3cm’ core shapes acceptable to the Engineer | |
|  |  |  | |
|  | Compressive Strength, min. non-loaded Blocks | 35 kg/sq. cm | |
|  | Loaded blocks | 70 kg/sq. cm | |
| Stone | | Class A white Local or limestone; outside face as shown on Drawings or as directed by Engineer. | |
|  |  | No cracks, cavities, or impurities; perpendicular angles. | |
|  | Max abrasion per ASTM C 241, percent | 10 | |
|  | Max water absorption, percent | 3 | |
|  | Relative density per ASTM C97 | 2.5 | |
|  | Compressive strength kg/sq. cm. | 550 | |
| Insulation | | As specified in the thermal Insulation Section. | |
| Anchor ties | | For cavity walls; 10 mm dia. bars with, figure 8 shape and length less than 8 cm than the total thickness of the cavity wall | |
| Reinforcing steel bond Breaker | | ASTM A 615 supplemental condition sl Grade 40 or 60, deformed Polyvinyl Chloride sheeting, clear, 250 micrometers nominal thickness. | |
| Compressible joint filler | | PVC foam with pressure sensitive back | |

**PART 3 - EXECUTION**

* 1. **PREPARATION**
     1. Masonry Units

All masonry units shall be free from dust, dirt, and surface moisture when laid.

* 1. **INSTALLATION**
     1. Laying Masonry Units

All masonry shall be laid to a line. Walls shall be plumb and straight and in level courses. At no time shall masonry construction at any point be more than 2400 mm above adjacent work. When work is suspended, the tops of masonry walls shall be covered and protected from the weather.

In case of cavity walls, the outside and inside walls shall be built together and no side shall be higher than 400 mm than the other.

Blocks should not be used while they are dry. Blocks shall be moistened before use. Blocks shall be sprayed by water for three consecutive days after construction.

Anchor ties for cavity walls shall be placed at distance of 1 m horizontal and 400 mm vertical in a staggered form.

Care shall be taken in corner construction and at jambs to maintain uniformity of appearance and to insure that only whole, undamaged units are used.

Where masonry units in exposed locations are laid in running bond, care shall be taken to lay out the work so that vertical joints in alternate courses lie in the same vertical lines midway between the vertical joints in adjacent courses to provide a regular and uniform joint pattern.

Masonry units shall be selected and laid so that the exposed face of each unit is free from broken corners, chipped edges, or other defects which would be deter-mental to the appearance of the wall surface.

Masonry unit shall be cut or clipped as necessary to provide openings and to accommodate embedded items. Anchors shall be securely embedded in mortar.

All embedded items shall be set and securely anchored in the masonry work in accordance with the details indicated on the Drawings or in a manner acceptable to the Engineer. Joints between masonry and embedded items shall be pointed.

Slots, chases, recesses, and openings shall be provided and constructed for installation of the work of other trades in locations and to the dimensions indicated or required. Temporary openings shall be closed after the work of other trades has been installed.

Wall plugs, grounds, shear bars, and anchors shall be built into masonry walls as the work progresses, at locations designated on the Drawings or required by other trades.

Insulation boards, as specified in the Thermal Insulation Section, shall be built into the cavity of exterior walls as the masonry work proceeds.

Lintels shall be provided over all openings of width greater than the length of a masonry unit. Lintels shall be of the type and size indicated on the Drawings or as required, and shall be acceptable to the Engineer.

Where slip planes are indicated on the Drawings, bond breaker material shall be installed.

Centering shall be provided as required to properly support masonry openings until mortar has set firm and hard.

Internal partitions shall have compressible joint filler at the head as indicated on the Drawings or as directed by the Engineer.

* + 1. Mortar Joints

Masonry shall be laid in straight, level, uniform courses with mortar joints of uniform width 6 – 15 mm. Head joints shall approximately equal the horizontal joints in width.

In laying up masonry, abutting surfaces of head joints shall be completely and solidly cemented together with mortar. All masonry units shall be laid in a full bed of mortar. All joints shall be completely filled.

The filling of masonry joints shall mean that the space between the units is full, and that the body of the mortar is forced tightly against the surface of each unit.

Masonry surfaces which are to be plastered shall have joints raked and left rough. All exposed mortar joints shall be tooled to a smooth uniform surface and finished free from voids, using a rounded tool. Mortar joints specified to be calked shall be raked to a dept of 12 mm. Tooling of joints shall be regulated so that the mortar for each wall space has a uniform appearance.

Stones shall be tied to the internal block wall. Class A concrete, as specified in the Cast-in-place ‘concrete Section, shall be poured in between the 70 mm gap between the stone and the block wall. The stone shall not be more than 2 layers above the block wall.

* + 1. Bonding and reinforcing

Unless otherwise indicated on the Drawings, all block shall be laid in running bond and shall be reinforced in the manner indicated on the Drawings and specified herein.

All joint reinforcement, when placed, shall be fully embedded in mortar and shall have ends lapped at least 200 mm. Joint reinforcement shall be lapped full width at corners and intersections, or prefabricated corners and tees shall be used.

Where masonry walls abut concrete columns or other concrete construction, the masonry shall be anchored to the concrete by 6 mm diameter by 200 mm bar anchors at every other course vertically.

Dovetail anchors shall be provided and installed as indicated on the Drawings. Anchor slots shall be case vertically in the concrete at 600 mm maximum horizontal spacing. Anchors shall be installed in each slot at 300 mm on center vertically. Where different spacing are noted on the Drawings, they shall be followed.

* + 1. Movement Joints

Movement joints (control joints) where masonry walls abut concrete wall and column surfaces shall be constructed as required by the Drawings.

Movement joints in masonry walls shall be constructed as indicated on the Drawings, including the installation of shear bars at 300 mm centers.

* + 1. Anchors and Inserts

All necessary anchors, bolts, inserts, flashings, sleeves for piping, conduits of every kind, window and door frames, and other work shall be accurately set and securely held in the masonry work in accordance with details indicated on the Drawings or as acceptable to the Engineer. Sleeves shall be provided where small piping (under 150 mm diameter) passes through the masonry.

* + 1. Finish Pointing

On completion of the work, all exposed masonry shall be pointed where necessary and all voids and holes in the mortar filled to match adjacent joint surfaces. Defective joints shall be cut out and re-pointed with mortar. Care shall be taken to produce a uniform overall appearance. Spottiness due to variations either in materials or workmanship will not be tolerated.

* 1. **FIELD QUALITY CONTROL**
     1. Protection from Damage

Masonry and all embedded or built-in items shall be carefully protected from damage until completion of the work. Masonry walls discolored by paint, mortar, or concrete shall be rebuilt with new materials.

Whenever concrete is placed adjacent to previously constructed masonry, the masonry shall be adequately protected against splashing of concrete paste and other damage.

* 1. **ADJUST AND CLEAN**
     1. Cleaning

Following finish pointing, all exposed masonry surfaces shall be carefully cleaned and all surface stains removed.

**END OF SECTION**

# SECTION 05500

# MISCELLANEOUS METAL FABRICATIONS

**PART 1 GENERAL**

**1.01 Work Included**

A. Metal fabrications include items made from aluminium and/or iron and steel shapes, plates, bars, and strips which are not a part of structural steel or other metal systems specified elsewhere.

B. Types of work, in this section include metal fabrications for the following, some of which are detailed on the structural and/or architectural drawings:

1) Steel gutters and framing.

2) Vertical aluminium ladders.

3) Fire escape staircases.

4) Aluminium louvers access doors.

5) Powder coated steel pipes balustrade.

**1.02 Related Work**

A. Section 05520: Handrails and Railings.

* 1. **Quality Assurances**

A. Field Measurements: Take field measurements prior to preparation of shop drawings and fabrication, where possible. Do not delay job progress; allow for timing and fitting where taking field measurements before fabrication might delay work.

B. Shop Assembly: Pre-assemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for re-assembly and coordinated installation.

* 1. **Submittals**

A. Submit items in accordance with the SPECIAL PROVISIONS.

B. **Product Data**: Submit Manufacturer’s specifications, anchor details and installation instructions for products used in miscellaneous metal fabrications, including paint products.

C. Shop Drawings: Submit shop drawings for fabrication and erection of miscellaneous metal fabrications, Include plan, elevations and details of sections and connections, Show anchorage and accessory items. Provide templates for anchor and bolt installation in critical area,

1. Where materials or fabrications are indicated to comply with certain requirement for design loading, include structural computations, material properties and other information needed for structural analysis.

D. **Samples**: Submit the following samples:

1) Fasteners: Threaded; standard fasteners; or wedged type.

2) Bolts, nuts and washers: Regular Hexagon head type washers, round, carbon steel.

3) Two pieces of floor bar grating size as ordered by the Engineer.

4) Welding Materials: Jordan General Specifications; type required for materials being welded.

**PART 2 PRODUCTS**

**2.01 Materials**

A. Ferrous Metals

1) Metal Surfaces, General For fabrication of miscellaneous metal work which will be exposed-to-view, use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness.

2) Steel Plates, Shapes and Bars

3) Stainless Steel Plate and Sheet.

4) Stainless Steel Bolts, Hex Cap Screws and Studs.

1. Steel pipe: Local or International Specifications; type and grade as required for design loading; black finish; standards weight.
2. Brackets, flanges and Anchors: Cast or formed metal of the same type material and finish as supported rails, unless otherwise indicated.
3. Concrete Inserts: Threaded or wedge type; galvanized ferrous castings, either malleable iron, or cast steel, provide bolts, washers and shims as required , hot dip galvanized.

B. Fasteners

1) Bolts and Nuts: Regular hexagon head type, Grade A.

1. Plain Washers: Round, Carbon Steel

C. Paint:

1) Shop Primer for Ferrous Metal : Manufacturer's or fabricator's standard, fast -curing, lead-free, "Koppers" primer; selected for good resistance to normal atmospheric corrosion, for compatibility with finish paint systems indicated and for capability of obtaining a sound foundation for field-applied topcoats despite prolonged exposure.

2) Galvanizing Repair Paint: High zinc dust content paint for re galvanizing welds in galvanized steel, complying with the Local or International Specification.

**2.02** **Fabrication, General**

A. Workmanship

1) Use materials of size and thickness indicated or, if not indicated, as required to produce strength and durability in finished product for use intended. Work to dimensions shown or accepted on shop drawings, using proven details of fabrication and support. Use type of materials shown or specified for various components of work.

2) Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 1 nun (I/32 inch), unless otherwise shown. From bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

1. Weld corners and seams continuously, complying with Local or International Specifications recommendations. At exposed connections, grind exposed welds smooth and flush to match and blend with adjoining surfaces. Welding to or on structural steel shall be in accordance with the Structural Welding Code of the American welding Society.
2. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of type shown or, if not shown, Phillips flat-head (counter sunk) screws or bolts.
3. Prepare for anchorage of type indicated, coordinated with supporting structure. Fabricate and space anchoring devices to provide adequate support for intended use.
4. Cut, reinforce, drill and tap miscellaneous metal work as indicated to receive finish hardware and similar items.
5. Galvanizing: furnish a zinc coating for those items shown or specified to be galvanized, as follows:
6. galvanizing iron and steel hardware.
7. Galvanizing rolled, pressed and forged steel shapes, plates, bars and strip 3 mm (1/8 – inch) thick and heavier.
8. galvanizing assembled steel products.
9. Shop Painting: Apply shop primer to surfaces of metal fabrications except those which are galvanized, stainless steel or as indicated to be embedded in concrete or masonry, unless otherwise indicated, and in compliance with requirements of the Local or International Specifications “ Paint Application Specification for shop painting”.
10. Surface Preparation: Prepare ferrous metal surfaces to comply with minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed metal fabrications.

1) Interiors (SSPC Zone 1 A) : SSPC-SP3 “Power Tool Cleaning”.

**2.03 Steel Gutters and Frames**

1. Steel gutters shall, unless otherwise indicated, conform to Local or International Standard Specifications. Edges of gutters shall be banded with bars 3 mm (1/8 inch) less in depth than the bearing bars. Banding bars shall be flush with top of bearing bars. Furnish frame of steel shapes and all –welded construction finished to match gutter. Frames shall be anchored to structural members with bolts or toggles bolts. Floor grating and frames shall be galvanized.

**2.04 Aluminium Louvers Access Doors**

1. Fabricate and install aluminium louvered access doors as indicated on the drawings, Bills of quantities.
   1. **Vertical Aluminium Ladders**
2. Fabricated and install vertical aluminium ladders for the locations shown, with dimensions, spacing,,, details and anchorage’s as indicated. Comply with the spacing, details and anchorages, as indicated on the approved Shop Drawings.
3. Fit rungs in centreline of side rails, plug rivet and grind smooth on outer rails faces.
4. Support each ladder using brackets as detailed.
5. Make good to other trades affected by the installation of the aluminium ladders and finish off to the Engineer approval.

**2.06 Fire Escape Staircases**

1. Furnish all requisite materials, fabricate and install fire escape star case complete with all accessories as shown on the detail drawings.
2. All work shall be carried out in strict accordance with approved shop drawings.
3. Clean all surfaces down to bare metal, obtain the engineer’s approval and apply heart resistant paint comprising primer , under coat and finish coats, touch up paint as deemed necessary after installation.,
4. All surfaces which are in direct contact with concrete shall be treated with an anticorrosion paint.

**PART 3 - EXECUTION**

**3.01 Preparation**

A. Field Measurements take field measurements prior to preparation of shop drawings and fabrication, where possible. . Do not delay job progress; allow for trimming and fitting where taking field measurements before fabrication might delay work.

B. Coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, such as concrete inserts, sleeves, anchor bolts and miscellaneous items having integral anchors, which are to be embedded in concrete construction. Coordinate delivery of such items to project site.

**3.02 Installation**

**A. General**

1) Fastening to In-Place Construction Install anchorage devices and fasteners where necessary for securing miscellaneous metal fabrications to in-lace construction; including, threaded fasteners for connectors as required.

* 1. Cutting, Fitting and Placement:

a. Perform cutting, drilling and fitting required for installation of miscellaneous metal fabrications. Set work accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels. Use temporary bracing or anchors in formwork for items, which are to be built into concrete, masonry or similar construction.

b. Fit exposed connections accurately together to form tight hairline joints. Weld Connections whom are not to be left as exposed joints, but cannot be shop-welded because of shipping size limitations. Grind exposed joints smooth and touch-up shop paint coat.

* 1. Field welding: Comply with Jordan General Specifications Code for procedures of manual shielded metal-arc welding, appearance and quality of welds made, and methods used in correcting welding work.

**3.03 Adjust and Clean**

A. Touch-Up Painting immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used *for* shop painting. Apply by brush or spray to provide a minimum dry-film thickness of .05 mm (2.0 mils).

B. For Galvanized Surfaces: Clean field welds, bolted connections and abraded areas and apply two coats of galvanizing repair paint.

**END OF SECTION**

# SECTION 05520

# HANDRAILS AND RAILINGS

**PART 1 GENERAL**

**1.01 Section Includes**

A. Steel pipe handrails and fittings; complete with all requisite accessories.

B. Paint finish hand railing.

**1.02 Related Sections**

1. Section 05500: Attachment plates, hold- down bolts, angles, including anchorage etc.
2. Section 09900: painting: Paint finish.

**1.03** **Design Requirements**

A. Railing assembly, wall rails, and attachments to resist lateral force of 35 kg. at any point without damage or permanent set. Test in accordance with the Local or International Specifications.

**1.04 Submittals for Review**

1. Shop Drawings: Indicate profiles, sizes, connection attachments, anchorage, size and type of fasteners, and accessories.
2. Samples: Submit long samples of handrail. Submit samples, of elbow, Tee, wall bracket, escutcheon and end stop.

**PART 2 PRODUCTS**

**2.01 Acceptable Manufacturers**

The Contractor shall submit to the Engineer the names of three manufacturers and their products, which will be acceptable under this section. Approval of the manufacturer or product must be obtained before proceeding with associated work.

**2.02** **Steel Pipe Railings and Handrails**

1. Fabricate Steel pipe railings and handrails to design, dimensions, and details indicated. Furnish railings and handrails members formed of the sized indicated conforming to the Local or International Specifications, standard weight, galvanized.
2. Fabrication: Jointing of post, rail, and corners shall be by one of the following methods:
3. Flush-type rail fittings of commercial stand, welded and ground smooth with railing splice locks secured with 10 mm (3/8 inch) hexagonal-recessed-head set screws.
4. Mitered and welded joints made by fitting post to top rail and intermediate rail to post, mitering corners, groove welding joints, and grinding smooth. Railing splices shall be butted and reinforced by a tight-fitting interior sleeve not less that 152 mm (6 inch) long.
5. Railings may be bend at corners in lieu of jointing, provide bends are made in suitable jigs and that the pipe is not crushed.
6. Furnish wall return at ends of wall-mounted handrails.
7. Close exposed ends of pipe by welding 5 mm (3/16 inch) thick steel plate in place or by use of prefabricated fittings.
8. Furnish removable railing where indicated.
9. Railings and handrails shall be capable of withstanding a concentrated load of 91 kg (200 pounds) applied at any point in any direction.

**2.03 Steel Railing System**

1. Rails and Posts: 50 mm diameter pipe; 25 mm posts and /or supports; welded joints
2. Fittings: Elbows, T-shapes, wall brackets, escutcheons, and caps; steel.
3. Mounting adjustable brackets and flanges, with steel inserts for casting in concrete with steel brackets for embedding in masonry. Prepare backing plate for mounting in wall and flow construction.
4. Exposed Fasteners: Flush countersunk screws or bolts; consistent with design of railing.
5. Splice Connectors: Steel welding collars.
6. Shop Refinishing: Powder coated to colour as selected.

**2.04 Fabrication**

1. Fit and shop assemble components in largest practical sizes for delivery to site.
2. Fabricate components with joints tightly fitted and secured. Provide spigots and selves to accommodate site assembly and installation.
3. Provide anchors, plates and angles, etc., as required for connecting railings to structure.
4. Exposed Mechanical Fastenings: Flush countersunk screws or bolts ; unobtrusively located; consistent with design of component, except where specifically noted otherwise.
5. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.
6. Exterior Components: Continuously seal joined pieces by continuous welds. Drill condense drainage holes at bottom of members at locations that will not encourage water intrusion.
7. Interior Components: Continuously seal joined pieces by continuous welds.
8. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints but tight, flush, and hairline. Ease exposed edges to small uniform radius.
9. Accurately form components, to each other and to building structure.
   1. **Fabrication (Cont’d)**
10. Accommodate for expansion and contraction of members and building movement without damage to connections or members.

**PART 3 - EXECUTION**

**3.01 Examination**

**A. Verify that field conditions are acceptable and are ready to receive works**

**3.02 Preparation**

A. Clean and strip primed steel items to bare metal where site welding is required.

1. Supply items required to be cast into concrete and/or embedded in masonry with setting templates, to appropriate sections.
   1. **Installation**
2. Install in accordance with manufacturers instructions.
3. Install components plumb and level, accurately fitted, free from distortion or defects.
4. Anchor railings to structure with anchors, plates, angles, etc., as approved by the Engineer.
5. Field weld anchors as indicated on approved shop drawings. Touch-up welds with primer. Grind welds smooth.
6. Conceal bolts and screws whenever possible. Where not concealed, use flush countersunk fastenings.

**3.04 Erection Tolerances**

1. Maximum Variation from Plumb: 3 mm per storey, non- cumulative.
2. Maximum Offset from True Alignment; 3 mm.
3. Maximum Out- of – Position: 3 mm.

**3.05 Schedule**

1. Refer to the Drawings and Book of Details for Detail Nos. and locations.
2. Steel pipe railings, paint finish.

**END OF SECTION**

# SECTION 05530

# METAL GRATINGS AND COVER PLATES

**PART 1 GENERAL**

* 1. **SCOPE OF WORK**

Furnish all labor, materials, equipment and incidentals required to install metal gratings and floor cover plates along with embedded or attached support frames as shown on the Drawings or as specified herein.

* 1. **RELATED WORK**

Grating or cover plate anchoring devices for attaching these supports to concrete are included in Section 05500.

* 1. **SUBMITTALS**

- Submit to the Engineer, for approval before fabrication, detailed Shop Drawings showing sizes of members, method of assembly, anchorage and connection to other members.

- Submit manufacturer’s product data for gratings and plates including span and deflection tables and details of construction.

- Submit manufacturer’s installation instructions.

- Submit samples 60 cm by 60 cm in size, illustrating surface finish color, texture and jointing details.

* 1. **REFERENCE STANDARDS**

- Aluminum Association

Engineering Data for Aluminum Structures (publication 33).

- American national Standards Institute (ANSI)

ANSI A202.1 – Metal Bars Grating Manual for Steel and Aluminum Grating and Stair Treads.

- American Society for Testing and Materials (ASTM)

ASTM A276 – Standard Specification for Stainless and Heat – Resisting Steel Bars and Shapes.

- American Welding Society (AWS)

AWS D1.2 – Structural Welding Code – aluminum

Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

* 1. **QUALITY ASSURANCE**

- The work of this Section shall be completely coordinated with the work of other Sections. Verify at the site the dimensions and the work of other trades adjoining items of work in this Section before fabricating or installing the items specified.

- Furnish to the pertinent trades all items included under this Section that are to be built into the work of other Sections.

**PART 2 PRODUCTS**

* 1. **RECTANGULAR ALUMINUM BAR GRATING AND APPURTENANCES**

- Provide aluminum grating of the depths and bearing bar thicknesses noted on the Drawings and specified, with bearing bars spaced at 3 cm on center and cross bars supports at 10 cm on center. Grating material shall be aluminum alloy 6063 – T6. Approved manufacturers are McNichols Co., Tampa, FL – GAL Series; or Seidelhuber Metal Products, Inc., San Carlos, CA – 19S4 Series; or equal.

* + 1. Grating cross bars shall be attached to the bearing bars with interlocked swaged joints having no exposed welding.
    2. Grating provided shall meet or exceed the following load and deflection criteria for the number of spans and span lengths at which it will be utilized:
       1. The span which the grating is installed shall not exceed the fabricator’s maximum recommended span,
       2. The grating shall produce a deflection of 0.6 cm or less under a uniform live load of 1.5 kg/cm2.
       3. Grating shall produce a deflection of 0.6 cm or less under a concentrated live load of 135 kg applied at mid-span.
    3. Openings 5 cm or greater in diameter / dimension and grating edges shall be banded with a bar of the same depth and thickness as the bearing bars. Cut bearing or cross bars shall be welded to the banding bar.
    4. Provide trench grating with equal “stubs”.

- Grating, frames and supports shall be all aluminum construction, as shown on the Drawings and specified, fabricated from aluminum alloy 6063-T6.

- Grating clamps, nuts, bolts, washers and other fastening devices for grating and grating supports shall be type 316 stainless steel.

* 1. Provide saddle clip welded grating anchors.

- Finishes:

* 1. Grating and frames – Mill finish
  2. Surface – Plain Aluminum Oxide
  3. **ALLUMINUM COVER PALTES**

- Cover plates shall be aluminum tread plate, alloy 6061 – T6 having a raised figure pattern on one surface to provide improved traction.

* 1. Unless otherwise noted, provide 10 mm plate thickness.

- Plate, frames and supports shall be all aluminum construction as shown on the Drawings and specified.

- Cover plate fastening devices and hardware shall be Type 316 stainless steel.

- Mill Finish.

* 1. **FABRICATION**

- Provide work true to detail, with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture free from defects impairing strength of durability.

- Field verifies dimensions prior to fabrication.

- Provide connections and accessories of sufficient strength to safely withstand stresses and strains to which they will be subjected. Threaded connections shall be made so that the threads are concealed by fitting.

- Angle frames for grating and floor shall be welded and mitered with welded strap anchors attached.

- Welded joints shall be rigid and continuously welded or spot welded as specified or shown. Dress the face of welds flush and smooth. Exposed joints shall be close fitting and located where least conspicuous.

- Welding of parts shall be in compliance with the latest edition of AWS D1.2. Welding only to be done where shown, specified, or permitted by the Engineer. Welding shall be done by welders certified to perform welding in accordance with the requirements of the AWS Code. Component parts of built-up members to be welded shall be adequately supported and lamped or held by other adequate means to hold the parts in proper relation for welding.

- Weld aluminum Work on the unexposed side when possible in order to prevent pitting or discoloration.

- Apply one coat of methacrylate lacquer to all aluminum before shipment from the factory.

**PART 3 EXECUTION**

* 1. **INSTALLATION**

- Install all items furnished except items to be embedded in concrete which shall be installed under Division 3. Install items to be attached to concrete or masonry after such work is completed and in compliance with the details shown.

- Field cutting of finished surfaces is not allowed unless specifically approved by the Engineer. When cutting is approved, use mechanical cutting tools; do not use flame cutting tools.

- Secure grating with fastening devices as specified to prevent movement, except where removable grating is called for on Drawings.

- Where aluminum contacts a dissimilar metal, field-apply a heavy brush coat of zinc-chromate primer followed by two coats of aluminum metal and masonry paint to the dissimilar metal.

- Where aluminum contacts masonry or concrete, field-apply a heavy brush coat of zinc chromate primer to the masonry or concrete. For embedded items, coat the embed.

- Where aluminum contacts wood, field-apply two coats of aluminum metal and masonry paint to the wood.

* 1. **FIELD QUALITY CONTROL**

- Tolerances

* 1. Maximum space between adjoining or abutting sections: 6 mm.
  2. Maximum variation from top surface plane of adjoining or abutting sections or structure: 3 mm.

**END OF SECTION**

# SECTION 05550

# FASTENERS

**PART 1 GENERAL**

**1-1 DESCRIPTION**

This Section covers fastening devices for the following Conditions:

Assembly and erection bolts

Assembly bolts for equipment

Structure anchor bolts cast in concrete, precast architectural concrete, and precast hollow core slabs.

Equipment anchor bolts cast in concrete.

Equipment anchor bolts not cast in concrete.

Expansion anchors installed in hardened concrete

Welding

Except where specifically indicated or specified otherwise, all anchor bolts shall be carbon steel at least 19 mm in diameter and expansion anchors shall be of the type specified.

**1-1.01 RELATED WORK**

1. General Equipment and Material Stipulations

The General Equipment and Material Stipulations shall apply to all materials furnished under this section.

2. Work Specified Elsewhere

The actual job conditions and locations where fasteners will be used are covered under other sections of this Contract. Other items of work that relate to and are referenced in this section are included in the SUBMITTALS Section.

**1-2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work of this section are listed. Codes and standards current at the time of bid shall be used.

**1-2.01 ASTM - AMERICAN SOCIETY FOR TESTING AND MATERIALS**

|  |  |
| --- | --- |
| A36 | Structural Steel, Standard Specification |
| A120 | Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) welded and Seamless, for Ordinary Uses, Standard Specification for |
| A153 | Zinc Coating (Hot-Dip) on Iron and Steel Hardware, Standard Specification |
| A164 | Electrodeposited Coatings of Zinc on Steel, Standard Specification |
| A307 | Carbon Steel Externally Threaded Standard Fasteners, Standard Specification |
| A320 | Alloy Steel Bolting Materials for Low-Temperature Service, Standard Specification |
| A325 | High-Strength Bolts for Structural Steel Joints, Standard Specification |
| A385 | Providing High-Quality Zinc Coatings (Hot-Dip), Standard Recommended Practice |
| A441 | High-Standard Low-Alloy Structural Manganese Vanadium Steel, Standard Specification |
| A490 | Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints, Standard Specification |
| A588 | High-Strength Low-Alloy Structural Steel with 50,000 psi (345 MPa) Minimum Yield Point to 4 in. (101 mm) Thick, Standard Specification |
| B316 | Aluminium-Alloy Rivet and Cold-Heading Wire an Rods, Standard Specification |

**1-2.02 ANSI - AMERICAN NATIONAL STANDARDS INSTITUTE**

B18.21.1 Lock Washers, American National Standard

B18.22.1 Plain Washers, American National Standard

**1-2.03 AISC - AMERICAN INSTITUTE OF STEEL CONSTRUCTION**

Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings.

Manual of Steel Construction

Specification for Structural Joints Using ASTM A325 or A490 Bolts.

**1-2.04 IFI - INDUSTRIAL FASTENERS INSTITUTE**

104 Mechanical and Quality Requirements for Stainless Steel and Nonferrous Bolts, Screws, Studs, and Nuts.

**1-2.05 AWS - AMERICAN WELDING SOCIETY**

D1.1 Structural Welding Code

**1-2.06 ALUMINUM ASSOCIATION**

Aluminium Construction Manual, Specification for Aluminium Structures.

Welding Aluminium

Aluminium Brazing Handbook

**1-3 QUALITY ASSURANCE**

**1-3.01 WELDING QUALIFICATION**

All welding procedures and operators for field welding shall be qualified in accordance with the applicable provisions of AWS D1.1.

All procedure and operator qualifications shall be in written form and subject to review by the Engineer. Accurate records of operator and procedures qualifications shall be maintained by the Contractor and made available to the Engineer upon request.

**1-4 SUBMITTALS**

**1-4.01 DRAWINGS AND DATA**

Complete assembly and installation Drawings, together with detailed specifications, design calculation and data covering materials used, forming a part of the anchorage materials to be furnished, shall be submitted in accordance with the SUBMITTALS Section.

**1-5 PRODUCT HANDLING**

**1-5.01 DELIVERY**

Anchor bolts shall be delivered in time to permit setting when structural concrete is placed.

**1-5.02 STORAGE**

Care shall be taken in the storage of anchorage materials to prevent rusting and damage to the threads.

**PART 2 PRODUCTS**

**2-1 MATERIALS**

**2-1.01 MATERIAL LIST**

Materials used for the manufacturer and fabrication of fasteners shall be as follows:

**Equipment Anchor Bolts, Washers, and Nuts**

|  |  |
| --- | --- |
| **MATERIAL** | **SPECIFICATION** |
| Carbon Steel | ASTM A307, with nuts conforming to ASTM A307 Grade B heavy hexagon. |
| Galvanized Steel | Carbon Steel Bolts and nuts; hot-dip galvanized ASTM A153 and A385, or zinc plated ASTM A164 Type GS. |
| Stainless steel | IFI-104, Grade 303 or 305. |
| Self-Locking Nuts | Prevailing torque type; IFI-100, Grade A. |
| Flat Washers | ANSI B18.22; of the same material as bolts and nuts. |
| Lock Washers | Spring type; ANSI B18.21.1. |
| Bevelled Washers | Table 1 of Specifications for Structural Joints using ASTM A325 Bolts, AISC Steel Construction Manual. |
| Sleeves | ASTM A120 Standard weight pipe or formed ASTM A36 plate; galvanized. |

**Structural Anchor Bolts**

Unfinished Carbon With lock washers, spring type, ANSI B18.21.1; and Steel nuts conforming to ASTM A307 Grade B heavy hexagon, Galvanized where either connection component is aluminium or galvanized steel.

|  |  |
| --- | --- |
| **MATERIAL** | **SPECIFICATION** |
| 19 mm and larger | ASTM A36. |
| Under 19 mm | ASTM A307, Grade A. |
| High Strength Bolts | High Strength ASTM A325, Type 1 bolts, nuts, and washers. |
| Stainless Steel Bolts | ASTM A320, B8. |

|  |  |
| --- | --- |
| **MATERIAL** | **SPECIFICATION** |
| **Assembly and Erection Bolts, Washers, and Nuts** | |
| Steel | Carbon Steel ASTM A307, Grade A. |
| Galvanized Steel | Carbon Steel Bolts and nuts; hot-dip galvanized ASTM A153, or zinc plated ASTM A164 Type GS. |
| Stainless Steel | IFI-104, Grade 303 or 305. |
| High Strength Steel | ASTM A325 |
| **Aluminium** | |
| Rivets | ASTM B316, Alloy 6061-T6. |
| Bolts | IFI-104, Grade 24T4. |
| Self-Locking Nuts | Prevailing Torque Type; IFI-100, Grade A. |
| Flat Washers | ANSI B18.22.1; of the same material as bolts and nuts. |
| Lock Washers | Spring type, ANSI B18.21.1. |
| Bevelled Washers | Table 1 of Specifications for structural Joints Using ASTM A325 or A490 Bolts, AISC Steel Construction Manual. |
| **Anchors** | |
| Expansions Anchors | Fed Spc FF-S-325, cinch anchor type, Group 1, Type 1, Class 2 (3-Unit); Group 1, Type 2, Class 2, Style (3-Unit); or self-drilling type, Group III, Type 1. |
| Concrete Anchors | Welded stud type, 10 mm by 100 mm. |
| Screws, Stainless Steel | IFI-104, Grade 303 or 305 |
| Welding Electrodes | AWS Specification, low hydrogen types. |
| ASTM A36 Steel and ASTM A441 Steel. | Class E70XXX or Grade  F7X-EXXX. |
| Aluminium | As per "Aluminium Construction Manual Specification for Aluminium Structures' by the Aluminium Association. |
| Stainless Steel | As recommended by the steel and electrode manufacturers to provide full strength welds without reduction in corrosion resistance of the parent metal.  Corrosion resistance of weld metal shall be not less than the corrosion resistance of the parent. |

**2-2 PERFORMANCE AND DESIGN REQUIREMENTS**

**2-2.01 EQUIPMENT ANCHOR BOLTS**

Equipment anchor bolts, which are cast-in-place in concrete for equipment installation, shall be provided with sufficient threads to permit a nut to be installed on the concrete side of the concrete form or supporting template. Three nuts shall be furnished for anchor bolts indicated on the Drawings to have lock nuts; two nuts shall be furnished for all other anchor bolts.

Unless otherwise indicated or specified, anchor bolts for items of equipment mounted on base-plates shall be long enough to permit 36 mm of grout beneath the base-plate and to provide adequate anchorage into structural concrete.

Anchor bolts shall be of the following types as indicated on the Drawings and/or as specified:

L-shaped hook type

Straight-bolt with square head

Straight-bolt with square plate welded to bolt, and nut welded to plate and bolt.

Coupled-bolt with sleeve welded to square plate and bolt.

Anchor bolt, nuts which are exposed to view after installation, shall be hexagonal cap nuts with rounded tops.

**A. Sleeved Anchor Bolts**

Anchor bolts of the sleeve type, or coupled sleeve type shall be centered in pipe sleeves with an inside diameter approximately 2-1/2 times the bolt diameter and with a length approximately 8 times the bolt diameter and a square plate with a minimum thickness of one-half the diameter of the bolt.

**2-2.02 STRUCTURAL ANCHOR BOLTS**

Structural anchor bolts shall be provided with all shields, anchor plates, and nuts as indicated on the Drawings. Each bolt shall be furnished with two nuts and sufficient threads to permit a nut to be installed on each side of the concrete form or template.

All anchor bolts 19 mm and larger shall be fabricated from ASTM A36 steel rods. Anchor bolts smaller than 10 mm shall conform to ASTM A307, Grade A.

High strength anchor bolts shall conform to all requirements for ASTM A325 bolts of the "Specifications for Structural Joints Using ASTM A325 or A490 Bolts", as approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation and endorsed by AISC, except as otherwise specified. Bolt length shall be determined in accordance with the Research Council's Specifications and Commentary.

**2-2.03 ASSEMBLY BOLTS**

Assembly bolts shall be of the style and fabricated from material as specified for the equipment or material.

**2-2.04 EXPANSION ANCHORS**

Expansion anchors shall be of the cinch anchor or self-drilling type.

**2-2.05 WELDING**

**A. Ferrous Metal**

Permissible weld stress for all structural fillet welding provided under these specifications shall be as tabulated in AWS D1.1 except as specified herein. The allowable shear stress on the effective throat of a fillet weld shall not exceed 145 MPa for ASTM A36, ASTM A441, and ASTM A588 steels. "Effective throat" shall be the shortest distance from the root to the face of the diagrammatic weld regardless of weld size.

Except as otherwise specified, welding shall be performed using only those joint details which have a prequalified status when performed in accordance with the AWS code and AISC specification.

Welds that are not dimensioned on the Drawings shall be sized to develop the full strength of the least strength component involved in the connection.

**B. Aluminum Welding**

Welding and brazing of aluminum shall be in accordance with the recommendations of the Aluminum Association as contained in its publications, "Welding Aluminum" and "Aluminum Brazing Handbook". All welding rod, filler wire, brazing wire flux, and other materials used in such welding shall be as recommended by the Aluminum Association for use in conjunction with the alloy to be welded in each case.

**PART 3 EXECUTION**

**3-1 INSTALLATION**

**3-1.01 Anchor Bolts**

Anchor bolts shall be furnished complete with all necessary nuts, pipe sleeves, and plates for proper installation. Anchor bolts or sleeves embedded in concrete shall be set prior to placing of concrete .

Anchor bolts of the sleeve type of coupled sleeve type shall be accurately located and centered in pipe sleeves.

Tightening of high strength bolts shall be done using either the calibrated wrench method or the "turn-of-nut" method. If the bolts are tightened by the calibrated wrench method, each impact wrench shall be calibrated at the start of each day's work and at least once during the day. Wrench calibration shall be performed using the same length of hose and air any ASTM A325 bolt, which has been tightened more than one-half, turn beyond snug-tight shall not be loosened and retightened. All such bolts shall be discarded and new bolts used in their place.

**3-1.02 Expansion Anchors**

Expansion anchors shall be installed in conformity with he manufacturer's recommendations for maximum holding power, but in no case shall the depth of the hole be less than four bolt diameters. Minimum distance between the center of any expansion anchor and an edge or exterior corner of concrete shall be not less than 4-1/2 times the diameter of the hole in which it is installed.

**3-1.03 Welding**

**A. Ferrous Welding**

Except as otherwise specified, all welds, welding, and related operations for structural steel shall be in conformity with the applicable provisions of the AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings, including its supplements, and AWS Structural Welding Code AWS D1.1.

All welded joints exposed in exterior locations or subject to submergence in any location shall be sealed watertight with continuous welds along all contact edges. Welds shall be sized to develop the full strength of the least strength component involved in the connection.

Components to be welded shall be accurately positioned and shall be rigidly secured during welding.

Each welding operator shall be qualified for all welding procedures and positions required in a joint that he weld. One operator shall make the entire weld of any structural joint.

**B. Aluminium Welding**

Welded and brazed joints shall be free of porosity cracks, and blowholes, and shall be finished to match adjacent surfaces. When welding and dressing operations are complete, all welding flux shall be removed without undue delay and all welded or brazed joints thoroughly cleaned and sealed.

**3-2 FIELD QUALITY CONTROL**

**3-2.01 Inspection**

The Contractor shall provide visual inspection of all welds and shall correct all defective welds in accordance with the requirements of AWS D1.1.

Defective welds shall be repaired at the Contractor's expense and the welder responsible for the weld shall be re-qualified at the Contractor's expense.

**END OF SECTION**

# SECTION 05570

# CORROSION PROTECTION

**PART 1 – GENERAL**

This Section covers the selection of the appropriate corrosion protection including the surface preparation, application and inspection.

Unless otherwise specified the full corrosion protection system shall follow the system specified for the particular operating conditions. Should conditions prevail that do not clearly fit into designated operating conditions the Contractor shall provide the required system for the next more onerous conditions.

The colour system shall be selected in conjunction with the Engineer during the design appraisal period.

**PART 2 – PRODUCTS**

**2.1 GENERAL REQUIREMENTS**

**2.1.1 General**

Paints, including primers and undercoats, shall be obtained as far as possible from one and the same manufacturer and shall, except where application has to be made within a limited time of mixing, be ready for use and compatible with one another. Only paint which is delivered in sealed containers, bearing the name of the manufacturer and properly labeled as to its quality, date of manufacture, shelf life and instructions for use, will be acceptable.

All finishes shall be applied strictly in accordance with the direction of the manufacturer and BS 5493.

Test plates carrying finishes from the actual coating used may be requested by the Engineer for test and inspection purposes.

**2.1.2 Application**

Paints shall be applied strictly in accordance with the paint manufacturer's instructions, with regard to surface preparation, temperature, humidity mixing procedure and method of application.

All surfaces of Plant shall be protected against corrosion and/or erosion. In the case of mating surfaces, the primary coats shall be applied to the mating surfaces prior to assembly. The mating surfaces of structural steelwork shall be sealed with a hydrocarbon mastic paste during erection. Where dissimilar metals are in contact, and the possibility of electrolyte corrosion exists, the mating surfaces shall be insulated.

Where site painting is required, this shall only be carried out when the surfaces are dry, the air temperature is above 5 o C and the relative humidity is less than 95%. The surface to be painted shall have a temperature of at least 3 o C above the dew point.

A maximum of 5% of compatible thinners may be added in accordance with the manufacturer's instructions and then only with the written approval and in the presence of the Engineer. Immediately after erection of Plant, any damage to its paint finish shall be made good in a manner approved by the Engineer. Damaged areas of galvanized metal or metal sprayed plant shall be made good by wire brushing, degreasing with a suitable solvent followed immediately by the application of appropriate etching primer containing not less than 90% zinc or aluminum in the dried film thickness. The color of the `touch-up' paint shall match that of the original finish.

Non-ferrous materials including aluminum and plastics shall not be painted. Glass reinforced plastic materials shall be pigmented to achieve the required finished colour.

Stainless steel components, fixings and fittings in grades 304 and 316 shall not be painted.

Galvanized structures and fittings shall not be painted unless otherwise specified.

**2.2 ZINC COATINGS FOR SMALL FERROUS COMPONENTS**

Electroplating or hot dip galvanizing will be acceptable as an alternative to painting for small ferrous components.

Hot dip galvanizing shall be carried out in accordance with BS 729 with a deposition rate of at least 610 g/m2 (75 micron thickness). After galvanizing all parts shall be passivated to minimize discoloration. All fixing bolts, washers, nuts and other items for supports and fixings shall be spun galvanized.

Zinc electroplated components shall be in accordance with BS 1706 Class 2. Cadmium coating shall not be used where the component might come into contact with potable water.

Chromium electroplating shall be in accordance with BS 4641 and the minimum coating thickness shall be greater than 75 μm.

Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, including the metal parts of relays and mechanisms shall be chromium or copper-nickel plated or have some other approved finish to prevent rust. Cores etc, which are built up of laminations or cannot for any other reasons be surface coated, shall have all exposed parts thoroughly cleaned and lacquered or compounded.

**2.3 COATING INSPECTION AND TESTING**

The Contractor shall ensure that all coatings are free from defects and adequate in all respects for the purpose intended. Coating defects are defined in BS 2015 `Glossary of Paint and related Terms'.

The painting system shall be deemed to have failed if:

a) After painting, damage has been caused by handling, impact, abrasion or welding.

b) Any portion of a paint film separates from any other or the parent metal.

c) After painting, the total dry film thickness measured by an elcometer or other approved instrument calibrated on smooth burnished steel, is less than75% of the nominal dry film thickness as defined in BS 5493.

Failure shall not include:

1. Loss of gloss.
2. Variation of shade, not affecting the anti-corrosive properties of the system.

**2.4 SURFACE PREPARATION, PAINTING AND PROTECTIVE SYSTEMS**

Unless otherwise specified or approved (e.g. if protection is of a special nature giving equal or better protection), the plant, pipework and structures shall be protected as specified in the following Schedule of Protection Systems and in accordance with BS 5493 `Protective Coating of Iron and Steel Structures against Corrosion' to suit the various environmental conditions indicated. Coatings shall be selected to give a time to first maintenance of 20 years for factory applied systems. Details of the numbered protection systems referred to in the Schedule of Protection Systems are specified below.

**2.4.1 Surface Preparation**

**a. Fettle to remove all flash, weld spatter, sharp and rough surfaces, by use of hand** operated tools.

b. Clean surfaces and remove rust, scale, dirt, loose paint, etc by use of powered hand operated wire brush or similar.

c. Blast clean, using air that is clean, dry and free from oil or other contamination. The type of abrasive used shall be selected to achieve a blast profile of 75 microns maximum and 25 microns minimum.

Blast cleaning shall be to the requirements of BS 7079 grade Sa 22.

d. Degrease surface by the use of solvents, which are compatible with and of the same manufacture, as the paint finishes.

e. Acid-pickling by the Footner /Duplex process shall be carried out immediately prior to galvanising.

**2.4.2 Metal Coatings**

Within four hours of surface preparation apply specified or appropriate metal coating in a manner as scheduled below:

a. Zinc metal spray to a nominal thickness of 100 microns in accordance with BS EN22063.

b. Hot dip galvanise BS 729. Minimum coating thickness 100 microns.

**2.4.3 Priming**

Within four hours of the final surface preparation and when all traces of grease have been removed, apply specified primer as scheduled below:

a. Inorganic zinc silicate primer, containing 40% zinc dust pigment to be applied to give a minimum film thickness of 75 microns above surface profile.

b. Appropriate polyamide cured epoxy etch primer to give a minimum film thickness of 50 microns above surface profile. Suitable for site fabrication post application.

c. Two pack epoxy sealer for sprayed metal coatings.

d. T wash' mordant solution for galvanised coatings.

The over coating interval should not be less than eight hours and not more than seven days.

No thinners are to be used and the ambient temperature for curing should not be less than 13oC.

**2.4.4 Finish Coatings**

Make good damaged areas of previous finish by powered or hand-operated wire brush. Degrease and clean with suitable solvent as required and apply further coats of the previous finish to obtain the original quality of thickness.

Previous finish to be thoroughly cleaned of all grease, dirt and dust coating and the specified finish applied within two hours.

a. High Build (HB) two pack polyamide cured epoxy micaceous iron oxide (MIO) to give a dry film thickness of not less than 100 microns.

b. High build polyamide cured epoxy resin incorporating inert pigments to be applied to give a dry film thickness of not less than 100 microns.

c. High build two pack coal tar epoxy coating with a dry film thickness of 150 microns application by airless spray.

d. Polyurethane two pack enamel to give a dry film thickness of not less than 35 microns.

e. White stove dried enamel gloss finish to give a dry film thickness of not less than 35 microns to internal surfaces.

f. Stove dried enamel primer and gloss finish to give a dry film thickness of not less than 50 microns.

g. Polyamide cured epoxy gloss coat to give a dry film thickness of not less than 35 microns.

h. Fusion bonded, dry powder epoxy coating in accordance with BGC PS/CW6 Parts 1 and 2 or equal and approved standard, to give a thickness of between 0.3 mm and 1.6 mm.

**2.5 PACKING AND PROTECTION**

Before any Plant is dispatched from a manufacturer's factory it shall be adequately protected and packed to ensure that it will arrive on Site in an undamaged condition. The methods employed for protection and packing must be suitable for withstanding the conditions which may be experienced during shipment, delivery to the Site and prolonged periods of storage in the open, whether the items are shipped in packaging cases, crates or only partially protected according to their nature.

Bright parts and bearing surfaces shall be protected from corrosion by applying a rust preventative lacquer, high melting point grease or similar temporary protection. A sufficient quantity of solvent shall be supplied with the Plant to enable this coating to be removed on Site.

All machined flanges and other mating surfaces shall be protected by means of wooden templates. The bolts for securing these templates shall not be reused in the final installation.

No one crate or package shall contain items of Plant intended for incorporation in more than one part of the Works.

All items of Plant shall be clearly marked for identification against the packing list, which shall be placed in a waterproof envelope inside every packing case or crate.

Every packing case and crate shall be indelibly marked to show its weight, serial number, top and bottom orientations, shipping marks and handling instructions.

Electrical equipment shall be enclosed in sealed airtight packages, containing dehydrating material, before being placed in packing cases on shock-absorbent material and secured therein by means of battens and shock absorbent pads.

**Schedule of Protection Systems**

| Environment  (Time to first maintenance -  20 years) | Shop Applied Coatings | | | | | Site  Coatings |
| --- | --- | --- | --- | --- | --- | --- |
|  | Substrate | Pre-treatment | First coat | Second coat | Third coat |  |
| Outdoor above water level in an exposed non-polluted coastal atmosphere  Machinery and Steelwork not in contact with Water or Sewage.  Interior of building frequently damp or wet | Steel  (Zinc sprayed)\* | Fettle, blast clean hot zinc spray  1(a), 1(c), 2(a) | Polyamide epoxy sealer  3(c) | Polyamide epoxy (HB)  4(b) | Note: overcoating for decorative purposes only. | - |
|  | Steel  (Galvanised) | Fettle, pickle, hot dip galvanise  1(a) 1(d) 2(b) | Normally unpainted | - | - | - |
|  | Cast or Ductile Iron | Fettle, blast clean  1(a) 1(c) | Zinc silicate primer  3(a) | Polyamide epoxy MIO (HB)  4(a) | - | - |
| Below Water Level  Machinery and Steelwork in contact with sewage, sludge or water | Steel  (Zinc sprayed) | Fettle, blast clean hot zinc spray  1(a) 1(c) 2(a) | Polyamide epoxy sealer  3(c) | Coal tar epoxy  HB  4(c) | - | Coal tar epoxy  HB  4(c) |
|  | Steel  (Galvanised) | Fettle, blast clean hot dip galvanise  1(a) 1(c) 2(b) | Coal tar epoxy HB  4(c) |  | - | - |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Cast or ductile iron | Fettle, blast clean  1(a) 1(c) | Zinc silicate primer  3(a) | Polyamide epoxy MIO (HB)  4(a) | Polyamide epoxy MIO(HB)  4(a) | - |
| In contact with Potable Water  Machinery and Steelwork | Steel  (Zinc sprayed) | Fettle, blast clean hot zinc spray  1(a) 1(c) 2(a) | Polyamide epoxy sealer  3(c) | Epoxy HB non-toxic for potable water | Epoxy HB non-toxic for potable water | - |
|  | Steel  (Galvanised) | Fettle, blast clean hot dip galvanise  1(a) 1(d) 2(b) | Degrease `T wash' mordant solution  3(d) |  |  |  |
|  | Cast or ductile iron | Fettle, blast clean  1(a) 1(c) | Zinc silicate primer  3(a) |  |  |  |
| Pipework | Steel - large dia | Blast clean  1(c) | Fusion bonded epoxy powder WRC approved  4(h) | - |  | - |
| Internal, external and buried | Dia < 200 Mott MacDonald | Fettle pickle hot dip galvanised  (1a) 1(d) 2(b) | Unpainted |  |  | Buried pipework shall be wrapped with hydrocarbon mastic tape |
| Within Buildings  Machinery and Steelwork Factory assembled | Steel, cast iron non ferrous materials | Fettle, wire brush clean  1(a) 1(b) | Polyamide cured epoxy primer  3(b) | Polyamide cured epoxy gloss  4(g) | - | Two pack polyurethane enamel  4(d) |
| Switchgear Control Gear  Shells frames backplate | Steel (Zinc coated) | Degrease Deburr  1(a) 1(d) | Polyamide epoxy etch primer  3(b) | Stove enamel primer  4(f) | Stove enamel gloss  4(f) and 4(e) | - |

**END** **OF SECTION**

# SECTION 05910

# GALVANIZING

**PART 1 GENERAL**

* 1. **SCOPE OF WORK**

1. Hot dip galvanizing of structural steel members, assemblies and metal fabrications.
2. Definitions
   1. Hot Dip Galvanizing: The dipping of steel members and assemblies into molten zinc for lasting (or long-term) corrosion protection. The resultant zinc coating fuses permanently with the base steel material.
   2. Electro-galvanizing: Electrodepositing or electro-plating with zinc by electrolysis for limited corrosion protection.
   3. Passivating: The chemical treatment of freshly galvanized steel materials to prevent humid storage stain (white ruse or white corrosion). This treatment (passivation) consists of quenching freshly galvanized steel in water to which a chromate or a chromic-acid solutions, or other proprietary solution, has been added.
   4. **REFERENCE STANDARDS**
3. American Hot Dip Galvanizers Association, Inc. (AHDGA)
   * 1. Publication, “Inspection Manual for Hot Dip Galvanized Products”.
4. American Society for Testing and Materials (ASTM)
   * 1. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-coated Welded and Seamless.
     2. ASTM A123 – Standard Specification Zinc (Hot – Dip Galvanized) Coatings on Iron and Steel Products.
     3. ASTM A143 – Standard Specification Safeguarding Against Embitterment of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embitterment.
     4. ASTM A153 – Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
     5. ASTM A325 – Standard Specification for Structural Bolts, Steel, Heat Treated 120 / 105 ksi Minimum Tensile Strength.
     6. ASTM A384 – Standard Practice for Safeguarding Against War-page and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
     7. ASTM A385 – Standard Practice for Providing High Quality Zinc Coating (Hot-Dip)
     8. ASTM A563 – Standard Specification for Carbon and Alloy Steel Nuts.
     9. ASTM A780 – Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
     10. ASTM B6 – Standard Practice for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting.
     11. ASTM D2092 – Standard Practice for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting.
5. Certification: Furnish Certificates of compliance with ASTM Specifications and Standards specified herein. Each certificate to be signed by Contractor and Galvanizer certifying that steel materials, bolts, nuts; washers and items of iron and steel hardware conform with specified requirements.
6. Inspections and Tests: Inspections, tests and samples to conform with ASTM Specifications and Standards. Inspections rights and privileges, procedures and acceptance or rejection of galvanized steel materials to conform with ASTM A123 or A153, as applicable. Inspections and tests include the following:
   * 1. Visual examination of samples and finished products.
     2. Tests to determine weight or mass of zinc coating per square foot of metal surface.
     3. Tests to determine distribution and uniformity of zinc coating.
   1. **SUBMITTALS**
7. Furnish Certificates of compliance with certified original and two copies forwarded to the Engineer.
   1. **DELIVERY, STORAGE AND HANDLING**
8. Packaging: Of type to prevent damage to galvanized surfaces and distortion of steel materials and components.
9. Handling and Storage: Handle and protect galvanized materials from damage to zinc coating. To avoid humid storage stain, space surfaces of galvanized materials to permit free circulation of air.
10. Damaged Material: Repair material showing evidence of damage to zinc coating. If not repairable, material with damaged coating will be subject to rejection.

**PART 2 PRODUCTS**

* 1. **STEEL MATRIALS**

1. Material for galvanizing to be geometrically suitable for galvanizing as specified in ASTM A384 and A385. Steel materials suitable for galvanizing include structural shapes, pipe, sheet, fabrications and assemblies.
2. Material to be chemically suitable for galvanizing..
   1. **IRON AND STEEL HARDWARE**
3. Bolts, nuts, washers and items of iron and steel hardware furnished or galvanized to be suitable for hot dip galvanizing.
4. Inspect iron and steel hardware before galvanizing and ascertain whether suitable for galvanizing. Replace items, which are not suitable for galvanizing.
   1. **ZING FOR GALVANIZING**
5. Conform with ASTM B6 as specified in ASTM A123.
   1. **GALVANIZING**
6. Steel members, fabrications and assemblies to be galvanized after fabrication, by hot dip process in accordance with ASTM A123, as applicable. Weight of zing coating to conform to requirements specified under “Weight of Coating” in ASTM A123, as applicable.
7. Safeguard against steel embitterment in conformance with ASTM A143.

Safeguard against war-page or distortion of steel members to conform with ASTM A384. Notify Engineer of potential war-page problems, which may require modification in design, before proceeding with steel fabrications.

1. Finish and uniformity of zinc coating and adherence of coating to conform with ASTM A123 or A153, as applicable.
2. Bolts, nuts and washers, and iron and steel hardware components to be galvanized in accordance with ASTM A123 or A153, as applicable.
3. Bolts, nuts and washers, and iron and steel hardware components to be galvanized in accordance with ASTM A153. Weight of zinc coating to conform to requirements specified under “Weight of Coating” in ASTM A153. Nuts to be tapped after galvanizing to minimum diametric amounts specified in ASTM A563. Coat nuts with waterproof lubricant, clean and dry to touch. High strength bolts for structural steel joints to be galvanized in accordance with ASTM A325.
   1. **PASSIVATING**
4. Galvanizing materials subject to extended periods of storage in open, exterior locations to be given passivating treatment or light oiling to prevent humid storage stain. Treatment, solution and process subject to review and acceptance by Engineer. Chromate passivation should not be used on items galvanized after fabrication and are to be painted after erection.
   1. **PRESERVATIVE OILS**
5. Do not treat freshly galvanized or passivated surfaces with oils, grease, or chemicals, which might interfere with adhesion of subsequent paint primers and coatings.
   1. **PAINTING**
6. Prepare galvanized metal surface to be field painted in accordance with ASTM D2092.
7. Shop coat galvanized metal surfaces with approved galvanized primer.

**PART 3 EXECUTION**

* 1. **INSTALLATION OF STEEL MATERIALS**

1. Steel materials, fabrications and assemblies are specified to be installed in various other sections under Division 5.
   1. **FIELD INSPECTION**
2. Inspect installed galvanized materials, fabrications and assemblies to conform with applicable requirements of AHDGA, consisting of visual inspection.
   1. **TOUCH UP AND REPAIR**
3. Repair damaged galvanized surfaces in accordance with ASTM A780.
4. Dry film thickness of applied repair materials to be not less than galvanized coating thickness required by ASTM A53, A123 or A153, as applicable.
5. Touch up prime-painted surface with same galvanized primer applied in shop. Clean damaged surfaces first to assure proper paint adhesion.

**END OF SECTION**

# SECTION 05990

# MISCELLANEOUS METALS

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This specification covers the supply and installation of all Miscellaneous metals as indicated on the drawings.

**1.2 APPLICABLE STANDARDS**

Except as otherwise required, materials and workmanship shall conform with the latest revision of the specification of the British Standards Institution.

**1.3 SHOP DRAWINGS**

Shop drawings together with catalogue cuts plus erection and installation details shall be submitted for all metal items. Each submittal shall be complete in detail and shall completely show construction details, reinforcement, anchorage, dimensions and installation with relationship to other items of building construction. Verify all measurements and take all field measurements necessary before fabrication.

**1.4 SAMPLES**

Samples shall be submitted prior to acceptance of materials in duplicate. Samples of manufacturer's stock shelf items shall be full size; samples of custom fabricated items shall be submitted in adequate size and detail to indicate compliance with standards of work specified. Samples shall show the quality of welding and grinding of all architectural metal items and shall serve as standard of all work after approval by the Engineer.

**PART 2 - MATERIALS**

**2.1 GENERAL**

Materials shall conform to the respective specification and other requirements specified herein.

**2.2 ALUMINIUM FOR NATURAL OR CLEAR ANODIC COATING**

Aluminum shall conform to the following specifications and be suitable for natural or clear anodizing.

Extrusions : BS 1474, Alloy HE 9 - TF.

Bars (round and square), hinges and fasteners: BS 1474, Alloy HE 30 - TF.

Plates and sheets: BS 1470, Alloy HS 5 - 0.

Rivets, bolts, screws : BS 1373, type best suitable for the purpose.

Tubing : BS 1471, type best suitable for the purpose.

**2.3 BRASS**

Extruded brass shall conform to BS 2874, Table 7, designation CZ 121.

Sheet brass shall conform to BS 2870, Table 7, designation CZ 109.

Brass fastener materials shall be of an alloy best suited for the purpose which is capable of receiving the finish specified in Paragraph 2.20 : Finishes.

**2.4 STAINLESS STEEL**

Stainless steel shall conform to the following specifications :

Sheets and strips : BS 1449: Part 4, Steel No. 304 S16.

Plates : BS 1449 : Part 4, Steel No. 304 S15.

Pipes and Tubes : BS 3605, Steel No. 801, thickness as specified.

Light gauge tubes : BS 4127.

**2.5 ANCHORS**

Expansion Shields : To the approval of the Engineer.

Toggle Bolts : To the approval of the Engineer.

**2.6 FASTENERS**

Bolts and nuts shall be suitable for use intended.

Power-driven fasteners may be used only when approved in writing.

Screws : BS 1210, BS 4174, BS 4183 and BS 4190, as suitable for the purpose.

Washers : BS 4464 for spring washers. Flat washers shall be suitable for use intended.

**2.7 FLOOR GRATING**

BS 4592, galvanized : sizes as specified on the drawings.

**2.8 SOLDER**

Solder shall conform to BS 219, Type F for copper and Type K for stainless steel.

**2.9 SOLDERING FLUX**

Soldering flux shall be paste or liquid, suitable for use with tin-lead solder.

**2.10 WELDING OF ALUMINUM**

Joints in aluminum sheet 1 mm and thicker shall be welded. Welding shall be of the inert-gas, shielded-arc type.

**2.11 SEAMS**

Seams shall conform to the following requirements :

Flat-lock seams shall finish not less than 25 mm wide.

- Soldered-lap seams shall finish not less than 25 mm wide.

- Unsoldered plain-lap seams shall lap not less than 80 mm unless otherwise specified.

- Flat seams shall be made in the direction of the flow.

**2.12 FLOOR PLATE, RAISED TREAD**

Steel plates, anti-slip surface thickness 6-8 mm, pattern to be selected by the Engineer.

**2.13 HARDWARE**

Miscellaneous hardware provided as an integral part of items specified herein shall be to the approval of the Engineer.

**2.14 INSECT SCREEN**

BS 481: Part 1 - Nom. aperture size R10 - 1, wire 0.355 mm. Material stainless steel.

**2.15 IRON CASTINGS**

Grey-iron castings: BS 1452, grade as hereinafter specified.

Malleable-iron castings: Ferritic malleable iron, tensile strength 350 N/mm2

**2.16 NICKEL-COPPER ALLOY**

Sheets and plates : BS 3072, alloy NA13. Strips : BS 3073, alloy NA13.

**2.17 STEEL PIPE AND FITTINGS**

Conforming to BS 1387, galvanized, type and class as hereinafter specified.

**2.18 STEEL SHEETS**

Uncoated : conforming to BS 1449, hot-or cold-rolled as required.

Zinc-coated : conforming to BS 2989.

**2.19 STRUCTURAL STEEL PLATES**

Conforming to BS 4360

**2.20 GALVANIZING**

Metalwork specified to be galvanized, when practicable and not indicated otherwise, shall be hot-tip processed after fabrication. Galvanizing shall be in accordance with BS 729, the coating weight being 610 gm/m2.

**2.21 SHOP PAINTING**

Unless otherwise specified, surfaces of all ferrous metal shall be shop primed in accordance with the requirements specified in Section: PAINTING AND DECORATING. Surfaces of items embedded in concrete shall not be painted.

**2.22 PROTECTING CONTACT SURFACES**

**a) Dissimilar Metals :**

Where aluminum components are in contact with, or fastened to dissimilar metals, except stainless steel or zinc, the dissimilar metals shall be given a coat of zinc chromate primer and a heavy brush coat of alkali-resistant bituminous paint. In permanently dry locations the metals may be separated by non-absorptive plastic tapes or gaskets.

**b) Masonry, Concrete or Plaster :**

Aluminum in contact with, or built into masonry, concrete or plaster shall be given a brush coat of alkali-resistant bituminous paint or clear methylacrylate lacquer.

**c) Wood :**

Where aluminum is in contact with wood or other absorptive material which may become repeatedly wet, the wood or other material shall be given a coat of aluminum pigmented bituminous paint. Joints shall be sealed with caulking compounds at points of contact with aluminum.

**2.23 PROTECTION FINISH**

**a) Fabrication and Finishing :**

After fabrication and finishing all aluminum and bronze, except surfaces in contact with sealants, shall be given two sprayed-on coats of clear, water-white, non-yellowing methylacrylate lacquer to a total minimum thickness of 0.01 mm and a total maximum thickness of 0.015 mm.

**b) Prior to Shipment :**

Prior to shipment from the factory, finished surfaces of aluminum, stainless steel and bronze shall receive a protective coating in addition to the coats of lacquer specified. Coating shall not chip, peel or flake due to temperature or weather and shall protect against discoloration and surface damage from transportation, storage and construction activities. Coating shall be readily removable without affecting the finish. Protection may be adhesive paper, waterproof tape or strippable plastic. Surfaces in contact with sealants after installation shall not be coated with any type of protective material. Such surfaces shall be thoroughly cleaned with lacquer solvent before sealants are applied.

**c) Completed Installation :**

Upon completion of installation protective coating, except methylacrylate lacquer, shall be removed and surfaces washed with water and detergent or any cleaning agent which will not effect the metal finish or adjacent surfaces. Carbon steel wool, pads, brushes or other steel tools shall not be used. Cleaning shall be done in the direction of the polishing.

**2.24 FINISHES**

**a) Finishes for all items or architectural metal shall be as follows :**

1. Aluminum shall have a clear (natural) anodic coating, to comply with BS 3987, with an average thickness of 25 micron, subject to approval by the Engineer.

2. Brass shall have a statuary finish, subject to approval by the Engineer.

3. Stainless steel shall have a ground finish, coarse 180.

**b) Uniformity of Colour Match**

Uniformity of colour match shall be controlled by photo-volt reflectometer with range not to exceed four units (Delta e) of colour measurement.

**c) Workmanship**

Items shall be shop fabricated as far as practicable. Joints shall be welded.

**d) Contact Surfaces**

Contact surfaces of connected members shall be ground true. Parts shall be so assembled that joints will be tight and practically unnoticeable without use of filling compound.

**2.25 ANCHORAGES**

Anchorage shall be provided where necessary for fastening miscellaneous metal items securely in place. Anchorage shall include slotted inserts, expansion shields and power-driven fasteners, when approved, for concrete; toggle bolts for masonry; machine and carriage bolts for steel; through bolting for masonry and wood; lag bolts and screws for wood. Slotted inserts shall be of types required to engage with the anchors and need prior approval. Anchorage shall be provided as indicated and specified herein for attachment of miscellaneous items.

**2.26 MISCELLANEOUS PLATES AND SHAPES**

Miscellaneous plates and shapes for items that do not form a part of the structural steel framework, such as lintels, sill angles, curb angles, equipment mountings and frames shall be provided to complete the work. Miscellaneous plates and shapes shall conform to BS 4360, grade 40.

**2.27 LADDERS**

Ladders shall be steel fixed-rail type, located and detailed as indicated. Ladders and accessories shall be galvanized or stainless steel as indicated on the drawings.

**2.28 PIPE BUMPER GUARDS**

Pipe bumper guards shall be steel pipe conforming to BS 1387 heavy grade and in addition shall be hot-tip galvanized conforming to BS 729: Part 1, with zinc-coating not less than 0.6 kg/m2/ Nominal diameter size of pipe shall be as indicated. Pipe guards shall be of height indicated, set plumb in concrete to depth indicated and filled solidly with concrete as specified in Section : CAST-IN-PLACE CONCRETE .

**2.29 SAFETY NOSINGS**

Safety nosing shall be installed in all concrete stair treads unless otherwise shown and in concrete platforms and landings, as indicated. Safety nosing shall be of galvanized cast-iron with cross-hatched or abrasive-surfaced nosing 76 mm wide and terminating 60 mm from the ends of treads for stairs and as indicated for platforms and landings. Safety nosing shall be provided with bent anchors for embedding into concrete and shall be flush with the top of the traffic surface.

**2.30 STEEL STAIRS**

Steel stairs complete with structural or formed channel stringers, steel-plate treads and risers, metal-pan cement-filled treads, grating treads, landings, columns, handrails and necessary bolts and other fastenings shall conform to the following requirements. Structural steel conforming to BS 4360, grade 40. Gratings for treads and landings shall conform to BS 4592. Gratings shall have non-slip nosing.

**2.31 VAULT VENTS**

Vault vents shall be galvanized steel pipe, as indicated. Screen and fittings shall be to the manufacturer's standards.

**2.32 COLUMN GUARDS**

Column guards shall be provided to protect corners of concrete columns where and as indicated on the drawings. Column guards shall be manufactured of galvanized mild steel.

**2.33 LOADING DOCK EDGE PROTECTION**

The edges of loading platforms, etc., shall be protected with galvanized mild steel angles cast into concrete. The angles shall be installed in the following places :

Cargo Building : To the edge of loading bay and ramp.

Dock edges shall be manufactured of galvanized mild steel.

**PART 3 - FABRICATION**

**3.1 HANDLING AND STORAGE**

Sheet-metal items shall be carefully handled to prevent damage to the surface, edges, and ends, and shall be stored at the site above the ground in a covered, dry location.

Damaged items that cannot be restored to like-new condition will be rejected and shall be replaced at no additional cost to the Employer.

**3.2 EXPANSION JOINTS**

Building expansion joints of the built-in bellows or flanged U-type shall be provided at locations indicated.

Expansion and contraction joints for sheet metal shall be provided at 12 m intervals for copper and stainless steel and at 6 m intervals for copper and stainless-steel distance between the last expansion joint and the end of the continuous run is more than half the required interval spacing an additional joint shall be provided. Joints shall be evenly spaced.

**3.3 ACCESS DOORS AND PANELS**

Access doors with frames shall be provided at each pipe space, at each plumbing chase and at other locations indicated. Frames and doors shall be flush type unless otherwise indicated. Frames shall be fabricated of not lighter than 2 mm nominal thickness steel with welded joints and anchorage for securing into construction. Doors shall be minimum 360 x 500 mm and of not lighter than 2 mm nominal thickness steel with stiffened edges and welded attachments. The jamb shall be hinged to frame and locked by flush-face turn-screw-operated latch. One removable access panel not less than 300 x 300 mm shall be provided and installed directly below each valve, flow indicator, damper or air splatter that is located above the ceiling and would otherwise not be accessible.

**3.4 CORNER GUARDS AND SHIELDS**

Corner guards and shields for jambs and sills of openings and edges of platforms shall be steel shapes and plates of sizes indicated and anchored in masonry or concrete with welded steel straps or end-weld stud anchors. Corner guards and shields shall be furnished and installed at locations indicated.

**3.5 STRUCTURAL STEEL DOOR FRAMES**

Structural steel door frames shall be made of rolled shapes of the sizes and weights indicated. Frames shall be neatly mitered and secured at the corners by welds and ground smooth. Jambs shall be provided with 50 x 6 x 300 mm bent metal anchors spaces not over 750 mm on centers. Provisions shall be made to stiffen the top member for all spans over 900 mm. The bottom of the frames shall extend below the finish floor line and shall be secured to the slab by means of angle clips and expansion bolts. Stops shall be made of 38 x 16 mm bars welded or top-screwed to the frame or not more than 460 mm centers. Screws shall be countersunk. Stops shall be so placed that full contact with the frame will be assured. Any necessary reinforcements shall be made and the frame shall be drilled and tapped as required for hardware.

**3.6 FLOOR GRATINGS AND FRAMES**

Floor gratings shall be designed to support a live load of 500 kg/m2 for the spans indicated. Edges of gratings shall be banded with bars of the same size as bearing bars.

Frames of steel shapes and all-welded construction finished to match grating shall be provided as indicated. Frames set in concrete shall be provided with welded-on anchors. Frames shall be anchored to structural members with bolts, toggle bolts or expansion shields and bolts. Floor gratings and frames shall be galvanized.

**3.7 STEEL STAIRS**

Steel floor plate, metal pan for cement fill and steel gratings shall be supported on angle cleats welded to stringers. Sheet-steel landings shall have angle stiffeners welded on. Stringers shall be continued around landings as shown and shall have an angle welded on to support the steel landings. Exposed ends shall be closed. Stair treads and landings shall have self-furring or rib lath securely attached as reinforcement for the cement finish. The lath shall be installed immediately before the cement finish is applied. Minimum weight of lath to be 1.35 kg/m2.

**3.8 LADDERS**

Rungs shall be solid-section rods, fitted into punched holes in rails, welded and ground smooth. All splices and connections shall have a smooth transition with original members without projections that are sharp or more extensive than required for joint strength.

Rails shall be fitted with brackets for anchorage to structure. Bracket spacing shall be as indicated.

**3.9 CONCRETE ANCHORAGE**

Concrete anchorage for posts shall be by means of steel pipe sleeve inserts set and anchored in the concrete as indicated. Posts shall be inserted into steel pipe sleeves, leveled, plumbed and aligned. The annular space between pipe posts and pipe sleeve inserts shall be filled solid with molten lead or a quick-setting hydraulic cement. anchorage joint shall be covered with pipe collar pinned to post. Ends of rails shall be secured by means of standard steel pipe flange anchored to concrete walls by expansion shields and bolts.

Masonry anchorage for posts shall be standard steel pipe flange secured to masonry with expansion shields and bolts or toggle bolts. Rail ends shall be anchored with a standard steel pipe flange bolted to the wall.

Steel anchorage for posts and rails shall be with base plates bolted to stringers or structural framework.

**3.10 TRENCH COVERS AND FRAMES**

Frames and anchors shall be all welded construction of structural steel shapes and plates. Frame construction shall be such that tops of frames and cover plates will finish flush with the floor. Covers shall be steel floor plate. Holes for drainage shall be provided. Flush drop handles for removal shall be formed from 6 mm round bar and burrs shall be removed from cover plates and exposed edges of frames.

**3.11 COLUMN GUARDS**

Column guards shall consist of mild steel angles, sizes as shown, 2100 mm long with 10 mm diameter mild steel bar lugs 150 mm long, one end split and caulked and the other end welded to the inside of the angle at 450 to the legs and 90o to the length. Lugs shall be spaced at 150 mm centres.

**3.12 LOADING DECK EDGE PROTECTION**

Deck edge angles shall consist of 100 x 50 x 10 mm angle. Angles shall have 10 mm diameter mild steel bar lugs 150 mm long with one end split and caulked and the other end welded not o the inside of the angle at 45o to the legs and at 90 o to the length. Lugs shall be spaced at 150 mm centres.

**PART 4 - EXECUTION**

**4.1 GENERAL**

Except when specified in other sections of these specifications, all non-ferrous metal and stainless steel (corrosion-resisting steel) items shall be provided under this section of the specifications. Carefully examine all drawings for metal items not specifically noted but normally included in this trade. Materials and parts necessary to complete each item, even though such work is not definitely shown or specified, shall be provided including all bolts, anchors, supports, braces and connections necessary for the completion of the work.

**4.2 STANDARDS OF WORK**

Standards of work for the design, fabrication, welding and erection of all miscellaneous metal work with structural steel components shall be in accordance with the specifications of the British Standards Institution. All items exposed-to-view shall have welds ground and finished to match adjoining surfaces. Welds in internal corners shall be square-root welds; concave welds are not permitted. Miscellaneous metal items concealed from view shall not require grinding of welds. Mechanical fastenings shall be concealed where practicable; where concealed fastenings cannot be used, use exposed fastenings. Exposed fastenings shall be compatible materials, shall match in colour and finish and shall harmonize with the material to which fastenings are applied. Necessary rebates, lugs, brackets shall be provided so that the work can be assembled in a neat and substantial manner. Edges of flanged items shall be turned to form plaster keys where plaster occurs. Holes for bolts and screws shall be drilled or punched. Poor matching of holes shall be cause for rejection. Thickness of metal and details of assembly and supports shall give ample strength and stiffness. Joints exposed to the weather shall be formed to exclude water.

**4.3 WORKMANSHIP**

Miscellaneous metalwork shall be well formed to shape and size, with sharp lines and angles and true curves. Drilling and punching shall produce clean true lines and surfaces. Connections shall be welded. Welding shall be continuous along the entire area of contact except where tack welding is permitted. Exposed connections of work in place shall not be tack welded. Exposed welds shall be ground smooth. Exposed surfaces of work in place shall have a smooth finish and exposed riveting shall be flush. Joints shall be milled to a close fit. Corner joints shall be coped or mitered, well formed and in true alignment. Work shall be accurately fastened in place. Work shall be executed and finished in accordance with approved drawings, cuts, details and samples.

**4.4 LADDERS**

Anchor bolts, grating fasteners, washers and all parts or devices necessary for proper installation shall be furnished and installed. Lock washers shall be used under nuts.

**4.5 COLUMN GUARDS**

Column guards, where shown on the drawings, shall be temporarily fixed to the column framework and the lugs wired to column reinforcement with 16 gauge 1.5 mm black annealed typing wire. The guards shall be installed to protect the bottom 2100 mm of the columns.

**4.6 LOADING DECK EDGE PROTECTION**

Deck edge angles shall be temporarily fixed to framework and the lugs wired to reinforcement with 16 gauge 1.5 mm black annealed typing wire. The angles shall be fixed with the horizontal leg above the structural slab by the appropriate dimension to permit the application of an in situ finish up to and flush with the horizontal leg.

**4.7 STRUCTURAL STEEL DOOR FRAMES**

Metal door frames shall be built in completely plumb and free from twist. Temporary struts shall be inserted between jambs to ensure that the frames do not move inwards; the temporary struts and base ties shall remain in position until the mortar or concrete has set.

**END OF SECTION**

# SECTION 06100

# CARPENTRY WORK

**PART - 1 GENERAL**

* 1. **SCOPE OF WORK**

1. Furnish all labor, materials, equipment and incidentals required and install all items of rough and finish carpentry work complete as shown on the Drawings and as specified herein.
2. Set in place, all pressed metal frames which are to be built into walls. Install pressed metal frames which are to be installed in concrete openings. Install hollow metal and wood doors and finish hardware furnished under other Sections.
   1. **RELATED WORK**
3. Wood forms required for concrete work are included in Division 3.
4. Anchor bolts and other metal appurtenances except as specified herein are included in Division 5.
5. Metal and wood doors and metal frames are furnished under Division 8.
6. Finish hardware is furnished under Division 8.
   1. **SUBMITTALS**
7. Submit to the Engineer as provided in Section 01300, complete shop drawings showing details of fabrication and erection of all finish carpentry items and material furnished under this Section.
   1. **REFERENCE STANDARDS**
8. American Wood Preservers Association (AWPA)
   1. AWPA P-5 – Standards for Water Borne Preservatives.
9. Architectural Woodwork Institute (AWI)
10. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.
    1. **QUALITY ASSURANCE**

For finish carpentry items, comply with the specified provisions of the “Architectural Woodwork quality Standards’ Illustrated” of the AWI Premium Grade Standards.

**PART 2: PRODUCTS**

* 1. **MATERIALS – ROUGH CARPENTRY**

1. All lumber shall be of sound stock, delivered dry and shall be fuly protected at all times from injury and dampness. Split, broken, or otherwise damaged pieces will not be allowed in the work.
2. Wood for blocking and nailers shall be seasoned, 19 percent maximum moisture content, Construction Grade quality and of Douglas fir; Southern Pine or Ponderosa Pine spices.
   1. Wood members that will contact masonry or concrete shall be vacuum-pressure treated with 100 percent oxide pure chromated copper arsenate meeting AWPA Standard P-5. Minimum net retention of solid preservative shall be 0.40 lb per cu ft.
   2. All treatment shall be performed in accordance with the requirements of the Standard Specifications of the American Wood Preservers Association for treating wood. Apply a heavy coat of the same preservative used in treating to all surfaces cut after treatment.
3. Nails, spikes, bolts, nuts and washers where sizes are not indicated or specified, shall be of suitable size and number as approved to securely fasten and hold members in place. Hot dip galvanize after fabrication.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

1. All rough carpentry shall be accurately cut, fitted and installed as detailed.
2. Anchors shall be installed, where indicated or required, to anchor carpentry or other items securely to masonry or concrete.
3. Forms for structural concrete work shall be as specified under Division 3. Provide all other miscellaneous wood formwork as may be required for the completion of the work.
4. Temporary wood doors and cloth or transparent plastic covered frames shall be provided for exterior wall openings during winter construction.
5. Installation of Hollow Metal Doors and Finish Hardware:
   1. Doors and finish hardware will be furnished under Division 8 and shall be installed under the work of this Section, except where specifically designated otherwise herein.
   2. As soon as the hardware is delivered to the job site, receive, verify and check each set and report to the Engineer any defect or shortage. Give notice to the hardware supplier for all such items which may be defective or missing. Provide a receipt to the hardware supplier for all such items as are found to be correct.
   3. Finish hardware, after checking, shall be the responsibility of the Contractor until it is installed and the project is accepted in its entirety by the Employer.
   4. Hardware shall be attached and placed by skilled mechanics in accordance with approved hardware templates provided with the hardware, and shall be accurately fitted and adjusted. Lever handles shall be kept covered with heavy cloth and other hardware shall be protected from damage until final acceptance of the entire project by the Owner.
   5. Set each edges and grout threshold in mortar.
   6. Adjust and check each operating item of hardware and each door, to ensure proper operation or function of every unit. Lubricate moving parts with type lubrication recommended by manufacturer (graphite-type if no other recommended). Replace units which cannot be adjusted and lubricated to operate freely and smoothly as intended for the application made.
   7. Wherever hardware installation is made more than one month prior to acceptance or occupancy of a space or area, return to the work during the week prior to acceptance or occupancy and make a final check and adjustment of all hardware items in such space or area. Clean and relubricate operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for final operation of heating and ventilating equipment.
6. Install finish carpentry casework in a manner consistent with quality of specified Grade to be plumb, level, true and straight with no distortions. Shim as required using concealed shims. Secure to substrate with concealed fasteners where possible and blind nailing as required for complete installation. Scribe and cut for accurate fit to other finished work as required.
7. After completion of casework, clean exposed exterior and interior surfaces, remove and refinish damaged or soiled areas of finish and repair damaged or defective work or replace as directed to the satisfaction of the Engineer.
8. Protect finished surfaces with heavy-duty canvas or polyethylene sheets. Secure loose components from damage during delivery. If such items are to be delivered separately from main body of casework, wrap each piece separately to protect finish and clearly mark to show proper location in completed casework.

**END OF SECTION**

# SECTION 06200

# FINISH CARPENTRY

**PART - 1 GENERAL**

* 1. **SCOPE OF WORK**

1. Furnish all labor, materials, equipment and incidentals required and install finish carpentry as required and specified herein.
   1. **RELATED WORK NOT INCLUDED**
2. Rough carpentry is included in Section 06100.
3. Field painting (clear finishes) is included in Section 09903.
   1. **SUBMITTALS**
4. Submit to the Engineer as provided in Section 01340, complete shop drawings showing details of fabrication and erection of all items and material furnished under this Section.
5. Submit fully finished samples. Samples will be reviewed for appearance and finish only. Compliance with all other requirements is the exclusive responsibility of the Contractor.
   1. **STANDARDS OF WORKMANSHIP**
6. Comply with the specified provisions of the “architectural Woodwork Quality Standards’ Illustrated” of the Architectural Woodwork Institute (AWI) Custom Grade Standards, except as modified herein.

**PART 2: PRODUCTS**

* 1. **MATERIALS**

1. Wood for blocking, framing and for core material shall conform to AWI softwoods, Custom Grade Standards.

**PART 3 - EXECUTION**

* 1. **FABRICATION**

General

* 1. Before proceeding with fabrication of work required to be fitted to other construction, obtain field measurements and verify dimensions and shop drawing details as required for accurate fit.
  2. Employ only mechanics experienced in the fabrication and installation of items to be installed.
  3. Finished millwork shall be dressed and sanded, free from machine and tool marks, abrasions, raised grain or other defects on surfaces exposed to view.
  4. Millwork shall be continuous in lengths required. No splicing will be allowed. Scarf joints may be used for end joints where approved.
  5. Casework for hardwood and for plastic laminate finish shall comply with AWI Section 400, Custom Grade. Provide plastic self-edges where required. Provide balancing and back-up sheets as required in AWI 400, custom Grade. Provide doors with hardwood veneer for clear finish both sides.
  6. Optimum Moisture Content for shop and site fabricated work shall be as follows: Kiln dry solid wood to the average moisture content of 8 percent as recommended by AWI Section 100 G-3. Maintain optimum moisture content until final finish has been applied.

All millwork shall be fabricated to configurations shown and the shop drawing details.

All casework shall be fabricated to conform to the intent of the elevations, sections and details shown and shall be in accordance with the approved shop drawings and samples.

* 1. **DELIVERY, STORAGE AND PROTECTION OF MATERIALS**

1. All materials shall be delivered and stored inside where protected from the elements. Materials shall be stacked to insure proper drainage and ventilation. No materials shall be placed in any building until that building is completely closed in and sufficiently dry.
2. Millwork shall be accepted only when delivered dry. Interior finish shall not be stored or installed until after all concrete and masonry works have been completed.
   1. **EXAMINATION OF SUBSTRATE AND CONDITIONS**

Examine the substrate, including ground, stripping and blocking to which materials will be secured, and the conditions under which the work is to be performed, and notify the Engineer in writing of any unsatisfactory conditions. Do not proceed with the work under this Section until unsatisfactory conditions have been corrected in a manner acceptable to the engineer.

* 1. **INSTALLATION**

1. Protect finished surfaces with heavy-duty canvas of polyethylene sheets.
2. Install millwork in a manner consistent with quality of specified Grade to the plumb, level, true and straight with no distortions. Corners shall be mitered, invisibly glued and nailed. Scribe pieces where so required. Secure to substrate with finish nails, set and filled as approved to match color of finish.
3. Install casework in a manner consistent with quality of specified Grade to be plumb, level, true and straight with no distortions. Shim as required using concealed shims. Secure to substrate with concealed fasteners where possible and blind nailing as required for complete installation. Scribe and cut for accurate fit to other finished work as required.
4. After completion of casework, and millwork, clean exposed exterior and interior surfaces, remove and refinish damaged or soiled areas of finish, and repair damaged or defective work or replace as directed to the satisfaction of the Engineer.
5. Protect finished surfaces with heavy-duty canvas or polyethylene sheets. Secure loose components, such as adjustable shelving and sliding and hinged elements from damage during delivery. If such items are to be delivered separately from main body of casework, wrap each piece separately to protect finish and clearly mark to show proper location in completed casework.

**END OF SECTION**

# SECTION 06650

# WOODEN DOORS

**PART 1 - GENERAL**

**1.1 SYSTEM DESCRIPTION**

This section covers the work necessary for supply and installation, of wooden doors, complete in place, as required.

Doors shall be of type, size, core construction and design shown. Top and bottom edges of door shall be sealed with a clear water resistant varnish or a clear water resistant sealer. Doors shall be stored in fully covered, well-ventilated areas and protected from extreme changes in temperature and humidity.

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work under this section shall conform to the latest revision of the applicable specification of the British Standards.

**1.3 QUALITY ASSURANCE**

**Marking:**

Each door shall bear a stamp, brand or other identifying mark indicating quality and construction of the door. The identifying mark or a separate certification shall include name of the inspection organization, identification of the standard on which the construction of the door is based, identity of the plant to which the stamp was issued, identification of the standard under which preservative treatment, if used, was made, identification of the doors having a Type I glue bond, and a declaration of compliance by the plant.

**1.4 SUBMITTALS**

Refer to Section 01300: SUBMITTALS of these Specifications.

**Shop Drawings:**

Shop drawings shall indicate: location of each door; elevation of each type of door; details of construction; marks to be used to identify the doors; location and extent of hardware blocking; hardware installation data; cuts for louvers, grills and undercuts; and if factory primed or factory finished, materials and methods to be used. Shop drawings shall include catalogue cuts or descriptive data for weather stripping, thresholds and seals to be used.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 General**

Wooden doors of the types, sizes and thickness indicated shall be provided. Top & bottom edges shall be given two coats of an approved water- resistant sealer at the factory.

**2.1.02 Flush Wooden Doors:**

Flush wooden doors are to be constructed in accordance with BS 459:

Part 3 and are to be constructed of hardwood solid framing covered both sides with 10 mm thick plywood of 4.5 mm asbestos board and 6 mm plywood glued and pressed on and securely fixed with 20 mm hardwood lipping sill edges.

Doors scheduled to receive natural finish shall be premium grade with face veneer of hardwood, selected for uniformity in graining and colour with sequence matched where two or more doors occur within the same opening. Lippings shall match face veneers.

Doors scheduled to receive paint finish shall be good grade with face veneers of optional pieces of hardwood except that open grain hardwood will not be permitted.

Fire resistance of the doors shall be at least 30 minutes.

Special requirements to the doors, such as extra framing or fitting ventilation grilles, stainless steel, kicking plates, door closers, etc., or grooves to fit draught strip, etc., shall be provided where required.

**2.1.03 Hardwood Veneers**

Hardwood veneers to wooden doors shall be sliced cut supple Mahogany. The veneer shall be without knots, cracks, patching, sapwood and other defects properly selected with neat joints glued together, dried and finished smooth with a sanding machine. All veneers shall be WBP bonded.

**2.1.04 Adhesives**

Adhesives for gluing woodwork shall be moisture-resistant conforming to BS 1204, type WBP, non-staining when doors are scheduled to receive natural finish.

**2.1.05 Anchors and Fasteners**

Anchors and fasteners for securing wood items, unless noted otherwise, shall be as follows:

Bolts and nuts shall conform to BS 325 as applicable or to the approval of the Engineer.

Studs, rivets, lag-screws, lag-bolts and toggle-bolts, type and grade best suited for the purpose, shall be to the approval of the Engineer.

Expansion bolts, type, class and style best suited for the purpose, shall be to the approval of the Engineer. Shields shall be accurately recessed and, unless otherwise indicated, shall not be less than 64 mm.

Wood screws shall conform to BS 1210 or BS 1494, style and material as indicated or best suited for the purpose.

Nails and staples shall conform to BS 1202 and BS 1494 respectively, type and size best suited for the purpose.

Power-driven fastenings may be used when approved by the Engineer.

**2.1.06 Timber**

Species of timber for the various uses shall be any approved species having the following minimum structural properties:

Extreme fiber stress in bending : 100 kgf per cm2.

Compression stress parallel to grain : 60 kgf per cm2.

Modulus of elasticity : 90,000 kgf per cm2.

Timber for rough carpentry shall be the best quality, free from all defects rendering it unsuitable for the purposes, and to the approval of the Engineer. The kinds of timbers shall be as stated on the drawings or African pine complying with BS 563 and amendment No. 1 for Grade S.A. pine. Alternatively Swazi pine may be applied if complying with the same standards. The grade to be applied shall be MG.

Timber for finish carpentry shall be first class soft-woods and hardwoods showing no defect, subject to the approval of the Engineer. The hardwoods to be used shall be as specified above. Hardwood shall be judged from the samples submitted by the Contractor and approved by the Engineer.

Timber shall be planed four sides, and the dressed sizes of yard and structural timber shall conform to BS 4471. Timber shall be worked to such patterns as are indicated or specified.

Except as hereinafter specified, timber to be incorporated in the structure shall conform to the moisture content requirements of BS 4471, as applicable. Timber treated with water-borne preservatives shall be dried to a moisture content not exceeding 19 percent after treatment.

Timber shall be kiln-dried, and at time of delivery to the building site, the moisture content shall not exceed 12 percent for material 25 mm or less in thickness, and shall not exceed 15 percent for material over 25 mm thickness.

Woodwork that is assembled or built-up of more than one piece at the mill shall have a moisture content not in excess of 12 percent at time of delivery to the building site.

**2.1.07 Plywood**

Plywood shall be marine plywood conforming with BS 1088. Each sheet of plywood shall bear the mark of a recognized association or independent inspection agency that maintains continuing control over the quality of the plywood. The mark shall identify the plywood and designate compliance with the applicable product standard or commercial standard.

**2.1.08 Preservative Treatment**

a) All wood shall be preservative treated prior to permanent installation on the project, to the approval of the Engineer.

Surfaces exposed by cutting or planing after treatment must be thoroughly brushed with the same preservative.

b) All wood shall be preservative treated in such manner that it will be permanently insect, fungus and rot proof. The manufacturer's instructions for applying the preservative shall be strictly adhered to and the supplier of the preservative treated wood shall deliver a written fully comprehensive guarantee with each delivery.

c) Timber parts in contact with masonry or concrete to be treated with two coats of red lead.

d) Wood that is to be painted and wood that will make contact with painted parts shall be treated with either oil-borne or water-borne preservatives. Coal-tar creosote or creosote solutions shall not be used. Wood used in conjunction with built-up roofing shall be treated with water-borne preservatives. Wood treated with oil-borne preservatives shall be clean, free from surface oil and shall be properly seasoned for use in building construction. Wood treated water-borne preservatives shall be air dried or kiln dried to a moisture content not exceeding 19 percent. An affidavit signed by the preservative treatment manufacturer shall be furnished certifying for oil-borne preservative treated materials required to be painted or to make contact with wood to be painted, the paint-ability, drying time and surface deposit of the treated material. The name of the supplier of the timber must be submitted with an affidavit certifying that timber has been treated in compliance with the requirements of this specification.

**PART 3 - EXECUTION**

**3.1 INSTALLATION / APPLICATION / ERECTION**

Doors shall be installed only after completion of all other work which could raise moisture content of doors or damage the surface of doors. Doors shall be fitted, hung and trimmed as required by the individual openings they will close. Doors shall have a clearance of 1/8 inch (0.32 cm) at the sides and top and shall have a bottom clearance of 1/4 inch (6.4 mm) over thresholds and 1/2 inch (1.25 cm) at other locations unless otherwise shown. The lock edge of doors shall be beveled at the rate of 1/8 inch in 2 inches (0.32 cm in 5 cm). Cuts made on the job for fitting and hardware mounting shall be sealed immediately, using a clear water resistant sealer. Weather stripping and thresholds shall be installed at exterior door openings to provide a weather tight installation. Other seals or stripping shall be installed as indicated on Drawings.

**END OF SECTION**

# SECTION 07 100

# DAMP PROOFING

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers the work involved in damp proofing materials, paving slab supporting pads roof coating, metal counter-flashing and roofing accessories.

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work under this section shall confirm with the latest revision of the applicable specifications of the British Standards.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

The following materials shall conform to the respective specifications and other requirements hereinafter specified. All bituminous materials shall be products of one manufacturer.

**a) Asphalt Primer**

Asphalt primer shall conform to BS 3940, type 8a (ii), volatile solvent 60% by weight.

**b) Asphalt Bitumen**

Asphalt bitumen shall be of the blown type with an average melting point of 110oC and an average penetration of 30.

**c) Cants and Nailers**

(1) Cants shall be made from treated wood of size 100 x 100 mm and shall reduce the angle covered into two equal angles. Treated wood shall be of preservative-treated material.

(2) Nailers shall be made from treated wood and be equal to the width of the concrete parapet by 60 mm deep. Attach nailers as shown on drawings.

**d) Felt**

Felt shall be the asphalt saturated type and shall conform to the following requirements:

Glassfibre, asphalt saturated felts shall conform to BS 747, part 2. Glassfibre at least 50 g/m2.

Roofing felt type 3B, with minimum physical requirements modified as follows:

Weight ..... 36 kg per roll of 20 m2 approximately.

Roofing felt, type 3G, minimum physical requirements modified as follows:

Weight ..... 32 kg per roll of 10 m2 approximately.

Mineral surfaces roofing shall conform to roofing felt type 1E with one side completely mill treated with slate chippings. Colours shall be selected by the Engineer. Weight 36 kg per roll of 10 m2 approximately.

**e) Nails and Fasteners**

Roofing nails shall be nonferrous or galvanized steel, conforming to BS 1202: Part 1 - table 4 or part 2 - table 3. Lengths shall be as specified hereafter.

Metal discs shall be flat and not less than 25 mm diameter.

Mechanical fasteners shall be as shown on the drawings.

**f) Precast Concrete Paving Slabs & Steps**

Precast concrete paving slabs shall be best available locally or, made on site. Size 600 mm x 600 mm x 50mm. Steps shall be manufactured on site to the sizes shown on the drawings.

**g) Sandtex - Matt**

Sandtex - Matt resin based surface coating shall be as manufactured by Blue Circle Industries Ltd., Portland House, Stag place, London SWIE 5BJ, England or approved equal. The colour shall be white.

**h) Lightweight Screeds**

Lightweight screeds shall be a mixture of lightweight aggregate with bitumen or sand and cement binder, minimum compacted density 320 kg/m3, maximum compacted density 368 kg/m3. 'Insulpave' by W. R. Grace Construction Materials Ltd., or approved equal.

**i) Galvanized Metal Concealed Cleats**

Concealed cleats shall have minimum thickness 0.49 mm zinc coating on commercial quality sheet, stretcher leveled. Cleats shall be at least 40 mm wide and interlocked with metal flashing.

**j) Mastic Flashing**

(1) **Mastic**: Solvent based asphalt mastic containing high quality asbestos fibres.

(2) **Glass Fibre Mesh**: Heavy duty, porous, felted glass mat composed of chopped sections of stranded glass yarns as manufactured by Lexsuco Canada Ltd. or approved equal.

**k) Underlay for Wood Roofs**

Dry Rosin-sized kraft paper.

**l) Paving Slab Supporting Blocks**

(1) "Styrofoam" insulation pads 50 mm thick, sizes as shown on the drawings, styrofoam 'SM' as manufactured by Dow Corning Ltd. or approved equal.

(2) Asbestos cement tiles 10 mm thick, sizes as shown on the drawings.

**m) Roof Access Hatch**

Roof Access Hatch with spring latch and automatic opening as manufactured by Richards Wilcox Canada Ltd., or approved equal where shown in the drawings.

Materials shall be delivered, stored and handled in accordance with manufacturer recommendation and as directed by the Engineer.

**PART 3 - EXECUTION**

**3.1 GENERAL**

**a) Dampproofing materials - On Concrete Roofs**

Dampproofing over concrete roof consist of the following:

An application of a primer of a quick evaporating asphalt solution laid on lightweight screed. Rate of application to be 1.5 kg/m2.

One layer of perforated roofing felt type 3G in a partial coat of asphalt bitumen 110/3, thickness 1.5 mm, by a temperature of 240 - 260oC. The roofing felt to be lapped 75 mm on sides and 100 mm on ends.

One layer of roofing felt type 3B in a flood coat of asphalt bitumen 110/30, thickness 1.5 mm, by a temperature of 240 - 260oC. Laps of the roofing felt to be 75 mm on sides and 100 mm on ends. Care should be taken to stagger the laps with the joints of the first layer.

One layer of roofing felt type 3B equal to the layer specified in above.

The top surface shall be finished with either:

i) a layer of concrete paving slabs 600 x 600 x 50 mm to be laid on supporting pads as detailed. Tiles to be laid with joints of 10 mm. Joints to be straight and parallel to the building lines.

ii) a coating of Sandtex matt. .

**b) Dampproofing Materials - On Timber Roofs**

Dampproofing over wooden roofs shall consist of the following:

One ply of waterproof kraft paper, lapping 100 mm.

Two plies of roofing felt type 3B, lapping 75 mm on sides and 100 mm on ends. Nail the laps of the first layer with galvanized roofing nails 100 mm on centres to the wooden roof.

One ply of mineralized roofing felt, type 1E in a flood coat of asphalt bitumen 110/30 thick, 1.5 mm by a temperature of 240 - 260oC. The roofing felt to be lapped 75 mm on sides and 100 mm on ends, staggered on the joints of the first ply. Special care shall be taken that the laps are fully filled with the hot bitumen and that no surplus bitumen will show on the finished roofing.

**c) Dampproofing Materials - On Retaining Structures & Substructural Works**

Dampproofing to water retaining structures & substructural works shall be achieved by the application of Bituthene performed bitumen/PVC waterproof membrane to outer surfaces.

Bituthene shall be applied to the outer surfaces of all water retaining structures below ground and to the foundations as shown in the drawings & directed by the Engineer. Bituthene to the base slab shall be laid on the concrete blinding and protected by a layer of "Servipak" prior to fixing reinforcement and casting the slab. Bituthene to the sides and top of such structures shall be applied to the outer face of the walls and slabs and shall be protected against mechanical damage during and after backfilling around the structure by a layer of 12 mm thick "Korkpak" non-absorbent non-extruding joint filler. Laps to ends and edges of Bituthene membranes shall be at least 100 mm.

All materials shall be fixed in accordance with the manufacturer's detailed instructions including the use of the Bituthene priming coat.

Concrete surfaces shall be even and smooth with "high spots" cut back and local depressions and sudden changes filled with as epoxy based or similar approved high strength mortar to present a true surface on which the Bituthene is to be bonded. All sharp projections and arrises caused by formwork etc. should be "scabbled back" to give rounded corners.

All internal angles shall be filled with a 100 x 100 mm mortar fillet. The surface of the concrete shall then be brushed free of any loose stones dirt, etc. before applying a single coat of Bituthene 1200 HC. Bituthene primer shall be brushed onto the surface and care must be taken to avoid "ponding " in depressions.

Korkpak shall be laid over the Bituthene where it is not otherwise protected from mechanical damage from the ground. The boards shall be closely butted and joints taped.

**3.2 INSTALLER**

The dampproofing works shall be performed by a qualified specialist approved by the Engineer. A visit to the job site by an authorized representative of the manufacturer of dampproofing material who shall inspect and certify that the surface to which dampproofing was applied was in a condition suitable for that application and that the materials and application conform to the specified requirements and current recommendations.

**3.3 SURFACE PREPARATION**

Surfaces to receive dampproofing shall be cleaned of foreign matter and loose particles, and shall be surface dry at the time dampproofing is applied. Surfaces to receive asphalt dampproofing shall be given a priming coat. Priming coat shall be applied when the ambient temperature is above 5 C fully covering the entire surface to be dampproofed.

**3.4 APPLICATION**

**a) Asphalt and Felt**

Asphalt shall be heated between 240 and 260oC. Asphalt shall be hot when applied, and layers of roofing shall be laid immediately in the hot asphalt. Roofing shall be laid free of wrinkles or buckles at right angles to the slope of the deck. Layers of glass-fibred roofing shall be laid in not less than 10 kg of asphaltper 00 m2. Bitumen shall uniformly cover all roof areas to provide effective bond.

Asphalt primer, for concrete and masonry surfaces to receive asphalt products, shall be applied at a rate less than 4 L/10 m2. Each course of roofing felt, in addition to being mopped in hot bitumen, shall be lapped and nailed as specified in herein. Roofing including roll roofing felts shall immediately follow insulation application if required as a continuous operation. The surfaces of the felts shall be carefully broomed-in with a 450 to 500 mm wide soft fibre type floor broom to obtain complete adhesion between plies and to eliminate air pockets. The method of mopping a half-sheet width and turning the sheet back to mop under the other half shall not be used. Workmen shall not walk on mopped surfaces when the bitumen is sticky. Each layer of roofing felt shall be carried up abutting vertical surfaces at least 100 mm or to the top of the cant strip. At eaves, the bottom layer of felt shall be applied in a 230 mm wide strip of bituminous cement.

**b) Nails and Fasteners**

Nails and fasteners for securing metal flashings and asphalt roll roofing shall be 25 mm long roofing nails and shall be flush-driven through compatible copper or galvanized flat metal discs of not less than 25 mm diameter. Metal discs may be omitted where heads and fasteners are equivalent in size to the 25 mm diameter discs.

**c) Flashings**

Flashings shall be provided in the angles formed at walls and other vertical surfaces and where required to make the work watertight. Flashings shall be provided and installed immediately after the top ply of roofing is placed and shall be returned and sealed, or capped and sealed to waterproof edges and ends. Sheetmetal reglets, where shown on the drawings, shall be located not more than 350 mm nor less, above the roofing surface.

**d) Base Flashings**

**(1) General**

Base flashing shall consist of two layers of membrane or mastic flashing. Concrete over which flashings are to be installed shall be primed with asphalt primer which shall be allowed to dry thoroughly.

**(2) Membrane Flashing**

a) Apply 2-ply membrane flashing at eaves and junctions of roof with vertical surfaces using roofing felts and asphalt throughout. Start first ply 75 mm from base of cant strip. Carry each additional ply 25 mm beyond preceding ply. Extend flashing over cant strip, up vertical wall for 300 mm and terminate with mechanical fasteners.

b) At joints, lap each sheet 100 mm over preceding ply and completely seal with full mopping of asphalt.

**(3) Mastic Flashing**

- Apply mastic flashing over cant strips, 50 mm on the vertical surface above cant strip and 75 mm on horizontal surface at base of cant strip.

- Apply coat of mastic and embed layer of glass fibre mesh into same, overlapping joints a minimum of 50 mm.

- Apply second coat of mastic and embed second layer of glass fibre mesh.

- Apply heavy, third coat of mastic to completely cover all glass fibre mesh. The total thickness of mastic and glass fibre mesh shall be a minimum of 6 mm. Feather all edges.

All layers shall extend up the vertical surfaces to the mechanical fastener, or to the top of curb and the top layer shall be lapped completely over the curb and shall be secured at the top with mechanical fasteners at 200 mm centres.

Treated wood cants shall be installed in the angles formed at walls and other vertical surfaces as backing for base flashings. Cants shall be laid in a solid coat of bituminous cement just prior to laying the roofing plies. Cants shall have a 140 mm face dimension and shall be continuous and installed in as long lengths as practicable.

**e) Strip Flashings**

Roof flanges of cap flashings, base flashings, plumbing flashings, and mechanical flashings furnished and installed under other sections of the specifications shall be treated with two layers of roofing felt. After installation of flashings over the top ply of roofing, two layers of roofing felt, 250 and 300 mm wide, shall be successively mopped on top of the roof flange to form a waterproof joint between roofing and flashings.

**f) Sandtex - Matt ( or approved equal )**

Sandtex - Matt shall be applied to the top surface of dampproofed roofing in all situations where precast concrete paving slabs are not required.

Surfaces shall be brushed clean of all dust, washed down and allowed to dry. The surface shall then be primed with one coat of Blue Circle Bitumen Basecoat diluted with an equal quantity of water and allowed to dry out thoroughly for at least 24 hours before applying one coat of Sandtex - Matt finish. (or approved equal )

**g) Installation of Paving Slabs on Observation Deck**

After roofing felts have been laid and flashings installed, the entire roof surface to receive paving slabs except cants shall be flood coated uniformly with hot asphalt at the rate specified. While bitumen is still hot, supporting pads of styrofoam insulation and asbestos cement tiles as shown on the drawings shall be embedded therein at the correct locations shown. Paving slabs shall be placed in the manner specified in 3.1. When the flood coat and paving slabs cannot be applied the same day, the felts are laid, or if there is a probability of rain falling on the felts , before the flood coat can be applied, a light glaze coat of bitumen 5 to 7 kg/m2 shall be applied over the exposed felts. The glaze coat may be considered as part of the flood coat provided the surfacing operation is completed within 24 hours after application of the glaze coat.

Generally, method of installation shall be submitted for the Engineer's approval prior to commencement of work.

**3.5 SAMPLES**

**a) Roof Cutout Samples:**

After completion of the application of the roof felts, but prior to application of the flood coat, cutouts of the roofing shall be taken from the deck at locations directed by the Engineer. The cutout samples will be visually examined immediately after removal from the deck for free water between plies, or skips in bitumen application between plies, and then weighed to determine the total amount of bitumen used exclusive of the flood coat. Samples shall be 300 x 300 mm in area, accurately cut to a template. The complete sampling operation shall be performed without additional cost to the Employer.

**b) Patching Cutout Area:**

Immediately after being weighed, the sample shall be replaced and tamped into position in the cutout area which meanwhile has been flooded with hot bitumen. Should it become impossible to immediately replace the cutout sample in the roof, a new section of equivalent size and structure shall be substituted. The area shall then be covered with 3 plies of felt, hot mopped in place with the first ply overlapping the cutout area 80 mm on all sides and each succeeding ply overlapping the preceding ply 80 mm on all sides.

**c) Sampling Requirements**

Not less than one sample shall be cut from roofing applied to each building. At least one sample shall be taken during roofing work and an additional sample cut daily from each 1000 m2 or fractions thereof over the first 1000 m2. Should the first daily sample show free water or absence of bitumen between the plies, the roofing that has been laid that day shall be removed and relaid. In the event of free water or the absence of bitumen in other samples, or in the event of a deficiency in the amount of bitumen applied, additional samples shall be taken to determine the extent of the deficiency. Free water between plies or absence of bitumen between plies, shall be cause for removal of the affected portion of the roof and replacement in a dry condition. Where only bitumen deficiencies are found, the deficient areas shall have an additional ply of felt applied in a full mopping of bitumen. If the bitumen is deficient in 25 percent of the total area, an additional ply of felt shall be added over the entire deck in a full mopping of the bitumen specified. Correction of the above deficiencies shall be made at no extra cost to the Employer.

Sample cutting device shall be rectangular and of proper size for cutting a sample exactly 300 x 300 mm square. The device may be the self-cutting type or a metal template capable of being secured to the roof for use with a sharp roofing knife. Cutting edges of the device or knife shall be kept clean by washing in proper solvent after each cut.

**END OF SECTION**

# SECTION 07160

# BUILT-UP ROOFING, BITUMINOUS

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This specification covers the work involved in the supply and installation of the waterproof roof material, paving slab supporting pads "Sandtex" roof coating, metal counter-flashing and roofing accessories. Asphalt built-up roofing shall be applied to the roof surfaces indicated on the drawings. Bituminous-mastic type or membrane flashings shall be used throughout unless otherwise specified or indicated.

All roofing must be installed under direct supervision of an experienced installer approved by the Engineer.

Except as otherwise required, materials and workmanship shall conform with the latest revision of the applicable specifications of the British Standards Institution, or any equal International Standard approved by the Engineer.

**1.2 RELATED WORK SPECIFIED ELSEWHERE**

a) Prefinished or galvanized Metal Flashings, Sheet Metal Work.

b) Integral Flashing Collars for items of Mechanical and Plumbing work passing through roofs, Plumbing, heating, Ventilating and Air Conditioning.

c) Precast Concrete Paving Slabs & Steps, Section 03300: Cast in Place Concrete.

**1.3 REFERENCE STANDARDS**

The following publications of the British Standards, referred to thereafter by basic designation only, form a part of this specification. Any other equivalent international standard may be accepted, subject to the Engineer's approval.

BS 747 Specification for Roofing felts.

BS 202 Nails.

CP 144 Roof coverings.

Part 3. Built-up bitumen felt. Metric units.

**1.4 SAMPLES**

a) Roof Cutout Samples:

After completion of the application of the roof felts, but prior to application of the flood coat, cutouts of the roofing shall be taken from the deck at locations directed by the Engineer. The cutout samples will be visually examined immediately after removal from the deck for free water between plies, or skips in bitumen application between plies, and then weighted to determine the total amount of bitumen used exclusive of the flood coat. Samples shall be 300 X 300 mm in area, accurately cut to a template. The complete sampling operation shall be performed without additional cost to the Employer.

b) Patching Cutout Area:

Immediately after being weighted, the sample shall be replaced and tamped into position in the cutout area which meanwhile has been flooded with hot bitumen. Should it become impossible to immediately replace the cutout sample in the roof, a new section of equivalent size and structure shall be substituted. The area shall then be covered with 3 plies of felt, hot mopped in place with the first ply overlapping the cutout area 80 mm on all sides and each succeeding ply overlapping the preceding ply 80 mm on all sides.

**1.5 SAMPLING REQUIREMENTS**

Not less than one sample shall be cut from roofing applied to each building. At least one sample shall be taken during roofing work and an additional sample cut daily from each 1000 m2 or fractions thereof over the first 1000 m2. Should the first daily sample show free water or absence of bitumen between the plies, the roofing that has been laid that day shall be removed and relaid. In the event of freewater or the absence of bitumen in other samples, or in the event of a deficiency in the amount of bitumen applied, additional samples shall be taken to determine the extent of the deficiency. Free water between plies or absence of bitumen between plies, shall be cause for removal of the affected portion of the roof and replacement in a dry condition. Where only bitumen deficiencies are found, the deficient areas shall have an additional ply of felt applied in a full mopping of bitumen. If the bitumen is deficient in 25 percent of the total area, an additional ply of felt shall be added over the entire deck in a full mopping of the bitumen specified. Correction of the above deficiencies shall be made at no extra cost to the Employer.

Sample cutting device shall be rectangular and of proper size for cutting a sample exactly 300 X 300 mm square. The device may be the self-cutting type or a metal template capable of being secured to the roof for use with a sharp roofing knife. Cutting edges of the device or knife shall be kept clean by washing in proper solvent after each cut.

**1.6 PRODUCT HANDLING**

a) The Contractor shall protect sheet metal materials against bending, scratching and exposure which will cause corrosion or damage to their appearance.

b) The Contractor shall protect materials from inclement weather. Keep sheathing and roofing felts absolutely dry and remove only as much from storage as can be applied and flood coated in same day. Materials found to be damp at time of installation or having been damp or exposed to moisture shall be rejected by the Engineer.

c) Store roofing felts for at least 24 hours in an area kept at 21o C and remove for application with as little exposure as possible to low temperatures. Keep felts absolutely dry, stored off ground, on end and well ventilated.

**1.7 PROTECTION**

a) Hang tarpaulins to protect walls where hoisting is necessary. Locate kettles so that smoke will not discolour building or adjacent buildings. Keep masonry and finished surfaces clean and free from bitumen, sealants and mastic by approved methods.

b) Protect completed portions of roofs from damage due to traffic and materials handling until completion of work of this Section.

**1.8 WARRANTY**

a) The Contractor, under this Section, hereby warrants the work of this Section including membrane, insulation, mastic or flexible flashings and sheet metal work against defects in materials and workmanship in accordance with the General Conditions for a period of two years and agrees to promptly make good defects which occur or become apparent within the warranty period, such defects to include, but not be restricted to leakage, failure to stay in place, undue expansion, lifting, deformation, loosening and splitting of seams and angles.

**PART 2 - MATERIALS**

**2.1 GENERAL**

The following materials shall conform to the respective specifications and other requirements hereinafter specified. Al bituminous materials shall be products of one manufacturer.

**2.2 ASPHALT PRIMER**

Asphalt primer shall conform to BS 3940, type 8a (ii), volatile solvent 60% by weight.

**2.3 ASPHALT BITUMEN**

Asphalt bitumen shall be of the blown type with an average melting point of 110o C and an average penetration of 30.

**2.4 CANTS AND NAILERS**

a) Cants shall be made from treated wood of size 100 x 100 mm and shall reduce the angle covered into two equal angles. Treated wood shall be of preservative-treated material as specified in Section 08210.

b) Nailers shall be made from treated wood and be equal to the width of the concrete parapet by 60 mm deep. Attach nailers as shown on drawings.

**2.5 FELT**

Felt shall be the asphalt saturated type and shall conform to the following requirements:

Glassfibre, asphalt saturated felts shall conform to BS 747, part 2. Glassfibre at least 50 g/m2.

Roofing felt type 3B, with minimum physical requirements modified as follows :

Weight ..... 36 kg per roll of 20 m2 approximately.

Roofing felt, type 3G, minimum physical requirements modified as follows:

Weight ..... 32 kg per roll of 10 m2 approximately.

Mineral surfaces roofing shall conform to roofing felt type 1E with one side completely mill treated with slate chippings. Colours shall be selected by the Engineer. Weight 36 kg per roll of 10 m2 approximately.

**2.6 NAILS AND FASTENERS**

Roofing nails shall be nonferrous or galvanized steel, conforming to BS 1202: Part 1 - table 4 or Part 2 - table 3. Lengths shall be as specified hereafter.

Metal discs shall be flat and not less than 25 mm diameter.

Mechanical fasteners shall be as shown on the drawings.

**2.7 LIGHTWEIGHT SCREEDS**

Lightweight screeds shall be a mixture of lightweight aggregate with bitumen or sand and cement binder, minimum compacted density 320 kg/m3, maximum compacted density 368 kg/m3.

**2.8 GALVANIZED METAL CONCEALED CLEATS**

Concealed cleats shall have minimum thickness 0.49 mm zinc coating on commercial quality sheet, stretcher levelled. Cleats shall be a least 40 mm wide and interlocked with metal flashing.

**2.9 MASTIC FLASHING**

a) Mastic: Solvent based asphalt mastic containing high quality asbestos fibers.

b) Glass Fibre Mesh: Heavy duty, porous, felted glass mat composed of chopped sections of stranded glass yarns.

**2.10 UNDERLAY FOR WOOD ROOFS**

Dry Rosin-sized kraft paper.

**2.11 PAVING SLAB SUPPORTING BLOCKS**

a) "Styrofoam" insulation pads 50 mm thick, sizes as shown on the drawings.

b) Asbestos cement tiles 10 mm thick, sizes as shown on the drawings.

**2.12 ROOF ACCESS HATCH**

Roof Access Hatch shall be with spring latch and automatic opening.

**2.13 PRECAST CONCRETE PAVING SLABS & STEPS**

Precast concrete paving slabs shall be best available locally or, made on site. Size 600 mm x 600 mm x 50mm. Steps shall be manufactured on site to the sizes shown on the drawings.

**2.14 SANDTEX - MATT**

Sandtex - Matt resin based surface coating shall be as manufactured by Blue Circle Industries Ltd., Portland House, Stag Place, London SWIE 5 BJ, England or approved equal. The colour shall be white or as directed by the Engineer.

**PART 3 - EXECUTION**

**3.1 GENERAL**

**a) Built-Up Roofing - On Concrete Roofs**

The built-up roofing over concrete roof shall consist of the following:

An application of a primer of a quick evaporating asphalt solution laid on lightweight screed. Rate of application to be 1.5 kg/m2.

One layer of perforated roofing felt type 3G in a partial coat of asphalt bitumen 110/30, thickness 1.5 mm, by a temperature of 240 - 260o C. The roofing felt to be lapped 75 mm on sides and 100 mm on ends.

One layer of roofing felt type 3B in a flood coat of asphalt bitumen 110/30, thickness 1.5 mm, by a temperature of 240 - 260o C. Laps of the roofing felt to be 75 mm on sides and 100 mm on ends. Care should be taken to stagger the laps with the joints of the first layer.

One layer of roofing felt type 3B equal to the layer specified in above.

The top surface shall be finished with either:

i) a layer of concrete paving slabs 600 X 600 X 50 mm to be laid on supporting pads as detailed. Tiles to be laid with joints of 10 mm. Joints to be straight and parallel to the building lines. This surfacing to be used on observation deck of Terminal only.

1. a coating of Sandtex matt. This coating to be used in all other locations.

**b) Built-Up Roofing - On Timber Roofs**

Built-up roofing over wooden roofs shall consist of the following:

One ply of waterproof kraft paper, lapping 100 mm.

Two plies of roofing felt type 3B, lapping 75 mm on sides and 100 mm on ends. Nail the laps of the first layer with galvanized roofing nails 100 mm on centers to the wooden roof.

One ply of mineralized roofing felt, type 1E in a flood coat of asphalt bitumen 110/30 thick, 1.5 mm by a temperature of 240 - 260o C. The roofing felt to be lapped 75 mm on sides and 100 mm on ends, staggered on the joints of the first ply. Special care shall be taken that the laps are fully filled with the hot bitumen and that no surplus bitumen will show on the finished roofing.

**c) Dampproofing Materials - on Retaining Structures & Sub Structural Concrete**

Dampproofing to water retaining structures shall be achieved by the application of torch applied Bituthene performed bitumen/PVC waterproof membrane to outer surfaces.

Bituthene shall be applied to the outer surfaces of all water retaining structures below ground. Bituthene to the base slab shall be laid on the concrete blinding and protected by a layer of "Servipak" prior to fixing reinforcement and casting the slab. Bituthene to the sides and top of such structures shall be applied to the outer face of the walls and slabs and shall be protected against mechanical damage during and after backfilling around the structure by a layer of 12 mm thick "Korkpak" non-absorbent non-extruding joint filler. Laps to ends and edges of Bituthene membranes shall be at least 100 mm.

All materials shall be fixed in accordance with the manufacturer's detailed instructions including the use of the Bituthene priming coat.

Concrete surfaces shall be even and smooth with "high spots" cut back and local depressions and sudden changes filled with as epoxy based or similar approved high strength mortar to present a true surface on which the Bituthene is to be bonded. All sharp projections and arrises caused by formwork etc. should be "scabbled back" to give rounded corners.

All internal angles shall be filled with a 100 x 100mm mortar fillet. The surface of the concrete shall then be brushed free of any loose stones dirt, etc. before applying a single coat of Bituthene 1200 HC. Bituthene primer shall be brushed onto the surface and care must be taken to avoid "ponding" in depressions.

Korkpak shall be laid over the Bituthene where it is not otherwise protected from mechanical damage from the ground. The boards shall be closely butted and joints taped.

**3.2 INSTALLER**

The dampproofing works shall be performed by a qualified specialist approved by the Engineer. A visit to the job site by an authorized representative of the manufacturer of dampproofing material who shall inspect and certify that the surface to which dampproofing was applied was in a condition suitable for that application and that the materials and application conform to the specified requirements and current recommendations.

**3.3 PREPARATION**

The entire roof deck construction of any bay or section of the building shall be completed and the ambient temperature shall be not lower than 5o C before roofing work is begun. The surface on which the roofing or flashings are to be applied shall be free from frost, moisture, dirt, projections, and foreign materials, and be smooth and firm. Vents and other items penetrating the roof shall be secured in position and properly prepared for flashing. Surfaces shall be inspected and approved immediately prior to application of roofing and flashings.

**3.4 APPLICATION OF ROOFING**

Asphalt shall be heated between 240 and 260o C. Asphalt shall be hot when applied, and layers of roofing shall be laid immediately in the hot asphalt. Roofing shall be laid free of wrinkles or buckles at right angles to the slope of the deck. Layers of glass-fibred roofing shall be laid in not less than 10 kg of asphalt per 100 m2 . Bitumen shall uniformly cover all roof areas to provide effective bond.

Asphalt primer, for concrete and masonry surfaces to receive asphalt products, shall be applied at a rate less than 4 L/10 m2. Each course of roofing felt, in addition to being mopped in hot bitumen, shall be lapped and nailed as specified herein. Roofing including roll roofing felts shall immediately follow insulation application if required as a continuous operation. The surfaces of the felts shall be carefully broomed-in with a 450 to 500 mm wide soft fibre type floor broom to obtain complete adhesion between plies and to eliminate air pockets. The method of mopping a half-sheet width and turning the sheet back to mop under the other half shall not be used. Workmen shall not walk on mopped surfaces when the bitumen is sticky. Each layer of roofing felt shall be carried up abutting vertical surfaces at least 100 mm or to the top of the cant strip. At eaves, the bottom layer of felt shall be applied in a 230 mm wide strip of bituminous cement.

**3.5 LAPPING AND FASTENING FELTS**

Roofing felts and roll roofing shall be laid with not less than the laps stated in 3.1.

**3.6 NAILS AND FASTENERS**

Nails and fasteners for securing metal flashings and asphalt roll roofing shall be 25 mm long roofing nails and shall be flush-driven through compatible copper or galvanized flat metal discs of not less than 25 mm diameter. Metal discs may be omitted where heads and fasteners are equivalent in size to the 25 mm diameter discs.

**3.7 FLASHINGS**

Flashing shall be provided in the angles formed at walls and other vertical surfaces and where required to make the work watertight. Flashings shall be provided and installed immediately after the top ply of roofing is placed and shall be returned and sealed, or capped and sealed to waterproof edges and ends. Sheetmetal reglets, where shown on the drawings, shall be located not more than 350 mm nor less, above the roofing surface.

**3.8 BASE FLASHINGS**

**a) General**

Base flashings shall consist of two layers of membrane or mastic flashing. Concrete over which flashings are to be installed shall be primed with asphalt primer which shall be allowed to dry thoroughly.

**b) Membrane Flashing**

1) Apply 2-ply membrane flashing at eaves and junctions of roof with vertical surfaces using roofing felts and asphalt throughout. Start first ply 75 mm from base of cant strip. Carry each additional ply 25 mm beyond preceding ply. Extend flashing over cant strip, up vertical wall for 300 mm and terminate with mechanical fasteners.

2) At joints, lap each sheet 100 mm over preceding ply and completely seal with full mopping of asphalt.

**c) Mastic Flashing**

1) Apply mastic flashing over cant strips, 50 mm on the vertical surface above cant strip and 75 mm on horizontal surface at base of cant strip.

2) Apply coat of mastic and embed layer of glass fibre mesh into same, overlapping joints a minimum of 50 mm.

3) Apply second coat of mastic and embed second layer of glass fibre mesh.

4) Apply heavy, third coat of mastic to completely cover all glass fibre mesh. The total thickness of mastic and glass fibre mesh shall be a minimum of 6 mm. Feather all edges.

All layers shall extend up the vertical surfaces to the mechanical fastener, or to the top of curb and the top layer shall be lapped completely over the curb and shall be secured at the top with mechanical fasteners at 200 mm centers.

Treated wood cants shall be installed in the angles formed at walls and other vertical surfaces as backing for base flashings. Cants shall be laid in a solid coat of bituminous cement just prior to laying the roofing plies. Cants shall have a 140 mm face dimension and shall be continuous and installed in as long lengths as practicable.

**3.9 STRIP FLASHINGS**

Roof flanges of cap flashings, base flashings, plumbing flashings, and mechanical flashings furnished and installed under other sections of the specifications shall be treated with two layers of roofing felt. After installation of flashings over the top ply of roofing, two layers of roofing felt, 250 and 300 mm wide, shall be successively mopped on top of the roof flange to form a waterproof joint between roofing and flashings.

**3.10 SANDTEX - MATT (OR APPROVED EQUAL) :**

Sandtex - Matt shall be applied to the top surface of built-up bituminous felt roofing in all situations where precast concrete paving slabs are not required.

Surfaces shall be brushed clean of all dust, washed down and allowed to dry. The surface shall then be primed with one coat of Blue Circle Bitumen Basecoat diluted with an equal quantity of water and allowed to dry out thoroughly for at least 24 hours before applying one coat of Sandtex - Matt finish.

**3.11 INSTALLATION OF PAVING SLABS ON OBSERVATION DECK**

After roofing felts have been laid and flashings installed, the entire roof surface to receive paving slabs except cants shall be flood coated uniformly with hot asphalt at the rate specified. While bitumen is still hot, supporting pads of styrofoam insulation and asbestos cement tiles as shown on the drawings shall be embedded therein at the correct locations shown. Paving slabs shall be placed in the manner specified in

**3.11.1** When the flood coat and paving slabs cannot be applied the same day, the felts are laid, or if there is a probability of rain falling on the felts before the flood coat can be applied, a light glaze coat of bitumen 5 to 7 kg/m2 shall be applied over the exposed felts. The glaze coat may be considered as part of the flood coat provided the surfacing operation is completed within 24 hours after application of the glaze coat.

Generally, method of installation shall be submitted for the Engineer's approval prior to commencement of work.

**END OF SECTION**

# SECTION 07193

# VAPOR BARRIER

**PART 1 : GENERAL**

**1.1 SCOPE OF WORK**

Furnish all labor, materials, equipment and incidentals required to install vapor barriers under concrete where indicated and as specified herein.

**PART 2 : PRODUCTS**

**2.01 MATERIALS**

Vapor barriers shall be 250-micron (10 mil) thick polyethylene sheet with a vapor transmission rating of 0.20 perms or less. Provide with polyethylene tape recommended to seal joints in vapor barrier

**PART 3 : EXECUTION**

**3. 01 INSTALLATION**

Vapor barriers shall be installed under interior dry building slabs-on-grade and at other locations indicated. Laps between adjacent sheets shall be 250 mm minimum and taped continuously together with polyethylene tape. Vapor barrier will be carefully inspected prior to concrete placement by the Engineer. Additional polyethylene sheet required for repair and replacement of damaged vapor barrier shall be furnished and installed as directed by the Engineer at no additional cost to the Employer.

**END OF SECTION**

# SECTION 07500

# MEMBRANE ROOFING

**PART 1: GENERAL**

* 1. **SCOPE OF WORK**

1. General: The extent of membrane roofing work is indicated on drawings and in schedules and includes but not by way of limitation, the provision of an impervious, flexible waterproofing membrane.
2. Related Works:
   1. Lightweight Insulating Concrete, Section 03400.
   2. Sealants and Caulking Section 07920
   3. **QUALITY ASSURANCE**
3. Manufacturer: Provide roofing material from a reputable manufacturer with not less than 10 years successful experience in producing materials of the type specified and required for this project. Obtain roofing materials from one manufacturer only.
4. Codes and Standards: comply with the applicable provisions of ASTM standards, except as otherwise shown and specified.
   1. **SUBMITTALS**
5. Product Data: Submit manufacturer’s specifications, installation instructions and general recommendations for the required waterproofing material. Include manufacturer’s certification or other data substantiating that the materials comply with the requirements.
6. Shop Drawings: submit shop drawings showing details of membrane fixation and in particular at abutments with walls, up-stands, service ducts and outlets and other locations of special requirements. Include details of material termination and fixation at flashings.
7. Samples: Submit 300 mm square sample of roofing material. Engineer’s review will be for general appearance only. Compliance with all other requirements is the exclusive responsibility of the Contractor.
8. Guarantee: Provide 5-year guarantee for the work, which cover repair required to maintain roof in watertight condition. Carry out repairs at no expense to the employer.
   1. **PRODUCT DELIVERY STORAGE AND HANDLING**
9. Delivery: Deliver materials in original, sealed containers, clearly labeled with manufacturer’s name, product identification and lot numbers and date of manufacture. Protect the materials from damage during loading, shipment, delivery and storage.
10. Storage and Handling: Store materials off the ground in covered storage sheds and in strict accordance with the manufacturer’s instructions.
    1. **JOB CONDITIONS**
11. Coordination: Coordinate roofing work with all other works, whether forming part of membrane roofing work or not, so that all works are carried out in a timely and proper manner, without delay or interference.
12. Substrates and other conditions: Do not install roofing work until all concrete work and other surfaces to which roofing membrane is to be applied are dry and properly cured. Comply with any requirements by the manufacturer regarding installation and weather condition limitations.

**PART 2: PRODUCTS**

**2.01 MATERIALS**

1. Waterproofing Membrane:
   1. Bituminous Membrane: The waterproofing membrane shall be 4 mm minimum thickness of thermoplastic modified bitumen, with a multilayered, non-woven core of appropriate material, coated on both sides with bitumen. The membrane shall have the following characteristics:
      1. Tensile Strength (ASTM D 146): 950 N/5cm.
      2. Ultimate Elongation (ASTM D 146): 45%
      3. Water Vapour Permeability (ASTM E96):
         * Water Vapour Transmission; 0.28g/m2/24hrs
         * Permeance; 0.01 perms.
      4. Softening Point (ASTM D 36): 155 C
   2. Supplier: “POLYFLAME” as manufactured by Bitumat Co.Ltd., Kingdom of Saudi Arabia, or approved equivalent.
   3. Surface finish: The membrane shall be suitably surface finished, according to the requirements for the overall waterproofing system.

**PART 3: EXECUTION**

* 1. **INSPECTION**

1. The contractor shall examine the substrates and the conditions under which roofing membrane shall be installed and correct any unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.
2. Well in advance of commencement of roofing operations but after representative new roofing substrate has been constructed and prepared for roofing, a pre-roofing conference shall be held to inspect the substrate. All parties having an interest in the roofing or work on the roofs shall be informed of the conference by the Contractor.
3. Parties to the conference shall include the Engineer, Contractor, roofing subcontractor and his foreman, roofing membrane and insulation manufacturer’s, plumbing subcontractor, HVAC subcontractor and a representative of any other trade classification having work on a roof and deemed by the Engineer to attend.
4. The conference shall include an inspection by all parties of the membrane substrate and its conformance with the Drawings, the approved shop drawings and the approved roofing manufacturer’s specifications and instructions. All objections to approval of the substrate shall be noted by the Engineer. The Contractor shall coordinate efforts to remedy objections and prepare the substrate properly to receive roofing and flashing so that the warranty can be issued. Work of this section shall commence after remedies are made.
   1. **INSTALLATION**
5. Preparation: All surfaces to receive waterproofing membrane shall be clean, dry, smooth, free from dirt, oils and cement laitance and all other extraneous materials. All concrete works must be properly cured before the installation of waterproofing. Remove all projections, sharp edges and patch all holes, local depressions and sudden changes in level and ensure that construction operations do not puncture the membrane.
6. Application:
   1. All installation work shall be carried out by competent workmen, experienced in the installation of waterproofing, in strict compliance with the manufacturer’s instructions.
   2. Torch-apply waterproofing membrane to provide a layer fully bonded to the substrate, with air excluded from under the membrane, overlap joints at sides and ends as recommended by the manufacturer, but not less than 100mm, providing a continuous adhesion and water-tight membrane.
   3. Cut and fit around ducts and services and provide the necessary additional membrane strips, appropriately bonded to the structures to ensure continuity of waterproofing system. Extend waterproofing to all surface including crevices, grooves and corners.
   4. At abutments with up-stands, walls and other vertical structures and elements, extend the waterproofing membrane to a minimum height of 150 mm and as shown on the drawings. Build-in membrane where required and provide the necessary sealants as specified. Refer to Section 07005 “WATERPROOFING DAMPROFFING AND CULKING”.
   5. Where indicated and at internal angles of roof slab and parapets, provide fillets in plain concrete, troweled smooth to provided adequate backing for the membrane. Provide the necessary flashings and all other accessories as needed.
   6. Refer to Section 03400 “LIGHTWEIGHT INSULATING CONCRETE”.
   7. Project waterproofing membrane from damage and repair all damaged work to the satisfaction of the Engineer.

**END OF SECTION**

# SECTION 07920

# SEALANTS AND CAULKING

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This Section covers sealing and caulking. The terms "sealant" and "caulking" as used on the Drawings and in these specifications are synonymous, and either or both terms shall indicate the materials specified herein. Oil-base caulking shall not be used. The Contractor shall furnish all labor, materials, tools, and equipment required to complete the work. Provide all sealant and caulking work essential to the continued integrity of all joints between items where sealants are required to provide a positive barrier against penetration of air and moisture.

The required application of sealants and caulking include, but are not necessarily limited to, the following general locations:

1. Coping members, bed and joints.

2. Exterior wall joints.

3. Masonry control joints (exterior & interior)

4. Flooring joints.

5. Isolation joints between structure and other elements such as windows, doors, sheds, lintels, etc.

6. Paving and sidewalk joints.

7. Joints at penetration of walls, deck, floors by piping and other services and equipment.

8. Joints between items of equipment and other construction.

9. Expansion and contraction and crack inducer joints.

**1.1.01 Related Work**

Other items of work that relate to and are referenced in this section include, but are not limited to, the following sections:

Brickwork and Blockwork

Steel Doors

Wood Doors

Aluminum Windows

Glass and Glazing

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work of this section are listed. Codes and Standards current at the time of bid shall be used.

* + 1. BS British Standard
    2. ASTM – American Society for Testing and Materials

**1.3 SUBMITTALS**

The following items shall be submitted in accordance with the SUBMITTALS Section.

* + 1. Three samples of each type of material proposed for use in the work**.**
    2. 1-3.02 Three copies of the manufacturer's published recommendations to support the selection of and compatibility of the various related materials with respect to the type of joint for which each material is intended.

**1.4 ENVIRONMENTAL CONDITIONS**

**1.4.01** No sealant work shall be done when the air temperature is below 4 °C or above 32 °C without the written concurrence of the sealant manufacturer.

**1.4.02** No exterior sealant work shall be done during conditions of blowing sand.

**1.4.03** The Contractor shall provide adequate ventilation when using sealants indoors which contain toxic ingredients.

**PART - 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Material List**

Materials used shall be:

|  |  |
| --- | --- |
| Polysulfide Sealant, Nonsag | Polysulfide rubber, one component. |
| Urethane Sealant, Self-Leveling | Polyurethane, two component |
| Acrylic Latex | Acrylic latex based caulking compound, paintable, for interior use only, not for expansion or control joints. |
| Silicone Sealant | One part silicone rubber sealant |
| Silicone Sanitary Sealant | One part silicone mildew resistant, white. |
| Primer | As recommended by the sealant manufacturer. |
| Backup Material (Backing Strip, Compressible Filler) | Closed cell polyethylene foam or resilient polyurethane, as recommended by the sealant manufacturer. |
| Backer Rod | Extruded from closed cell neoprene rubber. |
| Bond Breaker | Where required, polyethylene tape or as recommended by sealant manufacturer. |

**2.2 PERFORMANCE REQUIREMENTS**

**2.2.01 Color**

Unless otherwise indicated on the Drawings, the caulking colors shall be the Manufacturer's standard color that most nearly matches adjacent masonry or other materials.

**2.2.02 Backup Material**

Backup material shall be of suitable size so that, when compressed 25 to 50 %, the space will be filled.

**2.2.03 Submerged Service**

Sealants used in submerged service shall be recommended by the manufacturer for submerged services.

**PART 3 - EXECUTION**

**3.1 LOCATION**

**3.1.01 Exterior Sealants**

**a.** Silicone sealant shall be used for sealing vertical joints in concrete, precast concrete, and for perimeter sealing.

**b.** One-part polysulfide may be used for vertical or overhead joints and for sealing between dissimilar materials, and for filling expansion joints.

**c.** Two-part polyurethane shall be used for horizontal application on areas subject to traffic and on concrete joints.

**3.1.02 Interior Sealants**

1. Acrylic latex based caulking compound shall be used in fixed or nonmoving joints including but not limited to such joints as hollow metal frames and adjacent material, wood cabinets, and wall materials.
2. Silicone sealant shall be used where dynamic joint movement will occur.
3. Silicone sanitary rubber sealant shall be used to seal around sinks, urinals, and for sealing fixtures in bath/washroom facilities.

**3-1.03** Application of sealants shall be in strict conformance with the Manufacturer's written directions.

**3.2 PREPARATION**

**3.2.01** Joints shall be thoroughly cleaned, removing foreign matter such as dust, oil, grease, water, and surface dirt. Joints shall be primed as required. Primer must adhere permanently or be entirely removed and replaced as required by joint condition.

**3-2.02** Porous materials such as concrete, masonry or plaster shall be cleaned, where necessary, by grinding, sand or water blast cleaning, mechanical abrading, acid washing, or a combination of methods as required to provide a clean, sound base surface for proper adhesion.

**3-2.03** Nonporous surfaces, such as metal and glass, shall be cleaned, either mechanically or chemically. Protective coatings on metallic surfaces shall be removed by a solvent that leaves no residue. Use solvent with clean white cloths or lintless paper towels and wipe dry with same. Do not allow solvent to air dry without wiping. Joint areas protected with masking tape or strippable films shall be cleaned as above after removal of tape or film.

**3-2.04** Joints shall not be sealed until they are in compliance with the Drawings.

1. Joints to receive sealant shall be a minimum of 6 mm wide by 6 mm deep.
2. Joints in concrete or masonry: Depth of sealant shall be equal to the width of joints up to 13 mm wide. For joints between 13 mm and 25 mm wide, the depth shall be 13 mm. For expansion and other joints between 25 mm and 50 mm wide, depth shall be not greater than 13 mm deep. For joints exceeding 50 mm in width, depth shall be as recommended by the sealant manufacturer.
3. Joints in metal: Joints between 6 mm and 13 mm shall have a sealant depth of 6 mm; joints between 13 mm and 25 mm shall have a sealant depth of 6 mm to 13 mm; joints over 25 mm shall have a sealant depth of 13 mm.
4. Above dimensions should be increased as directed by the sealant manufacturer when application is made at temperatures above 32 °C or below 4 °C.

**3.3 APPLICATION**

**3.3.01** Backup material of joint filler shall be installed at proper depth in joints to provide proper sealant dimension. Backup material shall be of suitable size and shape so that when compressed 25 to 50 per cent, it will fit in joints as required. Sealant shall not be applied without backup material and, if necessary, bond breaker strip.

**3-3.02** Surfaces shall be primed, where required, with a primer recommended by the sealant manufacturer.

**3-3.03** Sealant shall be applied under pressure with hand or power actuated gun or other appropriate means. Gun nozzle shall be of proper size and provided with sufficient pressure to completely fill joints as detailed. Neatly point or tool joint surfaces to provide the contour indicated on the Drawings or, if not indicated, joint shall be tooled concave. When tooling light colored sealants, use clean water-wet tools or a tooling solution recommended by the sealant manufacturer.

**3.4 CLEANING**

Adjacent surfaces shall be cleaned until free of sealant or soiling resulting from this work as work progresses. Use solvent or cleaning agent recommended by the sealant manufacturer. Exercise due care to prevent damage or discoloration to adjacent materials when removing excess sealant materials.

**END OF SECTION**

# SECTION 08114

# STEEL DOORS AND FRAMES

**PART 1 - GENERAL**

**1.1 SCOPE OF WORK**

Furnish all labor, materials, equipment, and incidental required to deliver the following as shown and as specified herein:

* 1. Steel hollow-metal doors and transom panels.
  2. Pressed-metal door, transom and glass frames.
  3. all fasteners, frame closure pieces, system reinforcing and appurtenances required.

**1.2 RELATED WORK**

Other sections directly related to work covered in this section include the following:

* 1. Section 04200 - Masonry.
  2. Section 06100 – Carpentry Work.
  3. Section 07902 – Sealer and Caulking.
  4. Section 08700 –Hardware.
  5. Section 09903 – Painting.
  6. **SUBMITTALS**

1. Submit to the Engineer, as provided in the submittals section, data and drawings of all metal doors, doors, frames, panels and appurtenances.
   1. Shop drawings shall show elevations and details of each frame type, schedule of doors and frames, door elevations and details, conditions at openings with various wall thickness and materials, location and installation requirements for hardware, thickness of materials, joints and connections and trim.
   2. Where acceptable to be fabricated in more than one piece, locate and detail field splices and indicate complete instructions for making field splices.
2. Hardware templates shall be furnished to the door manufacturer by the Contractor for correct hardware alignment and reinforcing.
3. Provide samples and certification as follows:
   1. Door frame corner with 150 mm long legs showing construction with the galvanized material specified, welding, touch-up and priming.
   2. Door panel corner, 150 mm square, showing door and insulating materials, construction and finishing as specified above.
   3. Provide certification that all materials and construction specifications herein will be met in the project.
   4. **QUALITY ASSURANCE**
4. Provide custom hollow metal work manufactured by a single firm specializing in the production of this type of work, unless otherwise acceptable to the Engineer.
5. Provide custom hollow metal work by one of the following or equal:
   1. Overly Manufacturing Co.
   2. Pioneer Industries.
   3. Superior Fireproof Door.
   4. **DELIVERY, STORAGE AND HANDLING**

Deliver materials in manufacturer’s original unopened and undamaged packages with labels legible and intact. Doors and panels shall be individually wrapped in corrugated cardboard with wood strips on vertical edges and banded with metal straps. Store materials in unopened packages in a manner to prevent damage from the environment and construction operations. Handle in accordance with manufacturer’s instructions.

**PART 2 - PRODUCTS**

**2.1 MATERIALS – HOLLOW METAL DOORS AND FRAMES**

1. Galvanized steel sheets – Zinc-coated carbon steel sheets of commercial quality, complying with ASTM A562, with ASTM A525, G60 zinc coating, mill phosphatized.
2. Zinc-rich primer – 95% metallic zinc dust primer in a vehicle compatible with the specified painting system. Apply to properly prepared substrates where galvanizing is damaged by fabrication. Follow with full coat over all steel surfaces and components.
3. Supports and anchors – fabricate of not less than 1.5 mm (16 gage) sheet metal. Galvanize after fabrication units complying with ASTM A153, Class B.
4. Inserts, bolts and fasteners – Hot –dip galvanize, complying with ASTM A153, Class C or D as applicable.
   1. **FABRICATION, GENERAL**
5. Fabricate hollow metal units to be rigid, neat in appearance, and free from defects, warp, or buckle. Accurately form metal to required sizes and profiles. Wherever practicable, fit and assemble units in the manufacturer’s plant. Clearly identify work that cannot be permanently factory-assembled before shipment, to assure proper assembly at the project site. Weld exposed joints continuously; grind, dress, and make smooth, flush, and invisible. Metallic filler to conceal manufacturing defects is not acceptable.
6. Prepare hollow metal units to receive mortised and concealed finish hardware, including cutouts, reinforcing, drilling and tapping in accordance with final Finish Hardware Schedule and templates provided by hardware supplier. Comply with applicable requirements of ANSI A115 series specifications for door and frame preparation for hardware.
7. Reinforce hollow metal units to receive surface-applied hardware. Drilling and tapping for surface-applied finish hardware may be done at project site.
8. Shop Painting
   1. Clean, treat, and paint exposed galvanized surfaces of fabricated hollow metal units.
   2. Clean steel surfaces of mill scale, rust, oil, grease, dirt, and other foreign materials and apply approved zinc-rich primer to galvanized surfaces damaged in fabrication.
   3. Apply pretreatment to cleaned metal surfaces, using cold phosphate solution (SSPC-PT2), hot phosphate solution (SSPC – PT4) or basic zinc chromate-vinyl butyral solution (SSPC – PT3) as approved compatible with zinc primer to be used.
   4. Apply shop coat of prime paint within time limits recommended by pretreatment manufacturer. Apply a smooth coat of even consistency to provide a uniform dry film thickness of not less than 50 microns.
9. Shop Painting – Steel Plate Doors and Channel Frames
   1. Surface preparation and shop prime painting shall conform to all applicable specifications in Section 09901.
   2. **DOORS**
10. General
    1. Provide flush design doors, 44 mm (1 – ¾ - in.) thick, seamless hollow construction, unless otherwise indicated.
    2. Bevel both vertical edges 3 mm (1/8 – in.) in 50 mm (2-in).
    3. Provide filler of mineral-wool or other approved insulating material solidly packed full door height to fill voids between inner core reinforcing members. No asbestos products will be allowed.
    4. Reinforce hollow metal doors with rigid tubular frame where stiles and rails are less than200 mm (8-in) wide. Form tubular frame with 1.5 mm (16 gage) steel, welded to outer sheets.
11. Galvanized Steel Hollow Metal Doors
    1. Fabricate doors of 2 outer, galvanized, stretcher-leveled steel sheets not less than 1.5 mm (16 gage). Construct doors with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges, except around glazed or louvered panel inserts. Provide weep hole openings in the bottom of doors to permit escape of entrapped moisture.
    2. Reinforce inside of doors with vertical galvanized sheet steel sections not less than 0.75mm (22 gage). Space vertical reinforcing 150 mm o.c. and extend full door height. Spot-weld at not more than 125 mm o.c. to both face sheets.
    3. Reinforce tops and bottoms of doors with 1.5 mm (16 gage) horizontal steel channels welded continuously to outer sheets. Close top and bottom edges to provide weather seal, as integral part of door construction or by addition of inverted steel channels.
12. Finish hardware reinforcement. Reinforce doors using galvanized steel for required finish hardware, as follows:
    1. Hinges – Steel plate 4.5 mm (3/16 – in) thick x 40 mm (1- ½ -in) wide x 150 mm longer than hinge, secured by not less than 6 spot-welds.
    2. Mortise locksets and dead bolts – 1.9 mm (14 gage) steel sheet, secured with not less than 2 spot-welds.
    3. Cylinder locks – 2.7 mm (12 gage) steel sheet, secured with not less than 2 spot – welds.
    4. Flush bolts – 2.7 mm (12 gage) steel sheet, secured with not less than 2 spot-welds.
    5. Surface-applied closers - 2.7 mm (12 gage) steel sheet, (except when through bolts are shown or specified), secured with not less than 2 spot-welds.
    6. **HOLLOW METAL PANELS**
13. Provide pressed metal frames for doors, transoms, side-lights, borrowed lights, and other openings, of size and profile as indicated.
14. Fabricate frames of full-welded unit construction, with corners mitered, reinforced, continuously welded full depth and width.
15. Form frames of 1.9 mm (14 gage) galvanized steel sheets.
16. Finish hardware reinforcement. Reinforce frames using galvanized steel for required finish hardware, as follows:
17. Hinges – Steel plate 4.5 mm (3/16 – in) thick by 40 mm (1- ½ -in) wide by 150 mm (6 in.) longer than hinge, secured by not less than 6 spot-welds.
18. Strike plate clips – steel plate 4.5 mm (3/16 in.) thick by 40 mm (1 – ½ in.) wide by 75 mm (3 in.) long.
19. Surface-applied closers – 2.7 mm (12 gage) steel sheet, secured with not less than 6 spot-welds.
20. Mullions and transom bars – Provide closed or tubular mullions and transom bars where indicated. Fasten mullions and transom bars at crossings and to jambs by butt-welding. Reinforce joints between frame members with concealed clip angles or sleeves of same metal and thickness as frame.
21. Head reinforcing – Where installed in masonry, leave vertical mullions in frames open at top for grouting.
22. Jamb anchors – Furnish jamb anchors as required to secure frames to adjacent construction, formed of not less than 1.2 mm (18 gage) galvanized steel.
    1. Masonry construction – Adjustable, flat, corrugated, or perforated, t-shaped to suit frame size, with leg not less than 50 mm wide by 250 mm long. Provide U.L. approved fixed anchors at labeled openings. Furnish at least 3 anchors per jamb up to 2250 mm height; 4 anchors up to 2400 mm jamb height; one additional anchor for each 600 mm or fraction thereof over 2400 mm height.
    2. In-place concrete or masonry- anchor frame jambs with minimum 10 mm (3/8–in) diameter concealed bolts into expansion shields or inserts for masonry and adhesion anchors for concrete 150 mm from top and bottom and 600 mm o.c., unless otherwise shown. Reinforce frames at anchor locations. Apply removable stop to cover anchor bolts unless otherwise indicated.
23. Floor anchors – Provide floor anchors for each jamb and mullion which extends to floor, formed of not less than 1.9 mm (14 gage) galvanized steel sheet, as follows:
24. Monolithic concrete slabs – clip type anchors, with 2 holes to receive fasteners, welded to bottom of jambs and mullions.
25. Separately finished tile areas and concrete slabs – Adjustable type with extension clips, allowing not less than 50 mm height adjustment. Terminate bottom of frames at finish floor surface.
26. Head strut supports – Provide 10 mm x 50 mm (3/8 – in x 2 – ion) vertical steel struts extending from top of frame to supporting construction above, unless frame is anchored to masonry or to other structural support at each jamb. At frames without mullions provide struts at 1200 mm o.c. along head members. Bend top of struts to provide flush contact for securing to supporting construction above. Provide adjustable bolted anchorage to frame jamb members with no parts of fasteners exposed in the finished work.
27. Structural reinforcing members – Provide built-in as part of frame assembly where indicated at mullions, transoms, or other locations.
28. Head reinforcing – For frames over 1200 mm wide in masonry wall openings, provide continuous steel channel or angle stiffener, not less than 2.7 mm (12 gage) for full width of opening, welded to back of frame at head.
29. Spreader bars – Provide removable spreader bar across bottom of frames, tack welded to jambs and mullions.
30. Plaster guards – Provide galvanized sheet steel plaster guards or dust cover boxes, welded to frame, at back of finish hardware cutouts where mortar or other materials might obstruct hardware installation.
    1. **STOPS AND MOLDINGS**
31. Provide stops and moldings around glazed panels in hollow metal units and in frames to receive doors and panels, where and as indicated.
32. Form fixed stops and moldings integral with frame, unless otherwise indicated.
33. Provide removable stops and moldings where and as indicated or required, formed of not less than 0.9 mm (20 gage) steel sheets matching steel of frames. Secure with countersunk machine screws spaced uniformly not more than300 mm on center. Form corners with butted hairline joints.
34. Coordinate width of rabbet between fixed and removable stops with type of glass or panel and type of installation indicated.
35. Provide angles of not less than 1.5 mm (16 gage) for securing fixed transom panels to frames as approved.
    1. **LOUVERS**

Provide louvers of not less than 1.5 mm (16 gage) steel as specified for doors. Fabricate louvers with stationary; sight proof inverted V-shaped blades and U-shaped frames, not less than 25 mm (1 – in) deep. Space louver blades not more than 19 mm (3/4 – in) on center. Assemble louvers by welding.

**PART 3 - EXECUTION**

* 1. **INSTALLATION**

1. Install hollow metal units and accessories in accordance with approved shop drawings, manufacturer’s data, and as herein specified.
2. Setting masonry anchorage devices – Provide masonry anchorage devices where required for securing hollow metal frames to in-place concrete or masonry construction. Set anchorage devices opposite each anchor location, in accordance with details on shop drawings and anchorage device manufacturer’s instructions. Leave drilled holes rough, not reamed, and free from dust and debris.
3. Placing Frames – Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete remove temporary braces and spreaders leaving surfaces smooth and undamaged.
4. In masonry construction, coordinate frame setting with the building of masonry walls.
5. At in-place concrete or masonry construction, set frames and secure in place with anchor bolts as specified.
6. Make field splices in frames as detailed on final approved shop drawings, welded and finished to match factory work.
7. Remove spreader bars only after frames or bucks have been properly set and secured.
   1. **ADJUSTMENT AND TOUCH-UP**
8. Leave work in complete and proper operating condition. Remove and replace defective work, including doors or frames which are warped, bowed or otherwise unacceptable.
9. Immediately after erection, sand smooth any rusted or damaged areas of zinc primer and apply touch-up of same primer.

**END OF SECTION**

# SECTION 08120

# ALUMINIUM DOORS AND FRAMES

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK**

1.1-1 The extent of each type of aluminum doors and frames is shown on the Drawings and in schedules.

1.1-2 Related work is specified elsewhere.

**1.2 QUALITY ASSURANCE**

1.2-1 Codes & Standards

Except as otherwise required, materials & workmen ship shall conform with the latest revision of the specification of the British Standards current at the time of bid.

1.2-2 Manufacturer

Provide units produced by firms with not less than five years of successful experience in the fabrication of aluminum entrance doors and frames, of the types required for this project.

1.2-3 Wind Loading

Fabricate exterior door and frame units to withstand the wind pressure loading of 30 lbs. per sq.ft. (147 kg/sq.m.) on the gross area of the frames, doors, panels and glass, acting inward and acting outward.

**1.3 SUBMITTALS**

1.3-1 Manufacturer's Data, Aluminum Doors and Frames

For information only, submit two copies of manufacturer's data, recommendations and standard details for aluminum doors and frames, including fabrication, finishing, hardware, accessories and other components of the work to the Engineer.

1.3-2 Shop Drawings

Aluminum Doors and Frames, and associated components of the work. Include wall elevations at 1/2" scale, and half-size detail sections of every typical composite member. Show anchors, joint system, expansion provisions and other components, not included in manufacturer's standard data. Include glazing details.

1.3-3 Samples, Aluminum Doors and Frames

A. Submit three samples of each required aluminum finish, on 12" long extrusions or 6" square sheets, of the alloys to be used for the work. Where normal colour and texture variations are to be expected, include two or more unit in each sample, to show the range of such variations. Samples will be reviewed by the supervising Engineer for colour and texture only. Compliance with other requirements is the exclusive responsibility of the Contractor.

B. The supervising Engineer reserves the right to require sample of typical fabricated sections, showing joints, exposed fastenings (if any), quality of workmanship, hardware and accessory items, before fabrication of the work proceed.

**PART 2 - PRODUCTS**

**2.1 MATERIALS AND ACCESSORIES**

2.1-1 Aluminum Extrusions

Provide alloy and temper as recommended by manufacturer for strength, corrosion resistance, application of required finish and control of colour but not less than 22,000 psi (1550 kg/sq.cm.) ultimate tensile strength. Provide main extrusions of not less than 3.0 mm wall thickness for main sections and not less than 2 mm for secondary sections.

2.1-2 Fasteners

A. Aluminum, non-magnetic stainless steel or other non-corrosive metal fasteners guaranteed by the manufacturer to be compatible with the doors, frames, stops, panels, hardware, anchors and other items being fastened. For exposed fasteners, provide Phillips flat-head screws with finish matching the item fastened.

B. Do not use exposed fasteners except where unavoidable for the assembly of units, and unavoidable for the application of hardware. Provide only concealed screws in glazing stops.

2.1-3 Steel Reinforcement and Brackets

These shall be manufacturer's standard formed or fabricated steel units, or shapes, plates or bars; with 2.0 oz. hot dip zinc coating.

2.1-4 Inserts

For required anchorage into concrete or masonry work, furnish inserts of cast iron, malleable iron or twelve gauges steel hot-dip galvanized after fabrication.

2.1-5 Expansion Anchor Devices

Lead-shield or toothed-steel, drilled in, expansion bolt anchors.

2.1-6 Bituminous Coatings

Cold-applied asphalt mastic complying with SSPC-PAINT 12, compounded for 30 mil thickness per coat.

2.1-7 Protective Lacquer

Manufacturer's standard, clear, non-yellowing lacquer, compounded specifically for protection of anodic coatings during construction.

2.1-8 Compression Weather stripping

Provide manufacturer's standard replaceable stripping of either molded neoprene gaskets, or molded PVC gaskets.

2.1-9 Weather stripping

Provide manufacturer's standard replaceable stripping of wool, polypropylene or nylon woven pile, with nylon fabric and aluminum strip backing.

2.1-10 Sealants and Gaskets

Provide sealants and gaskets in the fabrication, assembly and installation of the work, which are recommended.

2.1-11 Glazing Gaskets

For glazing factory-installed glass and panels, and for gaskets which are factory-installed in a "captive" assembly of glazing stops, provide manufacturer's standard stripping of molded neoprene.

2.1-12 Glazing Materials

Refer to section for gaskets and sealants required for the installation of glass and "glazed" panels at the project site.

**2.2 EXTERIOR ENTRANCES AND FRAMES**

2.2-1 General

Design is based on entrance and framing design shown on drawings. Also provide at interior locations shown on the Drawings.

2.2-2 Doors

Doors shall be 2" nominal thickness. Aluminum section thickness shall not be less than 3.0 mm.

2.2-3 Frames

Frames shall be 1" x 41/2" 1-line with transom and sidelights as detailed on the Drawings. Aluminum sections thickness shall not be less than 3.0 mm.

2.2-4 Hardware

Hardware shall be as follows:

A. Center pivots.

B. Floor closers.

C. Push-pull.

D. Locks: Manufacturer's standard deadlock (cylinders to be furnished under Section HARDWARE.)

E. Panic hardware: Concealed rod panic hardware, crash bar, finished to match door, (only where shown).

F. Thresholds: Manufacturer's standard complete with anchors and clips, coordinated with pivots and closers, extruded aluminum, sizes as shown, mill finish.

**2.3 FABRICATION**

2.3-1 General

A. Sizes and Profiles: The required sizes for door and frame units, and the profile requirements are shown on the Drawings.

B. The details shown are based upon standard details. Details by other manufacturers will be acceptable, provided they comply with the size requirements, and with profile requirements as shown.

C. Coordination of Fabrication: Wherever possible, check the actual frame or door openings in the construction work by accurate field measurements on final shop drawings. However, coordinate fabrication schedule with construction progress as directed by the Engineer and avoid delays of the work. Where necessary, proceed with fabrication without field measurements, and coordinate installation tolerances to insure proper fit of door and frame units.

D. Prefabrication: Except as otherwise indicated, provide each continuous unit of framework, doors, side lights, transom panels, hardware, and all accessory items, as a "packaged entrance" unit. Complete the fabrication, assembly, finishing, application of hardware and all other work, before shipment to the project site, to the greatest extent possible. Disassemble only to the extent necessary for shipment and installation.

(1) Pre-glaze door and frame units to the greatest extent possible, in coordination with installation and hardware application requirements.

(2) Refer to Section GLASS AND GLAZING for glass and glazing requirements.

E. Complete the cutting, fitting, forming, drilling and grinding of all metal work prior to cleaning, finishing, treatment and application of coatings. Remove rises from cut edges and ease edges and corners to a radius of approximately 1/64".

F. Weld by methods recommended by the manufacturer to avoid discoloration at welds. Grid exposed welds smooth and restore by approved mechanical finish.

G. Conceal fasteners, wherever possible, except as otherwise shown.

H. Maintain continuity of line and accurate relation of planes and angles. Provide secure attachment and support at mechanical joints, with hairline fit of contacting members.

I. Reinforce the work as necessary for performance requirements, and for support to the structure. Separate dissimilar metals with bituminous paint or preformed separators which will prevent corrosion. Separate metal surfaces at moving joints with non-metallic separators to prevent "freeze-up" of joints.

J. Weather stripping: Where exterior door stiles or head rails do not close against fixed stops equipped with compression weather stripping, provide sliding weather stripping, retained in an adjustable strip in a mortise centered in the edge of door.

2.3-2 Stile and Rail Type Aluminum Doors

A. Provide tabular frame members, fabricated with mechanical joints of heavy inserted reinforcing plates and concealed tie- rods or J-bolts, in accordance with manufacturer's standard fabrication methods; or fabricate with structurally welded joints, at manufacturer's option.

B. Glazing: Fabricate doors to facilitate replacement of glass or panels (from inside only) without disassembly of door stiles and rails, except for ultra-narrow stile doors. Provide snap-on extruded aluminum glazing stops, with exterior stops anchored for non- removal.

2.3-3 Aluminum Door Frames

A. Fabricate tabular and channel frame assemblies, as shown, with either welded or mechanical joints in accordance with manufacturer's standards, with concealed fasteners wherever possible.

B. Provide glazing system for frames to receive lights or panels. Design system for replacement of glass, but for non-removal of glass or panels from the exterior.

**2.4 ALUMINUM FINISHINGS**

2.4-1 General

A. Preparation: After fabrication of doors and frames, prepare the aluminum surfaces for finishing in accordance with the aluminum producer's recommendations and standards of the finisher or processor. Process all components of each assembly simultaneously to attain complete uniformity of colour.

B. Samples: Match the Owner's sample for colour and texture requirements, except for finishes which are indicated to comply with industry standard colours and texture samples. Establish samples of the required finish, for the Engineer's acceptance, prior to fabrication of the work. The Owner reserves the right to reject material finishes with objectionable variations from the established samples.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

3.1-1 Comply with manufacturer's specifications and recommendations for the installation of aluminum doors and frames.

3.1-2 Set units plumb, level and true to line, without wrap or rack of frames doors or panels. Anchor securely in place. Separate aluminum and other corrodible metal surfaces from sources of corrosion or electrolytic action at points of contact with other materials.

3.1-3 Set sill members and other members in a bed of compound as shown, or with joint fillers or gaskets as shown to provide weather tight construction. Refer to Section SEALANTS AND CAULKING for sealants and compounds required.

3.1-4 Refer to Section GLASS AND GLAZING for installation of glass and other panels shown to be "Glazed" into doors and frames, and not pre-glazed by manufacturer.

3.1-5 Clean aluminum surfaces promptly after installation of frames and doors, exercising care to avoid damage. Remove excess glazing and sealant compounds, dirt and other substances.

3.1-6 Institute all protective treatment and other precautions required throughout the remainder of the construction period to insure that doors and frame will be without damage or deterioration (other than normal weathering at the time of final acceptance).

**END OF SECTION**

**SECTION 08330**

**ROLLING STEEL DOORS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers rolling steel doors. Doors shall be overhead coiling type, of sizes indicated, complete with necessary guides, hoods, hardware, fastenings, mechanisms, and accessories as indicated or specified.

Doors shall be installed complete and in proper operating condition in the openings required by the Drawings or as specified.

Details of doors, guides, hoods, and accessories shall be as specified herein.

* + 1. **Related Work**

1. General Equipment and Material Stipulations.

The General Equipment and Material Stipulations shall apply to all equipment furnished under this section.

1. Work Specified elsewhere

Other items that relate to and are referenced in this section include, but are not limited to, the following sections:

Submittals

Hollow Metal Doors and Frames

Finish Hardware

Painting

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work under this section are listed. Codes and Standards current at the time of bid shall be used.

* + 1. **BS British Standards**

**A48** Gray Iron Castings, Standard Specification for

**A386** Zinc Coating (Hot-Dip) on Assembled Steel Products, Standard Specification for

**A526** Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, commercial Quality, Standard specification for

**1.3 QUALITY ASSURANCE**

**1.3.01 Qualifications**

Doors shall be the product of a manufacturer who is regularly engaged in manufacturing the items specified.

**1.4 SUBMITTALS**

**1.4.01 Drawings and Data**

Complete detail and installation drawings shall be submitted in accordance with the Submittal – Section. Drawings shall indicate construction details, clearance requirements, metal gages, finish, counterbalancing, method of anchoring, and location of guides.

**1.5 PRODUCT HANDLING**

**1.5.01 Protection**

Doors shall be protected from damage during transportation and at the Work Site. Doors shall be protected from damage during subsequent construction activities. Damaged items will be rejected and shall be replaced with undamaged units.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Material List.**

Materials used in rolling steel doors shall be as follows :

* Curtain and Hood: Sheet steel, galvanized.
* Insulation: Polyurethane.
* End Locks: Malleable iron.
* Bottom Bar and guides: Steel angles or channels at lest 5mm thick.
* Bottom Weather Seal: Rubber or vinyl.
* Roller Shaft: Steel pipe or tubing.
* Roller Ends: Cast iron, ASTM A48
* Spring: Oil tempered steel.
* Brackets and Gearing: Cast iron or steel.
* Operating Chain: Zing plated steel

**2.2 DOORS**

**2.2.01 General**

Manual chain gear operated rolling steel doors shall be furnished and installed in accordance with doors schedules on the Drawings.

**2.2.02 Curtain**

Curtains shall be formed of interlocking insulated slats and shall be designed to resist wind pressure of 960 N per square meter. Curtain shall roll up on a drum supported at head of opening and shall be balanced by helical springs. Slats shall be formed of 0.76 mm thick galvanized steel with polyurethane insulation enclosed by backing sheet.

The ends of each slat in the curtain shall have a combination end lock and wind lock. Combination end locks shall have a flat surface engaging a seal of metal or other suitable material mounted on, or in the guides, in a manner which will provide an effective wind and water seal.

A bottom bar shall be provided on the bottom of the curtain in a manner to suit sill construction. Each exterior door shall have a replaceable, compressible weather seal attached to the bottom bar.

**2.2.03 Guides**

Guides shall form a pocket of sufficient depth to retain the curtain in place under the specified wind pressure. Guides shall be attached to adjacent construction with 10 mm bolts near each end and at intermediate spacing of not more than 750mm.

**2.2.04 Roller Shaft**

Roller shaft shall be designed so that deflection does not exceed 1 mm per 400 mm of span. A counterbalancing spring shall be installed inside the roller. The spring shall be capable of producing sufficient torque to assure easy operation of the curtain from any position. Provision for adjusting spring tension from outside of the bracket without removing the hood shall be made.

**2.2.05 Brackets**

Brackets shall close the end of roller-shaft housing and shall support the hood. Ends of the roller shaft shall be journaled into bracket hubs. The shaft shall be fitted with self-lubricating bronze bearings or permanently lubricated ball bearings.

**2.2.06 Hood**

Hood shall be at least 0.61 mm thick steel and shall be formed to fit contours of the brackets. Hood shall be reinforced with steel rods, rolled beads, or stiffening flange at top and bottom edges. Intermediate supporting brackets shall be provided for hoods at opening which exceed 370 mm in width. A flexible weather baffle shall be provided at the hood, mounted internally or externally, to prevent airflow around the coil.

**OPERATORS**

**Chain Operators**

Doors indicated in the schedules to be manually operated shall have an endless chain operating over a sprocket and extending to within 600 mm of the floor, reduction gearing shall be designed to reduce pull required on hand chain to 157 N maximum under full wind load conditions.

**2.3 FINISH**

Curtain slats, hood, and bottom rails shall be galvanized and given a shop prime coat. All other exposed metal parts of door and accessories except bearing and chains shall be given a shop prime coat. Shop prime coats shall be suitable for receiving chlorinated rubber finish coats.

Galvanizing shall comply with ASTM A526 for commercial steel sheets and ASTM A \386 for assembled steel products. Galvanized surfaces shall be phosphatized before painting.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

**3.1.01 General.**

Doors shall be installed in accordance with details, the Drawings, and manufacturer’s directions. All anchors and inserts for guides, brackets, and other require work shall be accurately located.

**3.1.02 Mounting**

Doors shall be installed on the face of the wall with the hood mounted above hed of the opening.

**3.2 ADJUST AND CLEAN**

**3.2.01 Lubrication and Adjustment**

After installation, doors shall be free from warp, twist, or distortion. They shall be lubricated and properly adjusted to operate freely and smoothly.

**3.2.02 Cleaning.**

Factory finished metal surfaces shall be thoroughly cleaned and touched up as recommended by the manufacturer. Abraded areas of shop prime-coated surfaces shall be touched up with the same primer used for the original coat.

**END OF SECTION**

# SECTION 08333

# OVERHEAD DOORS

**PART 1: GENERAL**

**1.01 SUBMITTALS**

1. Manufacturer’s product data and installation instructions.
2. Furnish UL “ Certificate of Inspection for Oversize Doors” for fire-rated coiling overhead doors exceeding 120 sq ft.

**PART 2: PRODUCTS**

**2.01 MATERIAL**

1. Coiling overhead Doors: Complete operating door assemblies including door curtain, guides, counterbalance, hardware, operators and installation accessories and certified to withstand a 20 psf wind load pressure.
2. Door Curtain: Interlocking slats, one-piece for door width, as follows:
   1. Steel salts, ASTM A446, Grade A, not less than 20 gauge, hot-dipped galvanized per ASTM A525, G90
   2. Provide heaver metal gauges as required for load deflection limitation.
3. End locks: Malleable iron casting, galvanized, secured to curtain slats.
4. Wind locks: Malleable iron casting, galvanized, secured to curtain slats 24-in o.c. on both edges.
5. Bottom Bar: Tow angles not less than 1/8-in thick of same metal as curtain slats. Provide flexible rubber, vinyl, or neoprene weather seal and cushion bumper.
6. Curtain Jamb Guides: Built – up of ASTM A36 steel angles, channels and flat bars as required.
7. Weather Seals: Manufacturer’s standard rubber or neoprene on metal pressure bars. Provide 1/8- in ‘thick continuous sheet secured to inside of curtain coil hood.
8. Counterbalance: Manufacturer’s standard adjustable helical torsion spring mounted around steel shaft in barrel, with grease-sealed ball bearings or self-lubricating graphite bearing for rotating members.
9. Hood: Enclose coiled curtain and operating mechanism and act as weather-seal. Provide closed ends for surface-mounted hoods.
10. Steel, not lees than 24 gauges, hot-dip galvanized.
11. Shop Finish: Clean and paint ferrous metal and galvanized surface with manufacturer’s standard rust inhibitive primer.
12. Manual Door Operators
    1. Provide except where electric operators indicated. When not shown, provide chain hoist operator unit.
    2. Chain-hoist operation with continuous Cadmium-plated alloy steel hand chain requiring not more than 35 ibs pull. Provide self-locking mechanism for stopping curtain at any point in travel until unit reactivated

**PART 3: EXECUTION**

**3.1 INSTALLATION**

* + 1. Set door and operating equipment complete with necessary hardware, jamb and head mold stops, inserts, hangers, equipment supports in accordance with manufacturer instructions.
    2. Install fire-rated doors in accordance with NFPA Bull No.80.

**END OF SECTION**

# SECTION 08510

# METAL WINDOWS

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This specification covers the supply and installation of metal windows as indicated on the drawings.

**1.2 APPLICABLE STANDARDS**

Except as otherwise required, materials and workmanship shall conform with the latest revision of the applicable specification of the British Standards.

**1.3 RELATED WORK**

Installation of glass panels, Section GLASS AND GLAZINGS

**1.4 CONTRACTORS' SUBMITTALS**

**A. SHOP DRAWINGS :**

Shop drawings shall be submitted for approval. Shop drawings shall indicate elevations of windows, full-size sections, thicknesses of metal, fastenings, method of anchoring, the size and spacing of anchors, details of construction, method glazing, details of operating hardware, mullion details, method and materials for weather-stripping and installation details. Where metal sub-frames, stools, casings and other related items are required, shop drawings shall show details of the items to be furnished and the assemblage and connections of windows and the adjacent work. Window schedules shall be submitted with shop drawings. Windows shall not be delivered to the project site prior to approval of shop drawings.

**B. SAMPLES**

One complete, full-size samples window of each type proposed for use shall be submitted for approval by the Engineer. Sample units shall be taken from manufacturer's stock. Sample shall be complete with hardware, weather-stripping, anchors and other accessories, and shall be finished as specified. Additional samples of hardware items shall be submitted as requested. After approval, samples may be installed if each sample is clearly identified and its location recorded in the work. Except for varying sizes, windows furnished shall match approved samples.

**1.5 PROTECTION DURING CONSTRUCTION**

Before shipment, coat-exposed portions of aluminum with clear waterwhite methacrylate type lacquer, resistant to alkaline mortar and plaster. A protection of the manufacturer's choice will be allowed, providing the Engineer's approval is obtained, but the manufacturer will be held responsible for staining and damage to the aluminum work in case of failure of the protection.

**1.6 WARRANTY**

The contractor, under this section, hereby warrants the work of this section against defects in materials and workmanship in accordance with the General Conditions for a period of five years and agrees to promptly make good defects which become evident during the warranty period without cost to Employer. Defects shall include, but not be limited to, leaking, deformation of members, loss of seal in sealed glass units, breakage of glass caused by frame distortion and thermal forces and discoloration of anodized aluminum finishes.

**1.7 MEASUREMENT FOR PURPOSES OF VARIATION**

Additional items of metal window wall work, where authorized by the Engineer, will be measured on a lump sum basis.

**PART 2 MATERIALS**

**2.1 MANUFACTURERS**

**A. GENERAL**

Door and window frames shall be of aluminum manufactured to the sizes indicated. The glass and ventilating areas of the windows furnished shall be of the sizes indicated.

To ensure continuity of appearance all windows shall be supplied only from one manufacturer.

**B. LOUVERS**

Glazed louvers shall be compatible with the window frames in which they are to be installed. Louvers shall be standard "four-inch clip" or "six inch clip" louvers with head and sill weather-strips. Louver carriers and accessories shall be manufactured of aluminum.

**2.2 ACCESSORIES**

Furnish all necessary hardware, fastenings, clips, fins, anchors and other appurtenances necessary for complete installation of windows and operation of ventilators and louvers. Except as specified otherwise, anchors and fastenings shall be hot dipped galvanized steel.

**2.3 HARDWARE**

The items, type and function of hardware required shall be as specified under each individual window type. Hardware shall be of suitable design and have sufficient strength to perform the function for which it is used, it shall be attached securely to the windows with non-corrosive bolts or self-tapping screws. Al builders' hardware for doors and windows except items specified under Section 08700 shall be supplied by the window or door manufacturer.

**2.4 FINISHES - EXPOSED STEEL ITEMS**

The finish on all exposed steel surfaces shall be hot dip galvanized to BS 729. The galvanizing shall be weathered or treated with an approved weathering agent before painting.

**2.5 FINISHES - ALUMINUM WINDOWS**

The finish on all exposed aluminum surfaces shall be hard colour anodizing to the requirements of BS 1615, obtained by giving the aluminum material a caustic etch followed by an anodic treatment. Colour shall be clear anodizing.

**2.6 GLAZING**

Windows shall be arranged for inside glazing with screw-attached glazing beads. Glazing rebate legs shall be not less than 12.7 mm in height.

Fixed sash and ventilating sash shall be designed for glazing in conformance with Section : 08800, GLASS AND GLAZING, using glazing beads or stops furnished by the window manufacturer. Where insulating glass is specified, rebates shall be of adequate depth to receive the glass and glazing accessories.

**2.7 WEATHER - TIGHTNESS**

All ventilators shall be double weather-stripped using vinyl, propylene or wool pile weather-stripping securely interlocked into the inside and outside weathering contacts. The air infiltration shall not exceed 0.014 m3 per 300 mm of crack length when tested in accordance with BS 4315: Part 1.

**2.8 MULLIONS**

Mullions shall be provided between multiple-window units where indicated. Mullions shall be designed to withstand a uniform load of 85 kg/m2 without deflecting more than 1/400 of the span. Mullions shall be secured to adjacent window units to form a watertight joint and to allow for expansion and contraction. Mullion covers of manufacturer's stock design shall be provided at the interior to completely close the recess between the window jambs and to present a neat appearance. Special covers for structural mullions shall be provided.

**2.9 MASTIC**

Metal-to-metal joints between members of windows, frames, mullions, and mullion covers shall be set in mastic of the type recommended by the window manufacturer to provide completely watertight joints. Excess mastic shall be removed before the mastic hardens.

**2.10 FIXED SASH**

Where fixed-sash sections are used in combination with ventilator sections, fixed sash shall be of same type as the ventilators.

**2.11 FABRICATION**

**A) General**

Manufacture windows to produce results specified and to assure neat appearance. Make permanent joints by welding or by mechanical fastenings. Joints shall be of a strength to maintain the structural value of members connected. Welded joints shall be solid, have excess metal removed and dressed smooth on exposed and contact surfaces. The dressing shall be done so that no discoloration or roughness will show after finishing. When welding flux is used, it shall be completely removed immediately after the welding is completed. Joints formed with mechanical fastenings shall be closely fitted, sealed with mastic and made permanently watertight.

**B) Assembly**

Trial fit and assemble all units in factory, if permanent shop assembly is not practical.

**2.12 ALUMINIUM ENTRANCES AND SCREENS**

Fit and assemble as far as possible in factory, and fabricate with :

a) Metal sections drilled, tapped, welded, holed or slotted as may be required for the proper installation and fixing of all components and accessories, and supplied complete with necessary anchors, clips, bolts, screws, etc.

b) Members possessing sharply defined profiles, straight, square and true with surfaces in proper planes and exposed finished surfaces and edges smooth and free from defects.

c) Framing, bracing, reinforcing and anchors shaving structural properties adequate to safely sustain and withstand strains and stresses to which they will be subjected.

d) Provision for proper expansion and contraction.

e) Joints and intersections accurately formed and tightly fitted; units water and weather tight.

f) Regular sight lines.

g) Bolts tight and threads nicked to prevent loosening of nuts; bolting made as inconspicuous as possible.

h) Preparation of glazing as required.

**PART 3- EXECUTION**

**3.1 INSTALLATION OF WINDOWS**

**a) General**

All metal windows and doors shall be as indicated on the drawings. Insect screens are not required behind windows.

All accessories such as metal sills and tools, mullions in multiple openings and other appurtenances required for complete an proper installation shall be provided.

Installation shall be done by the main building contractor or his authorized representative, using only skilled window mechanics. Windows in concrete or masonry construction shall be set in prepared openings. Windows in steel or timber frames shall be installed as indicated. Windows shall be set plumb, level, in alignment and properly braced to prevent distortion.

The aluminum sub-frames shall be of appropriate section to accommodate standard louver components. The louver components shall be fixed to the window sub-frames strictly in accordance with the manufacturer's instructions.

Ventilators and operating parts shall be protected against accumulation of cement, lime and other building materials by keeping ventilators tightly closed. Sealing of window frame shall be as specified in Section 07920: CAULKING AND SEALING

**B) Glass Louvres :**

Glass louver blades shall comply with the requirements of Section 08800: GLASS AND GLAZING. Louver blades shall be of 6 mm thick float glass with arrissed and polished edges.

**C) Operation of Louvers :**

Louvers shall be fitted with standard operating handles. Where the operating handle is over 1500 mm above finished floor level the operating handle shall be fitted with a device to permit remote operation.

**D) Window anchors :**

Window anchors shall be properly spaced not exceeding 600 mm apart.

**E) Adjustment :**

After window installation and completion of glazing and painting, windows and operating hardware shall be adjusted to provide free operation and watertight conditions when sashes are closed and locked; hardware and operating parts shall be lubricated or waxed as required.

**3.2 PROTECTION AND CLEANING**

**A) Protection :**

Care shall be used in handling windows during transportation and at the job site. Windows shall be stored on edge and under cover. After installation, windows shall be protected from damage during subsequent construction activities.

**B) Cleaning :**

Anodized surfaces of windows shall be cleaned on both the inside and outside of all mortar, plaster and other foreign matter to present a neat appearance and prevent fouling of weathering surfaces, weather-stripping or the operation of hardware.

**END OF SECTION**

# SECTION 08520

# ALUMINUM WINDOWS

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers aluminum windows complete with hardware, insect screens, and all other appurtenances.

Windows and appurtenances shall be furnished and installed as specified herein and in accordance with the details and arrangements indicated on the Drawings. The Contractor shall furnish all labor, materials, tools, and equipment required to complete the work.

A. Related Work.

Other items of work that relate to and are referenced in this section include, but are not limited to, the following sections:

Cast-in-Place Concrete

Masonry

Sealants and Caulking

Glass and Glazing

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable to the work under this section are listed. Codes and Standards current at the time of bid shall be used.

**1.2.01 BS British Standards**

**1.3 DESIGN CRITERIA**

**1.3.01 Allowable Tolerances**

A. Hollow extrusions : + 0.25 mm

B. Size tolerances : dimensions within 1.6 mm

**1.3.02 Source Quality Control**

A. Air Infiltration Test : Window units when tested in accordance with ASTM E283 shall have a maximum infiltration of 0.000024 cu.m./sec/m crack length.

1. Water Penetration Test : Window units when tested in accordance with ASTM E331 shall have no water penetration for 15 minutes when window is subjected to rate of flow of 0.2 cu.m./sec/sq.m. with a differential pressure across window unit of 299 Pa.
2. C. Wind Load Test: Window units when tested in accordance with ASTM E330 to a minimum 1.44 kPa positive and negative load for 10 seconds shall have a maximum deformation of frame or such member 4/10 per cent of span length with no damage to fasteners or hardware.

D. All operable windows shall be designed so that the exterior glazed surfaces can be readily cleaned from the inside.

E. All operable windows shall be equipped with rust-proof insect screens, removable from the inside.

**1.4 SUBMITTALS**

The following items shall be submitted in accordance with the Submittals Section :

**1.4.01 Shop Drawings.**

Drawings shall include a complete window schedule, elevations of each type of window and anchorage details for each different wall condition. Head, jamb and sill details shall be full size.

**1.4.02 Samples.**

Three samples of corner assembly for each type of window showing joints, glazing frames, and accessories.

**1.4.03** Three copies of technical data showing that the finish proposed is suitable for the ……………….environmental condition of the Work Site.

**1.5 PRODUCT HANDLING**

**1.5.01 Protection**

Adequate protection shall be provided during shipment, site storage, and installation to prevent damage to materials or finished work.

Windows shall be individually wrapped or crated to avoid aluminum-to-aluminum contact during shipping.

Windows shall be stored in a vertical position above-ground and in a dry area.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1.01 Material List.**

Materials used in the manufacture and installation of the aluminum windows shall be as follows :

- Extrusions: BS 1474, Alloy HE 9 -TF.

- Bars (round and square), hinges and fasteners: BS 1474, Alloy HE 30 -TF.

- Plates and sheets : BS 1473, type best suitable for the purpose.

- Tubing : BS 1471, type best suitable for the purpose.

**2.2 PERFORMANCE AND DESIGN REQUIREMENTS**

**2.2.01 Construction.**

Aluminum windows shall be of the sizes indicated on the Drawings. Windows shall be designed for inside glazing with glazing beads as specified herein. All frames and sash shall be carefully machined and fit to hairline joinery. All screws, fasteners, and accessories shall be non-corrosive materials compatible with aluminum.

A. Glazing Beads.

Windows shall be provided with continuous extruded aluminum glazing beads. Glazing beads shall be designed to retain 6 mm thick glass or 12 mm insulating glass as indicated in the Window Schedule.

B. Weather stripping.

Projected type aluminum windows shall be provided with replaceable double weather stripping.

C. Tests.

Aluminum windows shall meet the requirements for air infiltration, water resistance, loading, and torsion tests set forth in ANSI A134-1.

D. Finish.

All surfaces of aluminum windows and accessories shall have a clear anodic coating, to comply with BS 3987, with an average thickness of 25 micron, subject to approval by the Engineer.

E. Insect Screens (Fly Screens).

Ventilation openings shall be provided with insect screens of the fixed flat type attached in such a manner that close fitting, continuous contact is made, and insect-tight construction is provided at all degrees of ventilator opening. Screens and screen hardware shall be supplied by the manufacturer of the windows. Screens shall be interchangeable for the same size windows. Screen wire shall be held taut by a removable spline.

F. Hardware.

All hardware shall be designed for the function of the window and shall provide positive closure and shall comply with section 08 100 of these specifications.

**PART 3 - EXECUTION**

**3.1 INSPECTION**

**3.1.01** The Contractor shall verify that all window openings conform with the dimensions and tolerances indicated on the Drawings and shall not proceed with installation until unsatisfactory conditions are corrected.

**3.2 INSTALLATION**

**3.2.01 General.**

Windows shall be set plumb, level, and in alignment, and shall be securely anchored to surrounding construction in compliance with the manufacturer's instructions. After windows are installed, but before glazing, all ventilators shall be adjusted to operate smoothly and to provide weather tight closing. Windows shall be left in closed position to protect against sand, dust, and the elements.

**3.2.02 Sealing.**

Except where vinyl seals are provided, all exterior metal-to-metal joints between members of windows, frames, mullions, and mullion covers shall be sealed with sealant or extruded tape. Excess sealant or tape shall be removed.

**3.2.03 Protection.**

Aluminum to be placed in contact with concrete, mortar, plaster, or dissimilar metals shall be given a heavy coat of coal tar paint. Glazed openings shall be marked during construction.

**3.2.04 Cleaning.**

Windows shall be thoroughly cleaned both inside and outside. After all foreign materials has been removed, windows shall be washed with soap and water and a stiff-fiber brush. If windows or sills have become stained or discolored, the finish shall be restored.

**END OF SECTION**

# SECTION 08700

# HARDWARE

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK**

A. The extent of builders hardware is shown on the drawings and in schedules. Builders hardware is hereby defined to include all items known commercially as builders hardware, as required for swing and sliding doors, except special types of unique and non-matching hardware specified in the same section as the door and door frame. Except as otherwise required, all materials and workmanship shall conform to the requirements and listings of appropriate standards of the British Standards Institution, American National Standards, British Hardware Manufacturers as required by the Engineer.

B. The required types of builders hardware include (but are not necessarily limited to) the following:

1. Butts and hinges.

2. Lock cylinders and keys.

3. Lock and latch sets.

4. Bolts.

5. Panic exit devices.

6. Push Pull units.

7. Closers and door control devices.

8. Door trim units.

9. Protection plates.

10. Weather Stripping and seals.

11. Thresholds.

**1.2 QUALITY ASSURANCE**

A. Acceptable Designs:

The hardware schedule included in article this section indicates products which are of acceptable design for primary exposure (lock sets, etc..). Do not change the selection of products, except with the Engineer or his representative's acceptance.

B. Manufacturer:

Obtain each kind of hardware (latch and lockets, hinges, closers, etc...) from only one manufacturer.

C. Supplier:

A recognized builders hardware supplier who has been furnishing hardware in the same area of the project for a period of not less than two years, and who is, or has in employment, an experienced hardware consultant who is available at reasonable times during the course of the work for project hardware consultation to the Owner, Engineer of his representative and Contractor.

D. Deviation From Scheduled Designation:

Except as otherwise indicated, the use of one manufacturer's numeric designation system in schedule does not imply that another manufacturer's products will not be acceptable, unless they are not acceptable in design, or not equal in size, weight, finish, function, or other quality of significance. However, do not change the selection after the Engineer or his representative acceptance of hardware supplier's completed hardware schedule.

E. Fire-Rated Openings:

Provide hardware for fire-rated openings which has been tested and listed by UL for the types and sizes of doors required, and complies with the requirements of the door and frame labels. Where emergency exist devices are required on fire-rated doors, (with supplementary marking on door UL label indicating "Fire Door to be Equipped with Fire Exist Hardware"), provide UL label on exist device indicating "Fire Exit Hardware".

**1.3 SUBMITTAL**

A. Manufacturer's Data; Builder's Hardware:

Submit manufacturer's product data for each item of hardware. Including whatever information may be necessary to show compliance with requirements, and include instructions for installation and for maintenance of operating parts and exposed finishes. Wherever needed, furnish templates to fabricators of other work which is to receive finish hardware.

B. Final Hardware Schedule:

Based on the builders hardware requirements indicated, organize final hardware schedule into "hardware sets", indicating complete designation of every item required for each door or opening. Furnish initial draft of schedule at the earliest possible date, in order to facilitate the fabrication of other work (such as hollow metal frames) which may be crucial in the project construction schedule. Furnish final draft of schedule after samples, manufacturer's products data sheets, coordination with shop drawings for other work, delivery schedule and similar information has been completed and accepted. Include a separate key schedule, showing clearly how the Owner's final instructions on keying of locks have been fulfilled.

C. Samples; Builders Hardware:

1. Prior to submittal of the final hardware schedule and prior to delivery of hardware, submit one sample of each exposed hardware unit, finished as required, and tagged with full description for coordination with the schedule. Sample will be reviewed by the Engineer for design, colour and texture. Compliance with other requirements is the exclusive responsibility of the Contractor.

2. Samples will be returned to the Contractor. Units which are acceptable and remain undamaged through submittal, review and field comparison procedures may, after final check of operation, be used in the work, within limitations of meeting coordination requirements.

**1.4 PRODUCT HANDLING**

A. Packaging of hardware, on a set by set basis, is the responsibility of the supplier. As material is received by the hardware supplier from the various manufacturers, sort and repackage in containers marked with the hardware set number. Two or more identical sets may be packaged in the same containers.

B. Inventory hardware jointly with representatives of the hardware supplier and the hardware installer until each is satisfied that the count is correct.

C. Provide secure lock-up for hardware delivered to the project, but not yet installed. Control the handling and installation of hardware items which are not immediately replaceable, so that the completion of the work will not be delayed by hardware losses, both before and after installation.

**1.5 JOB CONDITIONS**

A. Coordination

Coordinate hardware with other work. Tag each item or package separately, with identification related to the final hardware schedule, and include basic installation instructions in the package. Furnish hardware items of proper design for use on doors and frames of the thicknesses, profile, swing security and similar requirements indicated, as necessary for proper installation and function. Deliver individually packaged hardware items at the proper times to the proper locations (shop or project site) for installation.

B. Templates:

Furnish hardware templates to each fabricator of doors, frames and the work to be factory-prepared for the installation of hardware. Upon request, check the shop drawings of such other work, to confirm that adequate provisions are made for the proper installation of hardware.

**PART 2 - PRODUCTS**

**2.1 MATERIALS AND FABRICATION**

A. Handle of Door:

The drawings show the direction of slide, swing or handle of each door leaf. Furnish each item of hardware for proper installation and operation of the door movement as shown.

B. Manufacturer's Name Plate:

Do not use manufacturer's products which have manufacturer's name or trade name displayed in visible location (omit removable nameplates), except in conjunction with required UL labels and as otherwise acceptable to the Engineer. Manufacturer's identification will be permitted on rim of lock cylinder only.

C. Fasteners:

Manufacture hardware to conform to published templates, generally prepared for machine screws installation. Do not provide hardware which has been prepared for self-tapping sheet metal screws, except as specifically indicated.

D. Furnish Screws for Installation, with each Hardware Item:

Provide Phillips flat-head screws except as otherwise indicated. Finish exposed (exposed under any condition) screws to match the hardware finish or, if exposed in surface of other work, to match the finish of such other work as closely as possible.

1. Provide concealed fasteners for hardware which is exposed when the door is closed, except to the extent no standard units of the type specified are available with concealed fasteners. Do not use through bolts for installation where the bolt head or the nut on the opposite face is exposed in other work, except where it is not feasible to adequately reinforce the work.

**2.2 HINGES AND BUTTS**

Templates and screws. Except for hinges and butts to be installed entirely (both leaves) onto wood doors and frames, provide only template-produced units.

**2.3 LOCK CYLINDERS AND KEYING**

A. General:

Supplier will meet Owner or his representative to finalize keying requirements and obtain final instruction in writing.

B. Standard System:

Except as otherwise indicated, provide new masterkey system for project.

C. Key Quantity:

Furnish three change keys for each lock; five master keys for each master system; and five grandmaster keys for each grandmaster system.

**2.4 CLOSURE AND DOOR CONTROL DEVICES**

Except as otherwise specifically indicated, comply with the manufacturer's recommendations for size of door control unit, depending upon size of door, exposure to weather and anticipated frequency of use.

**2.5 HARDWARE FINISHES**

Provide matching finishes for hardware units at each door or opening, to the greatest extent possible, except as otherwise indicated. Reduce difference in colour and textures as much as commercially possible where the base metal or metal forming process is different for individual units of hardware exposed at the same door or opening. In general, match items to the manufacturer's standard finish for the latch and lock set (or push pull units if no latch lock sets) for colour and texture.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

A. Install each hardware item in compliance with the manufacturer's instructions and recommendations. Wherever cutting and fitting is required to install hardware onto or into surfaces which are later to be painted or finished in another way, coordinate removal, storage and reinstallation or application of surface protections with finishing work specified in appropriate section. Do not install surface-mounted items until finishes have been completed on the substrate and accepted.

B. Set units level, plumb and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.

C. Drill and countersink units which are not factory-prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.

D. Cut and fit threshold and floor covers to profile or door frames, with mitered corners and hair-line joints. Join units with concealed welds or concealed mechanical joints. Cut smooth openings, bolts and similar items, if any.

E. Screw thresholds to substrate with larger screws, of the proper type for permanent anchorage and of bronze or stainless steel which will not corrode in contact with the threshold metal.

F. At exterior doors, and elsewhere as indicated, set thresholds in a bed of either butyl rubber sealant or polyisobutylene mastic sealant to completely fill concealed voild and exclude moisture from every source. Do not plug drainage holes or block weeps. Remove excess sealant.

G. At exterior doors, and elsewhere as indicated, set each edge of threshold in a seal strip of butyl rubber sealant or polyisobutylene mastic sealant.

H. Doors, unless otherwise indicated, shall be provided with cast bronze name plates having titles and numbers of room function in English and Arabic and room number in English. Name-plate sizes, handwriting and numbering shall meet the Owner's approval. Screws shall be flush on the finish surface and name plate space shall built-in the door leaf.

**3.2 ADJUST AND CLEAN**

A. Adjust and check each operating item of hardware and each door to insure proper operation or function of every unit. Replace units which cannot be adjusted to operate freely and smoothly as intended for the application made.

B. Final Adjustment:

Wherever hardware installation is made more than one month prior to acceptance or occupancy of a space or area, return to the work during the week prior to acceptance or occupancy, and make final check and adjustment of all hardware items in such space or area. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for final operation of heating and ventilating equipment.

C. Continued Maintenance Service:

Approximately six months after the acceptance of hardware in each area, the installer, accompanied by the representative of the latch and lock manufacturer, shall return to the project and readjust every item of hardware to restore proper function of doors and hardware. Replace hardware items which have deteriorated or failed due to faulty design, materials or installation of hardware units. Prepare a written report of current and predictable problems (of substantial nature) in the performance of the hardware.

**END OF SECTION**

# SECTION 08800

# GLASS AND GLAZING

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers all glass and glazing for windows, doors, and other openings having glass as indicated on the Drawings and as stipulated herein. The Contractor shall furnish all labor, materials, tools, and equipment required to complete the work.

**1.1-1 Related Work**

Other items of work that relate to and are referenced in this section include but are not limited to the following sections:

Metal Doors and Frames

Aluminum Windows

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable at the time of bid shall be used.

**1.2-1 BS British Standard Institution.**

**1.3 SUBMITTALS**

**1.3-1** The following items shall be submitted in accordance with the Submittals Section:

A. Complete specifications and pertinent installation data for the items furnished.

B. Three samples of each type glass proposed, (300 X 300) mm, glazing sealants, and glazing accessories.

C. Certification from the manufacturer stating that all glass delivered to the site is in conformance with the provisions of the specification.

D. Shop drawings showing sections and details of glass installation at framing members such as head, mullions, transoms, jambs, and sills.

**1.4 PRODUCT HANDLING**

**1.4-1 Glass.**

Glass shall be securely and safely crated for delivery, handling, and storage. Cushions shall be provided at edges of glass to prevent damage. Glass faces shall be protected from scratches and abrasions. Glass shall be stored in a dry, well ventilated location, carefully protected at all times from soiling, atmospheric condensation, and other moisture.

Damaged or defective glass shall be replaced with new glass at no additional cost. Each piece of glass shall be delivered with factory labels intact, indicating glass type, quality, and thickness. Labels shall not be removed until installation has been accepted.

**1.4-2 Glazing Materials.**

Sealing materials shall be delivered in manufacturer's unopened containers, fully identified with trade name, color, size, hardness, type, class, and grade. Glazing and sealing materials shall be stored where they will be free from damage and in strict accordance with the manufacturer's recommendations.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

Materials used shall be:

Plate or Float Glass 6 mm, 8 mm, 12mm glazing quality, clear, free from bubbles, stones, knots, cracks, and waves.

Laminated Glass 6 mm thick, clear, two 3 mm sheets of float glass with 0.794 mm thick vinyl interlayer bonded between the sheets; free from bubbles, stones, knots, cracks, and waves.

Wire Glass 6 mm, diamond pattern, stainless steel wire mesh, polished both sides; free from wraps, bubbles, stones, knots, cracks, and waves. All wire shall be in the glass.

Patterned Glass 5.6 mm, obscure patterned, pattern one side only.

Double Glass A. Double Glassed Aluminum with outer skiing toughened bronze tinted, heat insulating glass and liner skin clear float glass. Thickness of glass & airspace for different window types shall be as follows:

GLASS AIRSPACE

THICKNESS WIDTH

(MM) (MM) NORMAL MAXIMUM SIZES (MM)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4 4 1200 X 1400

- 6 1200 X 2000

- 8,10 & 12 1300 X 2400

6 4 1200 X 1400

" 6 1600 X 2500

" 8,10 & 12 2200 X 3000

8 4 1200 X 1400

" 6 1600 X 2800

" 8,10 & 12 2200 X 3100

10 4 1200 X 1500

" 6 1600 X 2800

" 8,10 & 12 2200 X 3100

12 4 1200 X 1500

" 6 1600 X 2800

" 8,10 & 12 2200 X 3100

**BULLET RESISTANT GLASS**

All Bullet Resistant Glass where shown on drawings and mentioned in the Documents shall be multi-layered float glass laminated with PVb as manufactured by GLOBE AMERADA Co. Glass shall be U.L. Standard 752 and shall meet the requirements of ASTM C 1036-85 (Formally Federal Specifications DD-G-451d), ANSI 297.1 & CPSC 16 CFR 1201 Category I & II. Thickness shall be 3 cm with minimum clearance of face 1/8", Edge 3/8" & Bite 1/2". Color shall be toughened bronze.

Extruded Tape Butyl-polyisobutylene preformed sealant tape, or dense neoprene tape with a Shore A durometer hardness of 65-75 as required for specific glazing.

Glazing Compounds As recommended by glass manufacturer for intended application.

Acrylic Sealant As specified, in Sealants and Calking Section.

Setting Blocks Neoprene or EPDM with a Shore A durometer hardness of 80-90.

Spacers Cork and rubber compound, adhesive backed.

**2.2 PERFORMANCE AND DESIGN REQUIREMENTS**

**2.2-1 Design Criteria.**

The glazing system employed shall be designed and installed so that building movements inherent with wind loads or thermal effects are not transferred to the glass.

**PART 3 - EXECUTION**

**3.1 PREPARATION**

**3.1-1 General.**

The Contractor shall obtain all glass sizes from measurements of the work at the site, or from the manufacturer of the sash or door frames in which the glass is to be set. In all cases, however, the responsibility for the correctness of the size of the glass shall be assumed by the Contractor.

All glass furnished shall be identified by type when it is delivered to the Work Site.

**3.2 INSTALLATION**

**3.2-1 General.**

Glazers shall have had previous experience with the materials and systems being applied. Tools and equipment recommended by the glass manufacturer shall be used.

**3.2-2** All openings shall be measured and glass shall be cut accurately to fit each opening with minimum edge clearances. If glass is to be cut to size at project site, deliver each piece to project at least 50 mm larger (in both dimensions) than required so as to facilitate the cutting of clean-cut edges without the necessity of seaming or nipping. Tempered glass shall not be seamed, nipped, or abraded at the Work Site.

**3.2-3** Glazing stops and rebates to receive glazing materials shall be cleaned of all obstructions and deleterious substances which might impair the work. Protective coatings which may cause adhesion failure or interfere with bond of sealants shall be removed. Metal surfaces shall be wiped with xylol or toluol.

**3.2-4** Surfaces to receive glazing compounds shall be primed in accordance with the manufacturer's recommendations, using recommended primers.

**3.2-5** Each piece of glass shall be inspected immediately before installation. Pieces which have significant impact damage at edges, scratches, or abrasions of faces, or any other evidence of damage shall not be installed.

**3.2-6** Setting blocks, if required, shall be located at the quarter points of sill, but no closer than 150 mm to corners of glass. Blocks of proper size shall be used to support the glass in accordance with manufacturer's recommendations.

**3.2-7** Spacers shall be provided for all glass to separate glass from stops, except where continuous gaskets or tape are required. Spacers shall be located 915 mm on center maximum inside and out, with a minimum of two (2) spacers per edge of glass. Thickness equal to sealant or to compound thickness shown shall be provided. Width as required for minimum of 9 mm bite on glass at all 4 edges shall be provided.

**3.2-8** Glazing materials from different sources shall not be used in the same joint system unless the manufacturer of each material has stated in writing that his material is fully compatible with the other material.

**3.2-9** Masking tape or other suitable protection shall be used to limit coverage of glazing materials to the surfaces intended for sealants.

**3.2-0** Ends of sealant tape shall be butted in accordance with the manufacturer's recommendations.

**3.2-11** Exposed surfaces of glazing materials shall be tooled to provide a slight wash away from the glass. Exposed tapes and gaskets shall be installed with a slight protrusion above stops in the final compressed condition.

**3.2-12** Excess sealant or compound shall be cleaned from glass and frame members immediately after application, using solvents or cleaners recommended by the manufacturers.

**3.2-13** In wire glass installations, the wire pattern shall match in line that of adjacent panes.

**3.2-14** Installation of double glass units shall be in strict accordance with the glass manufacturer's recommendations.

**3.3 CLEANING AND PROTECTION**

Warning markings shall be attached to window frame immediately following glass installation. Warning ribbons which may stain glass, glazing material, or frame shall not be used.

All glass shall be cleaned just before final inspection, and all stains and defects shall be removed. Care must be exercised to remove paint, labels, and glazing compound without scratching or marring the surface of the glass or metalwork.

**END OF SECTION**

# SECTION 08920

# GLAZED ALUMINUM CURTAIN WALLS

**PART 1 - GENERAL**

**1.01 Work Included**

1. Design, fabricate, supply and install framed glazed curtain wall, double- glazed with condensation. The sub-structure shall be based on approved aluminum transom and mullion construction together with and including all metal anchors, hardware and accessories for the full and proper execution of the works.
2. 24 mm unit thickness: constructed of two lights of 6 mm reflective glass outboard glass, sky blue 12 mm airspace, and 6 mm clear float glass inboard glass.
3. Aluminum flashing as appropriates.
4. Perimeter Sealant.
5. Other requisite materials, equipment and labour, not specifically mentioned herein, but deemed to be necessary for the full and proper execution, completion and maintenance of the works.

**1.02 Summary**

1. This section includes a stick-framed glazed aluminum curtain wall system with interior and exterior metal framing.
2. Primary components of the glazed curtain wall system include:
3. Aluminum curtain wall framing system.
4. Internal Steel Reinforcement.
5. Glazing Gaskets.
6. Column covers, soffits, sills, copings, trim, and similar border and filler items.
7. Interior curtain wall that matches the exterior curtain wall.
8. Anchors, shims, fasteners, inserts, accessories, and support bracket.
9. Insulation and fire stopping within the curtain wall system.
10. Joint sealing within the curtain wall system.
11. Operable aluminum window included as part of the glazed aluminum curtain wall system.
12. Glass and glazing included as part of the curtain wall system refer to division 8 section “ Glass and Glazing for requirements”.

**1.03 System Description**

1. Aluminum System: the glazed aluminum curtain wall system shall consist of individual members erected separately. Major components.

**1.04 Related Work**

1. Section 08700: Supply of finish hardware, other than specified in this section.
2. Section 07900: Perimeter sealant and back-up materials.
   1. **Reference Standards**
3. General: Refer to the Conditions of Contract-Shop Drawings- Product Data and Samples for submittal provisions and procedures.
4. Shop Drawings and Product Data:
5. Submit shop drawings and product data in accordance with the Engineer’s instructions
6. Indicate pertinent dimensioning, layout, anchorages, construction details, method of installation and adjacent construction.
7. Indicate all units of curtain wall, their configuration and size, materials and types of anchorage items, and their locations.
8. Submit manufacturer’s/ supplier’s installation instructions; and field erection drawings.
9. Design Calculations
10. Submit two copies of curtain wall anchorage assemblies as specified in paragraph 1.07.
    1. **Submittals (Cont’d)**
11. Samples
12. Submit two sets of double-glazed units to indicate the type of finish and materials used. One of the two duplicate sample sets approved by the Engineer will be retained by him at the project site, the other being returned to the manufacturer/suppliers for his guidance.
13. Anchors: Two of each type to be incorporated in the works.
14. Manufacturer’s/ Supplier’s recommended cleaning agent and application procedure.
15. Submit samples of other materials specified herein upon request by the Engineer.
    1. **Guarantee/Warranty**
16. Attention is directed to the provisions of the conditions of Contract regarding guarantees/ warranties for the work.
17. Provide written guarantee in the name of the Owner, in accordance with Conditions of Contract, covering all materials and workmanship used in the structural glazed curtain walls for a period of Ten (10) years from the date of final acceptance of this project.
18. Manufacturers/Suppliers shall provide their standard guarantees for work under this section. However, such guarantees shall be in addition to and not in lieu of all other liabilities which the Manufacturer and Contractor may have by law or by other provisions of the Contract Documents.
19. All warranties/ guarantees to be issued by the Supplier, Manufacturers & Sub-Contractors shall be counter-signed by Main Contractor and both of them will be liable for repair/ replace the items/ works, etc. during the warrantee/ guarantee period.
    1. **Qualifications**
20. Fabricate/Supplier and installer: A firm with a minimum of Ten (10) years successful experience in the fabrication/ Supply and installation of structural glazed curtain walls works.
    1. **Design Criteria**
21. The method of fabrication and installation of the structural glazed curtain walls work shown on the Drawings is diagrammatic only and is not to be use d for the purpose of bidding or construction. It shall be the responsibility of the Contractor to design and guarantee the structural support and the permanent water and air inflation and sealing of all glazing work. The installation shall be designed to allow for expansion, contraction and differential deflection of supporting floors of the building structure. All fastenings into aluminum sub-structure both, anchors, inserts, etc., are to be stainless steel.
22. Performance: The following requirements shall apply:
23. Structural Properties: deflection under design loading shall not exceed 1/175 of clear span.
24. Wind Loading: The system shall be designed to withstand a wind load normal to the plan of the curtain wall equal to 45 m/s.
25. Thermal Movement: Provide expansion and contraction due to temperature changes without determent to appearance or performance for the temperature range of 50 degrees C.
26. Water Inflation: No uncontrolled water inflation when subjected to a water spray at the rate of 5 gallons per hour per square foot of fixed wall area, and a static pressure of 20% of the design wind load, or 6.24 psf, or both.
27. Air inflation: shall not exceed 0.06 CFM per square foot of fixed wall area under a static pressure of 1.56 psf (25 MPH wind).
    1. **Delivery, Storage and Handling**
28. Packing and Loading: Finished glazed units shall be carefully packed and loaded for shipment using all reasonable and customary precautions against damage in transit. No materials which may cause staining, scratching or discoloration shall be used for blocking pre-packing.
29. Site Storage: The site storage of finished units shall not be allowed without the prior approval of the Engineer.
30. Defective Finished Units: Any unit showing imperfections of any kind or whatever nature, upon receipt at the building site, shall be discarded and removed from the work site and at the Supplier’s/Contractor own expense.
31. Refer to the approved manufacturer’s instructions in respect of transport and storage.

**PART 2 - PRODUCTS**

**2.01 Materials**

A. Technical for Aluminum Tel.: 5827636

Fax: 5065636

OR-

Jordan German Aluminum Est. Tel.: 5893100

OR-

Cuhadaroglu Tel.: 4616451

Debbas Construction Enterprises Fax: 4616452

Or Approved Equal

B. Aluminum Finish:

1) Anodized, color to the approval of the Engineer.

1. Aluminum Accessories: As per manufacturer’s Standards, and approved by the Engineer.
2. Sealants: As recommended by the manufacturers and approved by the Engineer.
3. Glazing: Thermopane Insulating Glass –outside glazed.
4. Interspace: 12 mm dehydrated air space.
5. Glazing Accessories: As per manufacturer’s recommendations and approved by the Engineer.

**PART 3 - EXECUTION**

**3.01 Fabrication and Assembly**

1. General: Fabricate curtain wall system at the manufacturer’s shop to the fullest extent possible and before applying finishes. Provide concealed fasteners. Make provisions to weep penetrating eater and condensation to he exterior.

**3.02 Fabrication and Assembly (Condt’d)**

1. Transoms and mullions are always to be located towards the inside.
2. The insert elements are therefore put in from the outside.
3. The curtain wall construction shall be designed to withstand horizontal wind force and the vertical weight of panes.
4. The mullions shall be installed appropriately plumb and true, according to the module width.
5. The symmetry axis of the mullions must be vertical to the planned outer surfaces of the curtain wall.
6. Ensure by appropriate measures, that all the mullions of the curtain wall are on one plane, to avoid twisting of the elements used and undesired distortion in the curtain wall.
7. The module width is to be observed to a tolerance of plus of minus 1 mm.
8. The transoms are to be installed horizontally according to the module height. The module height and width are to be observed to a tolerance of plus or minus 1 mm.
9. The double-glazed units of the insert elements shall be hermetically sealed in the fabrication center.

**3.03 Preparation**

1. Furnish inserts at proper times for setting in concrete formwork, masonry, and similar work indicated to support curtain wall work.

**3.04 Installation**

1. Comply with manufacturer’s instruction s for protecting, handling, and installing fabricated curtain wall components, with particular are and attention to preservation of applied finishes. Discard or remove and replace damaged members.
2. Anchor components securely in place in the manner indicated. Shim and allow for movement resulting from changes in thermal conditions. Provide separators and isolators to prevent corrosion, electrolytic deterioration, and freeze-up of moving joints.

**3.05 Installation (Cont’d)**

1. Fire Stopping: Clean debris from behind curtain wall during erection and provide temporary closures to prevent accumulation of debris. Install fire stopping to comply with governing regulation and AAMA TIR-A3. Install fire stopping with securely anchored metal flanges or make equivalent provisions to prevent dislocation.
2. Glazing: Comply with requirements specified in “Glass and Glazing “ sections.
3. Sealants and Joint Filler : Comply with requirements specified in “Joint Sealers” sections.
4. Erection Tolerances: Install components plumb, accurately aligned, and located in reference to column lines and floor level. Adjust work to concur to the tolerances indicated below. Tolerances indicated below are maximum and are not cumulative.

1) Plumb: 3 mm in 3 m ; 6 mm in 12 mm [1/8 inch in 10 feet; ¼ inch in 40 feet].

2) Level : 3 mm in 6 mm ; 6 mm in 12 m [1/8 inch in 20 feet; ¼ inch in 40 feet].

3) Alignment : Limit offset of member alignment to 1.6 mm [1/16 inch] where surfaces are flush or less than 13 mm [ ½ inch] out of flush and separated by less than 50 mm [ 2 inches] by a reveal or protruding work; otherwise limit offsets to 3 mm [ 1/8 inch].

4) Location: 9.5 mm [ 3/8 inch] maximum deviation form the measured theoretical location of any member at any location.

* 1. **Cleaning**

1. Clean the completed system inside and out, promptly after erection and installation of glass and sealants, allowing for nominal curing of liquid.
2. Use a mild cleaning agent for cleaning process on the site, and for the removal of safety stickers.
3. Abrasive tools, razor blades and scrapers, should be avoided at all times.
4. Remove splashes of wet cement an other site building materials immediately.
   1. **Cleaning (Cont’d)**

B. Protection

1. Protection and final cleaning shall be the responsibility of Main Contractor.
2. The Main Contractor shall provide the necessary protection to protect all glazed units from miss-use or damage during the course of erection, and shall complete and handover all works to the Engineer’s acceptance and satisfaction.

**END OF SECTION**

# SECTION 09000

# ARCHITECTURAL FINISHES

**PART 1 GENERAL**

**1-1 SCOPE**

This section covers the general specifications for the following architectural finishes :-

(a) Floor, wall & ceiling finishes.

(b) Doors, windows, Glazing & Hardware.

(c) Roofing.

(d) Miscellaneous finishes.

**1-2 APPLICABLE CODES & STANDARDS**

The Codes and Standards generally applicable at the time of bid shall be used.

* 1. **SAMPLES**

Contractor shall submit samples of all Architectural finishes for the Engineer approval prior to commencement of work. Testing of samples when required by the Engineer shall performed by the contractor at the Contractor's sole cost.

* 1. **TERRAZZO TILES**

Shall be precast pressed tiles with a wearing surfaces not less than 6 m. thick comprising 2.5 parts of marble shippings & one part white cement with a backing of cement & sand (1:3). Tile size shall be 25x25x2.5 cm.

* 1. **CERAMIC TILES**

Shall be first quality & plain colour ceramic local product acceptable to the Engineer. Tile size shall 15x15 cm. Floor ceramic tiles shall be non-slip type 8 mm thick & 6mm thick glazed for walls.

* 1. **PAINTING**

Shall be of the best quality of approved local manufacturer. Paint shall consist of 3 coats; Primer (Sealer), undercoat (Putty) & finish coats. Paint type shall be as recommended by the Engineer.

* 1. **TEXTURED COATING**

Shall be 100% Acrylic ready mix applicable by roll, water repellent & moisture resistance, not peeling, flaking, blistering or looses adhesion, fire resistant, fungus resistant, washable, easily maintained & environmentally safe. Textured coating shall be of the product approved by the Engineer.

* 1. **DOORS, WINDOW, GLAZING & HARDWARE**

**(a) Steel Doors**

- Hollow metal frames shall be 16 gauge (1.58) steel.

- Doors shall be of cold rolled stretchers level sheet 16 USS gauge (1.58 mm). Continuous inner Z-shaped members.

- Doors shall be 44 mm thick.

- Provide steel louvers equipped with anti-rust insect screen where shown on the drawings.

**(b) Windows**

- Furnish and install sliding and pivot windows of silver anodized minimum (16 microns).

- Windows shall be furnished with anti-rust insect screen.

- Windows shall be furnished with necessary hardware.

- Glazing shall be of clear glass 6 mm thick and shaded glass for bathrooms.

**(c) Wooden Doors**

Flush wooden doors for interior doors only as shown on Drawings.

- Doors shall be framed in hardwood pine (sowaid).

- One way 3.5x3.5 cm soft wood fillers at 3 cm.

- 5 mm thick plywood to be pressed on both sides.

- Total thickness of door 4.5 cm.

- Frames shall be of hardwood pine 4.5x14 cm.

- Architraves shall be 6 cm x 1.5 cm of hardwood pine.

- The work covers all necessary hardware and paint.

- Materials and workmanship shall be in accordance with best quality and acceptable to the Engineer.

**2-6 ROOFING**

- The work covers the necessary concrete pitch course (to provide slope to roof) and the water proofing mixture.

- The water proofing mixture shall consist of asphalt, sand, lime and cement, heated, mixed and applied in two coats in opposite direction applied in the same day.

**PART 3 EXECUTIONS**

Any work rejected through non-compliance with the specification shall be removed and replaced at the contractor's expense. Before completion of the work, all defects shall be repaired and the works shall be inspected & tested as directed by the Engineer & left clean free from dirt, debris, & stains etc. ready for acceptance.

**END OF SECTION**

# SECTION 09820

# CEMENT BASE COATINGS

**PART 1- GENERAL**

**1.1 DESCRIPTION**

This section covers cement base coating.

Cement base coating (special concrete coating) shall be furnished and applied as specified in the cast-in-place concrete section. The coating shall consist of mill-formulated mixtures of white Portland cement; fine graded siliceous aggregate, pigments, and liquid acrylic additives.

* + 1. **Related Work**

**Work Specified Elsewhere**

Other items of works that related to and are referenced in this section include but are not limited to the following sections:

Submittals

Cast-in-Place Concrete

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards generally applicable at the time of bid shall be used.

**1.3 SUBMITTALS**

* + 1. **Data.**

Specifications and data covering physical properties, mixes, and application procedures shall be submitted in accordance with the Submittals Section.

* + 1. **Samples.**

Two samples of the cement base coating, applied to concrete panels not smaller than 300 mm by 300 mm and indicating the proposed color, thickness, and texture, shall be submitted to the Engineer. After acceptance, the samples will be held to be representative of the properties and characteristics of the finally applied coating.

**1.4 PRODUCT HANDLING**

**1.4.01 Delivery**

All materials shall be delivered to the work site in sealed containers bearing the manufacturer’s original labels.

**1.5 JOB CONDITIONS**

**1.5.01 Environnemental Conditions**

No application shall be made when the temperature is 4C or below, or is expected to drop below 4 C with 24 hours after application.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

* + 1. **Cement Base Coating**

The cement base coating shall be a cement base aggregate type , waterproof coating and shall comply with fed spec TT-P-0035. aggregates shall be non-metallic ,well-graded, and selected for hardness and structural strength.

* + 1. **Bonding Agent Admixture**

A bonding agent admixture shall be used in all cement base coating and shall be a special formulation of acrylic polymers and modifiers to improve adhesion and mechanical properties.

* 1. **PERFORMANCE AND DESIGN REQUIREMENTS**
     1. **Design Criteria**

The coating shall be of the “breathing “ type and shall contain no oils, paraffin’s, or waxes. The coating shall improve the weatherproofing qualities and bonding properties of the concrete surfaces on which they are applied.

* + 1. **Color.**

Color of the cement base coating shall be gray to match the architectural concrete and shall be acceptable to the Engineer.

**PART 3 - EXECUTION**

* 1. **PREPARATION**
     1. **Protection of Adjacent Surfaces.**

All adjacent surfaces not intended to be coated shall be suitably masked or otherwise protected during the coating operations.

* 1. **APPLICATION** 
     1. **Methods**

All details, methods, and procedures of mixing application, and curing of the coating material shall be in accordance with the recommendations of the manufacturer.

* 1. **CLEANUP**

All coating materials splattered or dropped onto surfaces not intended to be coating shall be immediately removed.

**END OF SECTION**

# SECTION 09900

# PAINTING & TEXTURED COATING

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers the work necessary for the application of paint for walls, woodwork, metal surfaces and textured coating works. Work includes supplying material, equipment, labor and services required to complete the painting in all respects.

It is the intent that all new interior wood surfaces, plastered surfaces, submerged metal (ferrous) surfaces including pipe supports and support brackets, be painted or coated in the field during or after installation as specified or shown on the Drawings. Aluminum surfaces (stop gate guides, frames for windows, for example) to be imbedded in concrete shall be insulated as specified herein.

**1.2 APPLICABLE CODES AND STANDARDS**

The Codes and Standards, generally applicable to the work under this Section are listed. Codes and Standards current at the time of bid shall be used.

1.2-1 BS - British Standards

**1.3 SUBMITTALS**

Submit material specifications, catalog information, color chips, manufacturers recommended application practices and techniques, and all other pertinent and necessary information. Furnish samples on rigid specimen surfaces if requested by the Engineer.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

**2.1 Paint Materials**

Manufacturers top line materials will be acceptable only if they conform to or exceed the quality requirements of the quality standards of the British Standards Institution.

**2.1 Exterior Ferrrous Metal (Galvanized)**

Pretreatment : Degreasing (and sand papering if possible)

1st coat : Primer

Thinner : 5-10% of thinner by volume

Spreading rate approx. 1kg/9 m2

2nd coat : Undercoat

Thinner : 0-5% of thinner by volume

Spreading rate approx. 1kg/8 m2

3rd coat : Enamel (gloss)

Thinner : 0-5% of thinner by volume

Spreading rate approx. 1 L/12 m2

**2.3 Exterior Ferrous Metal (Non-galvanized)**

Pretreatment : De-rusting by means of blasting or mechanical de-rusting, wire brushes, etc.

1st coat : Red Lead

Thinner : 0-3% of thinner by volume

Spreading rate approx. 1 L/9 m2

2nd coat : Red Lead/Iron oxide 90/10

Thinner : 0-3% of thinner by volume

Spreading rate approx. 1 L/9 m2

3rd coat : Undercoating

Thinner : 0-5% of thinner by volume

Spreading rate approx. 1 L/12 m2

4th coat : Enamel (gloss)

Thinner : 0-2% of thinner by volume

Spreading rate 1 L/12 m2

**2.4 Interior Ferrous Metals (Galvanized)**

Pretreatment : Degreasing (and sandpapering if possible)

1st coat : Primer

Thinner : 5-10% of thinner by volume

Spreading rate approx. 1 kg/9 m2

2nd coat : Undercoating

Thinner : 0-5% of thinner by volume

Spreading rate approx. 1 kg/8 m2

3rd coat : Enamel Satin

Thinner : 0-3% of thinner by volume

Spreading rate approx. 1 L/9 m2

Surface imperfections can be filled between the 1st and 2nd coat with Filler.

**2.5 Interior Ferrous Metals (Non-galvanized)**

Pretreatment : De-rusting by means of blasting or mechanical de-rusting, wire brushes, etc.

1st coat : Red Lead

Thinner : 0-3% of thinner by volume

Spreading rate approx. 1 L/9 m2

2nd coat : Red Lead/Iron oxide 90/10

Thinner : 0-3% of thinner by volume

Spreading rate approx. 1 L/9 m2

3rd coat : Undercoating

Thinner : 0-5% of thinner by volume

Spreading rate approx. 1 L/12 m2

4th coat : Enamel Satin

Thinner : 0-3% of thinner by volume

Spreading rate approx. 1 L/9 m2

**2.6 Interior Concrete Works**

Pretreatment : 1 coat of concrete primer paint

Thinner : 0-10% of water

Spreading rate approx. 1 L/6 m2

1st coat : Concrete finish paint

Thinner : 0-5% of thinner by volume

Spreading rate approx. 1 kg/4.5 m2

2nd coat : Concrete finish paint

Thinner : 0-5% of thinner by volume

Spreading rate approx. 1 kg/5.5 m2

Final coloring selection shall be determined by the client or Engineer on site.

Use paint as recommended by manufacturer.

**2.7 Wall Paint**

Pretreatment : (in case of strong absorption of the surface) 1 coat of latex primer paint

Thineer : 0-10% of water

Spreading rate approx. 1 kg/6 m2

1st coat : Latex wall paint

Thinner : 0-5% of water

Spreading rate approx. 1 kg/6 m2

2nd coat : Latex wall paint

Thinner : 0-50% of water

Spreading rate approx. 1 kg/6 m2

In case of an alkaline reacting substrate, it is advisable to neutralize the surface by repeated wetting with water or by neutralizing.

**2.8 Exterior Wood Pigmented**

Pretreatment : 1 coat of undiluted wood preserving agent

1st coat : Undercoating

Thinner : 5-10% of thinner by volume

Spreading rate approx. 1 L/12 m2

Filling : with Combination Filler

Spreading rate approx. 1 kg/3 m2

2nd coat : Undercoating

Thinner : 5% of thinner by volume

Spreading rate approx. 1 L/12 m2

3rd coat : Top coat

Thinner : 0-2% of thinner by volume

Spreading rae approx. 1 L/10 m2

**2.9 Exterior Wood - Transparent**

Pretreatment : 1 coat of undiluted wood preserving agent Spreading rate approx. 1 L/6 m2

1st coat : Wood Stain Impregnation, undiluted

Spreading rate approx. 1 L/8-13 m2

2nd coat : Wood stain satin, undiluted

Spreading rate approx. 1 L/12-14 m2

3rd coat : Wood stain satin, undiluted

Spreading rate approx. 1 L/13 m2

**2.10 Interior Wood - Pigmented**

Pretreatment : 1 coat of undiluted wood preserving agent

1st coat : Undercoating

Thinner : 5-10% of thinner by volume

Spreading rate approx. 1 L/12 m2

2nd coat : Undercoating

Thinner : 5-10% of thinner by volume

Spreading rate approx. 1 L/12 m2

3rd coat : Enamel Satin

Thinner : 0-3% of thinner by volume

Spreading rate approx. 1 L/9 m2

Surface imperfections can be filled between 1st and 2nd coat with combination filler.

**2.11 Interior Wood - Transparent**

Pretreatment : One coat of undiluted wood preserving agent Spreading rate approx. 1 L/6 m2

1st coat : Wood stain impregnation undiluted

Spreading rate 1 L/8-13 m2

2nd coat : Wood stain satin

Spreading rate approx. 1 L/13 m2

3rd coat : Wood stain satin

Spreading rate approx. 1 L/13 m2

**2.12 Central Heating Equipment and Piping**

(not factory finished)

Pretreatment : Degreasing and de-rusting

1st coat : Zinc chromate primer

Thinner : 0-5% of thinner by volume or white spirit Spreading rate approx. 1 L/13.7 m2

2nd coat : Heat resistant for radiators

Thinner : 0-2% of thinner by volume or white spirit Spreading rate approx. 1 L/9.5 m2

3rd coat : Heat resistant for radiators

Thinner : 0-2% of thinner by volume or white spirit Spreading rate approx. 1 L/9.5 m2

**2.13 Suwide Vinyl Wallcovering**

a) General:

Vinyl wall coverings shall be adhered to walls, in locations shown on the drawings and indicated in the Room Finish Schedules.

b) Materials :

Vinyl wall covering shall be Suwide textured and linen backed wall covering.

c) Application :

Suwide wall coverings shall be fixed with an approved adhesive strictly in accordance with the manufacturer's instructions.

**2.14 Colors.**

Colors shall be selected by the Engineer unless otherwise specified. Colors shall be formulated with colorants free of lead, lead compounds, or other materials which might be affected by the presence of hydrogen sulfide or other gas likely to be present at the project.

**2.15 Additives.**

Additives may only be used where recommended by the paint manufacturer.

**PART 3 - EXECUTION**

**3.1 PAINTING WORKS**

**3.1-1 Weather Conditions**

Perform work only when weather conditions are warm, dry, and dust-free.

**3.1-2 Preparation of Surfaces**

All surfaces to receive paint shall be inspected for defects which shall be corrected in an approved manner.

Specific surface preparation procedures shall conform to the following:

a. Wood surfaces - as specified under Standard Building Regulation

b. Metal surfaces - as specified under Standard Building Regulation

c. Plastered surfaces - as specified under Standard Building Regulation

**3.1-3 Application**

All paint shall be applied by brush unless otherwise permitted by the Engineer. All surfaces to be painted shall be dry. Each coat shall have dried a minimum of 24 hours, or as recommended by the manufacturer before applying the succeeding coats. Application rates (coverage) and dry film thicknesses shall not be less than recommended by the paint manufacturer.

**3.1-4 Protection of Materials not to be Painted**

Remove, mask, or otherwise protect hardware, lighting fixtures, tile work, porcelain fixtures, switch plates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not intended to be painted. Provide drop cloths to prevent paint materials from falling on or marring any adjacent surfaces. Protect working parts of all mechanical and electrical equipment from damage during surface preparation and painting process. All openings in motors shall be masked to prevent paint and all other materials from entering the motors.

**3.1-5 Paint Mixing**

Multiple-component coatings shall be prepared using all of the contents of the container for each component as packaged by the paint manufacturer. No partial batches will be permitted. Multiple-component coatings that have been mixed shall not be used beyond their pot life. The Contractor shall provide small quantity kits for touch-up painting and for painting other small area. Only the components specified and furnished by the paint manufacturer shall be mixed. No intermixing of additional components for reasons of color or otherwise, even within the same generic type of coating, will be permitted.

Paint materials shall be kept sealed when not in use.

**3.1-6 Manufacturer Applied Paint Systems**

In all cases where pre-coated items are to be shipped to the jobsite, all efforts will be made to protect the coating from damage. Coated items shall be battened to prevent abrasion. Contractor shall use nonmetallic or padded slings and straps in handling. Items will be rejected for excessive damage, in the opinion of the Engineer.

Abraded areas on factory finished items shall be repaired in strict accordance with the manufacturer's directions. Repaired areas shall be carefully blended into the original finish.

All shop primed items including the Secondary Clarifier equipment shall be inspected at the jobsite for compliance with these specifications. Schedule such inspection with the Engineer in advance. Areas of chipped, peeled, or abraded primer shall be hand or power sanded feathering the edges. The areas shall then be spot primed with the specified primer. Prior to application of finish coats, shop primed surfaces shall be cleaned free of all dirt, oil and grease, and a mist coat, 1.0 mm dry film thickness, of the specified primer applied, complete. Holdback areas for welding shall be prepared and primed, after welding, as required for the specified paint system. Application of primer shall be in accordance with manufacturer's instructions.

Units to be bolted together and to structures shall be painted prior to assembly or installation.

**3.2 TEXTURED COATING**

**3.2-1 Inspection**

A. Examine the areas and conditions under which work is to be applied and verify that the work may properly proceed in each area to be coated. Do not proceed with the work until unsatisfactory conditions have been fully resolved.

B. Starting of coating work will be understood as acceptance of the surfaces and conditions within particular area.

C. Never apply coating over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions otherwise detrimental to the formation of a durable coating.

D. Do not apply texture coating when surface or ambient temperatures are below 40 F (4.4 C) or when relative humidity is in excess of 90%.

E. Do not apply out-of-doors when there is a threat of rain.

**3.2-2 Surface Preparation**

A. Surface must be thoroughly cleaned to remove all dirt, dust, loose mortar, efflorescence, and any other foreign matter. Areas where the finished plaster coat is loose, and all broken, shattered or decomposed concrete should be removed to a solid surface and patched. If recommended procedures for applying stucco are followed and normal drying conditions prevail, the surface should be primed with alkali resistant primer and top-coated.

B. Make sure that concrete is cured for at least 30 days and concrete surface is as free of moisture as possible before coating applicator. Non-paintable curing compounds and form release agents must be removed. Oil, dirt and grease shall be sandblasted.

C. For metal and wood surfaces preparation works, refer to application specification available from the manufacturer, prior to applying texture coating to wood or metal.

**3.2-3 Application**

Application shall be executed by specialized, well trained technicians having long experience in textured coating application. Prior to commence working, Contractor shall make sample area. Application area shall be 1.2m x 1.2m as designated by the Engineer. This area should be in an inconspicuous location on the wall to be coated. Sample application should consist of actual approved texture coating colour and finish and shall serve as a standard of workmanship for the entire job.

Only spray application shall be made and in accordance with the manufacturer's direction.

Spray for fine texture may be sprayed by airless spray while other texture coating should be applied by air atomized spray. Tip size will depend on grade of texture.

Pumps, spray gun, material hose, air hose and compressor sizes and capacities shall be as recommended by manufacturers.

During application, spray gun must be hold perpendicular to, and approximately three feet from surface. Excessive material build-up by holding spray gun away from wall when pulling trigger, then bringing gun across area to be coated must be avoided. Application must be done in uniform, even coating avoiding pin holes. Wet edge must be maintained. Stopping and starting midway on walls and irregular spray patterns must be avoided.

Scaffolding and equipment to facilitate quick application without numerous interruptions must be placed. Immediately after application, all equipment shall be cleaned and flushed.

**3.3 CLEAN-UP AND PROTECTION**

All other trades of work shall be protected against damage and discoloration by coating materials. All damaged and stained items shall be repaired and/or replaced as acceptable to the Engineer and at no additional cost to the Owner.

"Wet Paint" signs shall be provided as required to protect newly coated surfaces. Temporary protective wrappings provided for protection of other trades shall be removed after completion of coating operations. Touch-up for damaged defaced coated surfaces shall be made at the completion of work of other trades.

**END OF SECTION**

# SECTION 09901

# SURFACE PREPARATION AND SHOP PRIME PAINTING

**PART 1: GENERAL**

* 1. **SCOPE OF WORK**

Furnish all labor, materials, equipment and incidentals required for the surface preparation and application of shop primers on all valves and mechanical equipment.

* 1. **RELATE WORK**

Field painting is included in section 09902

* 1. **SUBMITTAL**

1. Submit, in accordance with Section 01300, complete shop drawings, manufacturer’s specifications and data on the proposed primers and detailed surface preparation, application procedures and dry micron thickness.
2. Submit, in accordance with Section 01300, representative physical samples of the proposed primers.
   1. **REFERENCE STANDARDS**
3. Steel Structures Painting Council (SSPC)
   1. SSPC-SP-6 - Commercial Blast Cleaning
   2. SSPC-SP-10 - Near-White Blast Cleaning
4. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

**PART 2: PRODUCTS**

* 1. **MATERIALS**

1. Ferrous Metals submerged or subject to splashing.
2. Tnemec

1 Coat: 66-1211 Hi-Build Epoxline Epoxy Primer (90-115 DFT) [DFT = DRY FILM THICKNESS IN MILS]

1. Kop-Coat

1 Coat: Higard Gray Epoxy Primer (90-115 DFT)

1. Porter

1 Coat: M.C.R. 65 Gray Epoxy Primer (90-115 DFT)

1. Structural Steel and Non- Galvanized Miscellaneous Metals.
   1. Tnemc

1 Coat: 90-93 Tnemec-Zinc (60-75 DFT)

* 1. Kop-Coat

1 Coat: Higard Gray Epoxy Primer (60-75 DFT)

* 1. Porter

1 Coat: Zinc Loc 308 (60-75 DFT)

1. Other Non-Galvanized and Non-submerged Services (i.e. Mechanical Equipment, etc.)
   1. Tnemec

1 Coat: 66-BJ45 Gray Epoxy Primer (90-115 DFT)

* 1. Kop-coat

1 Coat: Higard Gray Epoxy Primer (90-115 DFT)

* 1. Porter

1 Coat: M.C.R. 65 Gray Epoxy Primer (90-115 DFT)

1. Non primed Surfaces

Gears, bearings surfaces and other similar surface and other similar surfaces obviously not be painted shall have a heavy shop coat of grease or other suitable rust-resistant coating. This coating shall be maintained as necessary to prevent corrosion during all periods of storage and erection and shall be satisfactory to the Engineer up to the time of the final acceptance test.

1. Compatibility of coating Systems

Shop priming shall be done with primers that are guaranteed by the manufacturer to be compatible with their corresponding primers and finish coats specified in Section 09902.

**PART 3: EXECUTION**

* 1. **APPLICATION**

1. Surface Preparation and Priming
2. Non-submerged components scheduled for priming, as defined above, shall be sandblasted clean in accordance with SSPC-SP-6, immediately prior to priming. Submerged components scheduled for priming, as defined above, shall be sandblasted clean in accordance with SSPC-SP-10 immediately prior to priming.
3. Surfaces shall be dry and free of dust, oil, grease, dirt, rust, loose mill scale and other foreign material before priming.
4. Shop prime in accordance with approved paint manufacturer’s recommendations.
5. Nonprime Surfaces
6. Apply approved coating as per manufacturer’s recommendations.

**END OF SECTION**

# SECTION 09903

# PAINTING AND COATINGS

**1. GENERAL**

A. Where practicable, each succeeding coat of paint shall be of different color. Where a particular color is specified herein, it is for bidding purposes only. Finish colors shall be as selected by the Engineer.

B. Each coat shall produce a minimum dry film thickness as specified herein. In areas where this thickness is not developed, sufficient additional coats shall be applied to produce it.

C. Where alternate painting systems are specified, selection from among the alternates is at the Contractor's option.

D. The Contractor may substitute other paint materials for those specified herein provided that he first receives written approval from the Engineer stating that said proposed substituted materials are equal to those specified and are approved for use in the work.

E. Unless otherwise approved by the Engineer in writing, all coatings applied under a single paint system shall be the product of a single manufacturer.

F. Manufacturer's instructions shall be strictly followed in the application of proprietary coatings.

G. If coatings shall be applied by painting subcontractors, these subcontractors shall be approved by the Engineer.

H. The paint materials shall be delivered to the job site in the manufacturer's unopened containers and a list of all batch numbers shall be furnished to the Engineer prior to the start of work.

I. Care shall be exercised not to damage adjacent work during sandblasting operations. Blasted surfaces shall not be left overnight before coating.

J. Paint shall not be applied in extreme heat, nor in dust or smoke laden air, nor in damp or humid weather.

K. Drying times shall be not less than called for in manufacturer's instructions.

L. Stainless steel surfaces shall not be painted.

M. Drop cloths shall be placed where required to protect floors and equipment from splatter and droppings.

N. Spray painting shall be conducted under controlled conditions, and the Contractor shall be fully responsible for any damage to adjacent work or adjoining property occurring from spray painting.

O. Each coat will be inspected by the Engineer prior to application of the next coat. Areas found to contain runs, overspray, roughness, or other signs of improper application shall be required to be recoated in accordance with the Engineer’s instructions.

P. The Contractor shall provide forced air ventilation, in accordance with applicable regulations, while work is being accomplished inside a tank or other closed area.

Q. Woodwork shall be sanded smooth and knots and pitch streaks shall be painted with a thick coat of orange shellac or a resin sealer, except for stained wood. Nail holes and minor imperfections shall be filled with putty between first and second coat; color of putty shall match stain in the case of stained work.

S. Interior surfaces of ducts behind grilles and diffusers, where duct is visible, shall be painted flat black.

T. Unless otherwise directed or permitted by the Engineer, all piping, vents, conduits, items of equipment, miscellaneous fixtures, appurtenances and the like, shall be painted to match the color of adjacent wall and ceiling surfaces.

U. Color samples and stain samples shall be submitted as required by the Engineer. Stain samples shall be provided on the same material as the stain will be applied in the final installation.

**2. FACTORY-APPLIED COATINGS AND TOUCH-UP**

Except where factory application of finish coatings is permitted elsewhere in these specifications or by the Engineer in writing, all items of equipment shall be finish-painted after installation with the color selected or approved by the Engineer. Shop priming will be permitted in all cases. Materials and application as specified herein shall govern regardless of whether coatings are factory-applied or field-applied. After installation, any damaged areas in prime or finish castings shall be repaired as directed by the Engineer.

**3. ALUMINUM METAL INSTALLATION**

Where aluminum surfaces come in contact with concrete or with lentils not compatible with aluminum (aluminum and galvanized surfaces considered compatible), the aluminum surfaces shall be prevented from coming into direct contact with such parts:

1. by painting the dissimilar materials with a prime coat of zincchromate primer or other suitable primer, followed by 1 or 2 coats of aluminum metal and masonry paint or other suitable protective coating, excluding those containing lead pigmentation, or

2. by painting the dissimilar material with a coating of heavy-bodied bituminous paint, or

3. by placing a good quality caulking material between the aluminum and the dissimilar material.

**4. HOLIDAY DETECTION**

All coated ferrous surfaces inside a steel tank which will be submerged in water or other liquid shall be tested for pinholes in the coating. Any ferrous surfaces to be tested for holidays shall be tested using an approved holiday detector furnished by the Contractor for use by the Engineer and in accordance with the provisions of this Section. Areas found to contain pinholes shall be repaired or recoated in accordance with the coating manufacturer's instructions and retested, all at no additional expense to the Employer.

**5. SYSTEM C - UNGALVANIZEN FERROUS METAL, CORROSIVE ENVIRONMENT**

A. AREA OF APPLICATION. All ungalvanized ferrous metal, indoors and outdoors; exclusive or surfaces which are buried, submerged, inside a hydraulic structure, or specified elsewhere. All ungalvanized ferrous metal in Chlorinator Room and Chlorine Storage Room.

B. SURFACE PREPARATION. Sandblasted per SSPC-SP-h (Commercial Blast Cleaning), except that SSPC-SP-3 (Power Tool Cleaning) or SSPC-SP-2 (Hand Tool Cleaning) will be permitted if Engineer determines that sandblasting will Homage adjacent work.

C. COATING

1. AMERCOAT ALTERNATE. Prime Coat Amercoat 86 (0.03 mm). Finish costs (minimum of 2) Amercoat 99 (0.23 mm). Total thickness of system (0.26 mm).

2. ENGARD ALTERNATE. Prime coat Engard 350 (0.05 mm). Finish costs (minimum of 2) Engard 360 (0.20 mm). Total thickness of system (0.25 mm).

3. KOPPERS ALTERNATE. Prime Coat Koppers 10 (0.04 mm). Intermediate coat Koppers 3SHB (0.11 mm). Finish Coat Koppers 401 (0.10 mm). Total thickness of system (0.25 mm).

**6. SYSTEM D - GALVANIZED FERROUS METAL, CORROSIVE ENVIRONMENT**

A. AREA OF APPLICATION. All galvanized ferrous metal, indoors and outdoors; exclusive of surfaces which are buried, submerged, inside a hydraulic structure, or specified elsewhere. All galvanized ferrous metal in Chlorinator Room and Chlorine Storage 200m.

B. SURFACE PREPARATION. Cleaned per SSPC-SP-1 (Solvent Cleaning).

C. COATING

1. AMERCOAT ALTERNATE. Pretreatment Coat Amercoat 59. Prime coat Amercoat 86 (O.08 mm). Finish coats (minimum of 2) Amercoat 99 (0.23 mm). Total thickness of system (0.25 mm).

2. ENGARD ALTERNATE. Pretreatment coat Engard 135. Prime coat Engard 350 (0.05 mm). Finish coats (minimum of 2) Engard 360 (0.20 mm). Total thickness of system (0.25 mm).

3. KOPPERS ALTERNATE. Pretreatment coat Koppers 40. Prime coat toppers 10 (0.05 mm). Intermediate coat Koppers 35HB (0.10 mm). Finish coat Koppers 401 (0.10 mm). Total thickness of system (0.25 mm).

**7. SYSTEM E - FERROUS METAL, BURIED, OR SUBMERGED IN WASTEWATER**

A. AREA of APPLICATION. All ungalvanized and galvanized ferrous metal, buried, submerged, intermittently submerged, or inside a hydraulic structure, except where another coating system is specifically indicated.

B. SURFACE PREPARATION. Sandblasted per SSPC-SP-5 (White Metal Blast Cleaning).

C. COATING

1. AMERCOAT ALTERNATE. Finish coats (minimum of 2) Amercoat 78 (0.40 mm). NOTE: This system may be used only when all coatings will be field-

2. ENGARD ALTERNATE. Prime coat Engard 422 (0.04 mm). Finish coats (minimum of 2) Engard 464 (0.40). Total thickness of system (n.44 mm). NOTE: Prime coat is for use as a shop primer only. Prime coat shall be omitted when both surface prep

3. KOPPERS ALTERNATE. Prime coat Koppers 654 (0.04 mm). Finish coats (minimum of 2) koppers 300-M (0.40 mm). Total thickness of system (0.44 mm). NOTE: Prime coat is for use a shop primer only. Prime coat shall be omitted when both surface preparation and coating are to be performed in the field.

**8. SYSTEM F - BURIED GALVANIZED AND BLACK STEEL PIPE**

A. SURFACE PREPARATION. Cleaned per SSPC-SP-3 (Power Tool Cleaning).

B. WRAPPING. Prior to wrapping the pipe with PVC tape, the pipe first shall be primed using a primer recommended by the PVC tape manufacturer. After being primed, the pipe shall be wrapped with a O.51 mm adhesive PVC tape, half-lapsed, to a total thickness of 1.02 mm.

**9. SYSTEM S - BURIED MISCELLANEOUS FERROUS SURFACES, COUPLINGS, VALVES, AND FLANGED JOINTS (EXCLUDING PIPE)**

A. SURFACE PREPARATION. Surfaces shall be thoroughly cleaned of all oil, grease, or other contaminants.

B. COATINGS. Rich Portland cement mortar coating to a minimum thickness of 3.2 mm, following which such surfaces shall be enclosed in a 0.20 mm thick polyethylene sheet with all joints and edges lapped and sealed with tape.

**10. IDENTIFICATION OF PIPING**

1. Piping System:

Identification of piping systems shall conform to the requirements of ANST A13.1 “Scheme for the Identification of Piping System”, unless otherwise specified herein.

1. Identification Tags:

All valves, except unit and fixture valves shall be tagged with engrave plastic tags or approved equal. The identification tags shall be a minimum of 60 mm. x 20 mm, but large enough to accommodate the required wording. The engraved lettering shall be a minimum of 0.5 mm. high. Valve tags shall be made from white laminated plastic with black letters, and attached to the valve with a stainless steel chain. Valve tags shall have wording such as “Potable Water” to show the function of the valve.

1. Colour Identification :

All unburied and buried pipe, including tubing, galvanized pipe, and HDPE Stainless Steel and polyvinyl chloride pipe, shall be identified by colour to show its use function. Adhesively applied colour bands of an approved tape type may be used on P.V.C., F.R.P., an stainless steel pipe and any other pipe not readily susceptible to painted finish. Colours shall be as follows :-

Fluid Colour Wording

Potable Water Blue Potable Water

Plant Water, Process Water Blue, Green, Bands Plant Water, Process Water

Sludge, Liquor, Centrate Green Sludge, Liquor, Centrate

Digestor Gas Yellow Digestor Gas

Scum Brown, Black Bands Scum

Return Activated Sludge Light Brown Return Activated Sludge

Excess Activated Sludge Light Brown Excess Activated

Yellow Bands Sludge

Plant Air Green Plant Air

Polymer Natural colour Polymer

Orange Bands

Propane Gas Orange Porpane

Clarifier Effluent Blue, Red Bands Clarifier effluent

Filter Backwash Water

Both direction of fluid flow, and the name of the fluid in the pipe shall be stenciled on the pipe at least once every eight meters and at every change of direction. Colour bands shall be spaced at eight (8) meter intervals and every change in direction. The size of the letters and colour bands shall be as specified in the Table below:-

Outside Diameter Width of Size of Legend

of pipe or covering Colour Band Letters

6 to 25 1 12

35 to 50 1 20

60 to 150 6 50

200 to 250 6 60

Over 250 6 90

All dimensions are given in millimetre.

**11. ALTERNATIVE CORROSION PREVENTION ( GERMAN STANDARD)**

**11-1 HOT GALVANIZING**

All parts which are to be galvanized must be hot galvanized with a layer of at least 80μm. The individual parts are to be completely assembled before being galvanized. They should not be drilled, welded of filed after the galvanizing has been finished.

**11-2 COATS OF PAINT**

The following anti-corrosive paints are to be used for the various parts. These are products from the company “Sika-Chemie”. Products of the same quality from other producers are also permissible.

The treatment must be carried out according to the manufacturer’s specifications, also the thickness of coating must correspond to manufacturer’s specifications .

**11-2.01 Preparation Of Surfaces**

Steel : Blasting with standard purity Sa 2 1/2 according DIN 55928, part 4 .

Galvanised Steel: Cleaning with steam jet .

**11- 2.02 Coats Of Paint**

K1: In under water areas and areas sometimes under water with high stress from abrasion (e.g. endless screws ) .

- 1 × Friazinc R .

- 2 × Icosit BW Panzer .

- 1 × Icosit BW .

K2: In under water areas and areas sometimes under water with normal stress (e.g. in reservoirs).

- 1 × Friazinc R .

- 1 × Icosit EG 1 .

- 1 × Icosit EG 5 .

For hot galvanised parts :

- 1 × Icosit EG 1.

- 1 × Icosit EG 5 .

K3: Outside parts which do not come into contact with waste water (e.g. silos, outside containers) .

- 1 × Icosit thick layer ground coat .

- 2 × Icosit 5530 EG thick layer .

For hot galvanized parts

- 2 × Icosit 5530 EG thick layer .

K4: Inside parts which do not come into contact with waste water (e.g. pipelines, pumps).

- 2 × Icosit K 24 thick

- 2 × Icosit K24 .

K5: Parts of the installation which, for technical reasons, cannot be sand blasted or hot galvanised, such as e.g. electric motors, gears, cast housed fittings, etc. should have the rust carefully removed by hand, be degreased and then the corrosion protective primary coat and top coats are applied as follows :

- 1× Friazinc-A, at least 80 μm dry layer thickness.

- 1 × Icosit - EG 1 DS at least 120μm dry layer thickness.

- 2 × Icositt - EG 4 or 5 total dry layer thickness 120μ m .

The corrosion prevention coats and final coat of paint is to be included in the flat price. The final coat is to be applied on-site after installation. The colour of the last coat of paint is to be determined by the customer.

**END OF SECTION**

# SECTION 09950

# WALL CLADDING

**FIRST: CERAMIC GLAZED WALLS**

**PART 1 - GENERAL**

This section covers the ceramic tiling of walls.

**1.1 DESCRIPTION**

Ceramic tile shall be applied to the wall surfaces scheduled on the Drawings. Final selection of colours and patterns will be made by the Engineer from manufacturers' standards. Tile shall be furnished complete with trimmers and special shapes as required for sills, jambs recesses, offsets, external corners, and other conditions to provide a complete and neatly finished installation. Work required under this section shall not be performed unless the area's ambient temperature is at least 10o C and rising. Tile, trimmers and special shapes shall be delivered to the project site in manufacturers' original containers, bundles or packages, unopened, with seals unbroken and labels intact.

**PART 2 - MATERIALS**

2-1 Ceramic Wall Tile shall be natural clay tile and unless otherwise specified or shown shall be glazed. Trimmers and special shapes shall be of same material as the tile. Tile, trimmers and special shapes shall be thoroughly and evenly matured and free from defects that affect appearance and serviceability. Material that is chipped, broken, cracked or having other defects will not be acceptable.

2-2 Cement shall be high quality Portland, as approved by the Engineer.

2-3 Sand shall be clean, washed, sharp, durable particles, free from silt, loam, clay, soluble salts and organic impurities, and shall be well graded for the use intended.

2-4 Water shall be fresh, clean and free from harmful impurities.

2-5 Samples: Samples of materials proposed for use shall be submitted to the Engineer for approval before materials represented by the samples are delivered to the project site.

**PART 3 - EXECUTION**

Wall surfaces to receive tile shall be clean and free of dirt, dust, oil, grease, and other objectionable matter. Each tile shall be brought to true and level plane by use of a beating block, and a test of plane distortion shall be made with a straight edge. Positive beat-in of each tile is required to establish proper bond. Tiles that are out of true plane or misplaced shall be removed and reset. Joints between tiles shall be of uniform width as specified, and parallel over the entire area. Tiles shall be set over a mortar bed.

* 1. Mortar Bed

Mortar bed shall be composed by volume of 1 part cement to 5 parts damp sand, and mixed with the minimum amount of water necessary to produce a workable mass. Mortar bed shall be applied in sufficient quantity and with sufficient pressure to cover well the entire area and form a good key, shall be brought out flush with temporary screeds or guide strips so placed as to give a true even surface at the proper distance from the face of the finished face of tile, and shall have a finish suitable for reception of material used in setting tile.

* 1. Product and Color Selection

The Contractor shall submit color cards for all paints proposed for use, together with complete descriptive specifications covering all unlisted brands, to the Engineer for review and color selection. Requests for review submitted directly to the Engineer by paint suppliers will not be considered.

For the gloss alkyd enamel, semigloss alkyd enamel, and satin gloss latex emulsion finish paints, a total of not more than15 custom colors (excluding deeptone or high level colors) may be required. The manufacturer’s standard colors will be acceptable for all other paints.

* 1. Field Priming

In general, surfaces of equipment, steel, and cast iron are specified to be shop primed. Any such surfaces which have not been shop primed shall be field primed. Shop coatings which are damaged or have failed, and have been determined unsuitable by the Engineer, shall be removed and the surfaces field primed. Galvanized, aluminum, stainless steel, wood, and insulated surfaces shall be field primed. Primers used for field priming, unless otherwise required for repair of shop primers, shall be:

|  |  |
| --- | --- |
| **Surface to be Primed** | **Material** |
| Equipment, surfaces to be painted with |  |
| Alkyd enamel | Rust inhibitive |
| Aluminum paint | Rust inhibitive |
| Epoxy enamel | Rust inhibitive |
| Cool tar paint | Coal tar, or the same as finish coats |
| Taste and ador free coal tar | Same as finish coats |
| Vinyl | Vinyl |
| Steel and cast iron, surfaces to be painted with |  |
| Alkyd enamel | Rust inhibitive |
| Aluminum paint | Rust inhibitive |
| Epoxy enamel | Rust inhibitive |
| Cool tar paint | Coal tar, or the same as finish coats |
| Taste and ador free coal tar | Same as finish coats |
| Vinyl | Vinyl |
| Chlorinated rubber | Chlorinated rubber |
| Galvanized | Vinyl wash |
| Copper | Vinyl wash |
| Aluminum | Vinyl wash |
| Stainless steel | Vinyl was |
| PVC | Catalyzed epoxy |
| FRP | Catalyzed epoxy |
| Wood (painted) | Wood primer |
| Wood (varnished) | Wood stain |
| Insulated piping | As recommended by manufacturer of finish coats |
| Concrete, surface to be painted with: |  |
| Chlorinated rubber | Chlorinated rubber |
| Epoxy enamel | Epoxy enamel |
| Concrete block exposed in exterior locations | Concrete block filler |
| Concrete block to be coated with tile-like wall finish | Concrete block filler |

A tie coat shall be applied between the primer and top coats, if recommended by the paint manufacturer. Surfaces specified to be field painted with clear finish coats need not be primed. Unless otherwise recommended by the paint manufacturer, priming will not be required on concrete, or concrete block, or plaster or gypsum wallboard surfaces specified to be painted with latex paint or epoxy, taste and color free coal tar, and heat resistant paints. Priming will not be required on surfaces to be marked with chlorinated rubber traffic paint.

* 1. Painting Schedule

The following schedule lists paints for intermediate and finish coats for surfaces to be painted. All exposed surfaces, including sides and edges, shall be painted:

|  |  |
| --- | --- |
| Surface to be Painted | Material |
| * + 1. Metal Surface |  |
| All Surfaces of structural and miscellaneous steel exposed in exterior locations. (Galvanized surfaces are not to be painted unless otherwise specified) | Gloss alkyd enamel |
| All surfaces of structural and miscellaneous steel exposed inside buildings. (Galvanized surfaces are not to be painted unless otherwise specified.) | Semigloss alkyd enamel |
| All exposed surface of steel doors, door frames, steel handrails, steel floor plates, pumps, motors, speed reducers, and other machines and equipment. | Gloss alkyd enamel |
| Operators for sluice gates, slide gates, and control weirs. | Gloss alkyd enamel |
| Digester covers, all iron and steel parts that will be exposed to view. | Gloss alkyd enamel |
| Extension hoppers and accessories for chemical feeders. | Gloss alkyd enamel |
| Metal curbs for skylights and power roof ventilators. | Gloss alkyd enamel |
| Exterior surfaces of elevator car frame and enclosure | Gloss alkyd enamel |
| Interior surfaces of elevator car, car gates, and hoistway doors and frames | Gloss alkyd enamel |
| Elevator guide rails and structural steel in hoistway | Gloss alkyd enamel |
| Heating and air conditioning units, convector covers, electrical equipment cabinets, and similar items and equipment (unless factory finished). | Gloss alkyd enamel |
| Exposed surfaces of cranes and hoists. | Gloss alkyd enamel |
| Exposed surfaces of dockboard and metal parts of dock bumpers | Gloss alkyd enamel |
| Exposed surfaces of steel yard lighting poles. | Gloss alkyd enamel |
| All exposed surfaces of cast iron and steel piping inside building and above grade outdoors, including valves, fittings, flanges, bolts, supports, and accessories therefore, and including galvanized surfaces after proper priming. | Alkyd enamel; gloss for color coded piping; gloss or semigloss for all other piping. |
| Copper pipe and tubing, including fittings and valves | Semigloss alkyd enamel |
| Surfaces of ductwork exposed inside buildings, after proper priming. | Semigloss alkyd enamel or latex. |
| All exposed surfaces of electrical conduit inside buildings (except banks of conduits in multiple layers hung from ceilings), including fittings, boxes, supports, and accessories therefore, after proper priming. | Semigloss alkyd enamel or latex |
| Sludge colleting equipment , flocculators, and accessories, all iron and steel parts except motors and speed reducers | Vinyl |
| Outside surfaces of liquid chemical tanks | Vinyl |
| Basin launders, troughs, weir plates, and accessories. | Vinyl |
| Rapid mix equipment, all iron and steel surfaces specified to receive vinyl shop coating. | Vinyl |
| Surface aeration equipment, all iron and steel surfaces specified to receive vinyl shop coating. | Vinyl |
| All metal surfaces, unless otherwise specified, which will be submerged or buried, all or in part, including valves, valve boxes, weir plates, scum baffles, and sluice gates, but excluding piping laid in the ground. | Medium consistency coal tar |
| All fully or partially submerged surfaces of screening, grit removal, aeration mixing, and sludge mixing equipment. | Medium consistency coal tar |
| Miscellaneous castings, including manhole rings and covers, and manhole steps. (one coat, if not foundry dipped). | Medium consistency coal tar. |
| All exterior surfaces of cast iron and steel piping exposed in manholes, wetwells, grit basin, aeration basin, and similar locations, including valves, fittings, flanges, bolts, supports, and accessories. | Medium consistency coal tar |
| All metal harness anchorage for buried piping | Thixotropic coal tar |
| Digester covers, all iron and steel parts that will be fully or partially submerged, exposed to sewage gas, or concealed inside; and digester mixing equipment. | Coal tar epoxy (one top coat) |
| Cast iron filter surface wash piping inside filter boxes, including fittings, bolts, and supports. | Chlorinated rubber. |
| Supports and miscellaneous metal for equipment handling corrosive chemicals. | Epoxy enamel |
| Polished brass or bronze. | Clear satin varnish |
| Boiler breaching and other surfaces which will be hot during operation. | Heat resistant aluminum. |
| Pneumatic conveyor piping | Heat resistant aluminum. |
| Vacuum pump discharge piping. | Heat resistant aluminum |
| Engine exhaust piping | Heat resistant aluminum |
| * + 1. Concrete and Masonry Surfaces |  |
| All concrete and concrete block surfaces (except floor surfaces and surfaces scheduled to receive other coatings) which are exposed to view in interior locations (two coats). |  |
| Walls and columns | Sating gloss latex emulsion |
| Ceilings and overhead construction | Flat latex emulsion |
| Underside of concrete canopies (two coats). | Flat latex emulsion |
| Interior walls of filter boxes, full height above under drains and including edges of walkways | Chlorinated rubber. |
| Interior surfaces of filter wash water flumes | Chlorinated rubber |
| Filter wash water troughs. | Chlorinated rubber |
| Interior surfaces of sludge drawoff boxes. | Medium consistency coal tar |
| Concrete block surfaces in carbon handling rooms and janitor’s closets. | Tile-like wall finish |
| Where indicated on the drawings, walls, floors, and curbed areas adjacent to corrosive chemical storage and feed equipment. | Epoxy enamel |
| * + 1. Mescellaneous surfaces |  |
| Gypsum and Keen’s cement finish plaster, and gypsum wallboard surfaces (two coats). |  |
| Walls | Satin gloss latex emulsion |
| Ceilings | Flat latex emulsion |
| Wood doors and trim. | Gloss alkyd enamel |
| Insulated piping (except aluminum jacketed insulation) | Gloss or semigloss alkyd enamel. |
| PVC and FRP . | Gloss alkyd enamel |
| Interior wood doors. | Wood stain plus two coats of clear sating varnish |
| Wood bench tops (two coats). | Clear satin varnish |
| Pavement marking (one coat). | Traffic marking paint. |
|  |  |

* + 1. Surfaces not to be painted

Unless otherwise specified, the following surfaces shall be left unpainted:

* exposed surfaces of aluminum, except ductwork.
* Polished or finished stainless steel, unfinished stainless steel, except flashings and counter flashings, shall be painted.
* Nickel or chromium.
* Galvanized surfaces, except piping, conduit, ductwork, and other items specifically noted.
* Piping concealed in inaccessible plumbing and above suspended ceilings.
* Rubber and plastics.
* Portland cement plaster.
* Fireproofing plaster.
* Acoustical panel ceilings.
* Face brick.
* Exterior concrete.
* Surface specified to be factory finished.
  1. Piping Identification

Exposed piping, and piping in accessible chases, shall be identified with lettering or tags designating the service of each piping system, shall have flow directional arrows, and shall be color coded as scheduled below.

Piping scheduled to be color coded shall be completely painted with the indicated colors, except surfaces specified to be unpainted shall have segments painted with the specified coding color long enough to accommodate the required lettering and arrows. All other piping specified to be painted shall match adjacent surfaces, unless otherwise directed by the Engineer.

* + 1. Location

Lettering and flow direction arrows shall be provided near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe. If, in the opinion of the Engineer, the foregoing requirements will result in an excessive number of labels or arrows on a run of pipe, the number required shall be reduced as directed.

* + 1. Metal Tags

Where the outside diameter of pipe or pipe covering is 5/8 inch or smaller, metal tags shall be provided instead of lettering. Tags shall have the specified identifying lettering stamped- in, and shall be fastened to the pipe with suitable chains. Metal tags and chains shall be aluminum or stainless steel. Where tags are used, pipe shall be color coded as specified.

* + 1. Lettering

Lettering on piping shall be painted, stenciled, or snap-on markers. Snap-on markers shall be plastic sleeves equivalent to Seton Name Plate “Setmark”. Letter size shall be as follows:

|  |  |
| --- | --- |
| **Outside Diameter**  **of Pipe or Covering** | **Minimum**  **Height of letters** |
| 5/8 inch and smaller | Metal tags – ¼ inch |
| ¾ inch through 4 inch | ¾ inch |
| 5 inch and larger | 2 inches |

* + 1. Color Coding and Lettering Schedule

All 12 inch and smaller piping for the following services shall be color-coded. Where scheduled, bands shall be 6inches wide spaced along the pipe at 5 intervals.

|  |  |  |
| --- | --- | --- |
| **Letters** | **Color of Pipe** | **Color**  **of Letters** |
| Potable Water (hot or cold) | Light blue | Black |
| Non-potable or Raw Water | Light blue with red bands | Black |
| Distilled Water | Light blue with white bands | Black |
| Service Water (lines down- stream from a backflow prevention unit) | Dark blue with red bands | Red |
| Seal Water (lines downstream from an air gap, re-pump system) | Dark blue with red bands | White |
| Settled Sewage Service Water | Dark blue with orange bands | White |
| Compressed Air | Light green | Black |
| Low Pressure Air (aeration supply) | Light green | Black |
| Instrument air | Light green with dark green bands | Black |
| Ozone | Orange with green bands | Black |
| Sodium chlorite | Orange with red bands | Black |
| Chlorine Dioxide | Orange with black bands | Black |
| Potassium Permanganate | Orange with white bands | Black |
| Carbon | Black | white |

Electrical conduit shall be painted to match adjacent ceiling or wall surfaces as directed by the Engineer. Vent lines shall be painted to match surfaces they adjoin.

In addition, special painting of the following items will be required.

**Item** **Color**

Valve hand wheels and levers Red

Hoist hooks and blocks Yellow and black stripes

Numbers at least 2 inches high shall be painted on or adjacent to all accessible valves, pumps, flowmeters, and other items of equipment which are identified on the drawings or in the specifications by number.

* 1. Mixing and Thinning

Paint shall be thoroughly mixed each time any is withdrawn from the container. Paint containers shall be kept tightly closed except while paint is being withdrawn.

Paint shall be factory mixed to proper consistency of viscosity for hot weather application without thinning. Thinning will be permitted only as necessary to obtain recommended coverage at lower application temperatures. In no case shall the wet film thickness recommended by the paint manufacturer.

* 1. Surface Preparation

All surfaces to be painted shall be dry and free of dirt, dust, sand, grit, mud, oil, grease, rust, loose mill scale, or other objectionable substances, and shall meet the recommendations of the paint manufacturer for surface preparation. Cleaning and painting operations shall be performed in a manner which will prevent dust or other contaminants from getting on freshly painted surfaces. Oil and grease shall be completely removed by use of solvents or detergents before mechanical cleaning is started. The gloss of previously painted before mechanical cleaning is started. The gloss of previously painted surfaces shall be dulled if necessary for proper adhesion of top coats.

Surfaces shall be free of cracks, pits, projections, or other imperfections which would prevent the formation of a smooth, unbroken paint film except for concrete block construction where a rough surface is an inherent characteristic.

When applying touch-up paint, or repairing previously painted surfaces, the surfaces to be painted shall be cleaned as recommended by the paint manufacturer and sanded or wire brushed in such a manner that the edges of adjacent paint are feathered or otherwise smoothed so that they will not be noticeable when painted. All paint made brittle or otherwise damaged by heat of welding shall be completely removed.

* + 1. Galvanized Surfaces

Galvanized surfaces shall be prepared for painting in strict conformity with the instruction of the manufacturer of the vinyl wash primer. Thorough rinsing with clean water shall follow any chemical treatment of galvanized surfaces.

* + 1. Ferrous Metal Surfaces

Ungalvanized ferrous metal surfaces shall be cleaned for painting by means of solvents, high-speed power wire brushing, scraping, or other suitable methods. Surfaces of welds shall be given special treatment by scraping and wire brushing as necessary to remove all slag and weld spatter. Tools which produce excessive roughness shall not be used.

Blast cleaning may be used at the option of the contractor provided that no dust is permitted to settle on adjacent wet paint films.

Surfaces to be coated with zinc rich, coal tar epoxy, vinyl, and heat resistant coatings, except galvanized or zinc rich primed surfaces, shall be blast cleaned to the degree recommended by the paint manufacturer.

* + 1. Concrete Surfaces

New concrete surfaces, including floors, which are to be painted shall be prepared by removing all dirt, dust, efflorescence, oil or grease stains, or other foreign substances, by wire or fiber brushing or scrubbing, scraping, or other appropriate methods. Prior to mechanical cleaning, any oil or grease shall be removed with a solvent or detergent. Concrete surfaces to be painted with chlorinated rubber shall be etched with acid or brush blasted prior to priming.

New concrete floors shall be etched with muriatic acid solution mixed in the proportions of one part acid to 4 parts water and then thoroughly rinsed with clean water. The floor surfaces shall be completely dry when painted.

* + 1. Concrete Block Surface

Voids and openings in concrete block construction shall be pointed. Interior surfaces to be painted with latex paint need not be filled. All exposed exterior surfaces and surfaces to be painted with tile-like wall finish or epoxy enamel shall be filled so that a continuous unbroken paint film is obtained.

* + 1. Wood Surfaces

All wood surfaces shall be sanded smooth before painting. All dust shall be carefully wiped off after sanding.

* + 1. Copper Tubing

All flux residues shall be removed from joints in copper tubing. Immediately before painting is started, tubing shall be wiped with a clean rag soaked in xylol.

* + 1. PVC and FRP Plastic

All wax and oil shall be removed from plastic surfaces by wiping with a solvent of the type used for the specified primer.

* + 1. Hardware

Hardware and hardware items such as bolts, screws, washers, springs, and grease fittings need not be cleaned prior to painting if there is no evidence of dir, corrosion, or foreign material.

* 1. Application

Paint shall be applied in a neat manner, with finished surfaces free of runs, sags, ridges, laps, and brush marks. Each coat shall be hard and dry through the entire paint film before the next coat is applied. Each coat shall be applied in a manner that will produce an even film of uniform and proper thickness. In no case shall paint be applied at a rate of coverage which is greater than the maximum rate recommended by the manufacturer.

Paint showing sags, checks, blisters, teardrops, or fat edges will not be accepted and shall be entirely removed and the surface repainted.

* + 1. Priming

Edges, corners, crevices, welds, and bolts shall be given a brush coat of primer before the specified spot or touch-up painting of metal surfaces. Special attention shall be given to filling all crevices with paint.

Prime coatings shall be covered with a tie coat if recommended by the manufacturer of the finish coating.

Abraded and otherwise damaged portions of shop applied paint shall be cleaned and repainted as recommended by the manufacturer of the finish coating. Welded seams and other uncoated surfaces, heads and nuts of field installed bolts, and surfaces where paint has been damaged by heat shall be given a coat of the specified primer. This patch, spot, or touch-up painting shall be completed, and shall be dry and hard, before additional paint is applied.

* + 1. Latex Paint

Latex paint shall be applied by brushing or rolling; spraying will not be permitted. Latex paint shall not be thinned excessively.

* + 1. Coal Tar Epoxy Paint

The application of coal tar epoxy paint, including limitations of time for recoating, shall conform to the recommendations of the paint manufacturer.

* + 1. Film Thickness

The total paint film thickness including prime coat (if any), intermediate coats, and finish coat shall not be less than:

|  |  |
| --- | --- |
| **Type of Paint** | **Minimum**  **Dry Film Thickness** |
| Aluminum | 3 mils |
| Latex | 3 mils |
| Clear varnish | 2 mils |
| Tile-like wall finish | 4 mils (over concrete block filler) |
| Coal tar |  |
| Medium consistency | 20 mils |
| Taste and odor free | 15 mils |
| Thixotropic | 35 mils |
| Coal tar epoxy | 15 mils |
| Epoxy enamel |  |
| Floors | 4 mils |
| Other surfaces | 10 mils |
| Vinyl |  |
| With vinyl coating, shop applied | 7 mils |
| With vinyl primer, field applied | 6 mils |
| With zinc rich primer | 8 mils |
| Alkyd enamel |  |
| With shop finish or primer applied by electrostatic spray and baked-on, as on hollow metal doors and equipment cabinets. | 4 mils |
| With vinyl wash primer field applied to galvanized, copper, aluminum, and stainless steel surfaces | 4 mils |
| With all other primers, shop or field applied | 5 mils |
| Heat resistant | 3 mils |
| All other finishes | 5 mils |

* + 1. Weather Conditions

Paint shall not be applied, except under shelter, during wet, damp, or foggy weather, or when windblown dust, dirt, debris, or insects will collect on freshly applied paint. Paint shall not be applied at an air temperature below 50 F, or to surfaces of metals, such as the surfaces of a tank or pipe containing cold water, which have a temperature below 50 F, regardless of the air temperature, or when metal temperature and atmospheric conditions cause condensation on the surface of the metal.

* 1. Repairing Factory Finished Surfaces

Factory finished surfaces which have become damaged prior to acceptance by the Owner shall be spot primed and repainted with materials equivalent to those used in the original application. If, in the opinion of the Engineer, spot repair of the damaged area is not satisfactory, the entire surface or item shall be repainted as required by the Engineer.

* 1. Protection of Surfaces

Throughout the work the Contractor shall use drop cloths, masking tapes, and other suitable measures to protect all surfaces from accidental spraying, spattering, or spilling of paint. The contractor shall be responsible for and shall correct and repair damage resulting from his operations or the operations of those responsible to him. Paint deposited on surfaces which are not being painted at the time shall be immediately removed. Bituminous paints spilled or dropped on any material except metals shall be surface cleaned and spot painted with aluminum paint prior to applying the specified paint. Exposed concrete or masonry not specified to be painted which is damaged by paint shall be either removed and rebuild or, where authorized by the Owner, painted with two coats of masonry paint.

**END OF SECTION**

# SECTION 09951

# STONE WORKS

All unit prices in BOQ for stone works include supply, install and construct stone to comply with the following specifications:

a. Source and Color

White stone “Matabbeh" quarries, first class, of 25 cm course height or as shown in BOQ.

b. Classification

Stone shall be first quality complying to the special technical specifications and to the general technical specification..

c. Size and Texture

Stone course height 25 cm, and 1 cm for grooves between stone courses. Thickness not less than 5 cm after hammering with the necessary squaring for each stone before installation and by the use of mechanical saws. The texture to be (Matabbeh), price to include finishing for jambs and lintels of all windows and doors.

d. Grouting

Price to include tools, ties, dowels, formwork for walls and for opening of vaults, arches, …etc. and support of stone course and wherever.

e. Pointing and Cleaning

Pointing to be done using (impervious mortar) after opening of joints minimum 1x1.5 cm by use of a power saw. Mortar shall be of fine sand with white cement and bonding agents of acrylic base. Cleaning shall be by use of power saw and special brushes.

f. Method of Measurement

Measurement shall be by square meter with no paid allowance or additional price for any special pieces of stone whatever shape or size which is considered included in the price of the meter square.

**B. COPING STONE**

Coping stone made of first choice stone and the top of stone surface shall be inclined toward outside with minimum slope 4%.

Coping stone thickness should be 50 mm unless other wise as indicated in Drawings or BOQ.

Coping Stone length must be not less than 500 mm per piece and the weight of each piece not less than 35 kg, the piece less than 35 kg must be fixed by special anchor rod and to the Engineer approval.

**C. MARBLE WORKS**

The extent of marble work is shown on the drawings and in schedules and includes, but not by way of limitation, the following:

1. Marble to doors and windows sills.

2. Marble to stairs and landings.

For Location of marble, refer to the drawings.

**Quality Assurance**

Source: Provide local marble, each obtained from a single source "Quarry" renowned for the good quality of its material.

As far as practicable, each type of marble for each work area shall be obtained from the same "rock" or from "sister rocks" obtained from the same quarry to minimize variation in quality and assure continuity of color, vein arrays and pattern, and appearance.

Codes and standards: ASTM 503 & GTS/MOPW 1996 Clause 806/1.

Production Standards: Comply with the applicable codes and standards for cutting and surface smoothening marble. Adhere to a strict quality control in the machining of marble and only use workshops renowned for their workmanship and quality control.

Materials: All marble shall be best quality material obtained from reputable sources, factory polished and as follows:

1. Marble Stairs:

Marble shall be local obtained from a reputable source. Marble shall be supplied and installed as stair tiling to surfaces. Size shall be as per drawings fixed on a mortar bed 30mm thick on a sand bed underlay. Marble shall be grouted in white cement with color pigments.

2. Marble to Door & Window Sills:

Shall be local marble obtained from a reputable source. Marble shall be supplied and installed to sizes and at the locations indicated on the drawings, thickness shall not be in any case less than 30mm.

**END OF SECTION**

# SECTION 11115

# PUMPING EQUIPMENT

**PART 1 – GENERAL**

**1.1 DESCRIPTION:**

The works included under this section shall comprise the design, manufacture, works witness testing, delivery, storage, and installation, sites testing, commissioning and maintenance of

1. submersible well pumps

The duties of the pumps are given and the spare parts schedules of the pump sets shall be supplied in accordance with the following details.

**1.2 SUBMITTALS:**

Complete outline and installation drawing, together with detailed specifications and data covering material used, parts, devices and other accessories forming part of the equipment furnished shall be submitted in accordance with the submittals section. Operation and maintenance manuals shall be submitted in accordance with the submittal section.

**PART 2 – PRODUCTS**

The pump manufacturers recommended are KSB, RITZ, GOULDS, Ingersoll Dresser…or equivalent. Ay equivalent manufacturer should be in the Industry for not less than 40 years.

**2.1 Submersible Pump (Bore hole Pump)**

**2.1.1 Mechanical Part**

Submersible pump shall be of the centrifugal multistage type utilizing standard production parts and shall be well proven in design, quality of manufacturer and operational reliability.

Pump stage casing shall be of cast iron or cast steel withstanding the pressure and stresses specified in the bill of quantities, stainless steel is also accepted.

Renewable bronze wear rings have to be fitted to the stage casings to maintain good efficiency while operation in different water quality conditions - offers for pumps not provided with these wear-rings will not be accepted, renewable stainless steel wear rings are also accepted.

Pump impellers shall be casted from high grade bronze, where applicable balance holes shall be provided in the impeller hub to reduce imposed axial trust, stainless steel impellers are also accepted.

Pump shaft and the coupling shall be made of high tensile stainless steal of a diameter sufficient to prevent distortion from the stresses imposed on them. Critical shaft speed shall be above maximum running speed.

The shaft main guide bearing located in the suction and delivery housing of the pump shall utilise bronze material, and shall be provided with protection guards to prevent ingress of sand and incrustations (up to 25 g/m3).

Pump stage casing guide bearing shall be of approved abrasion-resistant materials. All bearings shall be lubricated by the water to be pumped.

The pump delivery and housing shall incorporate a thrust washer of suitable material at the shaft end to absorb up-thrust that occur during pump starting.

The pump shall incorporate a delivery check valve (non-return valve).

The pump shall be provided with screwed connection (no flange connection) at the delivery housing (thread of riser pipes API-SL).

A stainless steal strainer shall be provided on the pump suction housing (no synthetic material will be accepted).

The efficiency of the pump shall not be less than 75% for more than 50 kW pumps and closest to 75% for pumps with less than 50 kW motors!

**2.1.2 Material Specifications**

|  |  |
| --- | --- |
| Stage casings | cast iron |
| Renewable wear-rings | Bronze |
| Impellers | Bronze |
| Pump shaft and coupling | stainless steel, 1.4301 or higher |
| Shaft guide bearings | Bronze |
| Suction strainer | stainless steel, 1.4301 or higher |

**2.1.3 Submersible Motor**

The diameter of the motors shall be selected also in view to the dia of the borehole casing diameters given in the bill of quantities .

The Submersible Motor shall be "wet“ squirrel cage induction type designed to operate continuously under submerged conditions and shall comply with the requirements of the IEC Publications 34 and shall be rewindable.

The motors have to be designed to the following specifications:

Water temperature not lower than 50°C

shall berated at least 15% above the maximum required power of the pump,

have to be selected for starting with auto-transformers - reduced voltage throughout the starting sequence (tapping about 70%),

the winding shall be insulated with an approved heat resistant material (e.g. PVC) of high insulation (class y recommended),

four starts in one hour when the motor is cold or hot,

shall be provided with a heavy duty multipad thrust bearing at the base of the motor to absorb the shaft down-thrust developed by the pump. The bearing design shall incorporate tilting thrust pads of stainless steel arrange to self adjustment according to thrust load. The thrust disc shall be of a suitable carbon based or similar approved material, has to be filled with cooling liquid (if additives are used, a certificate for drinking water application has to be added), a sand guard and mechanical seal to protect the motor, all motors have to be equipped with thermal protections (3-wire PT-100 system) thermally contacted to the windings at the upper part of the motor. (Offers only with 3-wire PT-100 system are accepted).The motor shall be equipped with the whole length from motors to the switch-gear double insulated marine cables ,which are allowed to be used in drinking water , with tinned annealed copper conductors. The cable alongside the pump casing shall be covered with a stainless steel plate screwed on the pump stage casings.

The diaphragm cover located at the end of the motor has to be made of cast iron or steel (no synthetic material will be accepted).

The cooling velocity of. provided the velocity is lower tan 0.5 m/s - upstream the motors have to be delivered with shrouds.

**2.1.4 Material Specifications**

|  |  |
| --- | --- |
| Motor Shaft | stainless steel, 1.4301 or higher |
| Motor Housing | stainless steel, 1.4301 or higher |
| Motor Guide Bearing | Bronze |
| Bolts, Nuts, Studs, Screws, Washers etc. | stainless steel |
| diaphragm cover | cast iron or steel |

**2.1.5 Riser pipes**

Between riser pipe and pump a stainless steel adapter shall be connected.

The riser pipes shall be in accordance with API-5L, GRADE-B line pipe. The pipe shall be seamless or seam welded by ERW and shall be threaded from both sides according to API-5L, 8 threads per inch.

The working pressure for the pipes shall not be less than 50 bars.

Pipe Joint and Jointing

The pipes shall be threaded from both sides 8 threads per inch according to API-5L. Each pipe shall be provided with coupling. Long type coupling 20-25 cm. Threaded from inside must be according to API-5L; and provided with the other end with protector to prevent damage of thread.

The pipes and couplers when jointed together must be aligned through the depth of the boreholes, which reach to 400m, and shall not have deflection through this distance.

The threading for both pipes and couplings shall be done by the manufacturer of the pipes and shall not have any failure during manual or machine threading. The pipes and coupling must be suitable to be used with submersible pump and boreholes in which depth reaches 400m, so it must be strong enough to carry the pump set, the weight of the pipes and the water column to withstand the vibration of the pump set and the pressure of the water when the valves shut during the operation of the pump set.

Average Length of pipes of 4" ND and 6" ND shall be 3m.

Coupling must be all screwed to the end of threading and ready to be installed.

The surface protection is either hot dip galvanized after sand blasting or polyethylene coating.

The pipes shall be marked with the manufacture's symbol or mark plus the code number of standard specification and inspector stamp.

The bidder should provide the following data in his bid:

|  |  |
| --- | --- |
| Description | Data |
| Standard of pipe |  |
| Standard of threading |  |
| Standard of coupling |  |
| Length of pipe |  |
| Length of threading |  |
| Length of coupling |  |
| Thickness of pipes |  |
| Thickness of coupling |  |
| Test pressure of pipe |  |
| Type of manual of pipe seamless seam welded |  |

**Table 1 Well Pump Duties and Pipe, Flow Control Valve (FCV) and Water Meter (WM) Diameters for Wellhead Installations**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Well** | **Discharge** | **Head** | **Riser Dia.** | **Length of** | **FCV Dia.** | **WM Dia.** | **Washout** | **Air Valve** | **Pump min eff** | **motor min eff** | **Min motor power** |
|  | **Q** | **H** | **DN1** | **Riser** | **DN2** | **DN2** | **Dia.** | **Dia.** |  |  |  |
|  | **(l/s)** | **(m)** | **(mm)** | **(m)** | **(mm)** | **(mm)** | **(mm)** | **(mm)** | **%** | **%** | **kw** |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
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**2.1.6 Protection and Operating Mode of the Primary Pump Sets**

For the protection of the pumps the criteria listed below are to be monitored by control equipment:

Dry run protection.

Low flow rate at the discharge side of the pump.

High pressure at the discharge side of the pumps.

Low pressure at the discharge side of the pumps.

Motor winding temperature.

Low level of water above submersible pump level.

These signals shall switch off the pump after a pre-determined time delay of 3 to 30 seconds, independent of the selected operating mode. Simultaneously, an alarm will be released. After the fault has been eliminated, a reset push button at the local control panel is to be pressed by the operator. “The pump does not restart automatically.”

An emergency push button switch will be installed close to each pump. A key has to be necessary for the reset of the emergency switch.

**2.1.7 Motor Protecting Devices**

For the protection of the motors the criteria listed below are to be monitored by control equipment, motor ratings 230, 400 V+ 10%, 50 HZ 1500 or 3000 rpm:

Over current, 3 phases, monitored;

Thermal overload, 3 phases, monitored;

Winding temperature;

Phase monitoring, 3 phases;

Over and under voltage monitoring and

Earth fault, 3 phases.

These signals switch off the pump independent of the selected operating mode. Simultaneously, an alarm will be released. After the fault has been eliminated, a reset push button at the local control panel is to be pressed by the operator. ”The pump does not restart automatically.”

The main (running) contactor rating shall be (125%) of the motor maximum current rating of 400 V at the motor nominal rated voltage.

The delta (bridging) contactor rating shall be 100% of the motor maximum current rating at 400 V at the motor nominal rated voltage.

For motors with a power rating of 50 kW and above, a micro-processor based MPM (Motor Monitoring Protection Unit) shall be installed in the motor starter, which measures the voltage, current and temperature, processes the measured values and performs arithmetical and logical operations in order to display the required information, and also to perform the necessary alarm and trips caused by failures and faults. The device shall have low power consumption, adaptability of self supervision, fault diagnosis by means of data recording, flexible construction and selection of relay characteristics.

The operating and setting of the device shall be by means of the device’s front panel push button, and all the measurements, messages, instructions, etc., are to be displayed on an alphanumeric, back lighted, display with two lines of 32 characters.

Also the unit shall have free selectable parameter settings of 4 output relay functions (alarm / tripping).

* 1. **Spare Parts and Tools**

**2.2.1 Spare Parts**

The Contractor shall provide the following;

* 1. One complete identical submersible motor
  2. 4 no. Impellers
  3. 1 set sleeve (upper, intermediate, lower sleeve)
  4. 1 set bearing (upper, intermediate or lower)
  5. 1 set “O” ring
  6. 1 set other spare parts recommended by manufacturer
  7. 1 no. Shaft.
     1. **General Tools**

The Contractor shall provide general tools equipment in accordance with this specification.

1. **Mechanical Hand Tools**

1 Set ring spanners size 6 mm – 36 mm

1 set open-end wrench spanners size 6 mm – 36 mm

1 Set LINK spanners size 3 mm – 36 mm

1 Set Box – ring spanners size 3 – 36 mm

1 Set Torque wrench unit size 12 – 36 mm

* + 1. Set pliers small, middle, and large
    2. Set scale measuring units

1. **Electrical Hand Tools**

1 Set flat screwdrivers size 2 – 10 inches

1 Set cross screwdrivers size 2 – 10 inches

1 Set test screwdrivers size 2 – 5 inches

1 Set pliers, cutting pliers, and dismantling pliers size 2 – 5 inches

In addition to the supply of measuring instruments mentioned in Section (Instrumentation) – Clause (Accessories) in the Electrical Works Specifications.

* 1. **SURGE PROTECTION EQUIPMENT:**

**2.3.1 Surge Protection Valve:**

Due to the rising main characteristics, it is necessary to provide surge protections system connected to the rising mains to prevent pressures at any point of the mains, during sudden shutdown of the pumps or other adverse event, exceeding the following maximum and minimum gauge pressures.

Maximum pressure 250m possible damage to pipe/fitting.

Minimum pressure -5m (possible damage to lining).

**2.3.2 Description:**

The water surge relief valve shall be made of best high quality and durability for the function materials.

**2.3.3 Function**

The valve-normally closed- shall open when the system pressure the spring adjustment setting. Its opening stroke shall be limited to that which is necessary to provide protection against surge exceeding the spring setting. The valve shall close at a slow speed consistent with adjustment of a self-contained oil cushion chamber tha is provided with the valve. THE cushioning device shall permit a range of adjustment for closing speeds to prevent hammer or bang.

**PART 3 – EXECUTION**

**3.1 INSTALLATION**

Installation of equipment and materials in this section shall be in strict accordance with the manufacturer’s recommendations.

**3.2 ELECTRICAL**

Electrical workmanship shall be as specified under the Electrical Sections.

**3.3 LEVEL CONTROL**

Level Controls and alarms shall be as further specified elsewhere.

**3.4 OPERATION AND MAINTENANCE MANUALS**

Comprehensive, computerized, operation and maintenance manuals in the English language and arabic language "where required" covering all items of plant and including all manufacturer's instructions, references, lists, etc. shall be produced.

The manuals shall include an outline of the general principles of operation and maintenance suitable for training purposes, and shall make specific reference to the particular equipment provided. Sales brochures may be included only as additional information.

The manuals shall be submitted in five copies, two copies original and three clear photo copies and shall cover the testing, operation, control, maintenance, dismantling and repair of all the motors, device, equipment and apparatus provided in the Works. All information shall be supported by:

All electrical and mechanical equipment shall have part lists in numbers according to exploded views of the same numbers.

Catalogues and brochures;

Dimension drawings;

Data sheets;

Descriptive text; "Arabic & English"

Comprehensive drawings, sketches, plans, sections as required and

All electrical power, control and electronic detailed drawings.

The greatest importance shall be drawn to the completeness and clearness of presentation.

The Contractor shall deliver to the Engineer, in duplicate, loose-leaf copies of draft operation and maintenance manuals for the Plant at least two months before start-up of the Works. The text or accompanying diagrams shall in addition show the electrical wiring, handling and erection instructions. Draft manuals shall, during the testing and commissioning of the Works, be carefully checked by the Contractor and updated and modified to ensure that they are fully descriptive and applicable to the final layout of Plant and process under operational conditions.

The final approved manuals for the Works shall be submitted before the start of the defects liability period. They shall be securely bound in A4 sized loose-leaf binders, clearly titled, index linked and cross-referenced. If prepared on computer, a standard PC word processor software such as Word for Windows shall be used, and a copy of the data file for each volume on CD shall be supplied in order to facilitate searching for information.

The final manuals shall incorporate instructions, recommendations and advice for the operation of the entire process covering the full range of flow and water conditions and include advice on the joint operation and control of all the process units on site. No section of the Works will be certified by the Engineer as completed unless this requirement has been met.

If during the defects liability period, the Contractor or the Engineer has found that the manual requires modification or enlargement as a result of subsequent operational and maintenance experience in the Works, the Contractor shall provide the approved modification for each relevant manual.

The manuals shall include explanations of the function and purpose in tabular form with look up program for each site of each item supplied and the operational, mechanical and electrical procedures for:

Lubrication, checking, calibration (including charts), testing and adjustment;

Attention at daily, weekly, monthly or other maintenance intervals to ensure reliable trouble-free operation;

Complete overhaul, dismantling and reassemble, testing and recommissioning;

The identification and selection of suitable lubricants standardized throughout the Works, including identifying equivalents available from local manufacturers where possible;

Defect location decision charts to facilitate tracing of the cause of malfunction or breakdown from symptoms or tests;

Routine and emergency safety precautions, procedures and recommendations;

Cleaning of the Plant and its components;

Guidelines for protection of equipment in case of taking the equipment out of service;

* + 1. **Maintenance Procedures**

The operation and maintenance instruction manual shall be supplemented by the submission of a comprehensive yearly maintenance programme for the operation and maintenance staff. A wall chart or charts shall be provided, covering a period of one year with coloured markers. It shall have vertical divisions in weeks and horizontal divisions for each item of Plant. A fitter's card system shall be provided with at least one card for each item of Plant. The cards shall detail maintenance required with the relevant space for work done and parts required. The cards will form the basis of a system to check that the mechanical and electrical maintenance staff is carrying out the necessary routine work. The markers shall be arranged with standard colours to indicate work required, parts outstanding, work completed and the like. The Scheme shall be capable of extension to include any further routine work, which may be required.

Draft proposals for the maintenance scheme shall be included in the training program. The basics of the electronic part of the manual are to be presented at the same time.

**3.5 TRAINING REQUIRMENTS**

The Contractor shall carry out on-the-job practical training of as many members of the Employer’s staff as recommended by Employer and shall provide a program for this training within three months of signing the Contract Agreement. Each member of staff shall receive not less than one month training during the course of the works on site.

The training courses shall cover all the activities of the Contractor, and shall concentrate especially on the field of polyethylene pipe works including installation, laying, connections, fittings, testing, sterilization as well as the adjustment, calibration and maintenance of pressure reducing valves, water meters, pressure relief valves, pressure gauges and sensors, connection and application of data logger and evaluation of recorded data, submersible pumps, horizental pumps and all other electromechanical equipment.

The Contractor shall further carry out, in co-operation with the Engineer and the Employer, a data monitoring program over 4 weeks at all flow and pressure measuring point including evaluation of recorded flow and pressure data with the aim to determine water losses in the system and to identify other pipeline deficiencies.

**3.6 TESTS, INSPECTION AND TRAIL RUN**

Performance tests conducted by the manufacturer in his works shall be in accordance to DIN standard, ISO 2548 or equivalent. The Employer and the Engineer reserve the right to witness the tests.

Pumps and motors shall be tested with their own individual motors, unless otherwise approved by the Engineer. Triplicate copies of test certificates and characteristic curves for pumps and motors shall be provided prior to acceptance of the equipment by the Engineer. Basic data obtained during testing shall be stamped on nameplates affixed to the equipment. Data from manufacturer’s catalogues will not be acceptable in lieu of test certificates and characteristics for the particular items supplied. Any arrangement required for the works testing of pumps, motors and engines are deemed to be included in the bid.

All pipework, pressure vessels, valves etc. shall be pressure tested according to DIN standards. Valves shall be tested and certified as being leak-proof against differential pressure.

For motors acceptable to VDE 0530, mainly comprising one heat run test, overspeed test at 20% over speed for five minutes, momentary overload to 60% for 15 seconds for all sizes of motors.

* + 1. **SITE TESTING-GENERAL**

After installation, the whole of the equipment shall be tested in the presence of the Engineer's Representative to demonstrate compliance with the requirements of the specifications in respect of performance, mode of operation and electrical and mechanical reliability. It shall be the responsibility of the Contractor to obtain any water required for test purposes and pipe it from the supply point to the filling point on the system, and to dispose off any such water after testing in a manner acceptable to the Engineer.

The Contractor shall submit a scheduled procedure and method of testing for approval of the Engineer, before proceeding with the tests.

The Contractor shall furnish all supervision, labor, service, tools, equipment, instruments, materials and supplies required for both the proper hydrostatic testing operation and running tests to the complete satisfaction of the Engineer. The Contractor shall also supply oils, greases, and spares required during the setting to work of the Plant.

The pipe work shall be hydrostatically tested to 1.5 times the working pressure and this pressure shall be sustained for a period of two hours. No visible sign of leakage will be accepted. The Contractor shall perform the hydrostatic test on all completed piping prior to field-coating of any welds and fittings, and prior to backfilling of any trenches associated with pipes under test. Any vent cocks used on tests shall be left in-situ after erection. Filling points shall be plugged.

In the event of any site tests indicating a reduction in standard of the Works or related to the performance of any equipment supplied, the Contractor shall take necessary steps to rectify the shortcoming.

After installation of pumps, acceptance tests shall be carried out according to DIN standard. Equipment not conforming to the bidding data shall be rejected and replaced or modified as directed by the Engineer and at the expense of the Contractor.

**END OF SECTION**

# SECTION 11130

# CENTRIFUGAL DRY WELL PUMPS

**PART 1 GENERAL**

**1-1 DESCRIPTION**

This Section covers the work necessary to furnish and install Centrifugal Dry well pumps and accessories at the Lifting and Pumping stations as shown in the drawings and as specified hereinafter.

**1-2 RELATED WORK**

The requirements of Section general equipment and material stipulations and submittals shall apply to all equipment furnished under this section. Other items of work that relate to this section include, but are not limited to the following : -

Section 01300-Submittal

Division 16-Electrical Sections

Section 05500-Metal Fabrications

Section 01600-General /Equipment and Materiel Stipulations

**1-3 SUBMITTALS**

Complete fabrication, assembly, and installation drawings, together with detailed pump curves, specifications and data covering materials used, part list, devices, and other accessories forming a part of the equipment furnished shall be submitted in accordance with the Submittals Section.

**PART 2 PRODUCTS**

**2-1 GENERAL REQUIREMENTS**

All pumps shall be manufactured by the same manufacturer and shall be heavy duty, non-clog type.

The Contractor shall recheck the charactaristics and calculations required for the pumps taking into considerations the actual levels of sites and actual transmission mains profile for the proper determination of the pump duty head at the required design flow rate. These calculations shall be submitted for Engineer review and approval.

Pump motors shall be suitable for across-the-line staring and the nameplate horsepower ratings shall not be exceeded at any point on the head/capacity curves.

**2-2 PUMP CONSTRUCTION**

Pumps are designed and manufactured in accordance with the latest hydraulic and mechanical engineering criteria-essentially maintenance-free and user-friendly. When fitted with spacer coupling the complete rotor (impeller, shaft and bearing housing) can be removed without having to disconnect the pipe-work and motor (back pull-out feature).

The pump casing is provided with a suction side wear plate with the gland/seal housing doubling as delivery side wear plate. The pump casing accommodates impellers of different shapes, pump and motor shall be connected with standard flexible coupling.

**2-2.01 Impellers :**

Vortex impeller, non-clogging type nominal bore of the pump branches suitable for liquids containing solid, fibrous and stringy materials tending to form larger lumps.

**2-2.02 Shaft and bearings :**

The shaft and bearings are designed for heavy duty continuous operation, horizontal mounting oil/grease lubrication.

**2-2.03 Shaft Seal:**

Double mechanical seal in back-to-back design, seal of tandem type, seal will be fed by a pressure-free liquid.

**2-2.04 Materials :**

Casing : C.I. GG25

Impeller : C.I. GG20 / cast chromium

Wear plate : C.I. GG20 / cast chromium

Shaft (sealed) : 1.4021

Shaft Sleave : S.S.1.4021 / S.S.-1.4021

Oxide ceramics coated

All parts in contact with liquid to be pumped zinc fr. Bronze G-Cu. Sn/nodular cast Iron-S.S. GG6-Ni Cr202/S.S.1.4408.

**2-3 CONTROLS**

Controls for starting and stopping the pumps shall be furnished by the pump manufacturer and shall be the manufacturers standard with the following additional requirements.

**2-3.01 Ultrasonic Water and Sludge Level Meter**

Unit shall employ an admittance level measurement technique, using a low power RF signal to measure the level of the water and produce an output signal linearly proportional to the level of the water. The system shall consist of a sensor and mounting-track, ground plate, interconnecting cable and termination box, and transmitter.

Sensor shall be flush mounted in a track on the wall of the tank presenting minimum disturbance to the water level. Sensor shall contain no moving parts and shall be easily removable for maintenance. Sensor and interconnecting cable shall be intrinsically safe in accordance with NFPA 493. Sensor shall be characterized to produce output linear with level of the water and shall have length as required for noted scale range.

Transmitter electronics shall be solid state, mounted in a NEMA 4 enclosure suitable for wall mounting, unless otherwise noted. Transmitter shall be intrinsically safe in accordance with NFPA 493 for Class 1, Groups C and D, Division 2, and Class 2, Groups E, F, and G, Division 2, unless otherwise noted. Provide 0 to 30 seconds of internal signal dampening. The system shall be designed to operate with water conductivities below 500 micromhos / cm when noted.

Output signal shall be linearly proportional to the level of the water within plus or minus 2 percent of actual level.

**2-.3.02 Level Control Switch :**

Level control switches shall be direct-acting float type consisting of a mercury switch enclosed in a float and connected to a three-conductor, combination support and signal cable to stop pumps in case of dry well- "Low Level". The entire assembly shall form a completely water tight and impact resistant unit. Floats shall be of smooth, chemical resistant polypropylene material. Cable shall be rugged and flexible with heavy polypropylene jacket. Units shall be pipe mounted with clamp to secure the cable to the pipe. Pipe to be schedule 80 PVC. Provide 6 meters (minimum) of unspliced cable with every level control. Level controls shall be suitable in all respects for controlling the operation of the equipment to which they are connected.

**2-3.02 Control Panels :**

All exterior wiring shall interface in the main control panel for each pump system.

**2-4 SURGE PROTECTION**

Due to the rising main characteristics, it is necessary to provide surge protection systems connected to the force main and siphon to prevent pressures at any point of the mains, during sudden shutdown of the pumps or other adverse event, exceeding the following maximum and minimum water gauge pressures:

Maximum pressure 100 m (possible damage to pipe/fittings)

Minimum pressure - 5 m (possible damage to lining)

There are six pumping systems namely:

1. LS1 Pumping Station
2. LS2 Pumping Station
3. LS3 Pumping Station
4. LS4 Pumping Station
5. LS5 Pumping Station
6. PS1 Pumping Station

The Contractor shall carry out a fully detailed computer based surge analysis for each of the pumping stations as listed above.

The successful contractor shall arrange for computer mathematical models of each pumping system to be built and operated by an approved specialist hydraulic analysis organization.

The analysis shall be used by the Contractor to determine and confirm the type and duty of surge mitigation devices (if any) required at each of the pumping installations.

The results of the surge calculations shall include:

(a) Pressure envelope, showing maximum and minimum pressures in graphical form.

(b) Full tabular output of pressure and flow along the pipeline during the analysis for the various pump combinations during starting and stopping.

The Contractor shall provide the Engineer with three copies of a draft report of the surge analysis for comment and approval. Before approving the report the Engineer may require additional requirements, the Contractor shall provide 6 copies of a bound final report and shall incorporate into the works the surge mitigation devices recommended.

The Tenderer shall include the cost of all these analysis and all the necessary surge protection equipment in his Tender price.

No increase in the Tender price will be permitted following the award of the Contract.

During the Contract period the Contractor shall maintain available for use the computer mathematical models used during the Tender stage and shall undertake further studies when required by the Engineer to test the effect of changes (a) proposed by the Contractor (on the pumping stations sites) (b) required by the Engineer.

**2-5 ACCESSORIES (SPARE PARTS AND SPECIAL TOOLS)**

The following items shall be furnished "for each type and size of the pumps included in this Section.

A Complete set of spare parts to be provided as follows:

1. Two sets of O-Rings and Gland
2. Three sets of mechanical seals for each type of pumps
3. One set of bearing for each type of pumps
4. One set of impellers for each type of pumps
5. One set of special tools and extraction tools as recommended by the manufacturer

**PART 3 EXECUTION**

**3-1 INSTALLATION**

Installation of equipment and materials in this section shall be in strict accordance with the manufacturer's recommendations.

**3-2 Shop Tests**

The submersible pumps shall be witness tested by the Engineer at the factory. All costs of visa’s, taxes, fees, transport, accommodation; separate room for each engineer; and food shall be paid by the Contractor to the satisfaction of Engineer. The testing shall be witnessed by one mechanical engineer from Engineer side and two engineers from Client side. Pocket money of US$ 150 per day shall be paid to each engineer by the Contractor as well. International tickets with all related expenses shall be arranged by the Contractor from home country of each engineer to the manufacturer country. The number of visits shall be to the satisfaction of Engineer on testing results.

All pumps characteristics shall be tested for output and input power parameters. These will include, flowrate, head, current, voltage, power factor, motor efficiency, pump efficiency at various points of duty to satisfy theoretical approved manufacturer technical data. Method statement shall be submitted for Engineer approval as well as the complete witness testing program with all related international standards for pumps testing.

**3-2 ELECTRICAL**

Electrical workmanship shall be as specified under the Electrical Sections .

**3-3 LEVEL CONTROL**

Level Controls and alarms shall be as further specified in Section 16920 EQUIPMENT CONTROL AND INSTRUMENTATION.

**3-4 OPERATION AND MAINTENANCE MANUALS**

Operation and maintenance manuals shall be submitted as specified in Section SUBMITTALS.

**END OF SECTION**

# SECTION 11725

# CHLORINE FEED SYSTEM

**PART 1 - GENERAL**

Equipment furnished and installed under this section shall be fabricated, assembled, erected and placed in proper operation condition in full conformity with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the Engineer.

Each item shall be furnished and installed complete with all mechanical and electrical equipment required for proper operation, all components indicated on the Drawings or specified, and all additional materials or construction required by the design of the system.

Chlorine feed equipment shall be of substantial construction with all parts designed for long life under working conditions, including corrosive atmospheres and intermittent or continuous operation. All wearing parts and items requiring adjustment shall be readily accessible. Each unit shall be completely enclosed and dust tight when in operation. All parts which are exposed to corrosive conditions shall be made from corrosion resistant materials or covered with suitable protective coatings.

* 1. **BRIEF DESCRIPTION OF WORKS**

The Contractor Drawings show the details of the Chlorination Rooms as they are to be constructed and also the layout of the equipment. If any departures from the arrangements shown are necessary for the efficient working of the plant, the Tenderer shall give full details in his Tender and show the suggested modifications in drawings submitted with his offer.

Chlorine dosing shall be either manual or automatic. The automatic system shall be based on 4-20 mA signal from a residual chlorine cell placed in the chlorine contact basin.

The system shall be capable of being conveniently switched between the two modes of operation. (manual, auto).

The Contractor shall provide all necessary chlorinators, metering equipment, handling equipment, safety devices, etc., to make the installation complete and acceptable to the Engineer in every detail.

All chlorination equipment shall be manufactured from corrosion-resistant materials selected to give a long life with low maintenance under the chemical and climatic working conditions. All items including those within the chlorinator cubicles shall be arranged to give ample access and maintenance facilities.

The chlorinator shall be floor mounted cabinet type.

* 1. **DETAILED DESCRIPTION OF WORKS**

Each chlorination facility shall provide storage facilities for liquid chlorine in 65kg capacity cylinders.

Chlorine gas shall be withdrawn from 3 No. cylinders header on duty, with another 3 cylinders connected to the common gas bus main on a standby basis, via an electric automatic changeover device with manual bypass valve. A further 3 No. cylinders will be in store.

2 No. sets of chlorinator shall be supplied, one set to operate as duty the other as standby. In the event of a duty chlorinator failing, the associated standby unit shall be manually selected as a duty unit.

Operation of the chlorination plant will normally be:

1. The feeding rate is fixed manually at the controller;
2. The feeding rate is automatically controlled dependent on the flow rate in the pipe where the chlorine is to be injected; or
3. The feeding rate is automatically controlled dependent on the flow rate in the pipe where the chlorine is to be injected together with the measured chlorine residual.

The analogue signals (4 to 20 mA) of the

* + flow rate measurement; and
  + measurement of chlorine residual according to standard specification

All necessary switches are provided to operate each function manually by the personnel, if the automatic control is switched off.

An injector shall be supplied for each chlorinator and this may be either externally mounted or integral with its associated chlorinator.

The chlorinator/injector shall be connected to the motive water pipe.

The automatic changeover shall be achieved by electrically operated valves as a result of a drop in pressure of the gas in the duty cylinder.

* 1. **RELATED WORK**

Other items of work that relate to and are referenced in this section include but are not limited to the following sections:

General Requirements

Electrical Works

Pumps

**1.4 QUALIFICATIONS**

**1.4-1 Supplier’s Qualifications**

The chlorine feed system shall be designed, coordinated and supplied by a feeder manufacturer or a recognized and authorized agent who is regularly engaged in the business of designing and assembling chemical feed systems. Authorized agents will be required to prove their qualifications by submitting the following:

Authorization of recognized agency from the major feeder manufacturer.

That he has the required financial capability.

The names of manufacture whose products are normally supplied and the type of business relationship with each.

That he maintains a qualified technical staff and design office.

That he has the physical plant and fabricating personnel to complete the work specified.

That he has and will maintain competent service personnel to service the equipment furnished.

That he has successfully provided similar work for at least 5 years.

The names of at least three references that are users of similar systems designed, assembled, and furbished by the agent.

**1.5 SUBMITTALS**

**1.5-1 Drawings and Data**

Complete fabrication, assembly, and installation drawings, schematics, and wiring diagrams, together with detailed specifications and data covering material used, parts, devices, and other accessories forming a part of the equipment furnished, shall be submitted in accordance with the submittals section.

**1.6 JOB CONDITIONS**

**1.6-1 Power Supply**

Unless otherwise specified the power supply will be 400/230 single phase, 50Hz. Where control voltage lower than the power supply voltage is required a suitable control power transformer should be furnished.

**PART 2 – PRODUCTS**

**2.1 CONSTRUCTION**

**2.1.1 Chlorine Storage Equipment**

The following equipment is to be supplied installed and tested; the material to connect and to fix the equipment is included:

Chlorine cylinders filled with 65 kg liquid Cl2, suitable for drinking water, welded type with connecting and fixing devices, test pressure p = 35 bar with official certificate of the test;

Isolating valves for each cylinder;

Gas header from the cylinders to the chlorinators;

Automatic change-over switch for the un-interrupted supply of gas;

Filter and moisture separator;

Electrical heater in flow pipes ;

Emergency shut-off valve;

Pressure reducing valve with pressure gauges and strainer;

Safety vent valve with outgoing pipe ending inside the reservoir;

Vacuum regulating valve and vacuum safety valve;

Control panel of the protecting class IP55 for the power supply and the controlling of the components installed outside the chlorine storage room including the caustic alarm and the alarm light;

Power cable and control cable within the chlorine storage room including the caustic alarm and the alarm light which are installed externally and

Gas detector nozzle.

**2.1.2 Chlorine Storage - Control**

**The pressure of the duty cylinder(s) is measured continuously. If the pressure drops to a pre-**determined value, a change over switch links the stand-by unit to the feeding line and triggers an alarm that the empty cylinders should be replaced by the personnel.

A spring loaded emergency shut-off valve shall be provided upstream of the pressure reducing valve to close the storage system when the gas alarm is activated.

**2.1.3 Chlorine Feeding Room - Equipment**

The following equipment is to be supplied, installed and tested; the material to connect and to fix the equipment is included:

Chlorinator(s)

Injector(s)

Control panel of the protecting class IP55, for the power supply and the controlling of the components installed within the chlorine feeding room; and

Power cable and control cable within the chlorine feeding room.

**2.1.4 Chlorinators**

Chlorinators shall be of the modular, V-notch, vacuum operated type, housed in free standing cubicles. The chlorinators shall be operated in conjunction with motive water and each chlorinator shall be complete with its injector unit, manifold gas inlet, vent and drain lines. Chlorine rate control valves shall be suitable for manual or automatic control to give flow rates within ± 4% of the set point. The mechanism for manual control shall act directly on the gas rate control valve.

The chlorinator shall also be complete with a flowmeter having a 20:1 range, differential pressure regulator and vacuum/pressure relief devices. Gauges shall be provided to indicate gas pressure and injector vacuum. The vacuum gauge shall be fitted with alarm contacts to initiate and alarm on high or low vacuum.

The chlorinator gas inlet shall be fitted with thermostatically controlled element heaters.

**2.1.5 Operating Water Pipes**

The operating water pipe as shown on the drawings leads from the connection at the main water pipe to the injector and to the diffuser, which is connected to the main water pipe. The valves to be included are shown in the PI-diagram and designed for a nominal pressure of 6 bar.

**2.1.6 Injectors**

One injector unit shall be provided for each chlorinator. The pipework shall connect each injector to the chlorinator. The injector shall be fitted with a check valve. A secondary check valve shall be provided in the chlorine line. Pressure gauges shall be fitted to both the motive water and chlorine solution lines on each injector system.

**2.1.7 Diffusers**

Chlorine solution diffusers shall be installed in the rising mains before discharge into the reservoirs.

Diffusers shall be horizontal perforated pipes fabricated from uPVC, suitable for installation and operation in the mains and shall be complete with all fixings. It must be possible to remove the diffuser from its installation without having to divert the flow.

**2.1.8 Electrical Power Supply**

The control panel of the chlorine storage room and the control panel of the chlorine feeding room are fed with a 400 Volt, 50 HZ, 3 Phase supply by two separate cables from the distribution panel of the pumping room. The distribution of the electrical energy for the chlorine plant will be achieved by the control panels described elsewhere in these specifications.

**2.1.9 Gas Leakage Monitoring and Alarm Equipment**

A wall mounted gas monitoring unit is to be provided in each feeding room connected to two sensors, one in the feeding room and the other one in the storage room. Contacts at the monitoring unit will effect the procedure described below:

**First Alarm:**

Should the concentration of chlorine in the atmosphere reach a level of 5 ppm, the fume detector shall initiate:

Visual alarm lights, mounted externally over the entrance doors;

An audible alarm and

LED flashing in the gas detector panel

The alarm lights shall be red in colour and display a steady light to indicate low alarm level.

**Second Alarm:**

Should the concentration of chlorine in the atmosphere reach a level of 10 ppm the fume detector shall display:

LED flashing in the detector.

The detector shall be with test buttons for both cases of alarms with LED lights:

With outside flasher and siren;

Open the sprinkler system to beat down the gas;

Initiate a visual alarm;

Initiate an acustic alarm; and

Close the emergency shut-off valve.

The acustic alarm shall be located alongside one of the alarm lights above the entrance door.

The supply and installation of the visual and audible alarms shall be complete with all necessary wiring and fume detector units.

**2.1.10 Safety Equipment**

The chlorinator plant shall be equipped with the following safety equipment:

Two sets of self contained breathing apparatus, as Sabre Series 600BA or similar approved, complete with positive pressure demand valve (complete with test set), air cylinder and whistle. One spare air cylinder shall be provided and all cylinders shall be charged ready for use. Each set shall be housed in a wall mounted cabinet and fixed in a position designated by the Engineer outside the chlorination rooms.

Two canister-type respirators complete with fitted service canister, and one spare canister. Each respirator shall be housed in a wall mounted cabinet adjacent to the entrance doors of the chlorinator room and the chlorine drum store. One set of gastight goggles shall be included in each cabinet.

Two sets of chlorine leak detection equipment, consisting of ammonia spray bottle and all ancillaries. Each set shall be housed in a wall mounted cabinet adjacent to the entrance doors of the chlorinator room and the chlorine drum store. Each cabinet shall be labeled in English and Arabic:

**CHLORINE LEAK DETECTION EQUIPMENT**

Respirators and leak detection equipment shall not be housed in the same cabinets. The cabinets are not being located in a location subject to direct sunlight. Deluxe shower complete with aerated eye/face wash on the outside wall of the chlorination building, complete with delayed action self-closing valve, connected to a potable water line, incorporating a limit switch initiating an alarm indicating and flashing light that assistance is required when the shower is in use. The shower must be linked electrically to the flashing light and sieren installed. Wall mounted cabinet containing all special keys and spanners required to connect and operate the chlorine cylinders, together with 50 sealing washers of approved type for the gas connections to the cylinders.

**2.1.11 Test Equipment**

Three sets of equipment for measuring chlorine residual shall be provided. The prices of the 3 sets shall be deemed to be included in the contract price.

A Lovibond Comparator DPDI kit for determining chlorine concentrations shall be provided for each chlorine station, complete with two years supply of consumables (2500 DPD1 tablets). A sample tap shall be installed.

**2.1.12 Nameplate and Safety Instructions**

Nameplates are to be fixed at each door of the chlorine rooms. Within the chlorine rooms the safety instructions are to be fixed at the wall.

**2.1-13 Pressure Regulating Valves**

A diaphram operated chlorinae gas pressure regulating/shut off valve shall be supplied and installed into each gas line immediately after the changeover device within the Chlorine Store. Diaphram protected pressure gauges shall be fitted to indicate the supply and regulated pressure.

**2.1-14 Electrical Equipment**

Al electrical equipment shall conform to applicable standards of the National Electrical Manufacturers Association and the National Electrical Code. Both power and control equipment shall be insulated for not less than 600 volts even voltage to the various items of equipment is indicated on the Drawings.

Unless otherwise specified, a manual motor starter shall be provided for each electrical device served by 230 volt. Single phase power supply.

All manual motor starters, motors, controls and rate changing devices shall be totally enclosed and dustproof. All associated equipment and controls shall be completely wired so that only one power connection to each item of equipment need be made after the equipment is installed.

In addition to the instructions and parts lists required by the submittal section, complete detailed instructions shall be provided for changing the range of each chlorine feeder. The instructions shall include lists of the parts, which must be changed, together with step-by step directions for making the changes and for calibrating and adjusting the equipment after the range change.

* 1. **PIPEWORK VALVES ETC.**

All the chlorine gas pipework within the Chlorination Rooms, and between the chlorine cylinders, chlorinators and injectors shall be provided by the Contractor.

The Contractor shall also provide all necessary valves, pipework, etc., between the motive water supply point, sample water pipes and chlorine solution pipes.

The Contractor shall provide all necessary changeover valves, pressure gauges etc. to achieve the automatic transfer of chlorine feed from the duty to the standby drum when the pressure in the duty drum falls below a preset figure. Indication shall be provided to inform operators that an exhausted drum requires changing after an automatic transfer of supply has occurred. Facility to manually initiate a changeover of supply source shall also be provided.

All necessary vent pipework to chlorinators, vacuum regulating valves, etc., shall be provided. Vent pipes shall terminate outside the building with a downward facing bend fitting with a suitable insect guard. Each chlorinator shall be fitted with an individual vent pipe and these shall not be joined together to form a common vent.

Pipework conveying gases and chemical solutions shall be selected according to the characteristics of the chemical being handled. Where high pressures or dangerous concentrations in solutions are handled, jointing shall be kept to the minimum and the in-situ test pressure and duration shall be selected bearing the hazards in mind. The highest standard of material selection and workmanship are an inherent requirement both in piping and jointing. The use of clear Perspex for appropriate applications will be considered. Care shall be taken to ensure adequate support is provided for flexible pipework to avoid sagging.

The Contractor shall provide all brackets, stays, backing boards, threader tubes, clips and bolts etc. necessary for the complete installations.

The Contractor shall supply and install on each motive water point a reflux valve, suction and delivery sluice valves and pipework to the chlorinator units, all complete with valves and connection.

* 1. **VENTILATION EQUIPMENT**

Ventilation equipment in the chlorinator and chlorine storage rooms shall be provided as shown in Drawings or specified elsewhere.

**PART 3 – EXECUTION**

* 1. **INSTALLATION**

Installation of the equipment in this section shall be strictly in accordance with the manufacturer’s recommendations. The Contractor shall agree with the Engineer the installation procedure and the key inspections.

* 1. **Works Testing**

Performance tests conducted by the manufacturer in his works shall be in accordance to DIN standard, ISO 2548 or equivalent. The Client and the Engineer reserve the right to witness the tests.

All chlorination equipment shall be tested at the manufacture and certificates shall be submitted to Engineer approval before shipment of equipment.

Pumps and motors shall be tested with their own individual motors, unless otherwise approved by the Engineer. Triplicate copies of test certificates and characteristic curves for pumps and motors shall be provided prior to acceptance of the equipment by the Engineer.

All pipework, pressure vessels, valves etc. shall be pressure tested according to DIN standards. Valves shall be tested and certified as being leak-proof against differential pressure.

* 1. **Site Testing – General**

The chlorination System shall be operated and tested for leakage, proper operation requirements according to manufacturer recommendation and engineer’s approval.

After installation, the whole of the equipment shall be tested by the manufacturer experienced and authorized representative and in the presence Engineer mechanical engineer to demonstrate compliance with the requirements of the specifications in respect of performance, mode of operation, electrical and mechanical reliability. It shall be the responsibility of the Contractor to obtain any water required for test purposes from the supply point to the filling point on the system, and to dispose off any such water after testing in a manner acceptable to the Engineer.

The Contractor shall submit a scheduled procedure and method of testing for approval of the Engineer, before proceeding with the tests.

The Contractor shall furnish all supervision, labor, service, tools, equipment, instruments, materials and supplies required for both the proper hydrostatic testing operation and running tests to the complete satisfaction of the Engineer.

In the event of any site tests indicating a reduction in standard of the Works or related to the performance of any equipment supplied, the Contractor shall take necessary steps to rectify the shortcoming.

After installation of equipment, acceptance tests shall be carried out according to DIN standard. Equipment not conforming to the bidding data shall be rejected and replaced or modified as directed by the Engineer and at the expense of the Contractor.

All expenses of tickets, visas, not less than four stars hotel accommodation, food, transportation to and from airports, 200$ pocket money per day (for all days of testing and commissioning) for Engineer attendance and all other related to testing attendance of the testing and commissioning expenses shall be paid by the Contractor and shall be deemed included under BoQ items prices.

The Contractor shall submit method statement for the commissioning procedure and schedule for commissioning for approval of Engineer.

The contractor shall arrange for all coordination required for 7 days continuous operation with all related authorities and related parties.

**END OF SECTION**

# SECTION 15008

# MATERIAL, INSTALLATION AND TESTING PROCEDURES FOR

# BLACK STEEL, DUCTILE IRON, HDPE AND GALVANIZED PIPES

# for water supply system

**PART 1 – GENERAL**

**1.1 Description**

This section covers installation and testing of black steel, ductile iron, HDPE, OPVC and Galvanized steel pipes.

**1.2 Coordination**

The Contractor shall assume full responsibility for the coordination and complete compatibility of all elements of each piping system. The Contractor shall furnish suitable transition pieces and special fittings acceptable to the Engineer where required to ensure compatibility of piping with valves, and other items of equipment.

**1.3 Applicable Codes and Standards**

Reference to any national standard or publication as ISO/BS/DIN in these specifications is intended to indicate general configuration, type and quality. Goods may be furnished which meet other internationally accepted standard, provided that overall quantity shall at least be equal to that required by the standard specified. Supporting documents / certificates shall be submitted hereto.

* 1. **Materials**

All materials shall comply with the standards mentioned hereinafter and shall be supplied from the accepted manufacturers for this contract.

**1.5 Potable Water Certification**

All pipes, coating, and lining materials shall be certified for potable water use and shall contain no ingredients that may migrate into water in amounts that are considered to be toxic or otherwise dangerous for health.

**1.6 Quantities of Pipes, valves, Fittings and specials**

Before ordering the pipes, the Contractor shall make a proper survey of the Pipelines and shall make sure of the necessary lengths of each kind of pipes, adapters, fittings, valves, and specials necessary to complete the works. The Contractor shall have no claims for extra or deficit amounts that he orders based on BOQ.

**1.7 Fittings**

Fittings unless otherwise specified shall be furnished with a type of joint compatible with the pipe system at the supplier’s option. Any adaptors necessary to joint fittings to the adjacent pipes, even of different materials, shall be provided by the Contractor at no extra cost unless specifically itemized in the BOQ.

**1.8** **Toxic Materials**

The Contractor is prohibited to import or to use any of the “Acrylamide and N-Methylolarcylamide Grouts” or any other toxic or poisonous materials or sub materials used in piping, kinds of concrete or in soil in any kind of usage. Any Contractor required to be licensed in writing by the Employer; otherwise, the Contractor shall be subject to legal pursuance.

**1.9** **Country Of Origin Of Materials**

The Contractor shall be specific as to the country of origin and manufacturing firm of the materials he intends to supply under the Contract, taking in mind this must be within the eligible Countries stated in the Tender Documents, and shall submit all relative catalogues to the Engineer. Prior to confirming the import of any materials, the contractor shall obtain the written approval of the Engineer.

* 1. **PRODUCT HANDLING**

Pipes, fittings, and appurtenances shall be transported, stored, and handled in a manner which prevents damage. Hooks shall not be permitted to contact joint surfaces. Damaged pipe shall be removed from the site.

* 1. **INSPECTION BY THE ENGINEER**

The Engineer reserves the right to inspect goods prior to shipment from the supplier’s factory. The Contractor shall, on request, provide all necessary facilities and cost to the Engineer or the authorized representative to carry out such inspection.

Inspection or approval by the Engineer of any equipment or materials shall not release the contractor from any of his obligations under this contract.

A third-party inspection for the material manufacturing, fabrication and quality control as well as packing of goods shall be included under the related bill items.

**PART 2 – PRODUCTS**

**DUCTILE IRON PIPES AND FITTINGS**

* **Description**

This section covers the requirements and of cast ductile iron pipe, fittings and accessories and their Joints to convey potable water of a temperature between 0° and 50° , with or without pressure, to be installed below or above ground. Cast ductile iron pipe shall be furnished complete with all fittings, joining materials, anchors, blocking, pipe hangers and supports, encasement and other necessary appurtenances.

Piping furnished hereunder shall be complete with all joint gaskets, bolts, nuts, lubricants, and all other materials required for installation of valves and equipment and for making connections to equipment to be installed under this Contract.

Pipe and fittings for the Project shall be in accordance with EN 545-2002 or ISO 2531 – 1998. And according to the specified requirements for materials, dimensions and tolerances, mechanical properties and standard coatings of ductile iron pipes and fittings.

* **Coordination**

The Contractor shall assume full responsibility for the coordination and complete compatibility of all elements of each piping system. The Contractor shall furnish suitable transition pieces and special fittings acceptable to the Engineer where required to ensure compatibility of piping with valves, and other items of equipment.

* **Applicable Codes and Standards**

The codes and standards generally applicable to the work under this section are listed below, equivalent standards are acceptable. Codes and standards current at the time of bid shall be used.

**ISO 2531:1998:** Ductile iron pipes, fittings, accessories and their joints for water or gas applications

**EN 545:2002:** Ductile iron pipes, fittings, accessories and their joint for water pipelines. Requirements and tests methods.

**ISO 4179:2005:** Ductile iron pipes and fittings for pressure and non pressure pipelines.- Cement mortar lining.

**ISO 8179-1:2004:** Ductile iron pipes-External zinc based coating.

**Part 1-** Metallic zinc with finishing layer.

**ISO 4633:2002:** Rubber seals- joint rings for water supply, drainage and sewerage pipeline-specifications for material.

**ISO 7005-2:1988 :** Metallic Flanges - Flange Dimensions

**EN 14910 :2006:** Ductile iron pipes, fittings and accessories-Epoxy coating (heavy duty) of ductile iron fittings and accessories-Requirement and tests methods.

**EN 15189:2006:** Ductile iron pipes, fittings and accessories-Polyurethane coating for pipes-Requirement and tests methods.

* **Submittals**

The following documents should be submitted :

1. Complete layout drawings.
2. Original Catalogues containing the details and specifications covering all cast ductile iron piping rings and accessories shall be submitted in accordance with the Submittals Section.
3. Certificates of manufacturer tests witnessed by third party (approved by Engineer) shall be submitted for Engineer before shipping products.
4. Manufacturer requirements of 1-8.

* **Potable Water Certification**

All pipes, coating, and lining materials shall be certified for potable water use and shall contain no ingredients that may migrate into water in amounts that are considered to be toxic or otherwise dangerous for health. The Contractor is prohibited to import or to use any of the “Acrylamide and N-Methylolarcylamide Grouts” or any other toxic or poisonous materials or sub materials used in piping, kinds of concrete or in soil in any kind of usage.

The contractor is required to submit certificates from third party recognized by the governmental tenders doctorate, (Buraeu Veritas, Loyds, SGS) that the components of the network must not be of any way toxic to the water being conveyed. And can be fully used for the distribution of potable water to a temperature up to 50°C. The Certificates should be submitted for the following materials :

- Cement mortar.

- Bituminous paint.

- Epoxy polyurethane varnish.

- Epoxy powder.

- EPDM Sealing Rings and Rubber Gaskets.

- Lubricating paste.

* **Quantities of Pipes, valves, Fittings and specials**

Before ordering the pipes, the Contractor shall make a proper survey of the Pipelines and shall make sure of the necessary lengths of each kind of pipes, adapters, fittings, valves, and specials necessary to complete the works. The Contractor shall have no claims for extra or deficit amounts that he orders based on BOQ.

* **Storage**

The contractor shall be responsible for the storage and well being of all materials purchased under this contract.

The contractor shall manage and maintain stock yards that can accommodate all materials purchased and approved by engineer under this contract. The materials shall be stored either in the open or under cover as required by the manufacturer/suppliers instructions. Stacking of the materials (pipes, fittings, accessories,…etc) shall be also as per the recommendations and instructions of the manufacturers, and shall be regularly inspected by the engineer staff and maintained to the engineer's satisfaction.

* **Product Handling**

Pipe, fittings, and appurtenances shall be transported, stored, and handled in a manner which prevents damage. Hooks shall not be permitted to contact joint surfaces. Damaged pipe shall be removed from the site.

* **Manufacturer Requirements**

The Contractor should submit the following documents for the manufacturer of the materials along with submittal documents:

1. Financial Capacity:

* Turnover : Has generated an average annual supply/production turnover during the last 5 years greater than US$ 20 Million (The average annual turnover is defined as the total of certified payment certificates for works in progress or completed by the firm or firms comprising the Bidder during the stated period, divided by the number of years stated.)

1. Experience:

* Years of Production : A certificate from the manufacturer (self Declaration) that he has at least 20 years in the field of production for the Ductile Iron pipes and fittings.
* Valid Quality References for the goods such as ISO 9001: 2000 certifications. (valid certificates should be attached).
* **Quality Assurance Requirements for The Manufacturer:**

1. Third party control: The contractor at his own expense provide the services of a third party, recognized by the governmental tenders doctorate, (Buraeu Veritas, Loyds, SGS), independent third party control agency to ensure that the pipes, fittings…etc. are all manufactured in accordance with the specific standards. Among other duties and obligations, shall testify that they have witnessed the tests, analyses required by the standards.
2. The manufacturer shall demonstrate the conformity of his products with the standards by submitting the below performance tests specified in the standards:
3. Compressive strength of the cement mortar lining.
4. Leak tightness of flexible joints to positive internal pressure.
5. Leak tightness of flexible joints to negative internal pressure.
6. Leak tightness of flexible push-in joints to positive external pressure.
7. Leak tightness of flexible joints to dynamic internal pressure.
8. Leak tightness and mechanical resistance of flanged joints.
9. Leak tightness and mechanical resistance of screwed and welded flanges.
10. Quality Assurance System: The manufacturer shall control the quality of his products during their manufacture by a system of process control in order to comply with the technical requirements of the standards.
11. Traceability System: The manufacturer shall clearly mention the method by which he can keep records and trace of the manufactured pipes, fittings,…etc. to ensure the capability of going back to the records for the manufactured item in case any problems accrues after the installation.

* **Quality Assurance after arrival of the materials:**

All materials supplied to the site in Jordan shall be subject to acceptance tests carried out by the Royal Scientific Society, or similar approved authority. The tests should confirm that the pipes are manufactured according to ISO 2531 and EN 545.

The test should include :

1. Dimensions Examination.
2. Wall Thickness.
3. External Diameter.
4. Internal Diameter.
5. Straightness of the pipes.
6. Ovality Test of the Pipes.
7. Cement Lining Thickness.
8. Tensile Test.
9. Hydrostatic pressure test.
10. Hardness Test.
11. Microstructure Examination.

* **DUCTILE IRON PRODUCTS**

All Materials Shall be EN, ISO or equivalent standard and shall be supplied from approved manufacturers. According to the International Standard ISO 9001:2000, the supplier must produce according to the latest version of the products Standards ISO and EN.

In order to insure the perfect compatibility between the different components of the complete system, all pipes, fittings and accessories shall be produced by the same manufacturer. The Contractor shall submit documentary evidence that Pipes and fittings shall be manufactured by the same manufacturer.

The Contractor shall be specific as to the country of origin and the manufacturing firm of the materials he intends to supply under the contract. All pipes fittings and valves shall be suitable for buried installation.

* **Material characteristics**

The ductile Iron Materials shall meet the following requirements:

|  |  |  |
| --- | --- | --- |
| Material characteristics | Pipes centrifugally cast | Pipes not centrifugally cast, fittings, accessories |
| Minimum Tensile strength (MPa) | 420 | 420 |
| Minimum elongation at break (%)  DN 40 to 1000 mm  DN 1100 to 2000 mm | 10  7 | 5  5 |
| Maximum Brinell hardness (HB) | 230 | 250 |

By agreement between manufacturer and purchaser, the 0.2% proof stress (Rp0.2) may be measured. It shall be not less than:

270 MPa when A≥ 12% for DN 40 to DN 1000 or A≥ 10 % for DN > 1000

300 MPa in other cases

* **Ductile Iron Pipes**

Ductile iron pipes shall be centrifugally cast in accordance with the International Standard ISO 2531:1998 and the European Standard EN 545:2002.

The effective lengths shall be 6 m, 7m or 8m, according to the International Standard ISO 2531:1998 and the European Standard EN 545:2002 depending on diameter.

Centrifugally cast pipes shall be subjected to a work hydrostatic test for duration of at least 10 s at a minimum pressure given in the European Standard EN 545:2002, depending of the class of the pipes:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DN** | **Hydrostatic test pressure at factory** | | | |
| **Class 40** | | **Class 30** | **K9** |
| 60 – 300 | 40 |  | | 50 |
| 350 – 600 |  | 30 | | 40 |
| 700 - 1000 |  |  | | 32 |
| 1100 – 2000 |  |  | | 25 |

Table 1 - Minimum Works Hydrostatic Test Pressure

Unless not specify in the specification, the manufacturer has to produce the pipes in according to the following requirements:

*Useable cutting length*

According to the International Standard ISO 2531:1998 and the European Standard EN 545:2002, cutting of pipe DN ≤ 300 mm can be made anywhere along 2/3rds of the length of the pipe working from the spigot according to the ISO 2531:1998 and the EN 545:2002.

* **Ductile Iron Fittings**

Ductile iron fittings shall be sand cast in accordance with International Standard ISO 2531:1998 and the European Standard EN 545:2002.

The dimensional requirements are indicated in the above mentioned Standards.

The fittings shall be submitted at the works to a leak-tightness test carried out either with air at a pressure of 1 bar or with water in accordance with ISO 2531:1998 and EN 545:2002.

The fittings shall be designed and manufactured as automatic push-on joint type, mechanical joints type (for collars and couplings only), flanged type and self anchored automatic push-on joint type.

Each Socket joint shall be supplied with its EPDM gasket, (and glands and bolts when mechanical or anchored type).

Each Flange joint shall be supplied with gasket and bolts (not less than zinc coated 15-20 microns in accordance to ISO 4014 and ISO 4032) for all side and flange connection shall be in accordance with ISO 7005-2.

* **JOINTS**
* **Flexible Joints**

Flexible Joint shall be of spigot socket automatic push-on type (i.e. Standard joint or equivalent), mechanical type (for collars or couplings only).

The joint shall be suitable for angular deflection.

Joints may permit angular deflection to accommodate ground movements and negotiate large radius bends. The angle deflection shall be as per the table below:

|  |  |
| --- | --- |
| Nominal diameter | Deflection |
| DN 80 to 300 mm  DN 350 to 1200 mm  DN 1400 to 2000 mm | 5 °  4 °  1.5 ° |

The material used for the rubber gaskets shall be an EPDM elastomer, in accordance with ISO 4633:2002 and duly certified as suitable for potable water up to 50°C

* **Flanged Joints**

Flanged ended pipes and fittings shall be used when connecting to valves or other special fittings.

The flanges shall be raised faced and integrally cast rotatable flanges may be used for fittings up to DN 600 mm

The dimensions and the drilling of the flanges shall be in accordance with the International Standard ISO 7005-2 or the European Standard EN 1092 -2. The pressure rating of the flanges shall be as given in the particular specifications of each project. Flanged joints shall be supplied complete with gaskets and bolts.

Rubber gasket shall be EPDM elastomer in accordance with the International Standard ISO 4633: 2002 suitable for drinking water up to 50°C. The gasket shall be reinforced and suitable for a minimum pressure rating of 10 bars and higher.

* **Anchored joints**

Ductile iron pipes and fittings may be anchored to be used where pipelines have to cross through existing ducts, in areas with restricted accessibility, when the use of concrete anchor blocks is prohibited or impossible, or when the pipes must be pulled during the installation and for mains on steep slopes ( > 25%).

Anchored joint shall be designed to resist to the axial thrust forces but maintaining flexibility and angular deflection. Anchored joints shall be designed to withstand the greater of the pressure or the service pressure + surge pressure or the site test pressure.

The self anchored joint type will be assured by using gasket with stainless steel metal inserts, or by using gland, bolt, locking ring and welded bead at spigot end. At least the type of anchored joint shall depend on the type of product, the DN and the pressure rating.

* **Wall Thickness**

The thickness shall be calculated either by the K class formula for pipes and fittings or defined according to Class 40 pipes of DN 40 to DN 600.

For pipes, the standardized thickness classes are given in the below table

For fittings, the thickness *e* given in tables and on figures of 8.3 and 8.4 is the nominal thickness corresponding to the main part of the body. The actual thickness at any particular point may be increased to meet localized high stresses depending on the shape of the casting (e.g. at internal radius of bends, at the branch-body junction of tees,...).

* **K classes for pipes and fittings**

The nominal iron wall thickness of pipes and fittings is given as a function of the nominal size, DN, by the following formula, with a minimum of 6 mm for pipes and 7 mm for fittings:

*e* ***=*** *K(0,5 + 0,001 DN)* (2)

where:

*e* is the nominal wall thickness, in millimeters;

*DN* is the nominal size;

*K* is a coefficient used for the determination of the thickness. It is selected from a series of whole numbers :....

8, 9, 10, 11, 12.....

* The contractor should note that if pipes are required from this category They should be Class K9 and the Fittings shall be made of ductile iron (to ISO 2531, EN 545) with push-on flexible joints or flanged as required. The pressure class of fittings and special castings shall be class K12 for fittings without branches and K14 for fittings with branches.
* **Pressure Class Class 40 , Class 30**

Pipes manufactured according to the pressure class should be as follow:

* Class 40 from Dia 60 to 300
* Class 30 form Dia 350 to 600.

The nominal iron wall thickness of pipes DN 40 to DN 600 is given as a function of the nominal size DN in the below table.

Minimum wall thicknesses shall be as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| DN | External Diameter DE  mm | WALL Thickness e  mm | | | |
|  |  | Class 40 | Class 30 | K9 | K10 |
| 60 | 77 | 4.8 |  | 6.0 | 6.0 |
| 80 | 98 | 4.8 |  | 6.0 | 6.0 |
| 100 | 118 | 4.8 |  | 6.0 | 6.0 |
| 125 | 144 | 4.8 |  | 6.0 | 6.2 |
| 150 | 170 | 5.0 |  | 6.0 | 6.5 |
| 200 | 222 | 5.4 |  | 6.3 | 7.0 |
| 250 | 274 | 5.8 |  | 6.8 | 7.5 |
| 300 | 326 | 6.2 |  | 7.2 | 8.0 |
| 350 | 378 |  | 6.3 | 7.7 | 8.5 |
| 400 | 429 |  | 6.5 | 8.1 | 9.0 |
| 450 | 480 |  | 6.9 | 8.6 | 9.5 |
| 500 | 532 |  | 7.4 | 9.0 | 10.0 |
| 600 | 635 |  | 8.6 | 9.9 | 11.0 |
| 700 | 738 |  |  | 10.8 | 12.0 |
| 800 | 842 |  |  | 11.7 | 13.0 |
| 900 | 945 |  |  | 12.6 | 14.0 |
| 1000 | 1048 |  |  | 13.5 | 15.0 |
| 1100 | 1151 |  |  | 14.4 | 16.0 |
| 1200 | 1255 |  |  | 15.3 | 17.0 |
| 1400 | 1462 |  |  | 17.1 | 19.0 |
| 1500 | 1565 |  |  | 18.0 | 20.0 |
| 1600 | 1668 |  |  | 18.9 | 21.0 |
| 1800 | 1875 |  |  | 20.7 | 23.0 |
| 2000 | 2082 |  |  | 22.5 | 25.0 |
|  |  |  |  |  |  |

* **Lining and coatings**
* **SOCKET AND SPIGOT PIPES (INCLUDING WELDED FLANGED PIPES)**
* **INTERNAL PROTECTION**

Pipes will be internally lined with a sulphate resisting cement mortar applied by a centrifugal process, in accordance with the International Standard ISO 4179:2005 and the European Standard EN 545:2002, with the following thicknesses:

|  |  |  |
| --- | --- | --- |
|  | **Thicknesses (mm)** | |
| **DN** | **Nominal** | **Tolerance** |
| 60 - 300 | 4 | - 1.5 |
| 350 - 600 | 5 | - 1.5 |
| 350 -600 | 5 | - 2 |
| 700 - 1200 | 6 | - 2.5 |
| 1400 - 2000 | 9 | - 3 |

* **EXTERNAL PROTECTION**

Pipes will be externally protected depending on the corrosiveness of soils, with:

* Pure metallic zinc followed by bitumen coating
* An alloy of zinc and aluminium, followed by epoxy coating
* Polyurethane coating

**DN 60 to DN 2000 mm for non corrosive soils**

* The pipes shall be externally protected with zinc coating followed by bitumen.
* The zinc content shall be minimum 99% and the mean mass of zinc coating shall not be less than 200 g/m² applied on the bare metal of the external surface of the pipe
* The external surface of the pipe spigot end at a minimum length of 250 mm shall have non-toxic bituminous paint applied to a minimum dry film thickness of 100 microns.
* The internal surface of the socket end shall be painted with a layer of zinc rich epoxy paint 150 g/m²(zinc content not less than 85% plus a layer of non toxic bituminous paint to a minimum dry film thickness of 100 microns.

**DN 60 to 600 mm – for corrosive and non corrosive soils**

* The pipes shall be externally protected with an alloy of zinc and aluminium coating followed by epoxy paint
* The alloy of zinc and aluminium shall content zinc at minimum 85% and aluminium at 15% and the mean mass of alloy zinc and aluminium coating shall not be less than 400 g/m² applied on the bare metal of the external surface of the pipe.
* The external surface of the pipe spigot end at a minimum length of 250 mm shall have non-toxic epoxy paint applied to a minimum dry film thickness of 100 microns.
* The internal surface of the socket end shall be painted with a layer of zinc rich epoxy paint 150 g/m²(zinc content not less than 85%° plus a layer of non toxic epoxy paint to a minimum dry film thickness of 100 microns.

**DN 600 to 2000 mm -- for very corrosive soils**

* The barrel of the pipe will be externally protected with a polyurethane coating in accordance with the European Standard EN 15189:2006. The nominal thickness will be 900 microns and the minimum thickness will be 700 microns. The external coating shall be holiday free. The holiday test shall be carried out at 4.2kV, according to the European Standard EN 15189:2006.
* The internal socket end and the external spigot end of pipes with polyurethane coating will be protected with alimentary epoxy paint in accordance with the European Standard EN 14901:2006.

The minimum thickness of epoxy paint will be 300 microns, except on the surface of the socket end in contact with the gasket where the minimum thickness will be 100 microns.

This protection applied at the factory does not require any extra protection at site such as polyethylene sleeve.

* **FITTINGS**
* **INTERNAL & EXTERNAL PROTECTION**

Fittings will be externally protected depending on the corrosiveness of soils, with:

**Fittings laid in non corrosive soils**

* In general Fittings shall be provided with standard coatings for normal soils, i.e. metallic zinc layer according to ISO 8179 with bituminous paint. Fittings shall be supplied with polyethylene sleeving of 200 microns minimum thickness ISO 8180.

The internal lining of the fittings shall be sulphate resisting cement mortar. The lining specifications and thickness on fittings shall conform with ISO 4179 and shall be projected onto the wall by means of a rotating projection head, or may be placed by hand using appropriate trowels.

* The fittings laid in non corrosive soils shall be internally and externally protected with a fusion bonded epoxy coating with a minimum dry film thickness of 250 microns, according to the European Standard EN 14901:2006.

**Fittings laid in corrosive soils**

* The fittings laid in corrosive soils, with pipes coated with polyurethane shall be internally and externally protected with a fusion bonded epoxy coating with a minimum dry film thickness of 300 microns, according to the European Standard EN14901:2006.
* The fittings laid in corrosive soils, with pipes coated with polyurethane, shall be internally and externally protected with a polyurethane coating according to the European Standard EN15189:2006. The minimum dry film thickness of the external coating shall be not less than 700 microns.
* **Marking**
* All pipes and fittings shall be legibly and durably marked and shall bear at least the following information:
* The manufacturer’s name or mark.
* The identification of the year of manufacture.
* The identification as ductile iron.
* The DN.
* The PN rating of flanges when applicable.
* The reference to this standard.
* The class designation of centrifugally cast pipes when other than K9.

The first five markings given above shall be cast-on or cold stamped; the other markings can be applied by any method, e.g. painted on the casting or attached to the packaging.

* If polyethylene film is supplied it shall bear a card or label giving the following information:

- the manufacturer's name or trademark;

- the year of manufacture;

- the number of the International Standard, i.e. ISO 8180.

- the nominal film thickness;

- the Applicable range of nominal diameter size(s).

* **Gaskets and Seals**

The material used for the rubber gaskets shall be an EPDM elastomer, in accordance with ISO 4633:2002 and duly certified as suitable for potable water up to 50°C, by one of the following national regulations.

Sufficient lubricant as recommended by the pipe manufacturer shall be provided for pipe installation plus ten percent as surplus material. Lubricant containers shall be adequate for extended storage and the pipe manufacturer shall supply instructions for storage limitations and environment.

* **FACTORY TESTING**

Inspection for external appearance, shape, dimensions, and weight shall be carried out on each pipe and fitting. All pipes and fittings shall be sound and free from surface defects.

Each pipe centrifugally cast shall be subjected to the hydrostatic pressure test as specified in EN 545-2002 / ISO 2531-1998. Each fittings and accessory not centrifugally cast shall be subjected to a leak tightness that carried out with water or air as specified in EN 545-2002 / ISO 2531-1998. Hydrostatic pressure tests shall be performed before the pipes are coated or lined.

Any pipe or fitting that leaks or does not withstand the test pressure shall be rejected.

Mechanical tests for hardness, tensile strength, and elongation shall be performed on test pipes selected at random out of castings grouped in lots. Each lot shall comprise 200 pipes successively cast.

* **DUCTILE IRON PIPES TESTING**

After completing the installation of a water main, or a section of the line, and before the joints are covered, a hydrostatic test of the line shall be made by the Contractor. The test pressure shall be 24 bars for all lines. A sufficient time for the curing of concrete thrust blocks must be allowed before the test is made. All backfilling and compacting over and around the pipes and thrust blocks must be completed except for the pipe joints to be left open for observation of any leaks, before the test is made.

The Contractor shall submit to the Engineer for approval, detailed procedures for performing hydrostatic pressure tests of installed pipes, fittings and valves. Procedures for performing the hydrostatic pressure test should indicate the location and capacity of the test pump for each test section, test pressure at the pump, procedure for venting the air from the pipeline, procedure of filling the pipe with water and length of the pipe section.

The initial test pressure shall be applied for a period of 24 hours before the test proper is deemed to begin, to allow for a soaking period. After that, all joints shall be carefully inspected for evidence of leakage. The test pressure for the main test shall then be applied for further three hours for pipe diameters up to DN200 and six hours for pipe diameters DN 250 up to 500mm. For pipe diameters greater than DN 500 further 24 hours is required.

During the test the pressure is to be maintained at the test value by the addition of water as required.

The “leakage” under test, taken as the aggregate quantity of water added to reinstate the test pressure during the 24 hr period, shall not exceed 1/3500 of the volume of water in the section under test and further the leakage rate and at any one joint shall not exceed Q, where:

Q = Allowable leakage in pipeline section under test

20 n

where:

Q = leakage rate in l/hr

n = number of joints in the test section

The test pressure is to be maintained at the lowest point of the pipe line under test and the readings corrected if necessary for variation in elevation. In any event no section shall receive a pressure of less than 20 bars and the maximum length under test should not exceed 500 m without approval of the Engineer.

When filling the pipe system for testing, the Contractor shall not exceed the following flow rates in litres per second:

- up to DN 200 1.5

- up to DN 300 3

- up to DN 400 6

- up to DN 500 9

- up to DN 600 14

The test pressure shall be applied by a suitable pump equipped with connection valves and gauges etc., to the satisfaction of the Engineer. The gauges and meters shall be new and shall be accompanied by a certificate for test and calibration.

A simple stop end consists of a section of steel pipe about 0.5-1.0 m long onto which a closing plate has been welded, with suitable openings for feeding water and venting air. The stop end may also include an opening through which the test water may be pumped from the line, if necessary. The stop end may be jointed to the pipe to be tested by means of a standard coupling or other method approved by the Engineer. Thrust blocks or a temporary anchorage must be provided to hold the stop end in place against the test pressure.

Before applying the test pressure, all air shall be expelled from the pipe. After all the air has been expelled, all cocks shall be closed and the test pressure applied as specified above. The line shall be filled slowly to prevent possible water hammer.

All exposed pipes, fittings, valves, hydrants and joints shall be carefully examined during the pressure test. All joints showing leaks shall be re-jointed until tight, or the pipe material replaced. The test shall then be repeated with the replacement material.

The Engineer shall prepare a written report of the results of the leakage test that identifies the specific test, length of pipe tested, the pressure, the duration of the test, and the amount of additional water required. The report shall be signed by the Contractor and the Engineer.

Pressure gauge shall be calibrated and to be approved by the Engineer.

* **LAYING OF DUCTILE IRON PIPES**

In general, all DI pipes shall be laid in accordance with the standard Drawings. All ductile iron pipes and fittings shall be laid true to lines and grades shown on the Drawings and specified herein unless otherwise approved by the Engineer. Pipes and fittings shall be lowered carefully into the trench in such a manner to prevent damage to the exterior surface and interior lining. Under no circumstances shall pipes or fittings be dropped into the trench. All trenches shall be free of water before installation of pipes.

The spigot and socket ends of pipes and fittings shall be inspected before installation and all lumps, blisters and excess coatings shall be removed. The spigot and socket ends of pipes and fittings shall be wiped clean and dry of all dirt, sand and foreign material. The rubber gasket shall be placed in the correct direction and be correctly seated. Lubricant shall be applied to the previously cleaned spigot end of the pipe. The Contractor shall ensure that the spigot end of the pipe is beveled, as square or sharp edges may damage or dislodge the gasket and cause a leak. All pipes cut in the field shall have the spigot beveled with a heavy file or grinder to remove all sharp edges. The spigot end shall be pushed into the socket end of the pipe or fitting making sure that the joint is straight and the spigot centered in the socket. The pipes once laid shall immediately be prevented from lateral or vertical movement by the addition of backfill.

The Contractor shall provide quantities of lubricant appropriate to the overall number of joints he has to make.

The Contractor shall familiarize himself fully with all literature furnished by the manufacturer with respect to installation of ductile iron pipes and fittings before starting to install the pipes and fittings.

Each day at the close of work or whenever pipe laying is not in progress, the open ends of the pipe shall be plugged, capped or otherwise made watertight to prevent the entry of foreign material. Care must be taken to prevent pipe flotation should the trench fill with water. The Contractor shall be responsible for any damage to the installed pipes, fittings and valves resulting from flotation.

Flanged joints shall incorporate full-faced, one piece gaskets. Flange faces should bear uniformly on the gasket, and bolts should be tightened uniformly until the joint is perfectly tight. The Contractor shall use torque wrenches for tightening all bolts.

When it is necessary to deflect pipes from a straight line in a horizontal or vertical plane, the joint shall be made in the normal manner before deflecting the joint. Deflections shall not exceed the recommended values of the pipe manufacturer.

Cutting of pipes may be authorized. Care shall be taken however, to ensure that such cuts are only made when strictly necessary. Cutting will be carried out according to the manufacturer’s instructions, without damage to the pipe or the protective coating and so as to leave a smooth face normal to the axis of the pipe. All cutting shall be done with proper cutting tools and apparatus. In all cases the Contractor shall be responsible for the accuracy of the measurement of the cut pipe required.

Backfill, bedding, and compacting shall be in accordance with the provisions of Clauses 2.5 and 2.6. All pipe trenches shall be backfilled to original or finished ground surfaces as specified. Selected backfill material shall be placed and compacted in such a manner as to not disturb the pipe.

If the cover to the pipe is less than 0.80 meter under surfaces that are subject to vehicular traffic or other external loads, concrete slabs or surrounds shall protect pipes. Execution of works shall be according to the Typical Drawings. The Engineer may instruct concrete protection to pipes in other circumstances he thinks fit.

* **PROTECTION OF STEEL COUPLINGS**

Viking Johnson Couplings , Viking Johnson Flange Adaptors and Viking Johnson Stepped Couplings shall be protected by the “Denso Plast Strip System” manufactured by Winn and Coales (Denso) Ltd., or other equal and approved. The metal surfaces to be protected shall be thoroughly wire brushed to remove all scale and rust and this prepared area shall be kept clean and dry during all subsequent operations. The entire joint shall then be primed with Denso Priming solution, including a minimum overlap of 100mm onto any existing pipe coating.

Denso Mastic Plast (Strips), measuring 915mm x 250mm x 10mm shall then be applied to the joint with the scrim carrier to the outside, after first having discarded the plastic film interleaving. Each strip shall be firmly moulded to the contours of the joint so that on completion the entire joint is firmly encased in mastic. On pipes of 219mm and above where more than one strip is required to go around the joint, the overlap between successive strips should be 25mm, the overlap being in downward direction. On pipes of 165mm and above, where two strips are required across the joint, the overlap between adjacent strips should be not less than 25mm. After application of the mastic two separate turns of Denso Tape shall be circumferentially wrapped around the joint, care being taken to form the tape into the angle between the flanges and the pipe and to smooth down any underlying air pockets or folds. The tape shall commence and finish on top of the joints and shall overlap onto the pipe barrel by a minimum distance of 25mm on either side of the joint.

* **TRENCH PREPARATION:**

To achieve a satisfactory installation for pipes, it is essential that the supporting soil provide stable and permanent support for the pipe.

Where rock is encountered, the trench should be excavated at least 150 mm, deeper than the grade and filled with an approved selected fine material. In very wet or soft conditions or where the trench bottom is very irregular it may be necessary to increase this thickness. All such work shall be done at Contractor’s expenses.

In uniform, relatively soft, fine grained soils free from large flints or stones or other hard objects and where the bottom can readily be brought to an even finish with no hollows and providing a uniform support for the pipes over their lengths, and to the satisfaction of the Engineer, it may be permissible to lay the pipes directly on the trimmed bottom of the trench. In other cases, the trench should be excavated to a depth below the bottom of the pipe sufficient to allow for the necessary thickness of selected fine bedding material as shown on the Drawings to the approval of the Engineer and as specified herein after.

**HDPE PIPES**

HDPE pipes shall comply with DIN 8074, DIN 8075 or ISO/161 Part I in connection with DIN 19533 or equivalent.

The pipes shall be designed for a nominal working pressure Class of PN 16, have a hydrostatic design (induced) stress of 80 kg/cm² at 20° C (designated as PE100) and be jointed with push-fit couplings.

The nominal outside diameter and wall thickness of the pipes are as shown in the following table:

|  |  |  |
| --- | --- | --- |
| **Nominal Diameter** | **Internal Diameter** | **Wall Thickness** |
| 25mm | 20.4 mm | 2.3 mm |
| 32mm | 26.2 mm | 2.9 mm |
| 50mm | 40.8 mm | 4.6 mm |
| 63mm | 51.4 mm | 5.8 mm |
| 75mm | 61.4 mm | 6.8 mm |
| 90mm | 73.6mm | 8.2 mm |
| 110mm | 90 mm | 10 mm |
| 125 mm | 102.2 mm | 11.4 mm |
| 160 mm | 130.8 mm | 14.6 mm |

The length of the coiled pipes shall be 50m to 100 m. If the pipes are to be coiled, this must be done at a temperature less than 30°C. The ends of the pipe shall be plugged or covered.

The minimum diameter of the rollers for coiled pipe should be such that kinking of the pipe is prevented. The minimum internal diameter of the rollers shall not be less than 24 times the nominal outside diameter of the pipe with a minimum of 60 cm. The end of the pipe shall be plugged or covered.

* **Material**

The pipes shall be manufactured from high density polyethylene containing only those antioxidants, UV stabilisers and pigments necessary for the manufacture of potable water black pipes and comply with ISO/DP 4427/ clause 4.1. The Contractor shall provide an approved third party certificate to verify the above. Rework material generated from a manufacturer’s own production of pipes, shall not be used.

Materials in contact with or likely to come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste or odour and cloudiness or discoloration of the water. Concentration of substances, chemicals and biological agents leached from materials in contact with potable water, and measurements of the relevant organoleptic / physical parameters shall not exceed the maximum values recommended by the World Health Organisation (WHO, 1984) or as required by the EEC, Council Directive 1980, whichever is in each case is the more stringent.

The pipe manufacturer shall provide evidence of the nominal values of the density and melt flow rate (index) of the raw material. The density of the raw material (compound) shall not be less than 0.945 g/cm³.

The melt flow rate (MFR) for the raw material shall not be less then 1.0 g/10 min. tested at 190° C/5 kg. Evidence of nominal value of (MFR) for raw material shall be provided. The nominal value is the average value indicated by the pipe manufacturer as a standard value for his production. The MFR for raw material and for extruded pipe should be measured. Change of MFR by processing shall be less than 20% for the tested values. In addition, the MFR measured on the extruded pipe can deviate by ±30% from the nominal value.

* **Factory Testing of Pipes**

Tests for determining the resistance of pipes to a constant internal pressure and the bursting time of these pipes are required and should comply with DIN 8075 or ISO/1167. Two types of tests are required:

Acceptance test, carried out at a temperature of 20°C (1 hour- test). This allows a fast verification of the conformity of a batch of pipes to a specified type. At least one sample test for each size shall be carried out for every batch of pipes delivered to the site. Maximum batch size for the purposes of this clause is to be 10 km.

Quality test (170 hr-test) carried out at an elevated temperature as a nature of the pipes tested. It is a test for the material type and should be carried out for each dimension of pipes as follows:

1. When a change is made in composition or method of manufacture of the pipe.
2. Not less than one test every twelve months.
3. At least one test for each lot not greater than 10km in length delivered to the site.
4. At least one test for each size of pipes.

The above tests allow evaluation of the standard of production and the pipe material used. The pipe material (PE 80) shall meet the minimum requirements of the related international standard for acceptance test and Quality Test

If the pipe leaks or ruptures during the period stipulated for the acceptance test it will be rejected.

When the pipe eventually fails during the acceptance test it shall show a ductile failure of the pipe wall (displaying visible yield deformation at failure.) A brittle or other shattering, cracking, splitting, or weeping pipe shall not be acceptable.

Failure of the wall during the quality test shall be a brittle failure.

* **Storage**

Polyethylene pipe, tubing and fittings should be stored according to the manufacturer’s recommendations.

The following general points should be taken into consideration:

1. Contact with burrs or sharp metal edges on racks, etc., should be avoided.
2. The ends of pipes should be protected from damage to avoid the risk of unsatisfactory jointing.
3. The pipes should be stored under cover and protected from direct sunlight including when stacked at the places of delivery.
4. The Contractor shall take all measures such as providing covers of suitable size and durability to protect the pipes from direct sunlight.
5. Coils may be stored either on edge or stacked flat one on top of the other, but in either case they should not be allowed to come into contact with hot water or steam pipes and should be kept away from hot surfaces. To avoid damage coils should not be dragged over rough ground
6. Pipes should be stored at less than 23°C.

If, due to unsatisfactory storage or handling, a pipe is damaged or kinked, the damaged portion should be cut out completely at the Contractor’s expense.

* **Tests after Delivery**

Samples of HDPE pipes shall be taken as instructed by the Engineer for every 10km of pipes DN 63 mm delivered and for every 5 tonne consignment of pipes DN 32 mm and 25 mm. An approved testing Authority in Lesotho, in addition to the Quality and Acceptance tests of Clause 3.11,any or all of the following tests on the samples taken:

* Visual inspection of inner and outer surfaces of pipes including dimension tests.
* Density test for raw material and pipes according to DIN 53479, ISO 4451.
* Melting factor for raw material and pipes according to DIN 53735 or ISO 292.
* Yield stress, elongation at yield point, ultimate tensile strength and elongation at break according to DIN 53455, ISO R 527 .
* Longitudinal reversion test according to ISO 2506
* Carbon blade antioxidant test for pipes according to BS 6920. (Suitability for drinking water).
* **Marking of pipes and fittings**

All HDPE pipes shall be indelibly marked at maximum intervals of one metre. The fittings shall be indelibly marked or labelled.

The marking shall show at least the following information:

1. Manufacturer’s name and/or trade mark.
2. Dimensions (nominal diameter, wall thickness).
3. Material, material class (e.g. PE 100) and
4. Pressure class e.g. (PN16)
5. Production period (date).
6. “Water”, to indicate that pipes or fittings are intended for potable water.
7. Serial number.
8. Batch number.

The pipes and fittings (especially the plastic type) shall be rejected, if the above information for marking is not shown clearly on each piece.

* **HDPE Joints and Fittings**

Jointing of the pipes shall be either mechanical or push fit. Jointing shall be made of Acetal or ABS or gunmetal.

The mechanical jointing shall consist of tightening the pipe by means of screwed connections with compression push in such away that water tightness is fully secured by means of elastomer “O” ring and PVC grip ring or equivalent material for “O” ring.

Push fit jointing shall consist of a PVC grip ring and nitrile elastancer “O” ring or equivalent material for “O” ring.

HDPE couplings and fittings shall be designed for a nominal working pressure of 16 bar and temperature of 40°C and shall be suitable for the HDPE pipes supplied. The Contractor shall liaise with the Engineer and the Employer to ensure that the fittings supplied under another contract are compatible with the pipes which the Contractor will supply.

The Tapping tees supplied shall be such as to ensure ease of assembly with an integrated moulded nut, retained in the body of the fitting to prevent loss or damage.

The cutter and sleeve shall be of corrosion-free metal with the cutting area free of the heating coils. The unit shall be complete with a plug and sealing-ring for permanent and reliable sealing when under pressure to PN 16. The electro-fusion of the tapping tee shall be as described above.

Tapping tees shall comply with DIN 3543, part 4 and DIN 3544, part 1 and shall be sealed with an electro-fused end cap.Testing of fittings and joints

* **Testing of fitting and joints**

The dimensions of the mechanical fittings and joints shall be chosen so that assemblies fulfil the requirements of the performance tests for the assembled joints mentioned below.

If the pipes and fittings are produced by the same manufacturer the Contractor shall provide certificates from an authorised third party demonstrating that the assembled joints comply with the following tests (performance tests) :

1. ISO 3458 Assembled joints between fittings and polyethylene pipes: test of leakproofness under internal pressure.
2. ISO 3459: Polyethylene pressure pipes joints assembled with mechanical fittings: test of internal pressure.
3. ISO 3501: Assembled joints between fittings and polyethylene pressure pipes: test of resistance to pull out.
4. ISO 3503: Assembled joints between fittings and polyethylene pressure pipes: test of leakproofness under internal pressure when subjected to bending.
5. If the pipes and fittings are not produced by the same manufacturer, the Contractor shall perform the above tests at his own expense at an approved laboratory.

* **Laying of HDPE pipes**

In general all HDPE pipes shall be laid in accordance with the Typical Drawings. To achieve a satisfactory installation for polyethylene pipes, it is essential that the supporting soil provide a stable and permanent support for the pipe. Where good soil conditions exist and the trench bottom can be cut accurately, the pipe can be installed directly on the prepared sand bed to a depth of 100 mm. The bottom must be flat with no hollows, no lumps and no rocks. In case of loose rocky soil, the trench should be excavated at least 150mm deeper than the grade and filled with suitable soils such as coarse sand. If the trench is excavated in solid rock, graded tamped granular material should be placed over the rock formation. The material should not be too fine in order to prevent washing out and subsequent settling of the pipe.

The width of the trench for the service connection shall be restricted to the absolute minimum of 500mm consistent with the required compacting of the backfill. All stones and hard materials which in the opinion of the Engineer could damage the service connection pipes shall be removed from the trench bottom and sand spread so that the polyethylene pipe may be embedded in soft material for its full length 150 mm above the crown of the pipe.

After the compaction of the first layer of base-course backfilling, a plastic strip with tracking tape should be laid along the trench for subsequent location of the pipe route. The tape shall be blue in color and of 200mm overall width and contain an aluminum strip throughout its length of minimum width 50 mm. The words “Caution water main below” along the top section of the tape and “Water Authority” along the bottom section of tape shall be written in English and Arabic the words. Samples of tape shall be submitted to the Engineer for his approval.

The Employer favours the use of push-fit service fittings. Some push-fit fittings do not require extractor tools and are provided with screwed end caps.

Where required (e.g. crossing of culverts etc.) HDPE service lines shall be guided and protected by GI protection tubes. If the span of the protection tube requires support, GI clamps shall be installed in accordance with manufacturer requirements.

The diameter of the protection tubes shall suit the water piping so as to allow easy installation, and shall be as follows :

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Water supply lines** | | **Protection Tubes** | | |
| **HDPE pipes** | **Outside dia** | **GI pipe**  **Protection** | **Inside dia** | **Support at max** |
| DN 63 or 2" | 63 mm | DN 100 | 103 mm | 2,00 m |
| DN 32 or 1" | 32 mm | DN 80 | 79 mm | 1,50 m |
| DN 25 or ¾" | 25 mm | DN 65 | 67 mm | 1,20 m |

If the piping crosses concrete culverts, penetration of the concrete walls shall be carried out by means of core drilling. Diameter of core drilling to suit GI protection tubes to be installed. The space between the protection tube and concrete shall be sealed by approved elastic sealant material.

The space between the inserted HDPE pipes and the G.I protection tubes at point of entry shall be closed by placing a pipe cap of PVC material at both ends of the G.I pipe (see typical Drawings).

* **Testing HDPE Pipes**

The test pressure shall be 24 bars. The service lines, including joints, fittings and appurtenance, shall be tested for water tightness in accordance with ISO 1167 as follows:

1. Allowable leakage <3 liters/km/25 mm dia of pipe/3 bar/24 hours.
2. Hydrostatic testing to be carried out at an ambient temperature of 20ºC, otherwise a correction factor shall be applied to the PN.
3. The test shall be applied on sections of length less than 800m.
4. Partial backfilling to maintain adequate support and anchoring and to avoid flotation of pipes during testing, with joints exposed and valves in the open position.
5. Slow filling with water, not with compressed air to avoid danger of injury or damage.
6. The filling of pipes should be at a rate giving a maximum water velocity of 0.5 m/s in the pipe, to ensure no surge and to give the air the necessary time to be released by the temporary air valves or cocks installed.
7. Water to be left for sufficient time to reach equilibrium, i.e., the same temperature as the pipe and the surrounding soil and to remove all existing air for the saturation of the pipe material.
8. Test pressure to be applied slowly to avoid surge and held for one hour. The system is to be isolated from the test pump, i.e. no pumping during the one-hour test period allowed. The test pressure shall be 24 bars for service lines including all couplings and fittings in the open position, with consideration for temperature variation.
9. Calculation to determine whether the section under test satisfies the requirements of point 1 above.
10. After successful completion of the test, the line shall be emptied slowly to prevent shocks or sudden contraction of parts of the pipes.

* **“Short Test” for HDPE**

The so-called “Short Test” may be used for pipelines of up to 30 meters and

DN ≤50. The short test may be used for pressure testing the house connections when approved by the Engineer. The test pressure for the short test is 24 bars (1.5 times the nominal pressure).

The test pressure is applied to the pipe and the first reading taken after 30 minutes. This pressure will usually be slightly less than the initial pressure due to the normal expansion of the pipeline under pressure, but no additional “top-up” pressure should be applied.

For the short test the results are deemed to be satisfactory when pressure loss from the HDPE pressure pipeline is ≤0.1 bar per 5 mins.

* **Saddles**

Saddles, ferrule cocks and self-contained ferrule straps/saddles shall be supplied by the Contractor for the purpose of making replacement and new house connections.

Saddles shall be suitable for a working pressure of 16 bar and for fixing around the existing and proposed main distribution lines of diameters equal or greater than 100 mm (4"). The saddle shall be of single strap design and in two parts, flat top and bottom-bolted at both sides, pressure through the disc of max. 1.5" in diameter for mains of 100 mm diameter or less, and 2" for mains of diameters greater than 100 mm (4"). The inside corners of the saddle strap should be rounded to prevent digging into the pipes. The saddles shall be manufactured from gunmetal to DIN 1705 or BS 1400 to suit DI pipes. The saddles shall be supplied complete with the following:

Bolts and nuts of stainless steel to DIN 601, DIN/ISO 3506 or equivalent. Bolt heads shall be clearly marked with the manufacturer’s name or his identification mark.

Nitrile rubber sealing “O” rings, suitable for service connections to be fixed between the disc and the pipe in groove in accordance with DIN 16963 and DIN EN 681. They shall be suitable for working pressure of 16 bar.

The saddles shall be suitable for use with screwdown ferrules. Saddles shall be tapped for internal pipe threads in accordance with DIN 2999, ISO 7/1 or B.S 21.

* **Ferrule cocks**

Ferrule cocks shall be designed with single outlet of 25, 32 or 63 mm suitable for pipes of a working pressure of 16 bars. They shall be screw-down type that can take the place of a stopcock and shall be designed as a main stem with a swivel outlet with control of water flow via a threaded inner plug.

The cock shall have inlets with tapered male threads to DIN 2999, ISO 7/1 or BS 21 for underground use. The ferrule should be easily “shut off” by means of a spindle attached to the inner plug. The single ferrule should be of push fit outlet.

The design of the ferrule shall permit service line installation via dry/under pressure machines which mount on to the ferrule / saddle assembly. The Contractor shall submit recommendations in respect of the tapping machine to be used.

The screw-down ferrule cock shall be manufactured of gunmetal complying to DIN 1705 or B.S 1400 with minimum percentage of zinc, complete with nitrile rubber washer in accordance with DIN 16963 and DIN EN 681.

Cast iron surface boxes with hexagonal lid as specified shall be supplied and installed for single ferrule house connections on mains of min. dia 100 mm. Surface boxes shall be suitable for a 100 kN load.

Extension rods with coupling sleeve and PE-protection tube shall be supplied so to facilitate operation of the ferrule cock from the surface box.

* **Ferrule strap**

Completely self contained integral cutter self tapping ferrule and saddle shall be used to connect the house connections (DN 20, DN 25) directly to the HDPE service lines as indicated on the Drawings, or as directed by the Engineer. The service saddle should be bolted around the service line and the house connection connected via the ferrule push-fit outlet. The tapping may be dry or under pressure.

The self tapping ferrule and saddle shall be manufactured from gunmetal to DIN 1705 or BS 1400, supplied complete with the following :

1. Bolts and nuts of stainless steel to DIN 601, DIN/ISO 3506 or equivalent. Bolt heads shall be clearly marked with the manufacturer’s name or his identification mark.
2. Nitrile rubber sealing “O” rings, suitable for service connections to be fixed between the disc and the pipe in groove in accordance with DIN 16963 and DIN EN 681. Self drilling cutters shall be of aluminum bronze to DIN 1725 and DIN EN 601 or other approved international standards.

* **Fitting of GI pipes**

Where instructed by the Engineer the Contractor shall supply and install galvanized iron pipes above ground between the connection to the HDPE service line and the water meter(s).

* **House Connections**

The Contractor shall make complete house connections in accordance with the requirements of the Standard Drawings and as instructed by the Engineer. Connections may be required for any combination of new and existing lines with new and existing consumers.

House connections of 3/4", 1" or 2" diameter HDPE pipe work shall be made from service lines as indicated on the Drawings or instructed by the Engineer. Sterilization of the service connection shall be carried out at the same time as the main to which it is connected.

House connections of 3/4" or 1" diameter from new HDPE service lines shall be made using a self-tapping ferrule and saddle placed on the service line, or by the use of an equal tee as indicated on Drawings.

Service connections on existing or proposed pipelines (MPVC for pipes of DN 90 or larger) shall be made by under pressure tapping. A gun-metal saddle is to be provided with stainless steel nuts and bolts and Nitrile rubber sealing ring/washer suitable for a working pressure of 16 bars. The tappings will be made for 3/4", 1", and 2". The gunmetal ferrules shall have single outlets suitable for 25, 32, and 63 mm push-fit outlets. The Engineer will issue instructions regarding the size, location and fittings for each service connection.

Tapping shall be made into saddles affixed to the main lines as shown on the Standard Drawings and care shall be taken to avoid breaking away concrete lining. The machine manufacturer’s recommendations shall be followed in respect of the tapping machine. Tapping shall be positioned on the main so that the ferrule is inserted into the main at the crown. The jointing of the threaded ferrule to the main line shall be made using lead free jointing compound or PTFE tape.

The outlet of the ferrule shall be set to point in the direction in which the service pipe is to be laid. The service pipe (HDPE) shall be laid with a cover of not less than 500 mm below the ground surface unless otherwise shown on Drawings.

The jointing on the HDPE pipe to the push-fit joint shall be in accordance with the instructions of the manufacturer of the push-fit fittings.

The house connection pipe shall be carried to about 1 m inside the property of the customer to a location to be proposed by the Contractor and approved by the Engineer. The service line shall be sleeved from where it passes through the boundary wall, to the connecting point on the GI pipe to facilitate subsequent withdrawal.

The transitional point from the HDPE to the GI pipe shall be protected as shown on the Typical Drawings (Detail A) with necessary excavation as instructed by the Engineer.

In all cases the house-connection line shall terminate in a gunmetal compression adapter manufactured to DIN 1705 or BS 1400, to connect existing or new GI pipe and stop valves before the water meter as shown on the Drawings.

The work may include the disconnection of the old existing water meter. The same water meter or a new one (supplied by the Water Authority) shall be installed, as directed by the Engineer.

The Contractor must fill the attached form “House Connection sheet Details”

House Connection Sheet Details

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Project:** | | | | |
| **Client:** | | | | |
| **Consultant:** | | | | |
| **Contractor:** | | | | |
|  | | | | |
| **Owner’s Name:** | | | | **Plot No:** |
| **Pipe Line:** |  | **Station: L/R** | | **H.C. No.:** |
|  | | | | |
| **Length and Diameter for H.C:** | | | | |
| **Scale: (1:500)** | | | | |
|  | | | | |
| **Prepared by:** | | | **Owner’s Signature:** | |
|  | | | **Date:** | |
|  | | | | |

**TECHNICAL SPECIFICATIONS FOR WELDED STEEL PIPES**

* **Welded Steel Pipes with Beveled ends for (4”, 6” and 8”) diameters:**

a. It shall be in accordance with API-5L, Grade (X42), or approved equivalent ………standards, high-tensile, longitudinally or spirally welded.

The wall thickness and the minimum mill-inspection test pressures shall be as the following:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Nominal  Diameter  (ND) inch | Outside diameter  (mm) (inch) | | | Thickness  (mm) | Test Pressure  (kg/cm2) |
| 4 | 114.3 | 4 | 1/2 | 4.80 | 146 |
| 6 | 168.3 | 6 | 5/8 | 5.60 | 143 |
| 8 | 219.1 | 8 | 5/8 | 6.40 | 126 |

b. Working Pressure:

The maximum working pressure of all pipes shall not be less than the value stated in the scope of work.

1. Average Length:

Pipes shall have an average length of 6 and/or 12 meters and as approved by the Engineer.

1. Internal Lining and External Coating:

All pipes shall not have internal bitumen lining as specified in the general specifications Clause (4.2.b) but coat tar epoxy of 0.2 mm which shall be odorless and tasteless suitable for the passage of chlorinated potable water 0-3 p.p.m.c12.

External bitumen coating protected by fiberglass felt and tissues strip wrapping soaked in bitumen and time washed (tropical quality) with a total thickness of not less than 4mm.

The coating shall show no tendency of flow at a temperature of (70) degrees centigrade.

The internal and external coating for beveled end pipes shall stop 6” from each end of the pipe.

* **Specifications for Welded Steel Pipes with Socket and Spigot ends for (10”, 12”, 16”, 20”, 24” and 32”) diameters:**

a. The pipes shall be in accordance with API-5L, Grade (X42), or approved equivalent standards, high tensile, longitudinally or spirally welded.

The wall thickness and the minimum mill inspection test pressures shall be as the followings:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Nominal Diameter  (ND) inch | |  | Outside Diameter  (mm) (Inch) | | |  | Wall thickness (mm) |  | Test Pressure (kg/cm2) |
| 10 | ¾” |  | 273.10 | 10 | ¾” |  | 5.6 |  | 100 |
| 12 | ¾” |  | 323.9 | 12 | ¾” |  | 6.4 |  | 96 |
| 16” |  |  | 406.40 | 16” |  |  | 6.4 |  | 77 |
| 20” |  |  | 508.00 | 20” |  |  | 7.1 |  | 73 |
| 24” |  |  | 610.00 | 24” |  |  | 7.1 |  | 61 |
| 32” |  |  | 813.00 | 32” |  |  | 9.5 |  | 61 |

1. Working Pressures:

The maximum working pressure for the pipes shall not be less than the value stated in the scope of works.

1. Joints:

Joints shall be slip joints (socket and spigot), joints shall meet all radiography, X-ray, thickness, dimension, mechanical and other requirements of the API. Standard.

The thickness of the slip joint, which must be part of the pipe, shall be greater than or equal to the pipe thickness.

The joint shall be welded externally in the field and shall be completed internally by a rubber ring built into the socket. The length of the socket shall be such that the rubber ring undergo any damage during the field welding operation.

The jointing ring shall be of Ethylene propylene Rubber (EPDM) or Styrene Butadiene Rubber (SBR) to an approved shape and shall be securely fitted, by gluing in the plant into the sockets against the cement mortar lining.

1. Average Length:

Pipes shall have an average length of 6 and/or 12 meters and as approved by the Engineer.

1. Internal Lining and External Coating:

The internal cement mortar lining shall be of 6.0 mm and conform to all relevant requirements of B.S.534/1990 or AWWA. C.205-85.

The unlined and/or uncoated wall of the pipe shall be protected by suitable harmless approved bituminous or epoxy paint.

The internal lining thickness shall not be less than the minimum thicknesses given in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
| Nominal Diameter |  | Minimum thickness (mm) | |
| (ND) (inch) |  | BS.534.1990 | AWWA.C.205-85 |
| 10 |  | 6 (+2 , -0) | 6 (+3.2 , -1.6) |
| 12 |  | 6 (+2 , -0) | 8 (+3.2 , -1.6) |
| 16 |  | 7 (+2 , -0) | 8 (+3.2 , -1.6) |
| 20 |  | 7 (+2 , -0) | 8 (+3.2 , -1.6) |
| 24 |  | 7 (+2 , -0) | 10 (+3.2 , -1.6) |
| 32 |  |  | 10 (+3.2 , -1.6) |

External coating of buried steel pipes and fittings shall be polyethylene sheathing (reinforced type) according to DIN. (30670), designation: Reinforced sheathing (V).

The polyethylene sheathing shall be applied at manufacturer's works (plant) extruded and homogeneous to steel pipes with APT 5L-X42 for buried installation.

Between the polyethylene sheathing and the pipe steel there shall be an adhesive film which is applied electro-statically.

The polyethylene sheathing shall be made continuous extrusion and the adhesive film shall be firmly bonded to the steel surface. The coating shall be spark-free when tested with a Holiday detector at 25,000 volts. The minimum coating thickness shall be 3.0 mm for pipes of nominal diameters up to 20”, and 3.50 mm for 24” diameter pipes.

In addition to tests to DIN 30670 for coating and coating materials, the coating shall be tested for cathodic disbanding in accordance with ASTM G8. The polyethylene coating shall be capable of operating at a continuous temperature up to 50 C. without any effect on coating and bonding. The polyethylene and adhesive shall stop at a distance of 100 mm plus the insert of the pipe for the spigot and 100 mm for the end of the socket of the pipe.

* **Black Steel fittings**
* **Scope of Use**

The fittings must be made of seamless pipes and shall be in accordance with ANST (B.16.9). The fittings shall be welded to black steel pipes type (API.5L-X42).

**Fabrication of Fittings:**

The fabrications of fittings shall be as follows:

1. Elbows must be fabricated by forging or by hot or cold forming of seamless pipes.
2. Rescuers must be fabricated by hot or cold forming and annealing of seamless pipes.
3. Tees must be fabricated by forming of seamless pipe or by cold or hot forming and annealing of seamless pipes.
4. Caps must be fabricated by hot or cold stamping or forging of plates heat treated.

Fabrication fittings by welding pieces of pipes are not accepted.

**Materials of Fittings:**

Elbows, Tees, Reducers etc… must be made of seamless pipe grade WPB (ASTM A234) or approved equivalent.

**Fittings Thickness and Pressure:**

The minimum thickness of the black steel fittings shall be sufficient to withstand the pressure rating of their respective pipelines.

**Elbows Bends:**

The Elbows must be of long radius type, but short radius elbows can be offered as an alternative.

**Reducers:**

The reducers must be concentric. Thickness of each side shall be equal to thickness of related nominal diameter, if thickness of reduced size equal to the thickness of the bigger size, higher thickness will be accepted.

**Straight Equal Tees:**

The straight equal tees, in which the run and branch (out let) is equal in nominal diameter thickness, must be equal to the thickness of its related nominal diameter.

**Tees Reducing:**

Tees Reducing, in which the Run is bigger than branch (out let) in nominal diameter thickness of the run, must be equal to the thickness of its related diameter, thickness of the branch (out let) must equal to its related nominal diameter.

**Coating and Lining:**

All fittings must be coated and lined by corrosion proof material and must be suitable for potable water. Coating and Lining must stop at the bevel ends for the purpose of welding.

* **Marking:**

Every fitting must be marked with:

* Trade mark.
* Nominal Diameter.
* Thickness.
* Standard.
* **Certificated of Compliance:**

Certificates of compliance of required standards are required.

**EXISTING MAINS CONNECTION**

Connections shall be made to the existing lines as shown on the Typical Drawings.

The connections shall be made from existing plugged ends or from existing lines to be cut, whether dry or under pressure. The Contractor shall always check the level of any existing line before work is started.

Before attempting any connection to the existing network, the Contractor shall inform the Engineer and the Authority responsible for operating the network and agree on a suitable procedure for the works. The Contractor shall give at least six working days notice to the Engineer and will be required to execute these works so as to cause minimal interference with the normal operation of the network, including night working where necessary. Extension of the Contract Period will not be granted for any delays arising out of the Contractor’s failure to follow the agreed procedure.

The Engineer will issue to the Contractor detailed instructions regarding each interconnection that has to be made to the existing mains. Cutting into the existing main pipe and effecting the interconnection shall only be made in the presence of the Engineer or Employer at the time specified by the Employer. The Contractor shall submit additional shop drawings and a detailed method statement for approval by the Engineer.

Cutting into the existing main pipe and installation of the connecting pipe work shall be carried out efficiently and rapidly so as to reduce to a minimum the interruption of the public water supply. Existing mains shall only be cut using special equipment approved by the Engineer. Under no circumstances shall oxyacetylene or electric arc cutters be used. The cut shall be perpendicular to ensure that the new pipe work shown on the Drawings may be installed. The Contractor shall agree with the Engineer the length of existing pipe work to be removed. The Contractor shall take every care to avoid any dirt or extraneous material entering existing pipes.

The Contractor shall have available at the site of the connection an efficient dewatering pump before commencing any cut into the existing main in order that excavation remains dry at all times and to reduce the risk of dirty or contaminated water entering the existing distribution system. The work shall be carried out in a clean and efficient manner. Sufficient length of hoses shall be provided to dispose the water to safe places.

The Contractor shall provide at the site of the connection sufficient quantities of clean water containing 10 ppm chlorine in solution. Every item of new pipe work to be installed shall be submerged in the chlorine solution for at least 15 minutes immediately before being incorporated into the permanent works. The Employer will in general wish to recomission the pipeline as soon as possible after its installation and will carry out an inspection to detect any evidence of leakage; any remedial work necessary to eliminate leakage shall be carried out by the Contractor. No pipe work shall be covered or backfilled until the Engineer is satisfied that the interconnection is free from any leakage.

**NETWORK DISCONNECTION**

**Disconnection of the old network where instructed by the Engineer under the Water Authorities Supervision shall be carried out by the Contractor. Each disconnected line should be cut and plugged on both sides and not by closing valves, and shall be carried out to the satisfaction of both the Resident Engineer and the Water Authority Representative.**

**The disconnection of old house connections shall be done inside the plot boundary before and after the water meter in the property of the customer, to the satisfaction of the Resident Engineer. Redundant meters are to be returned to the WAJ stores.**

**THRUST BLOCKS**

The Contractor shall construct all thrust blocks and collars (End Caps) as shown on the Drawings and specified herein. Thrust blocks shall be constructed at all bends, tees, tapers, valves, dead-ends etc. unless otherwise shown on the Drawings. Thrust collars shall be constructed at plugged dead-end pipes with push-on joints (EU-piece and X-piece, or F-piece and X-piece if required)

Thrust blocks and collars shall be constructed of in situ concrete in accordance with the requirements of Section 3 Concrete Works of General Technical Specification. The bearing faces of the thrust blocks shall be placed against undisturbed natural earth except as specified below.

Thrust forces and sitting of anchor blocks shall conform to the field test pressure and be calculated by the Contractor considering the prevailing soil bearing capacity. Dimensions where given on the standard drawings are approximate only. All concrete thrust blocks and collars shall be allowed to cure for at least 7 days before backfilling the thrust blocks and before any loads are applied.

In concrete chambers, thrust forces from bends or from closed valves shall be transmitted to the concrete walls by means of puddle flanges welded on the pipes. Additional structural reinforcements are to be provided by the Contractor where necessary.

**VALVE CHAMBERS**

Valve chambers shall be constructed of reinforced concrete C30 (fair faced class 1) for all valves with diameter ≥200 mm and air valves on pipes with diameter ≥ 200 mm.

Valve chambers and similar structures shall be built along the pipelines as required and in accordance with the Typical Drawings. Given dimensions on the drawings are to be verified by the Contractor so as to suit the pipe installation and the prevailing conditions on site.

Concrete supports for pipes, valves and any other fittings shall be placed at appropriate locations inside the chamber under the direction of the Engineer (even if not shown on the Typical Drawings).

Cast iron manhole covers with frames shall be installed for all valve chambers as specified or shown on the drawings. The wording on each cover shall be agreed with and approved by the Engineer prior to ordering.

Covers to be used in surfaces which are subject to vehicular traffic shall be tested for a load of 400 kN.

Manhole covers with bearing capacities of 400 kN and 250 kN according to DIN 1229 or equivalent shall be installed as instructed by the Engineer.

Two pairs of keys for use with each type of cover shall be handed over by the Contractor after completion of the Contract at no extra cost.

All valve chambers shall be equipped with step irons, as indicated in the Drawings or as directed by the Engineer.

Step irons shall be of malleable cast iron, according to DIN 1211 galvanized iron or as directed by the Engineer.

Types of draining for the valve chambers shall be according to the Typical Drawings or decided on site.

Penetration holes with GS sleeve pipes shall be inserted into the ceiling of valve chamber (details of which are shown on the Typical Drawings), so as to incorporate the extension spindles of the valves inside the chambers.

Ventilation pipes of DI DN 100, DN 150 or DN 200 shall be installed at the highest possible point in all valve chambers (considering traffic load) and led to the nearest convenient outlet above ground. End of pipe to be flanged with a stand pipe DN 100/150/200 of ductile iron equipped with protection cap including non-corrosive insect screen.

If agreed by the Engineer, the ends of ventilation pipes may be constructed as a double flanged bend as shown on the drawing.

Exposed parts of vent pipe are to be painted with a weatherproof material as instructed by the Engineer.

Structural calculations including reinforcement drawings for all valve chambers shall be made by the Contractor. These calculations are to take into consideration the prevailing load and soil conditions.

Reinforcement of concrete chambers shall be included in the unit rates of valve chambers.

Minimum requirement of steel reinforcement:

2 layers of 12 mm dia. at 200 mm spacing crosswise, the Contractor shall submit structural calculations for the chambers for the Engineer’s approval

All external pipe work before entering and after exiting a reinforced concrete chamber shall be fitted with flexible joints at a minimum distance of 300 mm from the external face of the chamber.

Isolation valve chambers shall be detailed by the Contractor to be constructed with appropriate thrust walls to resist any movement and to withstand full test pressure from either direction under closed valve condition.

**TESTING – GENERAL**

The Contractor shall provide a sufficient quantity of gauges, pumps, stop ends, pipes and connections and all things necessary and suitable for the pressure testing of all pipes.. The Contractor shall also provide all necessary temporary works in connection with the test, and shall remove the same on successful completion of the test. All tests shall be done in the presence of the Engineer and in accordance with the relevant standards for the pipe material under test The results shall be signed by the Contractor and handed to the Engineer who shall prepare the necessary test reports.

Should any test fail, the Contractor shall, after repairing and making good any leaks, carry out at his own expense further tests all as described above until such tests meet the requirements contained herein.

The results of the tests, specifying the layout of sections of system, pipes and fittings tested including all relevant data of testing as weather, time, duration, filling time, pressure, etc., shall be produced in the form of a report by the contractor and signed by the contractor and the Engineer. This report shall not relieve the Contractor of his responsibility for care and maintenance of the system until the date of final acceptance of the completed work.

**PART 3-EXECUTION**

**TRENCH PREPARATION:**

To achieve a satisfactory installation for pipes, it is essential that the supporting soil provide stable and permanent support for the pipe.

Where rock is encountered, the trench should be excavated at least 150 mm, deeper than the grade and filled with an approved selected fine material. In very wet or soft conditions or where the trench bottom is very irregular it may be necessary to increase this thickness. All such work shall be done at Contractor’s expenses.

In uniform, relatively soft, fine grained soils free from large flints or stones or other hard objects and where the bottom can readily be brought to an even finish with no hollows and providing a uniform support for the pipes over their lengths, and to the satisfaction of the Engineer, it may be permissible to lay the pipes directly on the trimmed bottom of the trench. In other cases, the trench should be excavated to a depth below the bottom of the pipe sufficient to allow for the necessary thickness of selected fine bedding material as shown on the Drawings to the approval of the Engineer and as specified herein after.

**RESTORATION AND CLEAN UP**

All road and street improvements excavated or damaged and any damage to adjoining property including curbs, gutter and sidewalks or facilities caused by construction operations shall be restored or repaired by the Contractor to a condition equal to that which existed prior to commencement of the work. Materials used and work done in such restoration and repair shall be of the same kind and of a quality equal to the original construction, and shall conform to the requirements of the agency having jurisdiction.

**END OF SECTION**

# SECTION 15090

# SUPPORTS, ANCHORS AND SEALS

**PART 1 GENERAL**

**1.01 WORK INCLUDED**

Pipe hanger and supports.

Sleeving for mechanical equipment.

**PART 2 PRODUCTS**

**2.01 INSERTS**

A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms.

B. Size inserts to suit threaded hanger rods.

**2.02 PIPE HANGERS AND SUPPORTS**

Pipe hangers and supports shall be in accordance with BS 3974 and the following: -

A. Hangers : Pipe sizes 12.7 mm to 38 mm : Adjustable wrought steel ring.

B. Hangers : Pipe sizes 50 mm to 100 mm and cold pipe sizes 150 mm and over, adjustable wrought steel clevis.

C. Hangers : Hot pipe sizes 150 mm and over, adjustable steel yoke and cast iron roll.

D. Multiple or Trapeze Hangers : Steel channels with welded spacers and hanger rods, cast iron roll and stand for hot pipe sizes 150 mm and over.

E. Wall Support : Pipe sizes to 75 mm, cast iron hook.

F. Wall Support for pipe sizes 100 mm and over: Welded steel bracket and wrought steel clamp, adjustable steel Yoke and cast iron roll for hot pipe sizes 150 mm and over.

G. Vertical Support : Steel riser clamp.

H. Floor Support for pipe sizes to 100 mm and all cold pipe sizes : Cast iron adjustable pipe saddle, lockout nipple, floor flange and concrete pier to steel support.

I. Floor support for Hot pipe sizes 150 mm and over : Adjustable cast iron roll and stand, steel screws and concrete pier or steel support.

J. Design hanger to impede disengagement by movement of supported pipe.

K. Provide copper plated hangers and supports for copper piping or provide sheet lead packing between hanger or support and piping.

**2.03 HANGER RODS**

A. Provide steel hanger rods, threaded both ends, or continuous threaded.

B. Vertical Support at Floor : Rolled angle.

**2.04 SLEEVES**

A. Pipes through Floor: Formed with 18 gage (1.20 mm) galvanized steel.

B. Pipes through Beams, Walls, fire proofing, footings, potentially wet floor : form with steel pipe or cast iron pipe diameter shall not be less than 50 mm larger in diameter than the pipe to be installed.

C. Round Ducts : Form with galvanized steel.

D. Rectangular Ducts : Form with galvanized steel or wood.

E. Size all sleeves large enough to allow for movement due to expansion and to provide for continuous insulation.

**PART 3 EXECUTION**

**3.01 INSERTS**

A. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.

B. Set inserts in position in advance of concrete work. Provide reinforcement rod in concrete for inserts carrying pipe over 100 mm or ducts over 1524 mm wide.

C. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.

D. Where inserts are omitted, drill through concrete slab from below and provide rod with recessed square steel plate and nut above slab.

**3.02 PIPE HANGERS AND SUPPORTS**

A. Support horizontal steel and copper piping as follows:

Nominal pipe Distance Hanger Rod

Size mm between Diameter mm

Support m

12.7 mm 1.83 m 9.5 mm

19-38 mm 1.83 m 9.5 mm

50 & 65 mm 3.05 m 9.5 mm

75 & 100 mm 3.66 m 15.8 mm

150 to 300 mm 4.27 m 22.2 mm

350 to 450 mm 6.1 m 25 mm

B. Install hangers to provide minimum 12.7 mm clear space between finished covering and adjacent work.

C. Place a hanger within 0.305 m of each horizontal elbow.

D. Use hangers which are vertically adjustable 38.1 mm minimum after piping is erected.

E. Support horizontal soil pipe near each hub, with 1.5 m maximum spacing between hangers.

F. Support vertical piping at every other floor. Support vertical soil pipe at each floor at hub.

G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

H. Where practical, support riser piping independently of connected horizontal piping.

**3.03 EQUIPMENT BASES AND SUPPORTS**

A. Provide for major equipment, reinforced concrete housekeeping bases poured directly on structural floor slab 100 mm thick minimum, extended 100 mm minimum beyond machinery bed plates. Provide templates, anchor bolts and accessories required for mounting and anchoring equipment.

B. Construct supports of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.

C. Provide rigid anchors for ducts and pipes immediately after vibration connections to equipment.

**3.04 PRIMING**

A. Prime coat exposed steel hangers and supports. Hangers and suspended ceiling spaces are not considered exposed.

B. Provide lead flashing around ducts and pipes passing from equipment rooms, installed according to manufacturer's data for sound control.

**3.05 SLEEVES**

A. Set sleeves in position in advance of concrete work. Provide suitable reinforcing around sleeves.

B. Extend sleeves through potentially wet floors 25 mm above finished floor level. Caulk sleeves full depth and provide floor plate.

C. Where piping or ductwork passes through floor, ceiling or wall close off space between pipe or duct and construction with non-combustible insulation. Provide tight fitting metal caps on both sides and caulk.

D. Install chrome-plated escutcheons where piping passes through finished surfaces.

**END OF SECTION**

# SECTION 15100

# MISCELLANEOUS VALVES

**PART - 1 - GENERAL**

**1-1 DESCRIPTION**

This Section covers all valves, except where specific requirements are given in other sections.

Related Work :

A. General Equipment and Material Stipulations.

The General Equipment and Material Stipulations shall apply to all equipment furnished under this section.

B. Work specified Elsewhere.

Other items of work that relate to and are referenced in this section include, but are not limited to, the following sections:

Submittals

Valve Schedule

Metal Fabrications

**1-2 APPLICABLE CODES AND STANDARDS :**

The codes and standards generally applicable to the work of this section are listed. Codes and Standards current at the time of bid shall be used.

**1-2.01 AWWA - American Water Works Association :**

C204 Chlorinated Rubber-Alkyd Paint

System for the Exterior of Above-

ground Steel Water Piping.

C500 Gate Valves - 3 in. Through

48 in. (75 mm through 1220 mm)

for Water and other liquids.

C502 Dry-Barrel Fire Hydrants.

C504 Rubber-Seated Butterfly Valves

**1-2.02 ASTM - American Society for Testing and Materials:**

B62 Composition Bronze or Ounce

Metal Castings, Standard

Specification for

**1-2.03 ISO - International Organization for Standardization:**

ISO 2531 Ductile Iron Pipes, Fittings,

and Accessories for Pressure

Pipe-Lines.

**1-2.04 ANSI - American National Standards Institute, Inc.:**

A21.11 Rubber-Gasket Joint for Ductile-Iron

and Gray-Iron Pressure Pipe and

Fittings, American National Standard

for

B26 Aluminum - Alloy Sand Castings,

American National Standard for

**1-22.05 NEMA - National Electrical Manufacturers Association:**

ICS Industrial Controls and Systems

**1-3 QUALITY ASSURANCE**

**1-3.01 Length Tolerance**

Actual length of valves shall be within 1.5 mm (plus or minus) of the specified or theoretical length.

**1-4 SUBMITTALS :**

**1-4.01 Drawings and Data**

Complete specifications, data, and catalog cuts, or drawings covering the items furnished under this section shall be submitted in accordance with the submittals Section. Operation and maintenance manuals shall be submitted in accordance with the Submittals Section.

Drawings and data submitted shall include complete connection and schematic wiring diagrams for electric operators and controls.

**PART - 2 - PRODUCTS**

**2-1 GENERAL**

**2-1.01 Manual Operators**

All valves, except those which are equipped with power actuated operators or are designed for automatic operation, shall be provided with manual operators. Unless otherwise shown or specified, each manual operator on valves larger than 100 mm shall be equipped with a hand wheel, manual operators on valves 100 mm and smaller shall have lever handle operators.

Unless otherwise indicated or specified, plug and ball valves shall be lever operated. One operating lever shall be furnished for each valve. One spare suitable operating lever shall be furnished for each type and size of lever operated valve.

**2-1.02 Rotation**

Unless otherwise required by the Engineer, the direction of rotation of the wheel, wrench nut, or lever to open the valve shall be to the left (counterclockwise). Each valve body or operator shall have cast thereon the word "OPEN" in English and Arabic and an arrow indicating the direction to open.

**2-1.03 Ends**

Unless otherwise specified or indicated on the Drawings, all 80mm or larger buried valves shall have push-on joint ends, all other 80 mm or larger valves shall have flanged ends, all 60 mm or smaller valves shall have threaded, socket welding, or solder ends. Flanges shall be ISO 2531 PN 10 or ANSI class 150. Push-on joints shall conform to ANSI A21.11. Wafer style valves shall be designed for installation between ISO PN 10 or ANSI Class 150 flanges.

**2-1.04 Unions**

A union or flanged connection shall be provided within 600 mm of each threaded end valve unless the valve can be otherwise easily removed from the piping.

**2-1.05 Shop Painting**

All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop painted for corrosion protection. The valve manufacturer's standard paint will be acceptable provided it is functionally equivalent to the specified paint and is compatible with the specified field painting.

**a.** **Materials**

Epoxy Epoxy resin and amine

adduct curing agent, semigloss finish.

Rust- Inhibitive AWWA C204, Section 3.1,

Primer zinc rich primer.

Rust- Preventive mporary removable coating,

Compound Black, semigloss, opaque

easily removed with solvents only.

**b.** **Surface to be Painted**

Unfinished Surface

Interior Asphalt varnish (2 coats); or epoxy

Exterior Asphalt varnish or coal tar.

to be Buried,

Submerged, or

located in

Manholes

Other Rust-inhibitive primer.

Exterior

Polished or

machined

Surfaced Rust-preventure compound.

Operators and

Accessories Rust-Inhibitive primer.

**2-1.06 Hydrant Color**

The hydrants on the NON potable water system and on the reclaimed water system shall be painted distinctly different colors and shall be labeled in accordance with the General Equipment and Material Stipulations. The color for each system shall be acceptable to the Engineer.

**2-1.07 Application**

The Valve Schedule Section specifics requirements as to valve number , size, service, and type for 100 mm and larger valves. Type, size, and service for other valves not scheduled are shown on the Drawings.

**2-2 GATE VALVES**

Gate valves furnished for installation inside structures shall be rising stem type with stuffing box stem seals. Gate valves which are buried or submerged shall be nonrising stem type with o-ring stem seals. All gate valves installed in vertical lines shall be square bottom, solid wedge type.

**2-2.01 Gate Valves - 80 mm and Larger**

Design Requirements AWWA C500

Special Requirements

Throttling Square bottom construction

Service when larger than 150 mm

Vertical Should be avoided

Installation

Pressure Rating PN 25 BAR

**2-2.02 Gate Valves - Smaller than 80 mm**

Pressure Rating 14 kg/cm2 nonshock (W.O.G.) Bronze, ASTM B62

Body Material

End Type Thread or soldered as required

Bonnet Type Threaded, union or screwed,

Temperature Rating -29 C to 66 C at 1370 kPa.

Seat Material Bronze, ASTM B62

Seal

Type Packing

Material TFE impregnated asbestos, asbestos graphite

Stem Material Bronze, silicone brass Special Solid wedge

Requirements.

**2-3 CHECK VALVES**

Check valves shall be furnished for installation where indicated on the Drawings and as specified.

**2-3.01 Check Valves - 80 mm Through 300 mm**

Service Service pump discharge piping

Pressure Rating PN 25 BAR

Body Material Cast iron

End Type Wafer style between two

pipe flanges.

Temperature Rating Up to 66 C 14 kg/cm2

Seat Material Bronze plates.

Seal

Type O-ring

Material Butadiene

Special Requirements Stainless and springs, hinge pins, and stops ;

TFE spring and hinge bearings; and standard

trim for IBBM construction, lever type with counter weight

**2-3.02 Check Valves - 350 mm and Larger**

Pressure Rating PN 25 BAR

Body Material Cast iron

End Type Wafer style between two

pipe flanges

Temperature Rating Up to 66 C at 1030 Kpa.

Seat Material Ductile iron plates.

Seal

Type O-ring

Material Butadiene

Special Requirements Stainless steel springs, hinge pins and stops;

TFE spring and hinge bearings; and standard

trim materials for IBBM construction, lever type with counter weight

**2-3.03 Check Valves - 150 mm or Larger, Spring-Loaded Horizontal Swing**

Service Sewage pump discharge, sludge piping

Pressure Rating PN 25 BAR

Body Material Cast iron

End Type Flanged, increasing or equal end.

Bonnet Type Flanged

Temperature Rating 66 C

Seat Material Bronze

Seal

Type Disc ring

Material Bronze or alloy.

Hinge Pin Material Bronze or stainless steel

Special Requirements Unobstructed waterway, quick closing

**2-3.04 Check Valves - 80 mm or Larger, Horizontal Swing**

Service All, unless otherwise specified

Pressure Rating PN 25 BAR

Body Material Cast iron

End Type Flanged

Bonnet Type Flanged

Temperature Rating 66 C

Seat Material Bronze

Seal

Type Disc ring

Material Bronze

Hinge Pin Material Bronze or stainless steel

Special Requirements All parts subject to wear shall be of bronze

**2-3.05 Check Valves - 50 mm or Larger**

Service Air

Pressure Rating Up to 10 Kg/ cm2

End Type Flanged, threaded, plain, wafer or grooved as

required

Temperature Rating 93 °C at 10 kg/cm2

Seat Material Seatless

Special Requirements A wide range of body materials, end types, and sealing materials are available for particular service requirements. Furnish appropriate valves as required

**2-3.06 Check Valves - Smaller than 50 mm**

Service Vacuum

Pressure Rating 0 to 0.2 kg/cm2

Body Material Brass

End Type Soldered

Temperature Rating Up to 93 °C

Seat Material Butadiene

Seal

Type O-ring

Material Synthetic rubber

**2-3.07 Ball Check Valves, All Sizes**

Service PVC piping

Pressure-Temperature 10 kg/cm2 at 24 C; 7kg/cm2

Ratings at 49C., 5kg/cm2 at 60 °C.

Body Material Polyvinyl chloride

End Type Threaded, socket, or

flanged as required

Seal

Type O-ring

Material Synthetic rubber

Special Requirements Install in vertical

piping only

**2-3.08 Check Valves - 65 mm and Smaller HORIZONTAL Swing**

Service Water, sludge, fuel oil, or

other liquid.

Pressure Rating 860 kPa steam; 1370 kPa

nonshock (W.O.G.)

Body Material Bronze

End Type Threaded or soldered.

Bonnet Type Threaded cap.

Temperature Rating -29 °C to 66 °C at 14 kg/cm2

Seat Material Brass or bronze

Hinge Pin Material Brass or bronze

Special Requirements Regrinding disc soldered end valves may be used in 80 mm copper tubing.

**2-4 BALL VALVES :**

All 65 mm or smaller shutoff valves shall be ball valves unless other wise shown or specified.

**2-4.01 Ball valves - 50 mm or Smaller for Water Service**

Pressure Rating 28 kg/cm2 nonshock (W.O.G.)

Body Material Bronze with bronze, brass or stainless steel ball

End Type Threaded

Temperature Rating 93 °C at 14 kg/cm2

Seat Material Butadiene, TFE or synthetic rubber

Seal

Type O-ring or packing

Material Butadiene, TFE impregnated asbestos, or TFE

Stem Material Bronze

Special Requirements End entry, thrust washer is TFE 15 per cent glass filled. Lever handle with vinyl grip preferred.

**2-4.02 Ball Valves - 65 mm for Water Service.**

Pressure Rating 28 kg/cm2 nonshock (W.O.G.)

Body Material Bronze with bronze, brass or stainless steel ball

End Type Threaded

Temperature Rating 93 C at 14kg/cm2

Seat Material Butadiene, TFE or synthetic rubber.

Seal

Type O-ring or packing

Material Butadiene, TFE Impregnated asbestos, TFE

Stem Material Bronze

Special Requirements Three piece bodybolted together; swings out of line for repair.

**2-4.03 Ball Valves - Larger than 65 mm for Air and Water**

Service

Pressure Rating 10 kg/cm2 steam; 10 kg/cm2 at 82 C.

Body Material Ductile iron with chrome plated ductile iron ball

End Type Flanged

Temperature Rating 82 C. at 10 kg/cm2

Seat Material TFE

Seal

Type O-ring or packing

Material TFE

Stem Material 316 stainless steel or zinc plated carbon steel.

**2-4.04 Ball valves - 50 mm or smaller for Air Service**

Service Steel piping

Pressure Rating 10 kg/cm2 steams; 50 kg/cm2 nonshock (W.O.G.)

Body Material Carbon steel with chrome Plated or stainless steel Ball

End Type Socket-welded

Temperature Rating 38 °C at 10 kg/cm2

Seat Material TFE

Seal

Type O-ring or packing

Material TFE

Stem Material Chrome plated or stainless steel

Special Requirements Thrust washer is glass filled TFE

**2-4.05 Ball Valves - 50 mm or Smaller for Air Service**

Service Copper piping

Pressure Rating 35 kg/cm2 nonshock (W.O.G.)

Body Material Bronze with bronze, chrome Pated or stainless steel ball

End Type Soldered

Temperature Rating 38 C at 10 kg/cm2

Seat Material TFE

Seal

Type O-ring or packing

Material TFE

Stem Material Bronze

Special Requirements Thrust washer is glass filled TFE

**2-4.06 Ball Valves - All Sizes for PVC and FRP Piping with full Size Port**

Service Chemical lines

Pressure-Temperature 10 kg/cm2 at 21 C; 7kg/cm2 at 32 °C; 4 Kg/cm2 Ratings at 52 °C.

Body Material Polyvinyl Chloride

End Type Threaded, socket, or

flanged

Seat Material TFE

Seal

Type O-ring

Material Synthetic rubber

Special Requirements Port diameter shall be not smaller than ID of Schedule80 PVC pipe.

**2-4.07 Ball Valves - 50 mm or Smaller**

Service Fuel oil piping or propane gas piping downstream of first stage regulator

Pressure-Temperature 14 kg/cm2 at 93 °C.

Rating

Body Material Carbon steel

End Type Socket weld

Seat Material

Primary TFE

Secondary Steel

Stem Seal Material

Primary TFE

Secondary Asbestos

Stem Material Carbon Steel

Special Requirements Fire rated design

**2-5 BUTTERFLY VALVES**

Butterfly valves shall be of the rubber-seat tight-closing type. Except where other types are specified, butterfly valves shall be wafer type. Valve discs shall seat at 90 degrees with the pipe axis.

Flanged end valves shall be of the short body type. Where mechanical joint ends are specified, either mechanical joint or push-on ends conforming to ANSI A21.11 will be acceptable. For buried or submerged service, shaft seals shall be O-ring type .

A valve position indicator shall be provided on each exposed operator and on each operating nut on and extension stem.

**2-5.01 Air Service Valves**

Butterfly valves in air piping shall be industrial valves suitable for 1 kg/cm air service, a maximum air velocity of 30 M/S, and an operating temperature of 107.2 C.

Materials used in manufacture shall be as follows:-

Body Cast iron

Shaft Stainless steel, one piece

Disc. Bronze, or cast iron with

corrosion resistant metal

plating

Seat Synthetic rubber, or other

elastomer, with suitable

temperature rating

Shaft Upper and lower bearings,

bronze or teflon.

Shaft Seal Suitable synthetic rubber

rings.

Each valves shall be provided with an operator with a torque capability sufficient to seat, unseat, and maintain intermediate positions under the operating conditions specified above. Lever operators may be furnished for 6 inch and smaller valves, except where chainwheel operators are required . All 200 mm and larger valves shall have enclosed, geared, handwheel or chainwheel operators with position indicator. Operators shall be designed to produce the rated torque with a maximum pull of 36.3 kg on the lever or wheel.

**2-5.02 All Other Butterfly Valves.**

All other butterfly valves and operators shall conform to AWWA C504. Metal mating seat surfaces shall be 18-8 stainless steel or monel. Each valve shall be provided with an operator with a torque rating at least equal to the torques listed in AWWA C504, Table 1.

Valves for throttling service shall be equipped with an infinitely variable locking device or a totally enclosed geared operator. Other lever operators shall be designed so that the valve can be readily locked open, closed, or in at least five intermediate positions.

**2-6 AIR AND GAS RELIEF VALVES:**

Air and gas relief valves shall be of the double orifice pattern with grey or ductile cast iron bodies. The inlet flange shall be faced and drilled.

The valves shall be adequately sized for the release of gas from the pipeline(or other container) without restriction of rate of filling or flow due to back pressure and also to allow admission of air during pipeline emptying at rate sufficient to prevent excessive depression of pressure in the pipe.

Valves shall be designed to prevent the operating elements being in contact with the pipeline liquid by approved means such as the provision of an auxiliary float and chamber sufficiently large to isolate the orifice valves and seats throughout the rated operational range.

Air valves shall be fitted with an isolating sluice valve and gearing shall be provided where necessary to facilitate operation.

In applications where the pipeline characteristics may lead to liquid column separation with consequent possibility of surge, a vented non- return valve shall be provided which allows air to enter freely on separation but controls expulsion of air/gas as the liquid column regions.

All air and gas relief valves and associated isolating valves shall be works tested hydraulically and capable of withstanding test pressure of 25 bar and working pressures of 16 bar.

All valves and operating linkages shall be prepared and painted in accordance with the General Specification for Painting and Protective Coating.

All materials used in the manufacture of valves shall conform to the following minimum standards:

Float Chamber - Grey Cast Iron

Flange and Cover - Grade 220 or Spheroidal Graphic Iron

Liquid Float - Copper, Polycarbonate or approved equivalent.

Air Valve Float and Guide - Polycarbonate or approved equivalent

Orifices, Guides and Mechanisms - Stainless Steel

Direct mounting Safe main operation requires the ingress and expulsion of air venting to be guarantees and automatic . This Safety requirement is met by the instullation of air valves at high spots in a main .

Triple function air valves give total protector as of a main within the normal operating praraments, when installed at high spost .

**2-6.01 Material**

Body: Made of ductile Iron

Ball: ball floats of steel, encased in elastomer

Vent: large air Volums through orifice and provide constant & degasification through out orfice.

Air valves shall be equipped with a stop-clock.

**2-7 ECCENTRIC PLUG VALVES**

All valves for sewage sludge, scum, basin sludge, and basin drain service shall be eccentric plug valves. All other 75 mm. or larger valves which are not otherwise specified shall be eccentric plug valves.

**2-7.01 Materials**

Body and Plug Semisteel, ASTM A126, Class B.

Plug Facing Neoprene or Buna-N, 70 durometer hardness.

Body Seat Welded nickel overlay or bronze replaceable seat rings.

Upper and Lower Sleeve, type, 18-8 stainless steel, bronze ,

Trunnion Bearings or rigidly backed TFE

Upper Thrust Bearing TFE or Delrin

Stem Seal V-type packing, Buna or TFE; or double

O-ring, Bunna.

**2-7.02 Design**

The valve port area shall be at least 80 % of the cross section of the connecting piping. Valves shall provide tight shutoff with rated pressure from either the upstream or the downstream direction. Valve ends shall be as required to match connecting piping.

Valves shall be rated for working pressure of at least 10 kg/cm. The opening motion shall be eccentric and shall lift the plug away from the body seat. Fully adjustable plug position stops shall be provided.

The valve shaft shall be sealed with two O-rings or four packing rings. Stuffing boxes and packing glands shall be designed to allow adjustment or replacement of packing without disassembly of valve or operator.

The valve shall be plainly marked to indicate the seat end.

**2-7.03 Operators**

Totally enclosed operators shall be provided on all valves larger than 100 mm. Manually operated valves 100 mm and smaller shall be lever operated.

Operators shall be adequate to seat, unseat, and maintain valve position under all operating conditions. Operators shall produce the required torque with a maximum pull of 36 kg on the lever or handwheel. Manual operator components shall withstand, without damage, a pull of 90 kg on the handwheel or an input of 40 kg/m on the operating nut.

Position indicator shall be provided on each exposed operator and on each operating nut on an extension stem.

**2-7.04 Electric MotorOperator**

The 75 mm plug valve on the waste sludge drawoff line shall be furnished and installed with an electric motor operator, actuated by an electric timer. The motor shall be 230 V single phase or 400 V three phase, 50 Hz. The motor shall have a double torque limiting feature which prevents valve or actuator damage if any obstruction interfered with normal plug rotation in either direction. The motor and gear unit shall be totally enclosed and sealed to protect working parts. A declutchable handwheel shall be provided for manual actuation in case of power failure. Pressure of liquid passing through the valve shall be 0.10 kg/cm2. The valve shall be fully open for 5 minutes and closed for 25 minutes. Time of opening and closing shall be regulated by setting a timer located in the Service Building. The valve shall be suitable for sewage use.

Operators shall be adequate to seat, unseat, and maintain valve position under all operating conditions. Operators shall produce the required torque with a maximum pull of 36.3 kg on the lever or handwheel. Manual operator components shall withstand, without damage, a pull of 90.72 kg on the handwheel or an input of 41.6 kg/m on the operating nut.

Position indicator shall be provided on each exposed operator and on each operating nut on an extension stem.

**2-7.05 Testing**

Except as modified herein, eccentric plug valves shall be tested in accordance with AWWA C504, Rubber-Seated Butterfly Valves, Section 5. Each Valve shall be performance tested in accordance with Paragraph 5.2, and shall be given a leakage test and a hydrostatic test as described in Paragraphs 5.3 and 5.4. The leakage test shall be applied to the face of the plug (tending to unseat the valve) at the rated pressure of the valve, or the service rating of the operator, whichever is less.

The manufacturer shall furnish certified copies of reports covering proof-of-design testing as described in Paragraph 5.5. Upon completion of cycle testing, the valve shall be droptight with pressure applied to the face of the plug and also to the back of the plug.

**2-7.06 Installation**

Unless otherwise necessary for proper operation or permitted by the Engineer, all eccentric plug valves shall be installed with the shaft horizontal and the plug in the upper half of the valve body. Valves in sewage or sludge lines shall be installed with the seat on the upstream end.

**2-8 KNIFE GATE VALVE**

Valve sizes are indicated on the Drawings. All valves shall be furnished with thick stainless steel stems having doublepitch threads. The body shall be of one piece extending into the chest chamber, and shall be of stainless steel, 304 Alloy B.

Gate guides shall be welded in place and machined. Flange faces shall have raised machined faces. The valve shall have a bronze yoke sleeve and ring packing with plastic coated packing gland. Gates shall be stainless steel. Valves shall be metal seated style with wafer end styles. All valves of this type shall have handwheel actuators.

**2-8.01 Valve Boxes**

All buried valves shall be provided with valve boxes. Boxes shall be as specified in Section GATE VALVES AND VALVE BOXES.

**2-9 FLAP VALVES**

The flap valves designed to with stand the stresses resulting from high seating head conditions and to maintain sensitivity & unseating heads the cast-iron body and cover are furnished with either bronze seats or a resilient seat bounded directly into body with wall thimbles.

The flap value size as indicated on the drawings will be flanged framed with resilient or bronze seats.

The body will be cast-iron AStM A126-B.

Bronze seats ASTM B21-CA 482 OR ASTM B301-CA 145, will be pneumatically impacted into above-tailed grooves machined in the cast-iron body and cover and machined to a 63 micro-inch finish for maximum water tightness.

Resilient seat will be bonded in a groove machined in the body to provide a wide seating surface for the seat machined in the cover.

The cover, or flap, will be cast-iron ASTM A 126B, with spherically dished design to with stand maximum operating loads. The hinge arms will be high-tensile bronze ASTM B584-CA865. The hinge pins designed in double shear, will be silicon bronze , ASTM B98-CA655, or Type 304 stainless steel, each hinge arm will have two pivot points, an adjustable lower pivot with limited rotation and threaded upper hinge post to adjust flap valve sensitivity. A lubrication fitting will be supplied for each pivot. Flap valve will open when there is a differential head across the flap of 0.2 feet or less.

**2-10 SEWAGE PRESSURE RELIEF VALVE**

**2.10.1 Description**

The sewage surge relief valve shall be of a 90-degree elbow body configuration, with cast iron body containing a securely fastened bronze or stainless steel ring.

**2.10.2 Construction**

The valve disc will have a resilient replaceable seat firmly held in place by a bronze or stainless steel ring fastened to the disc with screws. In the closed position with line pressures below the spring setting, the valve shall provide drop-tight closure. The disc movement shall be guided for proper alignment throughout its stroke and provide for full opening of the pipe line area when required. The valve body shall be furnished with an access opening to that area above the seat opening for flushing/ cleaning.

External springs shall be enclosed in protective casings, and shall be in compression. Springs that appear to be under extension are not permitted. The disc stem bushing shall be bronze capped with a lantern type gland vented to atmosphere for revealing seal leakage.

All materials and workmanship shall be first class quality throughout, and the purchaser reserves the right to inspect the valve before shipment.

**2.10.3 Function**

The valve-normally closed- shall open when the system pressure the spring adjustment setting. Its opening stroke shall be limited to that which is necessary to provide protection against surge exceeding the spring setting. The valve shall close at a slow speed consistent with adjustment of a self-contained oil cushion chamber that is provided with the valve. THE cushioning device shall permit a range of adjustment for closing speeds to prevent hammer or bang.

**2-11 AUTOMATIC FLUSHING VALVE**

**2-11-1 General**

The flush valve is used to flush the pump sump. At the beginning of each pumping period the valve is open and water from the pump is forced through the valve into the sump as a jet flushing stream. The water in the sump is subjected to violent motion and the sludge is stirred into suspension.

The valve is mounted on the pump. It is based on the ejector principle with a ball as closing device. The operation is automatic and induced by the pump flow and pressure . No electrical components or cabling are required.

**2-11-2 Applications**

Sewage pumping stations.

**2-11-3 Mounting The Flush Valve on the Pump**

Flush valve can be mounted on the same pump housing as flush valve. These pump housings are predrilled for the flush valve

**2-12 SLIDE GATE**

**2-12-1 Materials for Slide Gates**

Frames, Guides, Slides, Reinforcing Members and Yoke Beams for Slide Gates Aluminium, ASTM B209, B221 or B308, Alloy 6061. DIN 1725.

Flush Bottom Closure Seal for Slide Gates.

Operating Stems

Flush Bottom Seals and “J” Bulb Seals

Fastners and Anchor Bolts

Compressible Neoprene.

Stainless Steel, ASTM A-276, Type 303, 304 or 316. DIN 17440.

Rubber, ASTM C-2000, BC 610 – 615.

Stainless Steel, ASTM A-276 Type 304 or 316.

**2-12-2 Performance and Design Requirements**

Gates shall be designed to fit into the structures as indicated on the Drawings. Sluice gates are circular in shape, shall have maximum unseating heads of not less than 3.0 meters and maximum seating heads of not less than 5 meters. Slide gates with either square or rectangular shape shall have seating heads of not less than 5 meters.

**2-12-3 Construction**

**2-12-3-1 Frames**

For sluice gates the frame shall be cast in one piece. All surfaces framing joints or bearings shall be machined. The frame shall be of flat back type. Frames for sluice gates having top and bottom wedges shall have integrally cast pads machined with key ways to receive wedges seats.

The slide gate frame shall be a rigid, welded unit, composed of the guide rails, cross bars, and headrails with a clear opening the same size as the waterway. They shall be flatback.

The bottom of each slide gate frame shall be recessed so that the waterway is not obstructed. A compressible seal shall be securely attached to the bottom of the slide or to the frame invert. The seal shall be of sufficient length to seal the bottom corners of each slide.

**2-12-3-2 Slide Guides**

Side guides of sluice gates shall be bolted or integrally cast with the frame and machined on all bearing and contact faces. Wedges or wedge facings shall be securely attached to the guides at points, where in the closed position, they will make full contact with the wedging surfaces on the slides.

For slide gates, the guides shall be of extruded aluminum incorporating a dual slot design. The primary slot will accept the plate of the slide (disc) and the secondary slot will be sufficiently wide to accept the reinforcing ribs of the disc. The guides shall be designed for maximum rigidity. All guides shall be of sufficient length to support two-thirds (2/3) the height if the slide, when the gate is fully open.

The yoke to support the operating device shall be formed by members welded or bolted at the top of the guides.

The yoke shall be sufficiently strong to support the lift forces when subjected to a load of 40 kg pull on the operator.

Additional members shall be added to the frame as specified in this specification, for flush bottom closure, and “J” bulb seals.

**2-12-3-3 Slides**

For sluice gates, slides shall be cast one piece construction with stiffening ribs. Each slide shall have fully machined tongues running the full length of each side to properly engage corresponding grooves in the guides. Machined dovetail grooves shall be provided in the back face to retain seating faces.

Slides of slide gates shall have a thickness of not less than 6mm. Slides shall be adequately reinforced to withstand, without permanent distortion, the maximum thrust which can be transmitted by the operating stem. Each slide shall have a reinforced pocket or internally threaded nut welded to the slide for connection of the stem. The pocket or nut shall be designed to withstand the maximum thrust which can be transmitted by the operating stem.

**2-12-3-4 Wedges**

Wedges shall be bronze. A;; sluice gates shall have adjustable side wedging devices for all head conditions to provide contact between the slide and frame facings when the gate is in the closed position. Wedges are to be fully adjustable and designed to remain in the fixed position after adjustment.

**2-12-3-5 Seating Faces**

Seating faces shall be made to strips of rolled or extruded bronze. They shall be firmly secured in finished grooves in the frame and slide faces in such a way as to ensure that they will remain in place, free from distortion and loosening during the life of the gate. Seating faces shall be so finished that the maximum clearance shall not exceed 0.10 mm between seating surfaces with the slide in the fully closed position.

**2-12-3-6 Stems**

Each gate shall be provided with a rising stem. All stems shall be of sufficient size to withstand, without permanent distortion, the forces from the handwheel.

Where stems are furnished in more than one piece, the sections shall be joined by solid threaded couplings of the same material as the stem. Couplings shall be securely attached to stem sections and shall utilize a key, bolts or set screws to prevent stem rotation.

**2-12-3-7 Stem Guides**

Stem guides shall be so constructed that when properly spaced they will hold the stem in alignment and yet allow it enough play to permit easy operation. Each stem guide shall consist of a guide housing with replaceable bronze bushings and a mounting bracket. The guide shall be sufficiently adjustable with respect to the bracket to provide proper concentric alignment with the stem.

**2-12-3-8 Thrust Nut**

Each sluice gate shall provided with a bronze thrust nut for connecting the stem to the slide. The thrust nut shall be threaded and keyed or threaded and pinned to the stem.

**2-12-3-9 Flush Bottom Closure**

Slide gates shall be furnished with a flush seal arrangement. A resilient neoprene seal with a minimum width of exposed face of 20 mm shall be securely attached to the frame along the invert and shall extend to the depth of the primary slot.

**PART 3 EXECUTION**

**3-1 INSTALLATION**

Unless exceptions are noted by the Engineer, valves shall be installed in conformity with the manufacturer's recommendations, as indicated on the Drawings, and as specified in this and other sections of these technical specifications.

**END OF SECTION**

# SECTION 15101

# WELLS VALVE CHAMBERS

**PART 1 - GENERAL**

The Contractor shall furnish and install all valves as required. In addition, valve-operating units, stem extensions and other accessories shall be furnished and installed by the Contractor, where required in the opinion of the Engineer, to provide for convenience in operation. Where buried valves are required, the Contractor shall furnish and install valve boxes to grade. All valves shall be new and of current manufacture.

**1.1 DESCRIPTION**

This section covers the work necessary for furnishing and installing all types of valves.

Other valve types not mentioned hereinafter shall be in accordance to approved international standards.

Unless otherwise shown on Drawings or directed by the Engineer, gate valves installed at or above ground level or in vaults and all gate valves smaller than 100 mm shall have hand wheel operators.

All others shall have standard square wrench nuts suitable for opening and closing with a valve wrench.

**1.2 SUBMITTALS**

With the Tender –

* Completed Schedule of Particulars
* Manufacture’s specifications including, materials of construction, corrosion protection, accessories, spare parts to be supplied list and priced recommended spare parts.
* Manufacturer's drawings showing overall dimension and sections.
* After the awarding of the Contract and in accordance with the program –
* Installation drawings (shop drawings)
* Details of any proposed changes from the information supplied with the Tender
* Calculations demonstrating the maximum on and off seating pressures
* Factory QA procedures, inspections and test reports
* Installation information and requirements
* Operation and Maintenance Manuals

**PART 2 - PRODUCTS**

**2.1 General**

The Contractor shall furnish all valves and other accessories for pipe installation as specified herein and as shown on the drawings and in the BoQ. All valves and other accessories shall be of the size specified and, as far as possible; all valves of the same type shall be of one manufacturer.

All valves and accessories shall have the name of the manufacturer, working pressure, diameter and direction of flow cast on the body. All flanges for pipes, fittings, valves shall comply with DIN EN 1092-2.

Stuffing boxes shall be of the "O" ring or packing type, unless otherwise specified.

The Contractor shall submit construction/shop drawings to the Engineer for approval. Construction/shop drawings shall include:

List and schedules of materials;

Details of joints (and adapters if necessary);

Names of manufacturers; and

Size, details, materials and thickness of all items.

All valves and accessories shall be designed for a working pressure of not less than 16 bar, unless otherwise specified.

The Contractor shall submit a certificate from the manufacturer certifying that each valve meets the requirements of these specifications.

Valves shall be equipped with hand lever, hand wheel, operating nuts, or as specified. Operating nuts shall be approximately 50 mm square. Valves shall have arrows cast thereon to indicate the direction of rotation for opening the valve.

Except as otherwise provided herein, steel for bolts, anchor bolts and cap screws shall be in accordance with DIN Standards and shall meet the following additional requirements:

The nut material shall be St 35, and the nuts shall be capable of developing the full strength of the bolts.

All bolts and cap screws shall have hexagon heads and nuts shall be Heavy Hexagon Series.

Bolts, nuts and washers shall conform to the flange schedule.

Gaskets shall conform to the flange schedule and shall be of a rubber composition free of corrosion ingredients, either alkaline or acid.

Valve ends shall be flanged unless otherwise described. Screws and rubber ring gaskets shall be provided by the Contractor as necessary to join the valve with the pipe material supplied.

Enamel coating shall be applied to the ferrous part of the valve water passages, except finished or bearing surfaces. Surfaces shall be clean, dry and free from grease before application. Three spray coats shall be applied. Minimum dry coating thickness shall be 0.20 mm (8 mils).

Valves of a diameter larger than DN150 installed in horizontal pipe runs shall be provided with their own support and shall not be supported by the pipework alone.

**2.2 Gate Valves**

Gate valves are to be provided according to DIN 3352 for water up to 40 °C with fixed, non-rising hand-wheels. The body shall be of cast iron GG-25 or ductile iron. Inside protection shall consist of enamel coating.

**2.3 Butterfly Valves**

2.3.1 General

Each valve shall consist, essentially, of a cast-iron or ductile iron body with a rubber seat, a disc, a valve shaft, and an operating mechanism. It shall conform in all respects to DIN 3354.

Each valve disc shall rotate through an angle of 90 degrees from the fully opened to the fully closed position. When the disc is in the closed position, a plane through the axis of the valve shaft and through the seating surfaces shall be normal to the axis of the pipe. The axis of rotation of valve disc shall be horizontal.

The operating mechanism shall be attached to the valve body. Operator nuts shall be 50 mm square. Hand wheels, extension stems, and operator stands shall be supplied as indicated in the BoQ or otherwise specified.

Each operating mechanism shall be removable for inspection and repair. Provision shall be made for locking the disc in the fully-opened or tightly-shut position when the operating mechanism is removed.

All parts of the operating mechanism shall be readily accessible for inspection, adjustment, repair, and replacement. A position indicator shall be provided, actuated directly by the valve shaft, or extension thereof, which will indicate the position of the disc relative to the water passage in the valve body.

The operating mechanism for manually operated valves shall be self-locking so that the force of water or vibration will not cause the disc to move from the set position.

Each valve shall be designed for a watertight shutoff pressure differential across the disc equal to the pressure rating of the valve.

All valves to be furnished under these specifications shall be suitable for frequent operation in throttling and controlling flow of potable water, as well as for operation after long periods of idleness in either, the open or closed position.

2.3.2 valve Body

The valve bodies and flanges shall be of cast iron with nodular graphite GG 25.

2.3.3 Valve Seating

Valve seats shall be retained in a machined groove in the valve bodies by means of retainer segments, or shall be cemented, or otherwise firmly bonded, to the bodies and securely held in position. All retaining pins, retaining segments, bolts, nuts and washers in the interior of the valve shall be of stainless steel.

2.3.4 Valve Discs

The valve discs shall be cast iron containing 2 percent nickel. The seating edge of the cast iron discs shall be of stainless steel and shall be ground smooth.

2.3.5 Valve Shafts

Valve shafts shall be of stainless steel.

2.3.6 Stuffing Boxes, Glands and Packing

The stuffing box shall be provided with a bronze gland and Teflon packing. All bolts, screws, studs and nuts used in connection with the stuffing box shall be made of corrosion resisting steel. The design of the valve and stuffing box assembly shall be such that the packing can be adjusted or completely replaced without disturbing any part of the valve or operator assembly excepts the packing gland.

**2.4 Valve Actuators**

Electrical three-phase motors with integrated gear are to be provided for the following data:

Service voltage : 400 V ± 10%, 50 HZ

Control voltage : 48 V - AC

Protection class: IP55

The motor capacity is to be designed to open the motor from the final closed position while the maximum operating pressure is effective at one side of the valve. The operating time is fixed as about one minute.

Two limits switches each, with a floating change-over contact, are to be installed for the messages "valve open" and "valve closed".

Furthermore, the torque shall be monitored for both directions of the motor by adjustable limit signallers each with a floating change-over contact for the message "over torque while opening" and "over torque while closing".

An additional floating contact is to be provided for a flashing message "Valve in motion".

Manual operation of the valve must be possible by hand wheel.

The valve shall have a rotating indicator showing the position of the valve opening (close to open)

**2.5 Air Release Valves**

Air release valves shall have high strength cast or ductile iron bodies stainless steel floats and be designed for a working pressure of 16 bar. Valves shall contain integrally, or include externally, a shut-off valve for use during maintenance. All moving parts shall be of stainless steel.

Large orifice valves for vacuum breaking, used for pipe filling and pipe emptying shall have a ball-sealed orifice. Fully open when the valve chamber is empty and close "drop-tight" when the valve chamber is full of water, and shall be of the kinetic type in which air escaping at high velocity cannot close the valve by forcing the ball up against its seat.

Double orifice air valves shall incorporate the characteristics of both, small orifice and large orifice valves. The valves shall exhaust pockets of dissolved air through the small orifice when the line is under pressure. , The large orifice shall be fully open when the valve chamber is empty, and fully close "drop tight" when the chamber is full of water.

A complete unit with gate valve connection of the single or double type shall be provided where shown on the drawings and wherever necessary for venting of air.

Each valve shall be hydrostatically tested at a water pressure of 1.5 PN and shall show no leakage.

**2.6 Safety Valve**

Safety valves shall be of the loaded spring type with adjustable pressure range as shown in the BoQ. The safety valve shall be manually releasable by a lever arm.

**2.7 Check Valves (non return valve)**

The body shall be made of ductile iron positions of minimum space.

Valves shall be tight, with double eccentric valve disk, easy interchangeable, endless sealing element and retaining ring. Shafts shall be in slide bearings running, shaft sealing by means of O-rings. Flanges shall be according to DIN or equivalent.

Each valve shall be subjected to a hydrostatic pressure of 16 bar with both ends bulk headed. A second test shall be made at 16 bar applied through a bulkhead on the inlet side with the outlet open for inspection. Any leakage through the disc shall not exceed a rate of 11 ml/hr/cm of nominal valve size.

**2.8 Dismantling Piece**

Dismantling pieces shall be of the rigid type and provided with a steel middle ring, steel followers, gaskets and necessary bolts and nuts of galvanized steel.

**2.9 Pipe Compensator**

Pipe compensators shall be the rubber type and be provided with flanges as specified in the BoQ. The pipe compensator shall contain anchor studs of strength adequate to hold the pipe together under tension equal to the longitudinal strength of the pipe.

**2.10 Strainer**

Strainers shall be stainless steel sheet body and provided with a loose flange according to DIN EN 1092-2, PN16. Strainer is a cylinder provided with a bottom plate, both being perforated.

**2.11 Water Meter**

2.11.1 Digital Propeller Type-Mechanical

Water meters, which will be installed in a horizontal steel pipe, shall be of the Woltman dry dial type, with rotary vane or turbine, magnetic coupling and waterproof encased gear trains and register. The inlet and outlet shall have a common axis suitable for water up to 40 °C.

The bodies of bulk

s shall be manufactured from best quality cast iron with integrally cast flanges PN16, designed for a maximum internal pressure of P=16bar.

This type of water meter shall be flange ended, of the helical type and shall have a registration dial with six-digit integrator calibrated to read in cubic meters and shall be of the straight reading type. The meter shall have a cover plate and a bank lid to be fitted in place of the lid fixed to the metering mechanism, in case the later is removed for repair.

Registration shall be in cubic metres. For ease and accuracy of calibration and adjustment, dials shall register so as to permit accurate readings of 0.05 % of the nominal maximum discharge. Dial covers shall provide an airtight seal. They shall be provided with a non-translucent (not painted) lid, which shall be recessed and shall overlap the registration box to protect the lens.

Registers shall have a minimum capacity of 10­6 cubic metres for sizes 80 and 100 mm and 100 \* 106 cubic metres for sizes above.

The water meter shall be suitable for a working pressure as indicated on the drawings and the Contractor shall supply the tapers and the necessary flanges required for the proper completion of the Work.

The length of the pipes connected to and from the water meter shall be at least ten times the diameter of each pipe away from fittings or valves.

Markings shall be provided on the meters such as an arrow indicating direction of flow, nominal size, type, year of manufacture and manufacturer's name.

The Contractor shall submit performance data to include head losses and minimum operating head to obtain the required accuracy. Also the Contractor shall fill in the respective data sheet where specified.

The Contractor shall supply install and operate this type of flow meters to measure the flow in water mains. The meter shall be installed as located on the drawings. The nominal working pressure of these flow meter types shall be as indicated on the drawings.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

Unless exceptions are noted by the Engineer, valves and appurtenances shall be installed in conformity with the manufacturer’s recommendations, as indicated on the Drawings, and as specified in this and other sections of these technical specifications.

All valves shall be thoroughly cleaned and installed in strict conformance with the manufacturer's recommendations, as approved. Faces of flanges shall be cleaned thoroughly before flanged joint is assembled. After cleaning, the gasket shall be inserted and the nuts tightened uniformly around the flange.If flanges leak under test, the nuts shall be loosened; the gasket reset or replaced the nuts retightened and the valve and/or pipeline retested.

All anchor bolts and necessary bolt setting plates shall be provided by the manufacturer and unless otherwise approved shall be cast-in-place during concrete placement. Threads shall be protected and shall be cleaned before nuts are started. Two nuts shall be provided for each anchor bolt.

All bolts shall be tightened and all items requiring lubrication shall be lubricated. Following the completion of each gate installation, the gate shall be operated through at least one complete open-close cycle, readjusted and reoperated as required, and left in perfect operating condition.

All valves subject to movement due to hydrostatic forces, as determined by the Engineer, shall be anchored to concrete blocks as shown on the Drawings, and as directed by the Engineer. After the valve is in place and properly jointed, the anchorage block shall be poured using waterproofed Class A concrete to the dimensions shown and as detailed on the Drawings. Cover the concrete with approximately 10 cm of gravel as specified for trench backfill to retard evaporation of moisture from the concrete. Sprinkle gravel with water as directed.

After the concrete for anchorage has cured for not less than 24 hours, the 150 mm PVC Pipe section shall be cut to the required length and shall be placed over the operating nut of the valve as shown in the Drawings, Backfilling shall be with graded gravel as specified for compacted backfill in Section Trench Excavation and Backfill. Compact the gravel in 200 mm layers by hand tamping with tamping tools.

When the backfill has been placed to the proper depth the cast iron frame and cover shall set so that the 150 mm PVC Pipe extends up into the cast iron frame. It is not allowed to rest the frame on the PVC Pipe, which would transmit traffic impact loads to the valve and piping.

After the cast iron frame is placed to the proper finish elevation, the concrete collar shall be poured around the frame, all as shown on the Drawings or as directed by the Engineer.

**3.2 TESTS ON COMPLETION**

All valves shall be visually inspected by Engineer. The Contractor shall submit method statement to the Engineer for the testing of each valve operation in full coordination with manufacturer and international Standards procedures.

**END OF SECTION**

# SECTION 15111

# MECHANICAL FLOW METERS

**PART 1 - GENERAL:**

**1.1 DESCRIPTION**

This section covers furnishing and installation of mechanical flowmeter.

**A. Related Work**

Other items of work that relate to and are referenced in this section include, but are not limited to, the following section :

Submittals.

**1.2 APPLICABLE CODES AND STANDARDS**

The submitted meters shall comply to the most recent relevant DIN, ISO, and BS standards with regard to design and performance.

**1.3 SUBMITTALS**

Complete outline and installation drawings, together with detailed specifications and data covering material used parts, devices and other accessories forming apart of the equipment furnished, shall be submitted in accordance to submittal section. Operation and maintenance manuals shall be submitted in accordance with submittals section.

**1.4 PRODUCT HANDLING**

The equipment furnished under this section shall be prepared for shipment, delivered, stored, and handled in accordance with the General Equipment and Material Stipulation.

**PART 2 - PRODUCTS:**

**2.1 MECHANICAL FLOWMETERS:**

**domestic Water Meters (Multi-Jet) Water Meter**

1. Scope of application: The meter will be used for the measurement of cold, chlorinated potable water.
2. Water Meters should conform to the requirements of ISO 4064, or any other equivalent international standards.
3. Applicable standards **Velocity Type Water Meter (Domestic Water Meter)**
4. Specifications are for velocity, dry, magnetic drive, multi-jet type domestic water meter (DN as per BoQ)
5. Approved in accordance with the Directive **2014/32/EU (MID)**
6. **Metrological characteristics**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Basic Technical Data** | **Symbol** | **Unit** | **DN15** | **DN20** | **DN25** | **DN32** | **DN40** | **DN50** |
| Overload Flow Rate | Q4 | m3/h | 3.125 | 5 | 7.88 | 12.5 | 20.0 | 31.25 |
| Permanent Flow Rate | Q3 | m3/h | 2.5 | 4 | 6.30 | 10.0 | 16.0 | 25.0 |
| lower ratio (R) | Q3/Q1 |  | ≥100 H | | | | | |
| Temperature class |  | 0 C | T50 | | | | | |
| Maximum Working Pressure |  | bar | 16 | | | | | |

1. **Material**

The water meter upper cases, lower cases, the cover and any other exposed parts shall be totally made of brass or bronze alloy; other materials shall not be accepted. The materials of all those parts which will come on contact with the water, shall safely withstand the effect of at least 2 PPM (parts per million) of residual chlorine in the water supply and shall also be resistant to corrosion.

The water meter and accessories shall be manufactured from materials of adequate strength and durability. The materials, which come in contact with the potable water, shall not create a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste or discoloration in the water supply. The spindle and bearings. However, it shall be made of stainless steel and sapphire.

1. **The counter and counter shield**

The counter shall be designed in such away so that if the counter protective glass is broken for any reason the counter still cannot be removed from its place, must be water proof IP68 . The counter protective cover shall be made of sturdy glass (as specified in item 18 hereinafter) and shall have a wall thickness of not less than ten (10) mm, The meter should resist any water hammers impact.

1. **Totalizer Register**
2. It shall be straight reading type.
3. The Totalizer shall register in cubic meter units.
4. The Totalizer shall be set at 0 (zero).
5. The Totalizer shall reset to 0 (zero) at 100,000 m3 .
6. The Totalizer shall consist of a arrow of a minimum of four on-line consecutive digits to read at least 99,999 m3
7. **Pressure**

The working pressure of the water meter shall be in accordance with the testing requirement of ISO 4064 or the British standards institution No BS 5728, as amended.

1. **Accessories**

The meter shall include the following accessories

1. Threaded tailpieces, which shall conform to British institution standards No. BS 1387 / BS 21
2. An internal non-return valve
3. **Conformance to Meter Testing**

testing benches comply with the standards ISO 4064 or international equivalent standard.

1. **Meter sealing**

For Domestic water Meter, the water meter shall be sealed by the manufacture before delivery and shall be provided with a hole for sealing the meter with service valve the inlet side of the meter

1. **Sturdy Glass**

Pursuant to clause 4 of the specifications, the glass will be tested to insure its sturdiness. For the purpose of this tender specifications, sturdiness is defined as the ability of the counter protective glass to withstand, without damage or break, a free fall of a metal ball that weighs 27.20 grams from a vertical distance of not less than 70 cm. Furthermore, the glass shall withstand a pressure of 20 pars in case the meter has to operate under wet conditions and will be tested according.

1. **warranty**

All water meters should be under warranty for I (one) years from the date of supply.

This warranty shall be comprehensive and against any defects arising from defective design, materials or workmanship. Such warranty must be supported by proofs that the material used does not age during the lifetime of the meter, nor will it be negatively affected by the water quality and temperatures prevailing in Yemen.

* **Marking**

Generally Marking each meter shall have to be marked with clearly information:

| **Item** | **Description** |  |
| --- | --- | --- |
| 1 | Manufacturer's name or trade marks |  |
| 2 | Permanent Flow Rate Q3 (m3/hr) and lower ratio (R). |  |
| 3 | Applicable Standards |  |
| 4 | Dimensions, mm (nominal diameter (DN), |  |
| 5 | Serial Number |  |
| 6 | measuring unit (m³) |  |
| 7 | One or two arrow/s indicating the direction of flow |  |
| 8 | Nominal pressure |  |
| 9 | date of manufacture |  |
| 10 | Mark of type approval. |  |
| 11 | Manufacturer's serial number of the water meter permanently affixed to the water meter body and not case |  |

**PART 3 - EXECUTION:**

**3.1 INSTALLATION**

The Mechanical flowmeter shall be installed as shown in drawings or recommended by Engineer.

The Contractor shall submit a comprehensive specification regarding meter type, design performance and installation, including required lengths and straight pipe on either side of the meter.

**END OF SECTION**

# SECTION 015112

# ELECTROMAGNETIC FLOW METERS

**PART 1 - GENERAL:**

**1.1 DESCRIPTION**

This section covers furnishing and installation of electromagnetic flowmeter.

**A. Related Work**

Other items of work that relate to and are referenced in this section include, but are not limited to, the following section :

Submittals.

**1.2 APPLICABLE CODES AND STANDARDS**

The submitted meters shall comply to relevant DIN, ISO, and BS standards with regard to design and performance.

**1.3 SUBMITTALS**

Complete outline and installation drawings, together with detailed specifications and data covering material used parts, devices and other accessories forming apart of the equipment furnished, shall be submitted in accordance to submittal section. Operation and maintenance manuals shall be submitted in accordance with submittals section.

**1.4 PRODUCT HANDLING**

The equipment furnished under this section shall be prepared for shipment, delivered, stored, and handled in accordance with the General Equipment and Material Stipulation.

**PART 2 - PRODUCTS:**

**2.1 ELECTROMAGNETIC FLOWMETERS:**

**2.1.1 Material of Components**

The bodies of the electromagnetic water Flow Meters shall be manufactured from the best quality cast iron with integrally cast flanges or stainless steel. The tubes shold be fitted with electrically insulating liner. Material in contact with water shall be non-toxic and shall not affect the quality of water. The metering tube shall be of stainless steel.

The lining shall have either of the following specifications, with all materials suitable for potable water use:

1. PFA-Perfluoro-alkoxy-UKWFBS
2. Elastomer-UKWFBS
3. Polypropylene-UKWFBS, listed for potable water,
4. Ebonite, Bonded FEP, Polyurethane and Neoprene,
5. Electrodes (including earthing electrodes) are to be field replaceable without removing the tube , stainless steel, Hastelloy “C” Titanium, Tantalum or Platinum Iridium.

Meters shall be designed for use in a tropical climate and for temperatures up to 50° C.

**2.1.2 Pressure Rating**

The minimum working pressure shall be to PN 25 and the meters shall comply with the relevant DIN, ISO and BS standards with regard to design and performance.

**2.1.3 Accuracy of Operation**

The meter shall be capable of achieving an accuracy of ± 0.2 % of reading within the specified flow range.

**2.1.4 Power Supply**

The power supply shall be as follows:

1. AC: 85-265 V, 45 to 400 Hz at 20 VA maximum, or
2. 11 to 40 V, at 20 VA maximum.

The transmitter display shall be a 32-character (2 line) high temperature LCD alpha-numeric type, capable of recording flow rates and total flow.

The field mounting shall be powder coated die-cast aluminium IP 68 output signals, 4 – 20mA, counting pulse, status output. Power supply, 230 VAC, 50 Hz.

The meter shall be either programmed before dispatch from the manufacturer and should be capable of being re-programmed on site to suit prevailing conditions.

**PART 3 - EXECUTION:**

**3.1 INSTALLATION**

The Electromagnetic flowmeter shall be installed at discharge main of pumping station as shown in drawings.

The Contractor shall submit a comprehensive specification regarding meter type, design performance and installation, including required lengths and straight pipe on either side of the meter.

**END OF SECTION**

# SECTION 15400

# PLUMBING

**PART 1 GENERAL**

**1.1 DESCRIPTION**

This Section covers all plumbing work. Plumbing work shall include the furnishing of all necessary materials, devices, appliances, fixtures, equipment, and appurtenances and the performance of all necessary labor required to install a complete plumbing system as specified in this section and indicated on the Drawings.

Equipment and material furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the Engineer.

Principal items of work to be performed, and materials, equipment, devices, and appliances to be furnished and installed hereunder, include the following :

All cleanouts, bell-ups, roof and floor drains complete with piping.

All vent piping and all connections to a piece of equipment requiring waste connection.

All hot and cold potable water supply piping as required, including connections to each fixture and piece of equipment requiring potable water.

All plumbing fixtures.

Water heater.

Service sink.

**1.1-01 Related Work**

A. General Equipment and Material Stipulations

The General Equipment and Material Stipulations shall apply to all equipment and material furnished under this section.

B. Work Specified Elsewhere.

Other items of work that relate to and are referenced in this section include, but are limited to, the following sections:

Submittals

Fasteners

Miscellaneous Piping

Miscellaneous Valves.

**1.2 APPLICABLE CODES AND STANDARDS**

**1.2-01 Laws And Ordinances**

All plumbing work shall be performed in accordance with all applicable municipal codes and ordinances, and laws and regulations of the country, which pertain to such work. In case of conflict between these specifications and any law or ordinance, the latter shall govern. All plumbing work shall conform to the local Uniform Plumbing and Building Codes and the Ministry of Public Works - General Specifications for Buildings (Arabic Only).

**1.3 SUBMITTALS**

**1.3-01 Drawings and Data**

Complete Specifications, Data, and Drawings covering all materials, fixtures, and equipment shall be submitted in accordance with the SUBMITTAL Section.

**PART 2 PRODUCTS**

**2.1 MATERIALS**

**2.1-01 Material List**

Materials used shall be as follows ;-

Water closet The Water closet shall be Arabic type ( Asiatic) vitreous china, size 610x510 mm with 100 mm outlet. Complete with flush tank 2 litres, flush pipe 32 mm from tank to the closet height of flush tank. not less than 1.8 meters.

Lavatory 508 mm by 457 mm, with back-splash, wall hung on concealed arms, 32 mm waste outlet, 102 mm center holes for faucet, front overflow and with a soap depression on one side, and made of vitreous china.

Faucet Water saver faucet, 11.5 litres per minute flow (max.), 102 mm centers for the 10 mm copper tubing inlets, single lever, washerless cartridge inside with aerator, pop-up drain with 32 mm tailpiece; all surfaces chrome finish.

Supplies 10 mm hot and cold supplies with angle valve , wheel handle, 10 mm male thread inlet, escutcheon plates at wall and flexible tube risers; all parts chrome finish.

Trap 32 mm "P" trap, chrome finish.

Spray Wash Unit For cleaning and personal hygiene at the toilets.

Nozzle with Hook Wall mounted nozzle spray hose, connection and hook, chrome finish.

Spray Hose 1 meter long spray hose, heavy-duty chrome plated brass flexible hose with rubber liner and chrome plated brass connectors, 15 mm female inlet and outlet.

Spray nozzle Nozzle control shall be 15 mm

Control male IP connection, 100 mm long angle arm with a straight spray nozzle with aerator for wash and cleanup; all brass with chrome plated finish.

Service Sink 610 mm by 610 mm by 160 mm deep with stainless steel cap, corner model with front drop with 152 mm high, minimum side thickness of 57 mm, 80 mm cast brass waste with nickel bronze strainer plate.

Supply Fitting Service sink fitting with vacuum breaker; 80 mm hose thread-on spout, wall brace, pail hook, 15 mm flanged female adjustable arms with integral stops; polished chromium plated; install faucet on wall above sink.

Shower Tray Off white or approved colour vitreous china nominal dimension 750 mm x 750 mm with slip resistant surface.

Water Heater Commercial electric, glass-lined with magnesium anode, 1.03 MPa working pressure, stainless steel cold water inlet tube. Electric heating elements shall be low watt density with zinc plated copper sheath. The element shall be controlled by an individually mounted thermostat and high temperature cutoff switch. Outer jacket shall be finished with baked enamel and shall be provided with full size control compartment for performance of service and maintenance through hinged front panel and shall enclose the tank with vermin-proof fiberglass insulation. Electrical junction box with heavy-duty terminal block shall be provided. A drain valve shall be provided on the tank side near the bottom. The electrical service will be 23o volts, single phase and one element for a total of 3 kW.

Storage Tank As shown on the drawings with 2m3 capacity made of galvanized steel complete with cover float valve, vent & drainvalve with inlet & outlet female threaded holes of 3/4 mm size.

**2.2 PERFORMANCE AND DESIGN REQUIREMENTS**

**2.2-01 Plumbing Fixtures and Accessories**

Plumbing fixtures and accessories shall be provided as indicated on the Drawings and as listed herein. Fasteners for mounting accessories shall be concealed and shall employ galvanized toggle bolts or expansion anchors. Fasteners shall conform to the Fasteners Section.

**2.2-02 Roof and Floor Drains**

All roof drains shall be as indicated on the Drawings. Roof drains shall securely and rigidly attached to the roof decks to prevent movement and shall be set at a proper level for flashing and drainage.

Floor drains shall be of the type and size noted. On the Drawings. Floor drains shall be carefully adjusted to the correct elevation for proper drainage.

**2.2-03 Piping**

All vent piping, drain piping, and hot and cold potable water supply piping required in the plumbing system shall be as galvanized pipe class C.

**2.2-04 Valves**

Valves, not specified herein but indicated on the Drawings or otherwise required by the Engineer for proper operation, shall be as specified in the Miscellaneous Valves Section.

**PART 3 EXECUTION**

**3.1 INSTALLATION**

**3.1-01 Plumbing Installation**

All plumbing work shall be installed in accordance with the applicable codes and manufacturer's recommendations, and as specified and indicated on the Drawings.

**3.2 ADJUST AND CLEAN**

**3.2-01 System Cleaning**

Upon completion of the work, all parts of the installation shall be thoroughly cleaned. All equipment, pipe, valves, and fittings shall be cleaned to remove grease, metal cuttings, and sludge. Any stoppage or other damage, due to the Contractor's failure to clean the piping system properly, shall be repaired by the Contractor's without additional cost to the Employer. All flush valves and other devices shall be adjusted for quiet operation.

**END OF SECTION**

# SECTION 15780

# VENTILATION AND AIR CONDITIONING UNITS

**PART 1 - GENERAL**

**1.01 SCOPE OF SECTION**

A. This technical specification establishes the quality of materials and workmanship to be used in the supply and installation of ventilation and air conditioning units.

**1.02 WORK INCLUDED**

A. Provision of all labour, materials and the performance of all operations in connection with the supply and installation of ventilation and room air conditioners as specified herein and shown on the drawings.

B. Coordination: The Contractor shall be responsible for proper coordination of the work of all trades.

**1.03 QUALITY ASSURANCE**

A. Manufacturers: Firms regularly engaged in the manufacture of ventilation or air conditioning equipment and fittings whose products have been in satisfactory use in similar service for not less than 10 years.

B. Installer: Firms regularly engaged in the installation of ventilation or room air conditioning equipment of a similar quality and scope as this project for at least 5 years.

**1.04 APPLICABLE CODES AND STANDARDS**

A. The room air conditioners shall comply fully with the latest relevant American International and British Standards in all respects.

B. The following are the most commonly used standards associated with air conditioners, however the Contractor shall ensure that all applicable standards are complied with, whether listed here or not.

BS: 3456 Part 2 - Room Air Conditioners

Section 2.34

BS: 2852 - Testing for Rating of Room Air Conditioners

BS: 5491 - Testing Unit Air Conditioners above 7Kw Capacity

UL 465-82 - Central Cooling Air Conditioners

UL 484-82 - Room Air Conditioners

NFPA 90A - Installation and Ventilating of Air-conditioning systems

NFPA 70 - National Electrical Code.

ASHRAE 37-1978 - Methods of Testing for Rating Unitary Air Conditioners

ASHRAE 15-78 - Safety Code for Mechanical Refrigeration

NEC Article 44 - Air Conditioning and Refrigerating Equipment.

IEC 328-ANSI - Safety Requirements for the Electri­cal Equipment Room Air Conditioners

ISO R859 - Testing and Rating Room Air Conditioners

ARI 210 - Unitary Air Conditioning Equipment

ARI 270 - Sound Rating of Outdoor Unitary Equipment

ARI 360 - Commercial Industrial Air Conditioning Equipment.

**1.05 SUBMITTALS**

A. Drawings refer related section

B. Products: Submit full manufacturer data for every item.

**1.06 WARRANTY**

A. Provide 12 months warranty in accordance with contract conditions.

**PART 2 - PRODUCTS**

* 1. **MINI SPLIT SYSTEM AIR CONDITIONERS**

1. Mini split system air conditioning units shall be installed as indicated on the drawings and shall be complete with all required refrigerant piping, temperature controls and all other necessary ancillary items.

B. The units shall deliver the design cooling capacity at the external ambient specified. The units shall be suitable for continuous operation with external ambient temperature at 46°C.

C. Controls shall be factory wired and completely enclosed within the unit. All operating controls shall be located in a single area. Adjustable thermostats shall automatically cycle the compressor to maintain space conditions and the sensing element shall extend across the complete face of the cooling coil.

D. Condensate removal shall be by means of gravity drainage.

E. Unit electrical power shall be 240 volts 1 phase 50 hertz. The unit shall be capable of operating within line voltage limits of +3% to -4.6% .

F. Evaporator and condenser coils shall be of copper tube construction with aluminum fins and additional anti corrosion coating suitable for salty spray atmosphere.

G. Compressor motor shall be 2 pole, permanent split capacitor type protected against both thermal and electrical overload.

H. Filters shall be washable type easily accessible and shall cover the full unit area of re-circulated air. Air filters may be nylon fiber, glass fiber, cellular plastic material and shall have a minimum efficiency of 60% when tested in accordance with BS 2831 Test Dust No. 3.

J. Refrigerant stop valves, which incorporate a spindle gland, shall be serviceable with the valves "in situ".

K. Gas line insulation shall be carried out using 19-mm thickness of a closed cell, foamed plastic, tubular pipe insulation. Tape all joints to form a good vapor seal, then wrap with glass cloth and paint with two coats of approved vapor seal.

L. The evaporator/fan coil section shall be ceiling, wall or floor standing and complete with concealed control panel and finishes as indicated on the drawings.

M. Fan coil unit shall be complete with an electric heater with heavy duty nickel chromium elements. The heater shall have an auto reset high limit control thermostat.

N. Control panel shall have at least the following functions:

1. On/Off/Heat/Cool Control

2. Low/High heating and cooling control

3. Adjustable Thermostat

4. Air discharge direction control On/Off

* 1. **VENTILATION FANS**

Ventilation unit shall be provided at the sites as shown on the drawings. The equipment shall be of heavy duty type, suitable for continuous operation in an ambient temperature of up to 50°C on 230V single phase, or 400V three phase, 50 Hz electrical supply. The equipment shall comprise sufficient units to provide a minimum of ten air changes per hour for pump rooms, 15 per hour for switchrooms, two per hour for toilets.

Wall mounted as shown in drawings. The fans shall be equipped with automatic shutters from outside open by air pressure.

Exhaust Fan shall be fixed to a wooden frame installed in the wall opening. The motor has , in addition, an oil circulation system in which oil circulates down to the metal bearing through the oil wick, lubricating the felt rings and bearing by capillary action.

Fan shall be noiseless rotation and maximum of air flow, the blade assembly is constructed of special unbreakable hard plastic material to resist heat deformation at temperature as high as 70 C ( 158 F ).

**2.2.1 Noise Levels**

Noise level – measured at a distance of 1 m– should not in general exceed 80 dB(A). Noise levels of the air conditioning units should not exceed 65 dB.

**2.3 LOUVERS**

Louvers shall be of the required size for operation in accordance with the following criteria:

* Air Intake Louvers shall be of the sand trap type and shall be constructed in anodized aluminum. The louver blades shall be constructed from 1.5mm thick aluminum and the casing from 2 mm thick aluminum. The size of the louver shall be such that the face velocity does not exceed 0.5 m/s and at this velocity the louvers shall be capable of removing at least 85% of a typical wind-blown sand and dust mixture from the incoming air flow. The sand and dust collected by the louvers shall be discharged continuously by gravity to the exterior of the building. The design of the louvers shall be such that the pressure loss across the louvers shall not exceed 25 N/mm2 when operating at a face velocity of 0.5 m/s.
* Panel filters shall be fitted on the downstream side of the louvers which shall be capable to handling the required volume at an efficiency of not less than 85% based on tests to BS2831 with test dust N°2.
* Filters shall be washable and complete with holding frame sufficiently robust to ensure no distortion in operation. All filters shall be installed with edge seals that shall prevent the air by-passing the filters. The seals shall remain effective even though the cells are periodically removed and refitted. The air velocity through the filters shall be such that the clean resistance of 60 N/m2 is not exceeded and the filter shall not be carried over into the system.

**PART 3 - EXECUTION**

**3.1 PRODUCT STORAGE AND HANDLING**

A. All products shall be delivered in manufacturer's original protective packaging.

B. All products shall be inspected at time of delivery for damage and for compliance with Specifications.

C. All products that are found to be damaged, or not in accordance with the Specifications shall immediately be repaired or removed from the site and replaced. Repairs shall not be undertaken before Engineer's review of the Contractor’s proposed action.

D. All products shall be handled and stored as recommended by manufacturer to prevent damage and deterioration.

E. The Contractor shall supply handling equipment such as lifting beams, reinforced canvas slings, protective padding, struts, cradles, etc., required to handle products without damaging hardware or linings and coatings.

**3.2 INSTALLATION**

A. All units mounted externally shall have a raised concrete base with a minimum height of 100mm above surrounding surfaces. The base shall be sloped to provide natural drainage and ensure that pounding does not occur under the unit.

B. Each A\C unit of whichever type shall be complete with a local electrical disconnect switch.

C. A\C units shall be of the sizes, capacities, duties and types indicated on the drawings and shall be installed in strict accordance with the manufacturers requirements.

**END OF SECTION**

# SECTION 16000

# ELECTRICAL – GENERAL PROVISIONS

**PART 1 - GENERAL**

**1.01 SCOPE OF WORK**

1. Furnish all labor, materials, tools and equipment required to install complete and operational electrical and process instrumentation systems as indicated in the drawings, BoQ, and as specified herein and as approved by the Engineer.

The Contractor shall coordinate with others involved in the general construction.

1. The work shall include furnishing, installing and testing the equipment and materials detailed in the following specifications Sections of division 16 mentioned herein after.
2. The work shall include furnishing and installing the following:
   1. Conduit, wire and field connections for all motors, motor controllers, control devices, motor control centers, power distribution panels, control panels SCADA & Telemetry System and electrical equipment furnished under other Divisions of these Specifications.
   2. Conduit, wiring and terminations for all field-mounted instruments furnished under other Divisions of these Specifications, including process instrumentation primary elements, transmitters, local indicators and control panels. Lightning and surge protection equipment wiring at process instrumentation transmitters. Install vendor furnished cables specified under other Divisions of these Specifications.
   3. Conduit, wiring and terminations for power factor correction capacitors furnished under other Divisions of these Specifications.
   4. Conduit, wiring and termination for power supply for all heating, ventilating, and air conditioning equipment furnished under other divisions of these Specifications, including power wiring for unit motor heater and thermostats.
3. Each bidder or his authorized representatives shall, before preparing his proposal, visit all areas of the existing building and structures (if there are any) in which work under this contract is to be performed and inspect carefully the present installation. The submission of the proposal by this bidder shall be considered evidence that he or his representative has visited the project sites and noted the locations and conditions under which the work will be performed and that he takes full responsibility for a complete knowledge of all factors covering his work.
4. Provide all electrical demolition work associated with the removal of equipment from the existing facilities, including disconnecting and removing all electrical wiring and conduit to equipment being removed under other Sections of these Specifications.
5. Provide all electrical relocation work associated with the relocation of equipment for the existing and new facilities, including disconnecting all existing wiring and conduits and providing new wiring and conduit to the relocated equipment.
6. Excavation, bedding material, forms, concrete and backfill for underground raceways; forms and concrete for electrical equipment furnished under Division 16. The work shall be in accordance with Divisions 2 and 3.

**1.02 RELATED WORKS**

1. Excavation and backfilling, including gravel or sand bedding for underground electrical work is included in Division 2.
2. Concrete work, including concrete electrical duct encasement, is included in Division 3.
3. Section 16050, Basic Electrical Material and Methods.

**1.03 SUBMITTALS**

1. Submittals in accordance with Section 01300, submittals for equipment, materials and other items furnished under Division 16.
2. Submit materials compliance data sheets with the specifications
3. Shop drawings shall be submitted for all electrical equipments, items and works.
4. The manufacturers name, country of origin, product designation or catalogs numbers shall be submitted for all electrical materials, devices, equipments, etc.
5. Check shop drawings for accuracy and contract requirements prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to contract documents. This statement shall also list all exceptions to the Specifications and Drawings. Shop drawings not so checked and noted shall be returned.
6. The Engineer’s check shall be for conformance with the design concept of the project and compliance with the Specifications and Drawings. Errors and omissions and approved shop drawings shall not relieve the Contractor from the responsibility of providing materials and workmanship required by the Specifications and Drawings.
7. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.
8. Submit type tests certificates and routine tests reports.
9. Submit calculation for verifying that the submitted materials are in compliance with the specifications.
10. Material shall not be ordered or shipped until the Engineer has approved the subject materials. All test certificates of the subject materials shall be submitted and accepted by the Engineer also before materials approval.
11. Operation and Maintenance Data:
    1. Submit operation and maintenance data for equipment furnished under this Division, in accordance with Section 01300, Submittals. The manuals shall be prepared specifically for this installation and shall include catalogs, data sheets, drawings, equipment lists, descriptions, parts listed, etc, to instruct operating and maintenance personnel unfamiliar with such equipment.
    2. Manuals shall include the following as a minimum:
       1. A comprehensive index.
       2. A complete “As-Built” set of approved shop drawings.
       3. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data. The list shall also include the manufacturers names, address, fax and e-mail.
       4. A table listing of the “as left” settings for all timing relays and alarm and trip set points.
       5. System schematic drawings “As-built”, illustrating all components, piping and electric connections of the systems supplied under this section.
       6. Detailed service, maintenance and operation instructions for each item supplied.
       7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
       8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
       9. Complete parts list with stock number, including spare parts.
       10. Safety instructions and precautions.
       11. The Contractor shall submit and include in the manuals, a table or diagram (3 Nos. size A2) of a periodic preventive maintenance for all equipments of the project (especially the electrical and mechanical parts) with periods of weekly, monthly, quarterly an yearly according to each individual equipments manufacturer recommendations and shall be approved by the Engineer.

Each copy shall thermally covered from both sides with transparent covers.

1. The Contractor is obliged to mention in each submittal, the codes and standards on which the appliance or the device is manufactured. The Contractor is also obliged to submit the related code or standards upon the order of the Engineer and to be included in the submittal (original copy) free of charge. Any failure to submit gives the Engineer the right to deduct 3 x price of the related standard from the Contractor invoices without any right to claim for this.

**1.04 APPLICABLE CODES AND STNDARDS**

* 1. All works shall be performed and all materials and equipment shall be in accordance with standards and codes referred to in Section 16050.
  2. The revision of the standard in effect at the time of bid opening shall apply.

**1.05 ENCLOSURE TYPE**

1. Unless otherwise specified herein or shown on the Drawings, electrical enclosures shall have the following ratings:
   * 1. NEMA 1 for dry, non-process indoor locations shown on the Drawings.
     2. NEMA 12 for “DAMP” locations shown on the Drawings.
     3. NEMA 4 for outdoor Locations, rooms below grade (including basements and buried vaults) and “WET” locations shown on the Drawings.
     4. NEMA 4 X for “CORROSIVE” locations shown on the Drawings.
     5. NEMA 7 (and listed for use in the area classifications shown) for “Class I Div. 1 Group D” and Class I Div. 2 Group D” hazardous locations shown on the Drawings.

**1.06 SERVICE AND METERING**

* + - 1. The power company serving this project is the Local Electric Power Company (LEC). Service will be obtained at 415/240 VAC, 3 phases, 4 wire, 50 hertz from pad mount transformers furnished and installed by LEC.
      2. LEC will be responsible for the following work:
  1. Furnishing and installing the primary overhead conductors and pole line.
  2. Furnishing and installing the riser pole, primary cutouts, lightning arresters and grounding.
  3. Furnishing and installing primary conduits and cables.
  4. Furnishing and installing transformer.
  5. Termination of underground primary cables at riser pole.
  6. Termination of underground primary cables at the transformer.
  7. Termination of LV cable at the LV side of the transformer.
  8. Furnishing metering current transformers (C.T.’s), meter and meter wiring.
  9. Furnishing, KWH meter, meter base and enclosure.
     + 1. The Contractor shall be responsible for the following work:
  10. Make all arrangements with LEC for obtaining electrical service.
  11. Furnishing and installing the transformer pad and grounding.
  12. Furnishing and installing secondary conduits and cables.
  13. Furnishing and installing a low voltage (600 VAC rated) 4-pole circuit breaker on the secondary side of the pad mount transformer as directed by LEC.

**1.07 HAZARDOUS AREAS**

1. Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with National and International Electrical Codes and Standards.
2. Equipment and materials installed in hazardous areas shall be UL listed for the appropriate hazardous area classification.

**1.08 CODES, INSPECTION AND FEES**

1. The supplied equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction.
2. The Contractor shall obtain all necessary permits and pay all fees required for permits and inspections.

**1.09 TESTS AND SETTINGS**

1. The Contractor shall test all systems and equipment furnished under Division 16 and repair or replaces all defective work. Make adjustments to the systems and instruct the Employer’s personnel in the proper operation of the systems.
2. The Contractor shall make the following minimum tests and checks prior to energizing electrical equipment:
   1. Mechanical inspection, testing and setting of circuit breakers, disconnect switches, motor starters, control equipment, etc for proper operation.
   2. Test grounding system as specified in Section 16060.
   3. Test motor control centers as specified in Section 16480
   4. Test 600 volt wire and cables as specified in Section 16120.
   5. Check wire and cable terminations for tightness.
   6. Field set transformer taps to obtain the proper secondary voltage.
   7. Check motor nameplates for correct phase and voltage. Check bearings for proper lubrication.
   8. Check the ampere rating of thermal overloads for motors and submit a typed record to the Engineer of same, including MCC cubicle location and load designation, motor services factor, horsepower, full load current and starting code letter. If inconsistencies are found, new thermal elements shall be supplied and installed.
   9. Check rotation of motors prior to energization. Disconnect driven equipment if damage could occur due to wrong rotation. If it rotates in the wrong direction, correct it.
   10. Check interlocking, control and instrument wiring for each system and / or part of a system to prove that the system will function properly as indicated by schematic and wiring diagrams.
   11. Verify all terminations at transformers, equipment, panels an enclosures by producing a 1-2-3 rotation on a phase sequenced motor when connected to “A”, “B” and “C” phases.
   12. Test and calibrate protective relays and circuit breakers.
3. Testing shall be scheduled and coordinated with the Engineer at least two weeks in advance. Provide qualified test personnel, instruments and test equipment.
4. Test instruments and equipments shall be calibrated and certified by the jurisdiction party within a period of one year of the testing date maximum.
5. Testing shall be performed by the Contractor in compliance with the equipment manufacturer instructions, recommendations and procedures. The Contractor shall submit site test report upon completion in accordance with Section 01300.
6. Submit type tests certificate and routine tests reports

**1.10 PROTECTIVE DEVICES COORDINATION STUDY**

1. Obtain and pay for the services of the major electrical equipment manufacturer to provide a complete computerized study of fault current and coordination of relays, fuses, circuit breakers, and all other protective devices. The coordination study shall include LEC protective devices switchgear main and feeder circuit beakers, and motor control center main, feeder, and branch circuit protective devices. The study shall include, but not be limited to, the following:
   1. Fault current available at each major equipment bus.
   2. A tabulation of all protective relay and circuit breaker trip settings and recommended fuse sizes and types.
   3. Transformer damage curves in accordance with ANSI C57.109 (latest revision).
   4. Motor starting profile for largest motor in each motor control center.
   5. A complete set of time-current coordination curves.
2. The coordination study shall be bound in a standard A4 size report. The final selection al all protective devices shall be based on a preliminary draft of the coordination study, which shall be submitted with the equipment shop drawings in accordance with Section 01300. The completed study shall be approved by the Engineer before any of the equipment is shipped. Protective devices shall be adjusted, tested, and calibrated in the field, prior to energizing the equipment per the settings listed in the study. This work shall be performed by the equipment manufacturer’s service representative prior to final acceptance by the Engineer.

**1.11 INTERPRETATION OF DRAWINGS**

1. the Contract Drawings are not intended to show exact locations of conduit runs. Coordinate the conduit installation with other trades and the actual supplied equipment.
2. Install each three-phase circuit in a separate conduit unless otherwise shown on the Drawings.
3. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed (electrical galvanized steel type); conduit shown concealed shall be installed concealed (electrical UPVC type) unless otherwise specified elsewhere in the Contract.
4. Where circuits are shown as “home-runs” all necessary fittings and boxes shall be provided for a complete raceway installation.
5. Verify the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
6. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Contract Drawings are approximate only. Exact locations shall be determined by the contractor and approved by Engineer during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.
7. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting and other electrical systems shown.
8. Redesign of electrical or mechanical work, which is required due to the Contractor’s use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at his own expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either his own or others, caused by such redesign.
9. Raceways and conductors for lighting, switches, receptacles and other miscellaneous low voltage power and signal systems as specified if not shown on the Drawings, shall be provided for a complete and operating system. Homeruns, as shown on the Drawings, are to assist the Contractor in identifying raceways to be run exposed and raceways to be run concealed. Raceways installed exposed shall be near the ceiling or along walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes hoists, monorails, equipment hatches, doors, windows, etc. raceways installed concealed shall be run in the center of concrete floor slabs, above suspended ceilings, or in partitions as required.

**1.12 SIZE OF EQUIPMENT**

1. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.
2. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to insure that the tilting does not impair the functional integrity of the equipment.

**1.13 RECORD DRAWINGS**

1. As the work progresses, legibly record all field changes on a set of project Contract drawings, hereinafter called the “record drawings”.
2. Record drawings shall accurately show the installed condition of the following items:
   1. Single line Diagram(s).
   2. Raceways and pull boxes.
   3. Conductor sizes and conduit fills.
   4. Panel Schedule (s).
   5. Control Wiring diagram (s).
   6. Lighting Fixture Schedule (s).
   7. Lighting fixture, receptacle and switch outlet locations.
   8. Underground raceway and duct bank routing.
   9. Plan view, sizes and locations of switchboards, motor control centers and panel-boards.
   10. Lightning & Earthing diagram(s).
3. Submit a schedule of control wiring raceways and wire numbers, including the following information:
   1. Circuit origin, destination and wire numbers.
   2. Field wiring terminal strip names and numbers.
4. As an alternate, point-to-point connection diagrams showing the same information may be submitted in place of the schedule of control wiring raceways and wire numbers.
5. Submit the record drawings and the schedule of control wiring raceways and wire numbers (or the point-to-point connection diagram) to the Engineer.

**1.14 EQUIPMENT INTERCONNECTIONS**

1. Review shop drawings of equipment furnished under other Divisions of this Specification and prepare coordinated wiring interconnection diagrams or wiring tables. Submit copies of wiring diagrams or tables with Record Drawings.
2. Furnish and install all equipment interconnections.

**1.15 MATERIALS AND EQUIPMENT**

1. Materials and equipment shall be new, except where specifically identified on the Drawings to be re-used.
2. Material and equipment of the same type shall be the product of one manufacturer and shall be UL listed.

**1.16 EQUIPMENT IDENTIFICATION**

1. Equipment identification shall be in compliance with Section 16075.
2. Identify equipment (disconnect switches, separately mounted motor starters, control stations, etc) furnished under Division 16 with the name of the equipment it serves.

Motor control centers, control panels, panel-boards, switchboards, switchgear, junction or terminal boxes, transfer switches, etc shall have nameplate designations as shown on the Drawings.

1. Nameplates shall be engraved, laminated plastic, not less than 2mm thick by 20 mm by 65 mm with 5 mm high black letters on a white background.
2. Nameplates shall be screw mounted to NEMA 1 enclosures. Nameplates shall be bonded to all other enclosure types using an epoxy or similar permanent waterproof adhesive. Two sided foam adhesive tape is not acceptable. Where the equipment size does not have space for mounting a nameplate, the nameplate shall be permanently fastened to the adjacent mounting surface.
3. Nameplates shall be engraved in both Arabic and English Languages.

**1.17 DEMOLITION**

1. Remove electrical work associated with equipment scheduled for demolition except those portions indicated to remain or be reused.
2. Remove unused exposed conduit and wiring back to point of concealment including abandoned conduit above accessible ceiling finishes. Remove unused wiring in concealed conduits back to source (or nearest point of usage).
3. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank covers for abandoned outlets which are not removed.
4. Disconnect and remove abandoned panel-boards, disconnect switches, control stations, distribution equipment, etc.
5. Disconnect and remove abandoned luminaries. Remove brackets, stems, hangers and other accessories.
6. Repair adjacent construction and finishes damaged during demolition and extension work.
7. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or be suitably relocated and the system restored to normal operation.
8. Coordinate outages in systems with the Employer. Where duration of proposed outage cannot be allowed by the Employer, provide temporary connections as required to maintain service.
9. Removal and relocation of existing conduit, wire and equipment have not been detailed on the Drawings. Survey the affected areas before submitting bid proposal.
10. Trace out existing wiring that is to be relocated, or removed and perform the relocation or removal work as required for a complete operating and safe system.
11. Continuous service is required on all circuits and outlets affected by these changes, except where the Employer will permit an outage for a specific time. Obtain employer’s consent before removing any circuit from continuous service.
12. Remove exposed conduits, wire ways, outlet boxes, pull boxes and hangers made obsolete by the alterations, unless specifically designed to remain.

**1.18 DISPOSITION OF REMOVED MATERIALS AND EQUIPMENT**

1. In general, it is intended that material and equipment indicated to be removed and disposed of by the Contractor shall, upon removal, become the Contractor’s property and shall be disposed of off the site by the Contractor, unless otherwise directed by the Employer. A receipt showing acceptable disposal of any legally regulated materials or equipment shall be given to the Employer.

**PART 2 PRODUCTS**

**2.01 PRODUCT REQUIREMENTS**

A. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design and manufacture year (Brand new). The products shall conform to the applicable codes and standards mentioned in item 1.06 of this specification.

B. All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated.

C. All equipment and materials shall be new, unless indicated or specified otherwise.

D. The Contractor shall submit proof if requested by the Engineer that the materials, appliances, equipment, or devices that he provides under this Contract meet the requirements of Underwriters Laboratories, Inc. BSS, IEC and all local authorities having jurisdiction, in regard to fire and casualty hazards. The label of or listing by the Underwriters Laboratories, Inc., will be accepted as conforming with this requirement.

**2.02 SUBSTITUTIONS**

1. Any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. The Contractor, in such cases may, at his option use any article, device, product, material, fixture, or item of equipment which in the judgment of the Engineer, expressed in writing, is equal to that specified.

**2.03 CONCRETE**

A. The Contractor shall furnish all concrete required for the installation of all electrical work, Concrete shall be Class A – fair face unless otherwise specified, and in complete conformance with the applicable requirements of Division 3 of the Specifications.

1. The Contractor shall provide concrete equipment pads for all freestanding electrical apparatus and equipment located on floors or slabs that are new or existing or provided by others. The Contractor shall provide all necessary anchor bolts, channel iron sills, etc. The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches [100mm] high unless otherwise indicated on the Drawings. Pads shall be reinforced with steel wire mesh and shall have dowel rods inserted into the floor for anchorage.

**PART 3 - EXECUTION**

**3.1 SLEEVES AND FORMS FOR OPENINGS**

1. Provide and place all sleeves (electrical galvanized steel or UPVC as approved by the Engineer) for conduits penetrating floors, walls, partitions, etc. locate all necessary slots for electrical work and form before concrete is poured.
2. Exact locations are required for stubbing up and terminating concealed conduit. Obtain shop drawings and templates from equipment vendors or other sub-contractors and locate the concealed conduit before the floor slab is poured.
3. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.
4. Seal all openings, sleeves, penetration and slots as specified in Section 16110.

**3.2 CUTTING AND PATCHING**

1. Cutting and patching shall be done in a thoroughly workmanlike manner. Sawcut concrete and masonry prior to breaking out sections.
2. Core drill holes in concrete floor and walls as required.
3. Install work at such time as to require the minimum amount of cutting and patching.
4. Do not cut joists, beams, girders, columns or any other structural members.
5. Cut opening only large enough to allow easy installation of the conduit.
6. Patching to be of the same kind and quality of material as was removed.
7. The completed patching work shall restore the surface to its original appearance or better.
8. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.
9. Remove rubble and excess patching materials from the premises.

**3.3 INSTALLATION**

1. Any work not installed according to the Drawings and Specifications shall be subject to change as directed by the Engineer. No extra compensation will be allowed for making these changes.
2. Electrical equipment shall be protected at all times against mechanical injury or damage by water. Electrical equipment shall not be stored outdoors. Electrical equipment shall be stored in dry permanent shelters. Do not install electrical equipment in its permanent location until structures are weather-tight. If any apparatus has been subject to possible injury by water. It shall be thoroughly dried out and tested as directed by the Engineer, or shall be replaced at no additional cost at the Engineer’s discretion.
3. Equipment that has been damaged shall be replaced or repaired by the equipment manufacturer, at the Engineer’s discretion only.
4. Repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer. The entire damaged panel or section shall be repainted as per the painting specifications and according to approval and instruction of the Engineer, at no additional cost to the Employer.

**3.4 MANUFACTURERS SEVICE**

1. Provide manufacturer’s services for testing and start-up of the following equipment:

|  |  |  |
| --- | --- | --- |
| 1. | Automatic Transfer Switches | 2 days 1 trip (minimum) |
| 2. | Switchboards | 2 days 1 trip (minimum) |
| 3. | Motor Control Centers | 5 days 2 trips (minimum) |

1. Testing and startup shall not be combined with training. Testing and start-up time shall not be considered as part of Defect Liability Period.

**3.5 TRAINING**

1. Provide manufacturer’s services for training of plant personnel in operation and maintenance of the equipment furnished under Division 16.

|  |  |  |
| --- | --- | --- |
| 1. | Automatic Transfer Switches | 2 days 1 trip (minimum) |
| 2. | Switchboards | 2 days 1 trip (minimum) |
| 3. | Motor Control Centers | 3 days 2 trips (minimum) |

1. The cost of training programs to be conducted with Employer’s personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.
2. Provide detailed O&M manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.
3. The training program and materials shall represent a comprehensive program covering all aspects of the operation and maintenance of each system.
4. All training schedules shall be coordinated with and at the convenience of the Employer. Shift training may be required to correspond to the Employer’s working schedule.
5. Within 120 days of Contract award to the Contractor, submit an overview of the proposed training plan for Engineer and Employer approvals; This overview shall include, for each course proposed:
   1. An overview of the training plan.
   2. Course title and objectives.
   3. Prerequisite training and experience of attendees.
   4. Recommended types of attendees.
   5. Course Content – A topical outline.
   6. Course Duration.
   7. Course Location – Training center of jobsite.
   8. Course Format – Lecture, laboratory demonstration, etc.
   9. Schedule of training courses including dates, duration and locations of each class.
   10. Resumes of the instructors who will actually implement the plan. Instructors shall be fluent in both Arabic and English languages.

**END OF SECTION**

# SECTION 16050

# BASIC ELECTRICAL MATERIAL AND METHODS

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

A. The Contractor shall furnish all labor, materials, tools, and equipment, and perform all work and services necessary for, or incidental, to the furnishing and installation of all electrical work as shown on the Drawings, and as specified in accordance with the provisions of the Contract Documents and completely coordinate with the work of other trades involved in the general construction. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work. The Contractor shall obtain approved Shop Drawings showing wiring diagrams, connection diagrams, roughing-in and hook up details for all equipment and comply therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and the Specifications for the electrical work.

B. The Contractor shall refer to the functional descriptions and other requirements found in Section 16920, Equipment Control and Instrumentations, for additional requirements pertaining to work under this contract. The functional descriptions referenced herein shall be considered as part of the work required under this contract.

C. The Contractor shall be responsible for all interconnecting devices, conduit, wire, and appurtenances not furnished by others but required for the operation of equipment whether specifically shown on the drawings or not.

1. The scope of work for this project primarily includes, but is not limited to, the following:
2. Construction, testing and start up of the complete power distribution, motor control equipment, illumination system, lightning protection systems, and all other associated electrical work for all the new reservoir sites that are part of this contract.
3. Spare Parts
4. Other electrical work as specified herein and indicated on the Drawings.
5. Maintaining the operation of existing facilities during the duration of the construction period is essential and required. The Contractor shall furnish and install temporary equipment as required to maintain facility operation. Reference Section 01760 of the Specifications for construction sequencing and specific operational constraint information.
6. All electrical equipment shall conform to the applicable NEMA specifications. All electrical equipment shall be properly identified in accordance with these Specifications and Contract Drawings. Nameplates shall be engraved high-pressure plastic laminate, black with white lettering for 230V equipment, and red with white lettering for 400V equipment. The nameplates shall be attached to the equipment cabinets with two (2) stainless steel sheet metal screws for nameplates up to 50-mm wide. For nameplates over 50-mm wide, four (4) stainless steel sheet metal screws shall be used, 25-mm in each corner of the nameplate. All panelboards, starters, control panels, cabinet enclosures, and equipment switches shall be labeled in the manner described, or in an equally approved manner.
7. All materials, equipment, sizes and capacities of electrical equipment incorporated in the project shall conform to the latest requirements of the current British Standard, IEC, National Electric Code (NEC), the National Electrical Manufacturer's Association, the local electrical codes, and to applicable rules and regulations of the electrical utility serving the project. In the case of conflict between the local codes and the electrical codes referred to in these specifications, the Contractor shall notify the Engineer.
8. All material and equipment must be the product of an established and reputable manufacturer; must be new and of first class construction; must be designed and guaranteed to perform the service required; where such approval is available for the product of the listed manufacturer as approved by the Engineer.
9. When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the Engineer shall be furnished and installed at no additional cost to the Owner.
10. Where the Contractor's selection of equipment of specified manufacturers or additionally approved manufacturers requires changes or additions to the system design, the Contractor shall be responsible in all respects for the modifications to all system designs, subject to approval of the Engineer. The Contractor's bid shall include all costs for all work of the Contract for all trades made necessary by such changes, additions or modifications or resulting from any approved substitution.
11. Furnish and install controls for each piece of equipment requiring the controls under this Contract. The controls shall be the size and type recommended by the manufacturer for the application and as otherwise specified or indicted on the Drawings. Refer to Divisions 1 and 13 of the Specifications for control, connection and coordination descriptions and requirements.
12. Furnish and install all stands, racks, brackets, supports, and similar equipment required to properly serve the equipment which is furnished under this Contract, or equipment otherwise specified or indicated on the Drawings.
13. When two or more than two sections of the specifications have different level of the specification for the same work, system or material, the higher level specifications will have the precedence and subject to the Engineer approval.

N. Cables schedules:

The Contractor shall early submit a perquisite submittal , a complete cables schedule of the plant including all power ,control , protection, SCADA and telemetry cables showing their tags ( labeling ), originating from and to last destination ( thru all manholes ,if there are ) , lengths, cross sections, types, Nos. of wires /cores /cable, terminal blocks ,type of routes (conduits, trays, trenches, manholes,…etc.) and the loads they feed ( name & kw.). This schedule shall be finalized again to be as built in the last stage before preparation for testing and commissioning period and to be included in the As-Built Drawings. Also it should be assumed as a base for the BOQ cables quantities to charge the Contractor to it.

O. All electromechanical works shall be shop tested then site /field-tested. The Contractor shall prepare a Testing time schedules and Check Lists for all tests to be executed including what stated in the test items in the Contract Specs. and as approved by the Engineer.

All instruments needed for testing shall be provided by the Contractor, each with calibration certificate (valid for 6 months) issued from 1st grade local specialized and authorized calibration centre approved by the Engineer.

1. Before the Substantial Taking Over takes place and after all testing are completed, passed and approved, a commissioning period of (14) continuous days shall be executed for all equipments in the project in the normal recommended operation manner without major faults (as classified by the Engineer) or minor faults (not frequent, intermittent, or repeated faults) as defined by the Engineer.

**1.02 DRAWINGS**

A. Conduits and wiring are shown diagrammatically only, and the layout does not necessarily show the total number of conduits for the circuits required, nor are the locations of indicated runs intended to show the actual routing of conduits. The Contractor shall furnish, install, and place in satisfactory condition ready for operation, all conduits, cables, and all other material needed for the complete lighting, power, and other electrical systems shown or indicated in the Contract Documents. Additional conduits and the required wiring shall be installed by the Contractor for wherever needed to complete the installation of the specific equipment furnished, at no additional cost to the Employer.

**1.03 EQUIPMENT LOCATION**

A. The Drawings show the general location of feeders, transformers, outlets, conduits, and circuit arrangements. Because of the small scale of the Drawings, it is not possible to indicate all of the details involved. The Contractor shall carefully investigate the structural and finish conditions affecting all of his work and shall arrange such work accordingly; furnishing such fittings, junction boxes, and accessories as may be required to meet such conditions. The Contractor shall refer to the entire Drawing set to verify openings, special surfaces, and location of other equipment, or other special equipment prior to roughing-in for panels, switches, and other outlets. The Contractor shall verify all equipment dimensions to insure that proposed equipment will fit properly in spaces indicated.

**1.04 LOCAL CONDITIONS**

A. The Contractor shall examine the site and become familiar with conditions affecting the work. He shall investigate, determine, and verify locations of any overhead or buried utilities on or near the site, and shall determine such locations in conjunction with all public and/or private utility companies and with all authorities having jurisdiction. All costs, both temporary and permanent to connect all utilities, shall be included in the Bid. The Contractor shall be responsible for scheduling and coordinating with the local utility for temporary and permanent services.

**1.05 SUBMITTALS**

A. The Contractor shall submit to the Engineer Shop Drawings of all electrical materials, apparatus, appliances, equipment and miscellaneous devices shown or specified and shall be in accordance with the requirements of the General Conditions and Section 01300, Submittals.

B. Shop Drawings shall be sufficiently complete in detail to enable the Engineer to determine compliance with Contract requirements. Details and information shown shall include but are not necessarily limited to the following:

1. Performance characteristics.

2. Physical sizes.

3. Material and equipment specifications, and construction and methods of fabrication details.

4. Compliance with standards (e.g. UL, NEMA, BS, IEC), rules, regulations, and codes.

5. Accessories.

6. Complete wiring diagrams showing circuit designations as shown on the Drawings. A complete wiring diagram shall be submitted for each controller furnished.

7. Complete product data sheets for all components of the specified equipment.

8. Electrical ratings (voltage, current, KVA, phase, etc.)

9. Weights of components parts and assembled unit weights.

1. Complete assembly, layout, and installation drawings with clearly marked dimensions.
2. Original catalogues.
3. Compliance sheets.

C. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

D. Shop Drawings will be approved only to the extent of the information shown. Approval of an item of equipment shall not be construed to mean approval for components of that item for which Contractor has provided no information.

1. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's specification section.
2. Each submittal shall be identified by the applicable specification section.
3. Submitals shall includes but not limitted to the following colculations:
4. Load calculations .
5. Short circuit calculations
6. Lighting calculations.
7. Lightning Protecion calculations
8. Emergency Lighting calculations.
9. Grounding system Calculations.
10. Cable &Wires Sizing Calculations.
11. MCCs & DBs Sizing Calculations.

**1.06 REFERENCE CODES AND STANDARDS**

* 1. Reference to the standadrs or codes of any technical society, organisation, or governmental authorities, shall mean the latest standard, code, specification, or tentative standardd adopted and published at the date of taking bids unless speicifically stated otherwise.
  2. Applicabe Codes and Standads:

BS British Standard, UK

VDE Verein Deutscher Elekroingnieure, Germany

DIN Deutsches Institut fur Normen, Germany

IEE Institute of Electrical Engineers, USA

IEEE Institue of Electrical and Electronic Engineers, USA

NEC National Electrical Code, USA

ANSI American National Standard Institute, USA

NEMA National Electrical Manufacturer Association, USA

NFPA National Fire Protection Association, USA

UL Underwriters’ Lbaratories, INC.

NESC National Electrical Safty Code, USA

ASTM American society for Testing and Materials, USA

IPCEA Insulated Power Cable Engineers Association, USA

OSHA Occupational Safety Hazards Act, USA

ICS Industrial Control and Systems

U/L 845 Standard for Motor Control Center

ISA International Society for Measurement and Control

API American Petroleum Institute.

JIC Joint Industrial Council

EPA Environmental Protection Agency.

SAMA Scientific Apparatus Manufacturers Association.

AWWA American Water Works Assciation

ISO International Standards Organization

NIST National Institue of Standards and Technology

Local authorities codes and standards or any better or equal and aproved by the Engineer.

* 1. Nonconformance

1. Any paragraph of requirements in these Specifications, or Drawings, deviating from the rules, requirements and Specifications of the above organizations shall be invalid and their (the above organizations) requirements shall hold precedent thereto. The Contractor shall be held responsible for adherence to all rules, requirements and specifications as set forth above. Any additional work or material necessary for adherence will not be allowed as an extra, but shall be included in the Bid Price. Ignorance of any rule, requirement, or Specification shall not be allowed as an excuse for nonconformity. Acceptance by the Engineer does not relieve the Contractor from the expense involved for the correction of any errors, which may exist in the drawings submitted, or in the satisfactory operation of any equipment.

**1.07 PERMITS AND INSPECTIONS**

The Contractor shall reference to the General Conditions and Section 01010, Scope of Work.

**1.08 TEMPORARY LIGHTING AND POWER**

The Contractor shall reference to the General Conditions and Section 01510, Temporary Utilities.

**1.09 TESTS**

A. Upon completion of the installation, the Contractor shall perform tests for operation, load (Phase) balance overloads, and short circuits. Tests shall be made with and to the satisfaction of the Owner and Engineer.

B. The Contractor shall perform all field tests and shall provide all labor, equipment, and incidentals required for testing and shall pay for electric power required for the tests. All defective material and workmanship disclosed shall be corrected by the Contractor at no cost to the Employer. The Contractor shall show by demonstration in service that all circuits and devices are in good operating condition. Tests shall be such that each item of control equipment will function not less than five (5) times.

C. The grounding system shall be tested to assure continuity and compliance with the requirement that ground resistances do not exceed 2-ohm when measured by a megohmeter or equivalent device. Ground resistance measurements of each grounding electrode shall be taken and certified by the Contractor. Upon completion of the Project, the Contractor shall submit to the Engineer the measured ground resistance of each grounding system, indicating the location of the rod and grounding system as well as the resistance and soil conditions at the time the measurements were made. Ground resistance measurements shall be made in normally dry weather not less than 48 hours after rainfall and with the ground under test isolated from other grounds. Ground resistance shall also be measured from each piece of equipment to the grounding electrode. Reference Section 16060, Grounding and Bonding, for additional requirements.

D. Each lighting and power distribution panelboard shall be tested with main circuit breaker disconnected from the feeder, branches connected, branch circuit breakers closed, all fixtures in place and permanently connected, lamps removed or omitted from the fixtures, and all wall switches closed.

E. Testing (Insulation Resistance Test) of all incoming and outgoing cables for switchgears, distribution and power panels, motor control centers, and similar equipment shall be done after the cables are in place and just prior to final terminations.

F. The Contractor shall furnish all equipment and personnel as required.

G. Feeder circuits shall be tested with the feeder conductors disconnected from the supplied equipment. Each individual power circuit shall be tested at the panel or motor control center with the power equipment connected for proper operation.

H. Megohmmeter tests of the insulation resistance of rotating machines and power feeders shall be conducted. The results will be accepted when the megger shows the insulation resistance to be not less than one megohm per 100 volts at 10°C using a 1,000‑volt megger.

I. All transformers shall be Megohmmeter tested in accordance with the manufacturer's recommendations.

**1.10 DOCUMENTATION**

A. Required Documentation

The work requirements of this Section is in addition to and does not supersede testing and adjusting specified in other portions of the Contract Documents. The Contractor shall submit to the Engineer test records and reports for all testing.

**1.11 FIELD TEST OF EQUIPMENT**

A. The equipment to be tested shall include, but not be limited to, the following:

1. 400-Volt Distribution Boards.
2. Motor control centers
3. Control Panels
4. Distribution Boards
5. Conduit System
6. Cable and Wire
7. Grounding System
8. General Purpose Dry Type Transformers
9. Lighting Fixtures (Indoor and Outdoor)
10. Lightning Protection
11. Telemetry system
12. SCADA System
13. Fire Alarm System
14. Other electrical systems included in this contract.

Refer to each specific specification section for detailed field tests.

**1.12 FINAL FIELD TEST OF SYSTEM**

A. The Contractor shall complete the installation and testing of the electrical installation at least two (2) months prior to the start‑up and testing of all other equipment. During the period between the completion of electrical installation and the start‑up and testing of all other equipment, the Contractor shall make all components of the Work available as it is completed for their use in performing Preliminary and Final Field Tests.

B. Before each test commences, the Contractor shall submit a detailed test procedure, and also provide test engineer resume, manpower and scheduling information for the approval by the Engineer. In addition, the Contractor shall furnish detailed test procedures for any of his equipment required as part of the field tests of other systems.

C. The Contractor shall perform an infrared inspection to locate and correct all heating problems associated with electrical equipment. The infrared inspection shall apply to all and new equipment.

**1.13 PROTECTIVE DEVICE SETTING AND TESTING**

A. All protective devices in the electrical equipment shall be set, adjusted, calibrated and tested in accordance with the manufacturers recommendations, the coordination study, and best industry practice.

B. Proper operation of all equipment associated with the device under test and its compartment shall be verified, as well as complete resistance, continuity and polarity tests of power, protective and metering circuits. Any minor adjustments, repairs and/or celebration necessary to achieve proper operation shall be considered part of this Contract.

C. All solid state trip devices shall be checked and tested for setting and operation using manufacturers recommended test devices and procedures.

* 1. Circuit breakers and/or contactors associated with the above devices shall be tested for trip and close functions with their protective device.
  2. When completed, the Contractor shall provide a comprehensive report on all equipment tested indicating condition, readings, faults and/or deficiencies in same. Inoperative or defective equipment shall be brought immediately to the attention of the Engineer.
  3. Prior to placing any equipment in service, correct operation of all protective devices associated with this equipment shall be demonstrated by field testing under simulated load conditions.

**1.14 SCHEDULES AND PLANT OPERATIONS**

1. Since the testing required in 1.12 above shall require that certain pieces of equipment be taken out of service, all testing procedures and schedules must be submitted to the Engineer for review and approval one month prior to any work beginning. When testing has been scheduled, the Engineer must be notified forty‑eight hours prior to any work to allow time for load switching and/or alternation of equipment. In addition, all testing that requires temporary shutdown of plant equipment must be coordinated with the Employer / Engineer so as not to affect proper plant operations.
2. At the end of the workday, all equipment shall be back in place and ready for immediate use should a plant emergency arise. In addition, should an emergency condition occur during testing, at the request of the Employer, the equipment shall be placed back in service immediately and turned over to plant personnel.
3. In the event of accidental shutdown of plant equipment, the Contractor shall notify plant personnel immediately to allow for an orderly restart of affected equipment.
   1. **MATERIALS HANDLING**
4. Materials arriving on the job site shall be stored in such a manner as to keep material free of rust and dirt, and so as to keep material properly aligned and true to shape. Rusty, dirty, or misaligned material shall be rejected. Electrical conduit shall be stored to provide protection from the weather and accidental damage. Rigid non-metallic conduit shall be stored on even supports and in locations not subject to direct sunrays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. Adequate protection shall be required at all times for electrical equipment and accessories until installed and accepted. Materials damaged during shipment, storage, installation, or testing shall be replaced or repaired in a manner meeting with the approval of the Engineer.
   1. **SPARE PARTS**
   2. Mandatory Spare Parts: Provide spare parts (20% or at least 2 No.) for all systems components.
   3. Recommended Spare Parts: Provide separate list of essential for maintenance proposed spare parts which are subject to the approval of the Engineer.
   4. List all mandatory and recommended spare parts at time of tendering.

**PART 2 PRODUCTS**

**2.01 PRODUCT REQUIREMENTS**

A. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable codes and standards mentioned in item 1.06 of this specification.

B. All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated.

C. All equipment and materials shall be new, unless indicated or specified otherwise.

D. The Contractor shall submit proof if requested by the Engineer that the materials, appliances, equipment, or devices that he provides under this Contract meet the requirements of Underwriters Laboratories, Inc. BSS, IEC and all local authorities having jurisdiction, in regard to fire and casualty hazards. The label of or listing by the Underwriters Laboratories, Inc., will be accepted as conforming with this requirement.

**2.02 SUBSTITUTIONS**

1. Any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. The Contractor, in such cases may, at his option use any article, device, product, material, fixture, or item of equipment which in the judgment of the Engineer, expressed in writing, is equal to that specified.

**2.03 CONCRETE**

A. The Contractor shall furnish all concrete required for the installation of all electrical work, Concrete shall be Class A (Fair face) unless otherwise specified, and in complete conformance with the applicable requirements of Division 3 of the Specifications.

B. The Contractor shall provide concrete equipment pads for all freestanding electrical apparatus and equipment located on floors or slabs that are new or existing or provided by others. The Contractor shall provide all necessary anchor bolts, channel iron sills, etc. The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches [100mm] high unless otherwise indicated on the Drawings. Pads shall be reinforced with steel wire mesh and shall have dowel rods inserted into the floor for anchorage.

**PART 3 EXECUTION**

**3.01 CUTTING AND PATCHING**

A. Coordination

1. The work shall be coordinated between all trades to avoid delays and unnecessary cutting, channeling and drilling. Sleeves shall be placed in concrete for passage of conduit wherever possible.

B. Damage

1. The Contractor shall perform all chasing, channeling, drilling and patching necessary to the proper execution of his Contract. Any damage to the building or any equipment shall be repaired by qualified mechanics of the trades involved at the Contractor's expense. If, in the Engineer's judgment, the repair of damaged equipment would not be satisfactory, then the Contractor shall replace damaged equipment at his own expense.

**3.02 EXCAVATION AND BACKFILLING**

1. The Contractor shall perform all excavation and backfill required for the installation of all electrical work. All excavation and backfilling shall be in complete accordance with the applicable requirements of Division 2.

**3.03 CORROSION PROTECTION**

1. Wherever dissimilar metals, except conduit and conduit fittings, come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

**END OF SECTION**

# SECTION 16060

# GROUNDING AND BONDING

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

A. The Contractor shall furnish and install grounding systems complete in accordance with the minimum requirements established by IEC and Article 250 of the NEC. Article 250 of the NEC shall be considered as a minimum requirement for compliance with this Specification.

B. Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and IEEE 1100-92, Powering and Grounding of Sensitive Electronic Equipment. Conflicts shall be promptly brought to the attention of the Engineer.

1. Reference Section 16050, Basic Electrical Requirements.
2. Reference codes and standards as referred to in Section 16050.

**1.02 TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

None required.

2. Field Tests

Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.

**1.03 SUBMITTALS**

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01330, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Reports of certified field tests.

B. Each submittal shall be identified by the applicable specification section.

* 1. **SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication.

1. Drawings and written description of how the Contractor intends to furnish and install the grounding system.
   1. **APPRILCABLE CODES AND STANDARDS**

All works shall be performed and all material shall be in accordance with standards and codes referred in Section 16050.

* 1. **AS BUILT DRAWING**

Drawings and calculations how the Contractor has performed the grounding system.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

**2.02 GROUND RODS AND GRID**

A. Ground rods shall be rolled to a commercially round shape from a welded copper‑clad steel manufactured by the molten‑welding process or by the electro‑formed process (molecularly bonded). They shall have an ultimate tensile strength of 520 N/mm2 and an elastic limit of 338 N/mm2. The rods shall be not less than 3/4 inch [20-mm] in diameter by 5 feet [1500-mm] in length; and the proportion of copper shall be uniform throughout the length of the rod. The copper shall have a minimum wall thickness of 0.013 inch [0.5-mm] at any point on the rod.

B. The maximum resistance to ground of a driven ground rod shall not exceed 2-ohm under normally dry conditions. Where the resistance obtained with one (1) ground rod exceeds 2-ohm, additional ground rods shall be installed not less than 6 feet [2000-mm] on centers. Except where specifically indicated otherwise, all exposed non current‑carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductors in nonmetallic raceways and neutral conductors of wiring systems shall be grounded.

C. The ground connection shall be made at the main service equipment and made to the driven ground rods on the exterior of the building.

D. Where ground fault protection is employed, care shall be taken so that the connection of the ground and neutral does not interfere with the correct operation of the ground fault protection system.

**2.03 FITTINGS**

A. Grounding connections to equipment shall be bolted. Cable end connections may be made by use of the crucible weld process or bolted type connectors. Bolted type connectors for this application shall consist of corrosion resistant copper alloy with silicone bronze bolts, nuts and lockwashers which are designed for this purpose.

**2.04 GROUNDING CONDUCTORS**

A. A green, insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor, shall be furnished and installed for all circuits. Equipment grounding conductors shall be furnished and installed in all conduits. Use of conduits as the NEC required equipment grounding conductor is not acceptable.

**2.05 EQUIPMENT GROUNDS**

A. Equipment grounds shall be solid and continuous from a connection at earth to all distribution panelboards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Metal surfaces where grounding connections are to be made shall be clean and dry. Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.

B. Ground Grid

1. A main ground grid shall be provided for each structure and interconnecting structure grids consisting of driven ground rods. The ground rods shall be driven deep enough to obtain a ground resistance of not more than 2-ohm and shall be interconnected by the use of copper cable bus, welded to the rods by the crucible weld process. The grounding cables shall be installed after the excavations for the building have been completed and prior to the pouring of concrete for the footings, mats, etc. Copper "pigtails" shall be connected to the ground system and shall enter the buildings and structure from the outside and shall be connected to steel structures, and equipment as described in this Section and as required to provide a complete grounding system.

2. Grounding conductors shall be continuous between points of connection; splices shall not be permitted.

3. Where conductors are exposed and subject to damage from personnel, traffic, etc., conductors shall be installed in metal raceway. The raceway shall be bonded to the grounding system.

4. Connections to ground rods shall be exposed to permit maintenance and inspection for continuity and effectiveness of grounding system.

5. Where subsurface conditions do not permit use of driven ground rods to obtain proper ground resistance, rods shall be installed in a trench or plate electrodes shall be provided, as applicable and necessary to obtain proper values of resistance.

C. Raceways

1. Conduit which enters equipment such as switchgear, distribution and control equipment, distribution boards and similar equipment shall be bonded to the ground bus or ground lug, where provided, and as otherwise required by the NEC.

**END OF SECTION**

# SECTION 16061

# LIGHTNING PROTECTON SYSTEM

**PART 1 - GENERAL**

**1.01 WORK INCLUDED**

The work under this section covers supplying, installing, testing and commissioning of a complete lightning protection system as indicated on the drawings and as specified herein.

**1.02 RELATED WORKS**

A. Section 16060: Grounding and Bonding

B. Section 16050: Basic Electrical Materials and Methods

**1.03 APPLICABLE CODES AND STANDARDS**

All works shall be performed and all materials shall be in accordance with standards and codes referred to in Section 16050.

**1.04 SUBMITTALS**

As specified in Section 16050 and in accordance with Section 01300; SUBMITTALS, of these specifications.

**PART 2 – PRODUCTS**

**2.01 GENERAL**

Except as specified in this Section, refer to the applicable provisions of Section16050.

**2.02 ACCEPTABLE MANUFACTURERS OR APPROVED EQUAL**

1. Furse
2. DEHN

**2.03 MATERIALS**

Materials used in connection with the installation of the lightning protection system shall be approved for lightning protection systems by the above-mentioned standards. All materials shall be supplied from the same manufacturer.

**2.04 FABRICATION AND MANUFACTURE**

1. The system to be furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems.
2. 2.04.2Air terminals shall be approximately 16 mm by 460 mm minimum solid copper and shall extend at least 460 mm above the object to be protected. All air terminal bases shall be case bronze with stainless steel bolt pressure cable connectors. The air terminals should be spaced so as not to exceed 6 meters apart around the outside perimeter of the roof or the ridge and not over 4.5 square meters apart through the center of flat roof areas. The air terminals in the center roof area shall be approximately 16 mm by 1220 mm solid copper with a proper brace. All air terminal bases for roof areas shall be of the 4-bolted type.
3. Conductors shall consist of UL listed 37 strands of 17 gauge copper wire weighing 90 kilograms per 305 meters and installed in accordance with the UL and BS 6651 codes. Conductors on the flat roof areas may be run exposed. Ground connections shall be made to the main down conductor at a maximum of 18 meters on centers.
4. Conductor fastener shall be an approved type of non-corrosive metal, have ample strength to support conductors and shall be spaced not to exceed 1meter centers. Masonry type cable fasteners spaced every 1meter on masonry. Bolted to roof clamp type cable fasteners spaced every 1meter on flat roofs shall be used.
5. Earthing rods and inspection pits, shall be as specified in Section 16060.
6. All cable connectors shall be case bronze with screw-pressure type stainless steel bolts and nuts.

**PART 3 - EXECUTION**

3.1 The Lightning protection system shall be installed as specified in this section and as ………..indicated on the drawings.

The lightning protection system for the buildings shall consist of copper ground wire with air terminals which shall be grounded to the building structural steel or ground grid at regular intervals. The Contractor has the option of submitting alternate methods of lightning protection for consideration in his Proposal, provided that the offer should be equal or greater degree of protection than those specified.

3.2 A. All materials shall be installed by experienced workmen that specialized in this type of work. The lightning protection system shall be installed per approved shop drawings.

B. The structural steel columns if available on the outside perimeter of the building may be utilized as the main down conductor from roof to ground for the lightning protection system. No other parts of the steel structure will be accepted to substitute for lightning conductors. The steel columns if available around the outside perimeter of the building shall be grounded at every other column and in no case shall average distance over 18 meters apart. Where the steel columns are used, a connection to the top of each steel column shall be made through the roof and connected to the roof conductor. A thru the roof connector shall be installed where a conductor penetrates the roof, by the lightning protection contractor. The thru the roof connector shall be 12 mm stainless steel threaded rod equipped with the necessary lead or neoprene washers and stainless nuts for a watertight seal. Also, copper pitch pans shall be furnished under this Section and installed by the roofing contractor.

C. For buildings that are of reinforced concrete or are wall bearing structures, down conductors shall be installed. Down conductors shall be fixed by copper clamp to the wall at 1m distances. Each perimeter roof cable shall be connected to at least 2 down leads. The average distance between down leads shall not exceed 30 meters from roof to ground connections. Irregularly shaped structures may require extra down conductors to provide a two way path to ground for each air terminal.

D. All concealed conductors shall be installed in PVC conduit.

E. All metal bodies within 2 meters of the conductor shall be bonded to the system with approved fittings and conductor. Connections between dissimilar metals shall be made with approved bimetallic connections.

3.2 All the required fixings, clamps, bonds, connectors and fittings for complete installation shall be provided by the Contractor.

Salient points of the structure shall be incorporated in the Air Termination Network.

3.3 All metallic projections, chimneys, ducts, vent pipes, railings, gutters, etc., on or above the main surface of the roof of the structure should be bonded, to, and form part of the Air Termination Network.

3.4 The Down Conductors shall be provided with a test clamp at a height of 2.4 m from the finished ground level and the Down Conductors shall be connected to the earthing rods directly driven into the ground inside inspection pits.

**END OF SECTION**

# SECTION 16075

# ELECTRICAL - IDENTIFICATION

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

A. All electrical equipment shall be properly identified in accordance with these Specifications and the Contract Drawings. All switchgear, switchboards, motor control centers, variable frequency drives, lighting and distribution panelboards, combination starters, control panels, pull/junction boxes, enclosures, disconnect switches, control stations, and similar equipment shall be identified in the manner described, or in an equally approved manner.

B. The types of electrical identification specified in this section include, but are not limited to, the following:

1. Exposed conduit color banding.

2. Operational instructions and warnings.

3. Danger signs.

4. Equipment/system identification signs.

1. Nameplates.

C. Reference codes and standards as referred to in Seciton 16050.

**1.02 SIGNS**

1. "DANGER‑HIGH‑VOLTAGE" signs shall be securely mounted on the entry doors of all electrical rooms.
2. Signs shall be both in Arabic and English Language.

**1.03 LETTERING AND GRAPHICS**

1. The Contractor shall coordinate names, abbreviations, and other designations used in the electrical identification work with the corresponding designations shown, specified or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment.

**1.04 SUBMITTALS**

1. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.
2. Submit materials compliance sheets with the specifications.

**1.05 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to equipment specifications and product data sheets identifying all materials used and methods of fabrication.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The material covered by these Specifications is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

**2.02 NAMEPLATES**

A. Nameplates shall be engraved, high pressure plastic laminate, white surface with black lettering.

**2.03 HIGH VOLTAGE SIGNS**

A. Standard "DANGER" signs shall be of baked enamel finish on 20 gage steel; of standard red, black and white graphics; 14 inches [350-mm] by 10 inches [250-mm] size except where 10 inches [250-mm] by 7 inches [170-mm] is the largest size which can be applied where needed, and except where a larger size is needed for adequate vision.

**2.04 CONDUIT MARKERS**

A. Conduit markers shall be bronze metal tag 1/2 inch [15-mm] in diameter, with 1/8 inch   
[3-mm] hole, with copper wire through hole and attached to conduit by twisting ends of wire. Lettering shall indicate conduit numbers.

**PART 3 EXECUTION**

**3.01 NAMEPLATES**

1. Nameplates shall be attached to the equipment enclosures with (2) two stainless steel sheet metal screws for nameplates up to 2-inches [50-mm] wide. For nameplates over 2-inches [50-mm] wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. The utilization of adhesives is not permitted.

**3.02 CONDUIT IDENTIFICATION**

A. Where electrical conduit is exposed in spaces with exposed mechanical piping which is identified by a color‑coded method, apply color‑coded identification on the electrical conduit in a manner similar to the piping identification. Except as otherwise indicated, use orange as the coded color for conduit marker backgrounds. Conduit identification shall be made after the conduit has been painted.

**3.03 OPERATIONAL IDENTIFICATION AND WARNINGS**

A. Wherever reasonably required to ensure safe and efficient operation and maintenance of the electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install plastic signs or similar equivalent identification, instruction, or warnings on switches, outlets, and other controls, devices, and covers or electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes. Signs shall be attached as specified above for nameplates.

**END OF SECTION**

# SECTION 16111

# CONDUITS

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

A. Under this Section, the Contractor shall furnish and install all conduits and conduit fittings to complete the installation of all electrically operated equipment as specified herein and as required.

B. The Drawings indicate the general location of conduits both exposed and concealed; however, the Contractor shall install these conduits in such a manner to avoid all interferences.

1. Reference Section 16050, Basic Electrical Requirements.
2. Reference codes and standards as referred to in Section 16050.

**1.02 TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed shop tests

Not required.

2. Field tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.

b. All conduit shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of suitable pulling tape.

**1.03 SUBMITTALS**

1. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification section.
2. Submit materials compliance sheets with the specifications.

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to equipment specifications and product data sheets identifying all materials used and methods of fabrication.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

**2.02 CONDUITS**

A. Concealed conduits shall be heavy gauge rigid PVC conduits of minimum. diameter 20mm. All exposed conduits shall be heavy gauge galvanized steel conduits, minimum diameter 20mm, 40% space factor (i.e area of conductors to taotal area of the conduit).

Reference the "Conduit Uses" portion of this specification for additional information regarding conduit.

B. Rigid Steel Conduit

1. Steel conduits shall be rigid type, hot-dipped galvanized inside and outside and as manufactured by Allied Tube and Conduit Corporation, Wheatland Tube Company, Jones & Laughling Steel Company, or equal.

1. Each length of conduit shall be shipped with a coupling on one end and a color coded thread protector at the other end.

C. Flexible Metal Conduit

1. Flexible metal conduit (FMC) shall be galvanized steel, single strip. FMC shall be used to connect all indoor vibrating equipment, installed in dry locations, above reflected ceilings to lighting fixtures, and other applications as accepted by the Engineer. FMC shall be as manufactured by Electri-Flex, Alflex Corporation, Anaconda or equal.

D. Liquid‑Tight Flexible Metal Conduit

1. Liquid‑tight flexible conduit (LFMC) shall be galvanized steel, single strip, with a copper strip interwoven and suitable as a grounding means. LFMC shall have an extruded moisture and oil-proof PVC jacket. LFMC shall be Type "LA" as manufactured by Electri-Flex, Type "Ultralite" as manufactured by Alflex Corporation, Type "A" as manufactured by Anaconda, or equal.

2. Watertight connectors shall be used with liquid‑tight flexible metal conduit on both ends. LFMC shall be used to connect all vibrating equipment installed outdoors, in wet or damp areas, and other applications as directed by the Engineer.

E. Rigid Nonmetallic Conduit

1. Rigid nonmetallic conduit shall be polyvinyl chloride (PVC), 90oC, and shall conform to NEMA TC‑2. Fittings and conduit bodies shall conform to NEMA TC3.

2. Rigid non-metallic conduit shall be as manufactured by Carlon, Triangle Conduit and Cable, Cantex, Inc., or equal.

F. PVC Coated Metallic Conduit

1. PVC coated rigid steel conduit shall be furnished and installed as specified herein and indicated on the Drawings. The product shall be rigid galvanized steel conduit covered with a bonded 40 mil (minimum) thickness PVC jacket and coated inside with urethane. The conduit shall comply with NEMA RN-1 and shall be "Plasti-Bond Red" as manufactured by Robroy Industries, "OCAL-Blue" as manufactured by Ocal, Inc., Perma-Cote Supreme by Perma-Cote Industries, or equal.

G. Intermediate Metal Conduit

1. Intermediate metal conduit (IMC) shall be galvanized. Installation of intermediate metal conduit shall be in accordance with Article 345 of the National Electrical Code and UL General Information Card #DYBY. IMC shall be installed only where specified herein or indicated on the Drawings.

H. Electrical Metallic Tubing

1. Electrical metallic tubing shall meet ANSI C80.3 and shall be UL listed. The conduit shall be furnished and installed in accordance with Article 348 of the NEC. Electrical metallic tubing shall be manufactured by LTV Steel Tubular Products Company, "Electrunite", Triangular PWC, Inc., Allied Tube and Conduit Corporation or equal.

2. The conduit shall be cold‑rolled steel tubing with a zinc coating on the outside and protected on the inside by a zinc, enamel, or equivalent corrosion‑resistant coating and conforming to the requirements of ANSI C 80.3, latest edition.

I. Conduit Fittings

1. Fittings for rigid metal conduit, rigid nonmetallic conduit, flexible metal conduit, liquid-tight flexible metal conduit, and electrical metallic tubing shall conform to UL 467 and UL 514 as applicable.

2. Fittings for electrical metallic tubing shall be rain-tight and concrete-tight, conform to UL 467 and UL 514, as applicable, and shall be plated steel hexagonal threaded compression type.

3. Set screw or indenture type connectors shall not be used. Fittings for conduit installed in wet locations and underground shall provide a watertight joint. Fittings for rigid conduit shall be threaded.

4. Fittings or bushings shall be installed in easily accessible locations.

5. Where conduits pass through expansion joints, approved weatherproof telescopic type expansion fittings shall be used. Fittings shall be OZ/GEDNEY Type AX, or equal, watertight and permit a movement up to 4 inches (100mm) and shall be equipped with approved bonding jumpers around or through each fitting. Bonding jumpers shall be Appleton, Crouse‑Hinds, OZ/Gedney, or equal.

6. Conduit fittings ("condulets") shall be used on exposed conduit work for lighting and power outlets, convenience outlets, changes in direction of conduit runs and breaking around beams. "Condulets" shall be cast ferrous alloy, galvanized or cadmium plated, as manufactured by Crouse‑Hinds, OZ/Gedney, Appleton Company, or equal. Epoxy coated fittings and boxes shall be used with coated conduit in all chemically aggressive areas or where called for on the Drawings. Covers shall be of a design suitable for the purpose intended. In damp areas, the outside condulets shall be made watertight. Install all condulets with the covers accessible. Use proper tools to assemble conduit system to prevent injury to the plastic covering. No damage to the covering shall be permitted.

7. Conduit fittings shall be cast type of non‑ferrous metal or malleable iron thoroughly coated inside and outside with metallic zinc or cadmium after all machining has been completed. Cast fittings shall be provided with heavy threaded hubs to fit the conduit required. Covers shall be of the same material as the fittings to which they are attached and shall be screwed on with rubber or neoprene gaskets between the covers and fittings. Cast fittings 1‑1/2 inches [38mm] and above shall be of the "mogul" type. Where cast fittings are used to house wiring devices such as receptacles and switches, they shall be of the "deep" type.

**PART 3 EXECUTION**

**3.01 CONDUIT AND FITTINGS**

A. Unless otherwise specified herein or indicated on the Drawings, the minimum size conduit shall be 3/4 inch [20mm] for concealed and exposed work.

B. Conduit home runs for some lighting circuits are not necessarily indicated on the Drawings; however, the circuit numbers are shown. Conduit shall be furnished and installed for these lighting circuits and shall be installed as required to suit field conditions, subject to review and acceptance by the Engineer.

C. Conduit shall be installed concealed unless otherwise indicated or specified. Conduit may be run exposed on walls only where concealing is not practical, or at the direction of the Engineer.

D. Where exposed, maintain a minimum distance of 6 inches [150mm] from parallel runs of flues or water pipes. Conduit runs shall be installed in such locations as to avoid steam or hot water pipes. A minimum separation of 12 inches [300mm] shall be maintained where conduit crosses or parallels hot water or steam pipes.

E. For floor mounted equipment, conduit may be run overhead and dropped down, where underfloor installation is not practical. Groups of conduits shall be uniformly spaced, where straight and at turns. Conduit shall be cut with a hacksaw or an approved conduit‑cutting machine and reamed after threading to remove all burrs. Securely fasten conduit to outlets, junction and pull boxes to effect firm electrical contact. Join conduit with approved couplings. Conduits shall be freed from all obstructions.

F. Empty conduit systems shall be furnished and installed as indicated on the Drawings and shall have pull wires installed. The pull wire shall be No. 14 AWG (2.5mm2) zinc‑coated steel, or of plastic material, having not less than 200 pound [90Kg] tensile strength. Not less than 12 inches [300mm] of slack shall be left at each end of the pull wire.

G. Each piece of conduit installed shall be free from blisters or other defects. Each piece installed shall be cut square, taper reamed, and a coat of sealing compound applied to threads. Threads on conduits shall be painted with a conducting compound prior to making up in a fitting. Conduit connections shall be made with standard coupling and the ends of the conduit shall butt tightly into the couplings. In exposed work only, where standard coupling cannot be used, only Erickson couplings are permitted, or as otherwise acceptable to the Engineer.

H. Conduit threaded in the field shall be of standard sizes and lengths.

I. All bends shall be made with standard factory conduit elbows or field bent elbows. Field bending of conduit shall be done using tools approved for the purpose. Heating of conduit to facilitate bending is prohibited. Field bends shall be not less than the same radius than a standard factory conduit elbow. Bends with kinks shall not be acceptable.

The equivalent number of 90º bends in a single conduit run are limited to the following:

1. Runs in excess of 300 feet [90 meters]: 0

2. Runs of 300 feet to 201 feet [90 meters to 60 meters]: 1

3. Runs of 200 feet to 101 feet [60 meters to 30 meters]: 2

4. Runs of 100 feet and less [30 meters and less]: 3

J. Unless otherwise specified herein, indicated on the Drawings, or required by the NEC, conduit shall be supported every 6 feet [1800 mm] and shall be installed parallel with or perpendicular to walls, structural members, or intersections of vertical planes and ceilings with right angle turns consisting of fittings or symmetrical bends. Conduits shall be supported within 1 foot [300mm] of all changes in direction. Supports shall be approved pipe straps, wall brackets, hangers or ceiling trapeze. Perforated strap hangers shall not be used. In no case shall conduit be supported or fastened to another pipe or installed to prevent the removal of other pipe for repairs. Fastenings shall be by expansion bolts on concrete; by machine screws, welded threaded studs, or spring‑tension clamps on steel work. Explosive‑drive equipment may be used to make connections where the use of this equipment complies with safety regulations. Wooden plugs inserted in masonry and the use of nails as fastening media are prohibited. Threaded C‑clamps may be used on rigid steel conduit only. Conduits or pipe straps shall not be welded to steel.

K. The load applied to fasteners shall not exceed 1/4 of the proof test load. Fasteners attached to concrete ceilings shall be vibration and shock resistant. Holes cut to a depth of more than 1‑1/2 inches [40mm] in reinforced concrete beams or to a depth of more than 3/4 inch [20mm] in concrete joints shall not cut the main reinforcing bars. Holes not used shall be filled. Spring steel fasteners may only be used to support lighting branch circuit conduits to structural steel members. Conduits shall be fastened to all sheet metal boxes and cabinets with two (2) locknuts where required to insure adequate bonding for grounding. Where insulated bushings are used, or where bushings cannot be secured firmly to the box or enclosure, a bonding jumper shall be installed to maintain suitable grounding continuity. Locknuts shall be the type with sharp edges for digging into the wall of metal enclosures. Bushings shall be installed on the ends of all conduits and shall be of the insulating type .

L. Conduit installed in concrete floor slabs or walls shall be located so as not to affect the designed structural strength of the slabs. Conduit shall be installed within the middle one‑third of the concrete slab except where necessary to not disturb the reinforcement. The outside diameter of conduit shall not exceed one‑third of the slab thickness, and conduits shall be spaced no closer than three (3) diameters except at cabinet locations. Curved portions of bends shall not be visible above the finish slab. Where embedded conduits cross expansion joints, suitable watertight expansion fittings and bonding jumpers shall be provided. Conduit larger than 1‑inch [25mm)]trade size shall be parallel with or at right angles to the main reinforcement. When at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Conduits shall not be stacked more than two (2) diameters high in floor slabs.

M. Install polyvinyl chloride (PVC) coated steel conduits when entering or exiting concrete except under electrical equipment where the conduit is not subject to physical abuse. Extend stub-ups at least 12 inches [300mm] above and below grade or finish floor. Conduits extending through the concrete floor shall be installed using straight runs (for vertical penetrations) or factory elbows (for conduits installed within the slab) of PVC coated rigid steel conduit.

N. All conduit extending through the floor behind panels or into control centers or similar equipment may be PVC Schedule 40 and shall extend a minimum of 6 inches [150mm] above the floor elevations, where practicable, with no couplings at floor elevations.

O. Unless specifically identified on the Drawings as "Direct Buried," all conduits in the earth outside of the structure shall be concrete encased. Joints in conduit shall be staggered so as not to occur side by side. Rigid non-metallic (PVC) conduit shall be connected to PVC coated rigid steel conduit at the point where it leaves the ground, with the transition to metal conduit occurring inside the concrete encasement.

P. No more than three (3) 90 degree bends will be allowed in any one conduit run. Where more bends are necessary, a condulet or pull box shall be installed. All bends in 3/4‑inch [20mm] conduit shall be made with a conduit bender, and all larger sizes shall have machine bends. Joints in threaded conduit shall be made up watertight with the appropriate pipe thread sealant or compound applied to male threads only; and, all field joints shall be cut square, reamed smooth, and properly threaded to receive couplings. No running threads are permitted. All conduit ends at switch and outlet boxes shall be fitted with an approved locknut and bushing forming an approved tight bond with box when screwed up tightly in place.

Q. Conduits stubbed up through concrete floors for connections to freestanding equipment and for future equipment shall be provided with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Wiring shall be extended in rigid metal conduit to equipment except that, where required, flexible metal conduit may be used 6 inches above the floor. Screwdriver operated threaded flush plugs shall be installed in conduits from which no equipment connections are made.

R. Where outlets are shown near identified equipment furnished by this or other Contractors, it is the intent of the Specifications and Drawings that the outlet be located at the equipment to be served. The Contractor shall coordinate the location of these outlets to be near the final location of the equipment served whether placed correctly or incorrectly on the Drawings. Changes in outlet locations required to serve the equipment furnished by other Contractors on the Project shall be brought to the attention of the Engineer.

S. Conduit shall be protected immediately after installation by installing flat non‑corrosive metallic discs and steel bushings, designed for this purpose, at each end. Discs shall not be removed until it is necessary to clean the conduit and install the conductors. Before the conductors are installed, insulated bushings shall be installed at each end of the conduit.

T. Where "all-thread" nipples are used between fittings and electrical equipment, they shall be so installed that no threads are exposed.

U. Connections from rigid conduit to motors and other vibrating equipment, limit switches, solenoid valves, level controls, and similar equipment, shall be made with short lengths of liquid‑tight flexible metal conduit. These conduits shall be installed in accordance with the NEC and shall be furnished and installed with appropriate connectors with devices which will provide an excellent electrical connection between the equipment and the rigid conduit for the flow of ground current. Flexible metal conduit and liquid-tight flexible metal conduit length shall be five feet [1500mm], maximum.

V. Flexible metal conduit or liquid-tight flexible metal conduit installed between rigid metal conduit and motor terminal box and/or any other apparatus shall have a green insulated grounding conductor running through flexible conduit. This conductor shall be terminated to the nearest pull box, motor terminal box, or any other apparatus ground terminal.

W. All threaded ends of conduits shall be coated with an approved conducting compound.

X. Conduits installed within or underneath floor slabs, underground direct-buried or concrete encased conduits, and all conduits installed in areas subject to liquid inadvertently entering the conduit system shall be sealed or plugged at both ends in accordance with NEC Article 300-5(g). This requirement applies to both conduits containing conductors and "spare" conduits. Where practicable, the interior of the conduit shall be sealed as well as around the conductors by using conduit sealing bushings. Where the conduit fill does not allow the use of these bushings, the conduits shall be tightly caulked or plugged.

Conduits passing through sleeves in interior walls and floors shall be tightly caulked.

Y. Weatherproof, insulated throat "Meyers" hubs shall be used on all conduit entries to boxes and devices without integral hubs in process areas to maintain NEMA 4X integrity. The Contractor shall furnish and install "Meyers" hubs on all conduit entries into non-cast enclosures such as metallic or non-metallic control panels, control component enclosures, wireways, pull boxes, junction boxes, control stations, and similar type equipment when this type of equipment is located in process areas requiring NEMA 4X integrity. This specified requirement for "Meyers" hubs does not apply to any area of the plant facilities where NEMA 4X integrity is not required.

Z. The use of two (2) locknuts and a grounding bushing shall be required at all conduit terminations where hub type fittings are not required; such as electrical rooms, control rooms, and office areas.

AA. Conduit installation shall be arranged to minimize cleaning. No horizontal runs of conduit will be permitted in brick or masonry walls.

AB. Install non-metallic conduits in accordance with manufacturer's instructions where specified herein or indicated on the Drawings.

AC. Join non-metallic conduit using cement as recommended by the manufacturer. Clean and wipe non-metallic conduit dry before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for twenty (20) minutes (minimum).

AD. Painting shall be as specified in Section 09900, Painting.

AE. The Contractor shall furnish and install conduit entering or leaving NEC Article 500 hazardous areas with conduit seals. The Contractor shall also install conduit entering or leaving chlorination facilities, or areas of buildings in which chlorine storage or distribution equipment is located with conduit seals. All exposed conduits and trunking in any chlorine rooms (for equipments or / storage) shall only be of UPVC or PVC material according to Engineer approval. The Contractor shall furnish and install conduit seals in other hazardous locations as required by the NEC.

**3.02 CONDUIT USES AND APPLICATIONS**

A. No PVC conduit shall be installed exposed

B. uPVC Schedule 40 conduit shall be installed in reinforced concrete encasement if subject to vehicular traffic and in non-reinforced concrete encasement if not subject to vehicular traffic. Conduit shall be "direct buried" only if specifically indicated on the Drawings.

C. uPVC Schedule 40 conduit shall be furnished and installed in concrete slabs (for slab-on-grade construction) and in walls when the conduit is shown to be encased.

D. All instrumentation wire and cable for analog signals shall be installed in rigid steel conduit or PVC coated rigid steel conduit to suit the application. This applies to all conduit installations including exposed, concealed in concrete encasement, and all other applications.

E. PVC coated rigid steel conduit shall be furnished and installed, where exposed, in the Chlorination Rooms

**END OF SECTION**

# SECTION 16114

# CABLE TRAYS

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

A. Under this Section, the Contractor shall furnish and install all cable tray systems as specified herein and as indicated on the Drawings. The tray systems shall be furnished and installed complete for installation of power and control cables and instrumentation cables.

B. The Drawings indicate the general location of the trays, however, the Contractor shall install these trays in such a manner to avoid all interferences.

C. The cable tray systems shall be manufactured and installed in accordance with the following:

1. National Electrical Manufacturers Association (NEMA) Standard VE-1 - Metallic Cable Tray Systems

1. National Electrical Code (NEC), Article 318 - Cable Trays
2. Standards and codes referred to in Section 16050.

D. Reference Section 16050, Basic Electrical Requirements.

**1.02 TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed shop tests

Not required.

2. Field tests

1. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.
2. All trays shall be tested to ensure mechanical and electrical continuity and the absence of obstructions.

**1.03 SUBMITTALS**

* 1. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification section.
  2. Submit materials compliance sheets with the specifications.

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets for trays, fittings, supports, and other components identifying all materials used and methods of fabrication.

2. Layout drawings showing plan and isometric views of each tray system. Drawings shall indicate tray dimensions, support points, and other pertinent layout information.

3. Manufacturer's instructions indicating application conditions and limitations of use stipulated by the specified testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of the tray systems.

**1.05 SYSTEM DESCRIPTION**

A. Cable tray systems shall include straight trays, fittings, covers, splices, barrier strips, and related accessory and support items.

1. Power and control circuit cable tray systems shall be for support of AC power and control circuit cable.

B. Performance requirements for power and control circuit tray systems shall be as follows:

1. Concentrated load supporting capacity shall be a minimum of 200 pound [100Kg] concentrated load applied to the middle 6 inches without permanent deformation.

2. Uniform load supporting capacity shall be 50 pounds [25Kg] per linear foot when supported at minimum 20 feet [6000-mm] on center with a safety factor of 1.5.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

B Metallic cable tray systems shall be as manufactured by B-Line Systems, Inc., Square D Company, or equal.

**2.02 MATERIALS**

A. The cable tray systems shall be heavy gauge, galvanized sheet steel (1.25mm thick minimum)

**2.03 COMPONENTS**

1. Barrier strips shall be full depth capable of separating cables in tray as required by NEC.
2. Covers shall be solid, flanged U shape, aluminum with 1/2 inch [10-mm] spacers for ventilation.
3. The cable tray shall have U shape with 1 cm bond on both edges to inside of the tray to fix the cover on it.
4. Fittings shall be horizontal and vertical elbows, tees, and cross fittings with minimum radii equal to cable bending radii as recommended by cable manufacturer.
5. Accessories shall include dropouts, end plates, splice plates and mounting supports, clamps and other devices required for a complete installation.
6. Tray bolts, nuts, washers, and fasteners shall be Type 304 or 316 stainless steel.
7. Grounding conductor, to be furnished and installed to the outside tray bottom flange, shall be No. 2/0 [70-mm2] bare copper.
8. Lashing ties shall be manufacturer's standard plastic type.
9. The covers shall be fixed on the tray at 1m intervals.
10. The tray and the cover shall be circularly shaped from inside and outsided of the tray on every outside corner of any building.
11. All trays and covers shall be sloted in rows to keep ventilation to the Engineer approval.

**2.04 TRAY TYPES**

A. Power and control circuit cable trays shall be NEMA Class 20A, ladder type with:

1. Double or box type rungs, free of sharp edges and corners, at minimum 9 inches [225mm] on center as required to provide adequate cable bearing surface.

2. Sides of minimum 2.5 inch [60mm] interior cable loading depth.

B. Instrumentation tray shall be NEMA Class 12C, corrugated solid bottom type with:

1. Sides of minimum 2.5 inch [60mm] interior cable loading depth.

2. Drainage holes one quarter (1/4) inch [5-mm] diameter spaced at 5 foot [1500-mm] on center, ground smooth and completed prior to cable installation.

**2.05 FABRICATION**

A. Fabricate fiberglass components in accordance with manufacturer's standard practice.

B. Seal trays ends with sealant to pronibit injuries.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Install the cable tray systems in accordance with NEMA Standards VE-1 and FG-1, the National Electrical Code (NEC), and the manufacturer's instructions.

B. Cantilever tray systems from walls or, when conditions dictate, suspend trays from ceilings. Space support brackets at maximum 5 foot [1500-mm] on center. Provide tray supports with channels under entire width of tray.

C. Install trays 2 inches [50mm] from wall surfaces, and with a minimum of 12 inches [300mm] clearance between cover and obstruction above, and a minimum (12) (18) inches [(300) (450) mm] between tray bottoms vertically.

D. Secure tray to supports with fittings approved for the purpose in accordance with tray manufacturer. Do not weld trays to supports. Where aluminum trays ( if applicable ) are supported on steel supports, separate and isolate aluminum and steel in accordance with Section 16070 – Electrical Hangars and Supports.

E. Install expansion joints at a minimum 50 feet [15m] on center of straight runs, or as recommended by tray manufacturer.

F. Securely bond to metallic tray a grounding conductor with lugs to outside the tray bottom flange. Run grounding conductor continuously for the full length of tray system. Attach grounding conductor to the facility grounding system. Verify continuity of the bond by a resistance test.

G. Where applicable, thermoweld the incoming ductbank grounding conductor(s) to the cable tray grounding conductor described above.

H. Group cables in trays by circuit type. Lash grouped cables with lashing ties at approximately 36 inches [900mm] on center for vertical runs and at approximately 10 feet [3000mm] on center for horizontal runs. Put sharp ends of lashing ties under cable tray runs or where ties will not damage the cable jacket or insulation. Label the cable groups to identify the circuit or cable group by plan designation.

I. Install tray covers in exterior locations, under stairs and gratings.

1. Use an anti-oxidant compound to prepare aluminum contact surfaces before assembly.

**3.02 CLEANING**

A. After installation, clean and touch up with paint cuts, scratches, or other damage to match color of trays in accordance with the manufacturer's instructions.

* 1. **PROTECTION**

A. Protect the tray systems until accepted by Owner.

**3.04 WARNING LABELS**

A. Furnish and install warning labels both in Arabic and English Languages with black letters on a yellow background which reads as follows:

WARNING! DO NOT USE CABLE TRAY AS A WALKWAY, LADDER, OR SUPPORT. USE ONLY AS A MECHANICAL SUPPORT FOR CABLES!

B. Install warning labels at 25 feet [7500mm] intervals along the length of the tray system, located to be visible.

**END OF SECTION**

# SECTION 16120

# WIRES AND CABLES

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

A. The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition, ready for service, all cables and wires indicated on the Drawings and as specified herein or required for proper operation of the installation, with the exception of internal wiring provided by electrical equipment manufacturers. The work of connecting cables to equipment, machinery, and devices shall be considered a part of this Section. All hardware, junction boxes, bolts, clamps, insulators, and fittings required for the installation of cable and wire systems shall be furnished and installed by the Contractor.

B. The Contractor shall submit Shop Drawings and other material required to substantiate conformance with the requirements set forth on the Drawings and in Section 16050, Basic Electrical Requirements, and Section 01300, Submittals. Shop drawings shall include, but not be limited to, detailed specifications and product data sheets for the power, control, and instrumentation cable required for this project.

C. The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum of ten (10) years.

1. Reference Section 16050, Basic Electrical Requirements.
2. Reference codes and standards as referred to in Section 16050.

**1.02 TESTING**

1. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witness Shop Tests

Not required.

1. Shop Test
2. Prior to the first shipment of each size of power, control, and instrumentation cable to be furnished and installed under this Contract, samples of each size of cable shall be subjected to complete physical and electrical factory production tests at the manufacturer's plant. Other cable and wiring shall be tested in accordance with the applicable ICEA Standards. Six copies of certified test data sheets shall be submitted to the Engineer for approval prior to installation at the site. Subsequent shipment of each size of wire shall be covered by certificates of compliance which shall list Contractor's name, point of delivery, reel numbers, size of wire, length of wire, and date of shipment. Certificates shall attest the wires and cables comply with specification requirements and that wires and cables are equal in every respect to wires and cables which have been successfully tested.
3. All test data or certificates shall be submitted.
4. 3rd Part Tests:

All power cables (of cross sections of 25mm2 / core and above) and all multi core/ wire control cable (control, telemetry, indication, SCADA, signals, Fiberoptic cables … etc) shall be tested success fully according to the international or local standards and to the Tender Specifications (if there is) by which the cable is manufactured. Otherwise the cable shall be rejected.

1. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.

b. After installation, all wires and cables shall be tested for insulation levels and continuity. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:

1. For 600V power and control cable, apply 1,000 VDC from a Megaohmeter for all 600V wires and cables installed in lighting, control, power, indication, alarm and motor feeder circuits. Testing for continuity shall be "test light" or "buzzer".

2. 600V instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter, or approved equal. The resistance value shall be 200 Megaohms or greater.

1. Low voltage wires and cables shall be tested before being connected to motors, devices or terminal blocks.
2. Voltage tests shall be made successively between each conductor of a circuit and all other conductors of the circuit grounded.
3. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner.
4. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment.

**1.03 SUBMITTALS**

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the wire and cable manufacturer and submit the following:

1. Shop Drawings

2. Reports of Certified Shop and Field Tests

3. Wiring Identification Methods

1. Each submittal shall be identified by the applicable specification section.
2. Submit materials compliance sheets with the specifications

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed material's compliance with the Contract Documents.

B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Material specifications and product data sheets identifying all materials used and methods of fabrication.

2. Cable pulling calculations.

3. Wiring identification methods and materials.

**1.05 IDENTIFICATION**

A. Each cable shall be identified as specified in Part 3, Execution, of this Specification.

**1.06 CABLE PULLING LUBRICANTS**

A. The Contractor shall submit a list with a minimum of four manufacturers standard lubricants for pulling used interchangeably for each type of lubricant required. Lubricant shall be non-hardening type.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

1. The wire and cable covered by this Specification is intended to be standard equipment of proven performance as manufactured by the Okonite Company, BICC Industrial Cable Company (Cablec), Southwire Company, or equal. Wire and cable shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings. Only one manufacturer for each wire and cable type shall be permitted.

**2.02 600 VOLT POWER WIRE AND CABLE**

A. 600 volt cable and wire shall consist of stranded, copper conductor with insulation rated THHN(Heat Resistant Thermoplastic), 90ºC for dry locations and THWN(Moisture and Heat Resistant Thermoplastic), 75ºC for wet locations.

B. Conductors shall be tin or alloy coated (if available), stranded copper per ASTM-B8, B-33 and B-189, Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be No. 14 AWG.

C. Uncoated conductors shall only be allowed if specifically accepted by the Engineer.

D. 600 volt individual power wire and cable shall be Okoseal-N as manufactured by the Okonite Company, BICC Industrial, local Cable Companies, Southwire Company, or equal. Multi-conductor power cables shall be Okoseal-N Type TC Cable as manufactured by the Okonite Company, BICC Industrial Cable Company (Cablec) equivalent, Southwire Company equivalent, local cable companies or equal.

**2.03 600 VOLT CONTROL CABLE**

A. 600 volt control cable shall consist of stranded, copper conductor with insulation rated THHN, 90ºC for dry locations and THWN, 75ºC for wet locations. The individual conductors of the multiple conductor cable shall be color coded for proper identification. Color coding shall be equal to ICEA S-68-514, Table K-1. Cables shall meet requirements of IEEE-383.

B. Conductors shall be tin or alloy coated (if available) stranded copper per ASTM B-8 and B‑33 or B-189, Class B or C stranding contingent on the size unless otherwise specified. Minimum wire size shall be No. 14 AWG.

C. Uncoated conductors shall only be allowed if specifically accepted by the Engineer.

D. 600 volt individual conductor control wire shall be Okoseal-N as manufactured by the Okonite Company, BICC Industrial Cable Company (Cablec) equivalent, Southwire Company equivalent, or equal. Multi-conductor control cable shall be Okoseal-N Type TC Cable as manufactured by the Okonite Company, BICC Industrial Cable Company (Cablec) equivalent, Southwire Company equivalent, or equal.

**2.04 LIGHTING AND RECEPTACLE WIRE AND CABLE**

A. The lighting and receptacle branch circuit wire shall consist of stranded, copper conductors with insulation rated THHN, 90ºC for dry locations and THWN, 75ºC for wet locations.

B. Conductors shall be tin or alloy coated (if available), stranded copper per ASTM-B8, B-33 and B-189, Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be No. 14 AWG.

C. Uncoated conductors shall only be allowed if specifically accepted by the Engineer.

D. Lighting and receptacle cables and wire shall be Okoseal-N as manufactured by the Okonite Company, BICC Industrial Cable Company (Cablec) equivalent, Southwire Company equivalent, or equal.

**2.05 INSTRUMENTATION CABLE**

A. The instrumentation cable for analog signals shall be single, shielded, twisted pairs or triads with 600 volt insulation and shall have a 90ºC insulation rating.

B. Conductors shall be tin or alloy coated (if available), soft, annealed copper, stranded per ASTM-B8, Class B stranding unless otherwise specified. Minimum size wire shall be No. 16 AWG.

C. The instrumentation cable shall be Okoseal-N Type P-OS for single pair or triad applications and Okoseal-N Type SP-OS for multiple pair or triad applications as manufactured by the Okonite Company, Belden equivalent, Southwire Company equivalent, or equal.

**PART 3 EXECUTION**

**3.01 600V CABLE INSTALLATION**

A. The cable and wires shall be installed as specified herein and shown on the Drawings.

B. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.

C. To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections.

D. Splices shall not be allowed in the underground duct, manhole and handhole systems. If splices are required, the Contractor shall obtain approval in writing from the Engineer prior to splicing. Splicing material shall be 3M cold shrink insulator PST or equal. No "Butt-Splicing" of AC or DC circuit control conductors or instrumentation cable shall be allowed.

E. Wire and Cable Sizes

1. The sizes of wire and cable shall be as shown on the Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be increased so that the voltage drop does not exceed 2.5%.

1. Minimum wire size within control panels, distribution and control centers, switchboards and similar equipment shall be No. 13 AWG [2.5-mm2] for power and No. 15 AWG [2.5-mm2] for control.

F. Number of Wires

* 1. The number of wires indicated on the Drawings for the various control, indication, and metering circuits were determined for general schemes of control and for particular indication and metering systems.

Every control cable of multi wires (of all kinds) shall have 20% extra Nos. of wires as a spare (3 wires minimum as approved by the Engineer).

* 1. The actual number of wires installed for each circuit shall, in no case, be less than the number required; however, the Contractor shall add as many wires as may be required for control and indication of the actual equipment selected for installation at no additional cost to the Owner. The addition of conductors shall be coordinated with and approved by the Engineer to avoid violations of the NEC regarding conduit fill.
  2. All spare field conductors shall be terminated on the terminal blocks mounted within the equipment.

G. Wiring Identification

1. All wiring shall be identified at each termination, shall have a unique wire number, and shall be labeled at both ends. Wire numbers shall correspond with the equipment terminal wire numbers as indicated in the accepted Shop Drawings. Where no wire numbers are indicated, the Contractor shall advise the Engineer in writing prior to assigning wire numbers. Wire numbers shall not be duplicated.
2. In addition to color coding, for all 1-phase and 3-phase systems, identify each cable (single or multi-conductor) and conductor at each end, in each manhole, pullbox, cable tray, or other component of the raceway system. This identification is applicable to all power, control, alarm, signal, and instrumentation cables, and conductors.
3. Identify each cable (single or multi-conductor) and groups or bundles of individual single conductors in each manhole, pullbox, cable tray or other component of the raceway system with circuit identification markers. Implement a "from-to" cable/conductor bundle tagging system as part of this identification effort.
4. For instrumentation wiring, the Contractor shall provide, on the Shop Drawings, a schedule indicating the wire number, color code, if applicable, origin and destination devices, and terminals.
5. Wire identification shall be accomplished through the use of a portable printer and white, polyolefin wire marking sleeves. The wire identification system shall be a "Bradymarker" XC Plus Printer with "Bradysleeve" wire marking sleeves, Panduit equivalent, Seton equivalent, or equal.
6. The Contractor shall submit a written description outlining his intended method of wiring identification and supporting information (i.e., product data sheets, etc.) identifying the materials to be used. The Contractor shall meet with the Owner and the Engineer to come to an agreement regarding wire identification prior to the installation of any wiring.

H. Cable Identification Tags

1. The Contractor shall furnish all labor and materials and affix in a permanent way to each cable in manholes, cable compartments and vaults, junction boxes, pull boxes and points of termination, a bronze metal tag, 2-inch [50-mm] in diameter, with a 1/8-inch [3-mm] diameter hole, with copper wire through the hole, the cable identification number approved by the Engineer. The tag shall be attached to the cable by twisting the ends of the copper wires. All cables shall be tagged with its full ID number immediately after it has been pulled.

I. Cable Installation

All interior cable not protected by a compartment enclosure shall be run in conduit.

All cables likely to be exposed or crossing floors or slabs shall be protected by galvanized steel pipes.

The contractor shall furnish and install all conduits, boxes, wire ways and fittings required for the lighting system as shown on the drawings or as directed otherwise.

Steel support channels shall be used to mount electrical equipment off walls and ceiling .

All sleeves through concrete floors shall be of rigid galvanized steel tubing sleeves shall be extended to 0.15m above floor level.

All necessary hardware, such as screws, bolts, hangers, concrete inserts, clamps, locknuts, bushings, sealing bushings, conduit pipe, tee drains and box drains, explosion - proof and waterproof conduit seals, couplings, pulling irons, tags, etc, shall be included. Blockouts and recesses shall be provided as specified on the drawings, adequate for present and future installation of flush mounted equipment, as required.

Buried Cables

The cable trench shall be dug to a depth of 800 mm (minimum) and with sufficient width in relation to number and diameter of the cable spacing. The bottom of the trench shall be covered with a 10cm thick bed of sand before laying the cables. A cable warning tape shall be placed not less than 30cm above the cables, and concrete tiles shall be placed at 20cm above cables.

Cables Laid in Channel Duct

The cable duct shall be made of concrete and shall be covered by not dip galvanized steel chequer plates with a minimum of 5mm thickness (excluding the checkers) combined with a sufficiently strong support structure and recessed handles for each cover.

The cable shall be laid straight and fixed with marking of the connection.

Cable on Trays

The cable shall be laid neatly and tight by the cable ties whether horizontally or vertically, avoiding cross over and respecting the minimum bending ratio of radius to diameter of the cables as specified by the manufacturer.

Cable in conduits

All conduits shall be swabbed and clean before cable are pulled through. All conduit ends shall be end with glands in the panels, No wires connection shall be allowed in the conduit.

Field Quality Control

Insulation resistance measurement shall be carried out on each circuit of the installation .

J. Wiring Supplies

1. Only electrical wiring supplies manufactured under high standards of production and meeting the approval of the Engineer shall be used.
2. Rubber insulating tape shall be in accordance with ASTM Des. D119. Friction tape shall be in accordance with ASTM Des. D69.

K. Training of Cable

1. The Contractor shall furnish all labor and material required to train cables around cable vaults within buildings and in manholes and handholes in the outdoor underground duct system. Sufficient length of cable shall be provided in each handhole, manhole, and vault so that the cable can be trained and racked in an approved manner. Instrumentation cable shall be racked separate from all other AC and DC wiring to maintain the required separation specified herein. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's recommendation. All manhole cables shall be arc and fire-proofed. The training shall be done in such a manner as to minimize chaffing.

L. Connections at Control Panels, Limit Switches, and Similar Devices

1. Where stranded wires are terminated at panels, and/or devices, connections shall be made by solderless lug, crimp type ferrule, or solder dipped.
2. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make 7‑strand, No. 13 AWG [2.5-mm2], wire terminations impractical, the Contractor shall terminate external circuits in an adjacent junction box of proper size and shall install No. 13 AWG [2.5-mm2] stranded wires from the device to the junction box in a conduit. The No. 13 AWG [2.5-mm2] field wiring shall also be terminated in the same junction box to complete the circuit.

M. Pulling Temperature

1. Cable shall not be flexed or pulled when the temperature of the insulation or of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature within a three day period prior to pulling of 40°F [0°C] or lower, cable reels shall be stored during the three day period prior to pulling in a protected storage area with an ambient temperature not lower than 55°F [13°C] and pulling shall be completed during the work day for which the cable is removed from the protected storage.

N. Color Coding

1. Conductor insulation shall be color coded as follows:

a. 400V AC Power

Phase A ‑ RED

Phase B ‑ YELLOW

Phase C ‑ BLUE

Neutral – BLACK

b. 230V AC Power

Phase A ‑ RED

Phase B – YELLOW

Phase C ‑ BLUE

Neutral ‑ BLACK

c. DC Power

Positive Lead ‑ RED

Negative Lead ‑ BLACK

d. DC Control

All wiring - BLUE

e. 24VAC Control

All wiring - ORANGE

f. Equipment Grounding Conductor

All wiring – GREEN or YALLOW / GREEN.

2. Conductors No. 2 AWG [35-mm2] and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape.

**3.02 INSTRUMENTATION CABLE INSTALLATION**

A. The Contractor shall install all cable or conductors used for instrumentation wiring (4‑20mA DC, etc.) in rigid galvanized steel or PVC coated rigid galvanized steel conduit. The use of asbestos cement or plastic conduit will not be permitted. Analog signal wires shall exclusively occupy these conduits. No other wiring for AC or digital DC circuits shall be installed in these conduits.

B. All shielding shall be continuous and shall be grounded in accordance with the instrumentation equipment manufacturer's recommendations, as approved.

C. A raceway containing instrumentation cable shall be installed to provide the following clearances:

1. Raceway installed parallel to raceway conductors energized at 400 through 230 volts shall be 18 inches [450mm] and 230 volts shall be 12 inches [300mm].
2. Raceway installed at right angles to conductors energized at 400 volts or 230 volts shall be 6 inches [150mm].

D. Where practical, raceways containing instrumentation cable shall cross raceway containing conductors of other systems at right angles.

E. Where instrumentation cables are installed in panels, manholes, handholes, and other locations, the Contractor shall arrange wiring to provide maximum clearance between these cables and other conductors. Instrumentation cables shall not be installed in same bundle with conductors of other circuits.

F. Grounding of cable shield shall be accomplished at one point only, unless otherwise required by instrumentation system's manufacturer.

G. Additional pullboxes shall be furnished and installed for ease of cable pulling and the cable manufacturer's recommended conduit fill factor shall be followed. Where required for specifically directed by the Engineer. The Contractor shall moisture seal the cables at all connections.

H. Special instrument cable shall be as specified or recommended by the vendor of the equipment or instruments requiring such wiring. Installation, storage, terminations, etc., shall be per manufacturer's recommendations.

I. All cable, insulation and jacket shall have adequate strength to allow for it to be pulled through the conduit systems. Sufficient conductors shall be installed to provide space and serve future equipment where shown and specified. All conductors shall be color coded and all wires shall be suitably tagged with permanent markers at each end.

**END OF SECTION**

# SECTION 16 122

# ARMOURED CABLE

**PART 1 GENERAL**

* 1. **WORK INCLUDED**

Armoured Cable

* 1. **RELATED WORK**

A. Section 16111 : Conduits

B. Section 16114 : Cable Trays

C. Section 16050 : Basic Electrical Materials and methods

* 1. **APPLICABLE CODES AND STANDARDS**

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.

**1.04 SUBMITTALS**

1. Submittals shall be compliance with Section 1300, Submittals
2. Provide Product Data.
3. Provide Operation and Maintenance Data.
4. Submit materials compliance sheets with the specifications

**PART 2 PRODUCTS**

**2.01 ACCEPTABLE MANUFACTURERS AND/OR APPROVED EQUIVALENT**

1. BICC

England

1. Siemens

Germany

1. Draka Kabel

Netherlands

The listing of "Acceptable Manufacturers" above is intended to indicate the quality of the equipment or materials required and it is not intended that the Contractor be in any way restricted to obtaining tenders or ordering equipment or materials from these sources.

**2.02 MATERIALS**

A. Standard copper conductors, 600 Volt PVC or cross-linked polyethylene insulation, steel wire armour (for multi core cables) or aluminum wire armour (for single core cables), PVC oversheath.

B. Provide connectors and terminations as recommended by cable Manufacturer.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Support internal horizontal and vertical runs on cable tray complete with clamps.

B. Arrange multicore cables to run parallel on tray with a lateral spacing of the diameter of the largest cable. Install non ferrous clamps at 1 m longitudinal spacing on horizontal and vertical runs.

C. Arrange single core cables with phases in trefoil formation providing one cable diameter space between trefoil groups. Install non ferrous trefoil clamps at a 1m longitudinal spacing on horizontal and vertical runs.

D. Install non-magnetic and insulating plates at cable termination points. Fit connectors at supply points with a grounding style bushing and a copper ground conductor to connect supply end of cable sheath to ground. Ground cable sheath at supply end only.

E. Install nonmetallic plate at load end of cable to terminate cable.

F. Provide non-magnetic plates, 15 mm brass or 10 mm aluminum, securely bolted over openings cut in enclosure. Brass plates shall be used for steel wire armored cable and aluminum plates for aluminum wire armored cable.

G. Brass cable glands shall be used for steel wire armoured cables and aluminum glands for aluminum wire armoured cables. Glands shall be liquid tight in exterior locations, the service building and in electrical and mechanical rooms. All glands shall be covered with an outer sheath. All cable lugs shall be sweated to the conductors.

H. Install exterior cables in PVC ducts buried at least 600mm below ground level.

**END OF SECTION**

# SECTION 16130

# BOXES

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

A. The Contractor shall furnish all labor, materials, tools and equipment necessary for furnishing, installing, connecting, testing and placing into satisfactory operation all pull, junction and outlet boxes for power, lighting and control as required for a complete electrical installation as shown on the Drawings and specified herein.

B. Coordination

1. The Contractor shall review installation procedures under other Divisions and coordinate them with the Work specified herein.

2. The Contractor shall notify others in advance of the installation of the Work included herein to provide them with sufficient time for the installation and coordination of interrelated items that are included in the Contract and that must be installed in conjunction with the Work included in this Division.

C. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Drawings.

1. Reference Section 16050, Basic Electrical Requirements and for codes & standards.

**1.02 TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Test

Not required.

2. Field Tests

Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.

**1.03 SUBMITTALS**

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer(s) and submit the following:

1. Shop Drawings

Each submittal shall be identified by the applicable specification section.

1. Submit materials compliance sheets with the specifications.
2. Submit materials data sheets as to manufacture.

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Material specifications and product data sheets identifying all materials used and methods of fabrication.

2. Complete assembly, layout, and installation drawings for each box with clearly marked dimensions.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

**2.02 PULL, JUNCTION, AND OUTLET BOXES**

A. Exposed Indoor Wet Process and Outdoor Areas

1. Exposed outlet boxes and junction boxes for outdoor and indoor wet process areas used for lighting fixtures, switches, and receptacles shall be of cast, rust‑resisting metal provided with rubber or neoprene gasketed covers of similar metal. The completed units shall be of NEMA 4X construction (i.e. Stainless Steel IP55) and of ample size to house the required devices.

B. Concealed

1. Outlet boxes for concealed work shall be a minimum of 4 inches [100-mm] square and 2 inches [50mm] deep consisting of zinc coated pressed steel provided with knockouts for the conduit required. Boxes shall be provided with approved covers or plastic rings where necessary.

1. Boxes for housing receptacles, switches and similar devices shall be of the deep type.

C. Indoors

1. Pull and junction boxes for indoor exposed use in dry locations shall be galvanized sheet steel with neoprene gasketed screwed‑on covers and of all welded construction.

D. Miscellaneous

1. The Contractor shall furnish and install enclosures for housing interfacing and transition equipment, or other equipment requiring an enclosure. The Contractor shall be responsible for mounting the enclosure. The enclosures shall be a low profile type, weatherproof, lockable, and securely mounted to a concrete support pad using anchoring devices by Unistrut, Kendorf, B-Line Systems, Inc., or equal. The enclosures shall be furnished and installed in complete compliance with the NEC and with all state and local codes. The enclosure shall be finished with light grey epoxy paint and shall be a Hoffman single door enclosure, or approved equal.

2. All welded, galvanized, sheet steel and stainless steel boxes with neoprene gasketed screwed‑on covers may be used outdoors in non‑hazardous areas only where specified herein or indicated on the Drawings.

3. For outdoor and indoor wet process area use, NEMA 4X junction and pull boxes shall be provided. Boxes shall be equipped with neoprene gasketed covers which have been crossed ribbed and checkered. Boxes shall be provided with removable covers. Stainless steel cover screws are required. Boxes shall match the conduit to which attached.

1. For boxes shown or required in hazardous locations, boxes shall be furnished and installed in accordance with the Class, Division, and Group suitable for the application.

E. Galvanizing

1. The inside and outside surface of the boxes and covers shall be hot dipped or electro-galvanized after fabrication.

F. Box Sizes

1. The minimum size of boxes shall be according to the NEC. No box shall be filled to more than 40% of capacity.

G. Barriers

1. Galvanized steel or aluminum barriers shall be provided in junction or pull boxes to isolate conductors of different voltages and functions. Isolation shall be provided between the following groups:

a. Power (400 and 230 volts)

b. Control wiring

c. Instrumentation wiring (twisted, shielded pairs or triads)

2. Barriers shall be provided in multi-gang outlet boxes when the voltage between switches exceeds 300 VAC.

**PART 3 EXECUTION**

3.01 INSTALLATION

A. Outlet Boxes

1. All outlet boxes required for supporting lighting fixtures shall be provided with fixture studs of sizes suitable for supporting the weight of the fixtures connected thereto. Fixture studs shall not be less than 3/8 inches [10mm] in diameter and shall be either integral with the box or of the type which is inserted and supported from the back of the box. In no case will the support of a fixture be dependent upon bolts holding the stud to the box.

2. Outlet boxes for concealed work shall be arranged and located so that tile, where required, may be cut in straight lines to fit closely around the boxes, and so placed that the cover or device plate shall fit flush to the finished wall surface.

1. The exteriors of exposed outlet boxes shall be field painted, where required, in accordance with Section 09900, Painting.

B. Junction and Pull Boxes

1. All junction boxes and pull boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Wooden plugs are not permitted for securing boxes to concrete. Sidewalk‑type boxes shall be cast into concrete structures and shall be flush with concrete services after installation.

2. Where control wires must be interconnected in a junction box, terminal strips, consisting of an adequate number of screw type terminals shall be installed. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected. Approximately 20 percent of the total amount of terminals provided shall consist of spare terminals. Terminals shall be lettered and/or numbered to conform with the wiring diagrams.

3. All junction boxes and pull boxes shall have identifying nameplates attached, which when installed on sidewalk type boxes shall not extend above the surrounding concrete slabs. All boxes shall be indicated and identified on the as-built drawings.

**END OF SECTION**

# SECTION 16140

# WIRING DEVICES

# (RECEPTACLES, SWITCHES, PLUGS, PLATES)

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

A. The Contractor shall furnish and install all switches and receptacles for lighting and miscellaneous power applications of the type and at the locations as specified herein and as shown on the Drawings.

B. All switches and receptacles shall be furnished and installed in outlet boxes as specified in Section 16130, Boxes.

1. Reference Section 16050, Basic Electrical Requirements.
2. Reference codes and standards as referred to in Seciton 16050.

**1.02 TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

Not required.

2. Field Tests

All field testing shall be done in accordance with the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.

**1.03 SUBMITTALS**

1. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.
2. Submit materials compliance sheets with the specifications.

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include, but not be limited to:

1. Equipment specifications and product data sheets.

**1.05 TOOLS, SUPPLIES, AND SPARE PARTS**

A. The switches and receptacles shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment and all spare parts as recommended by the equipment manufacturer.

B. The Contractor shall furnish 10% (minimum of 1) spare of each receptacle, switch, and plug furnished and installed for this project.

C. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

D. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

**1.06 IDENTIFICATION**

A. Each switch and receptacle shall be identified with the equipment item number, manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The equipment covered by these Specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The Contractor shall use the products of a single manufacturer for each type of wiring device.

C. The Contractor shall use the products of a single manufacturer for all device plates. Plate variations are allowed for the following devices:

1. Where the selected plate manufacturer does not manufacture a suitable finish plate.

2. For heavy‑duty receptacles rated at more than 30A.

3. Where non‑standard plates are required, specified, or shown.

D. The Contractor shall furnish and install all wiring devices and device plates. Wiring devices as listed herein are intended to indicate type, function, and quality of the products.

E. The receptacles, switches, device plates, and other appurtenances shall comply with the requirements of these Specifications. Receptacles installed in toilet, locker, and bathrooms shall be of ground fault interrupter type to meet the minimum NEC requirements. Ground fault circuit interrupter receptacles shall also be furnished and installed as specified herein, indicated on the Drawings, and required by the NEC.

F. The Contractor shall provide specification grade devices which shall be as manufactured by Appleton, Crouse-Hinds, Leviton, Harvey Hubbell Co., General Electric Company, Bryant Electric Company, Pass & Seymour, or equal.

**2.02 WIRING DEVICES**

A. Wiring devices shall be in accordance with the following for nonhazardous areas:

1. Wall Switches, Single Pole, 20 A, 230V equivalent to Hubbell No. 1221, Pass & Seymour No. 20AC2, Leviton equivalent, or equal. Switches rated 30 A, 230V shall be Leviton 3031, Hubbell equivalent, Pass & Seymour equivalent, or equal.

2. Wall Switches, Double Pole, 20 A, 230V equivalent to Hubbell No. 1222, Pass & Seymour No. 20AC2, Leviton equivalent, or equal. Switches rated 30 A, 230V shall be Leviton 3032, Hubbell equivalent, Pass & Seymour equivalent, or equal.

3. Wall Switches, Three‑Way 20 A, 230V rated equivalent to Hubbell No. 1223, Pass & Seymour No. 20AC3, Leviton equivalent, or equal. Switches rated 30 A, 230V shall be Leviton 3033, Hubbell equivalent, Pass & Seymour equivalent, or equal.

4. Convenience Receptacles 20 A, 230V, duplex polarized with grounding connection equivalent to Hubbell No. 5362, Pass & Seymour, No. 5362, Leviton equivalent, or equal.

5. Hubbell Cat. No. GF-5362, Pass & Seymour equivalent, Leviton equivalent, or equal, for 20A, 230V, duplex, ground fault circuit interrupting type.

B. Special Purpose Receptacles shall be rated to carry, at least where required the full load amperes and voltage of the unit connected thereto. These receptacles shall be provided with grounding poles and shall be equivalent to the following:

1. Hubbell Cat. No. 9430, Pass & Seymour No. 5740, Leviton equivalent, or equal, for 30A, 230V, 3‑phase service.

2. Hubbell Cat. No. 9450, Pass & Seymour No. 5750, Leviton equivalent, or equal, for 50A, 230V, 3‑phase service.

3. Hubbell Cat. No. 9460, Pass & Seymour No. 5760, Leviton equivalent, or equal, for 60A, 230V, 3‑phase service.

4. Hubbell Cat. No. 9330, Pass & Seymour No. 5930, Leviton equivalent, or equal, for 30A, 230V, single‑phase service.

5. Hubbell Cat. No. 9315, Pass & Seymour equivalent, Leviton equivalent, or equal, for 30A, 230V, single‑phase service.

6. Hubbell Cat. No. 23CM10, Pass & Seymour equivalent, Leviton equivalent, or equal, for 20A, single, 230V, polarized with grounding connection, twist lock type. Matching plug shall be Hubbell Cat. No. 23CM11, Pass & Seymour equivalent, Leviton equivalent, or equal.

1. Crouse‑Hinds "Arktite" Series, Appleton equivalent, Killark equivalent, or equal, 30A, 3P, 600 Volt, twist lock, weatherproof, power receptacle and box with matching plug.

C. For hazardous areas the following shall be provided:

1. Wall Switches, single pole, 20 A, 230 V equivalent to Crouse Hinds Cat. No. EFD3591 or EFDC3591 (as required); Appleton No. EDS175F1 or EDSC175F1, Killark equivalent, or equal.

2. Convenience Receptacles 20 A, 250 VAC, 2 wire, 3 pole equivalent to Crouse Hinds Cat. No. CPS152-201, Appleton No. CPE1-2375, Killark equivalent, or equal.

D. Plugs for hazardous and non-hazardous receptacles shall be provided:

1. One mating plug of the same or better grade for each 10 convenience receptacles, minimum of 2 each.

2. Plugs and respective cable shall be provided for equipment furnished under other Divisions (steam cleaners, welders, etc.) as necessary.

**2.03 DEVICE PLATES**

A. Wall plates with gaskets for flush‑mounted receptacles and switches shall be made of Type 304 stainless steel, not less than 0.040 of an inch [1mm] thick, with beveled edges and milled on the rear so as to lie flat against the wall. Wall plates shall be equivalent to Hubbell series 9600, Pass & Seymour series 93000, Leviton equivalent, or equal.

B. Device plates for weatherproof and watertight installations shall be Appleton Type FSR, Crouse‑Hinds #DS185, or equal for wall switches and Appleton Type FSK, Crouse‑Hinds #WLRD, or equal for convenience receptacles. “In-use” weatherproof covers shall be as manufactured by Carlon, TayMac, or equal.

**2.04 PLUGS**

1. The Contractor shall furnish suitable plugs with equipment furnished under the respective Contract. Plugs shall be black rubber or plastic. For waterproof receptacles, the plugs shall be similar in construction to the receptacles and shall be encased in corrosion resistant yellow housing provided with clamping nuts and stuffing gland cable outlets.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Switch boxes shall be of unit construction and of sizes as required to adequately house the number of switches required. No sectional type switch boxes shall be permitted.

B. Where more than one switch occurs at one point, gang plates shall be used.

C. All device plates shall be set true and plumb, and shall fit tightly against the finished wall surfaces and outlet boxes.

D. All devices shall be flush‑mounted in finished areas, unless otherwise noted. The Contractor shall determine the proper position of every outlet, and relocate any outlet without additional cost to the Employer if same is incorrectly or improperly located. The Engineer reserves the right to change the location of any outlet or connecting equipment up to the time of roughing in without additional cost to the Employer, provided conduit runs are not increased by more than 10 feet [3000mm].

E. In all areas where thermal or acoustic insulation is applied to the ceiling or walls, outlet boxes shall be set to finish flush with the finished surface of the insulation.

F. When indicated height would place any of the equipment at an unsuitable location such as at a molding or break in wall finish, the Engineer shall determine final location.

G. For the below-named items mounting heights from finish floor, or finish grade to top is applicable. Mounting heights shall be as follows:

1. Single‑pole light switches, 48 inches [1220 mm].

2. Duplex receptacles in dry areas, 16 inches [400mm]

3. Duplex receptacles in pump rooms, 48 inches [1220 mm].

**3.02 CIRCUITING**

A. Convenience receptacles shall be grouped on circuits separate from the lighting circuits. A maximum of eight (8) convenience outlets are permitted per 20A, 230V circuit.

**END OF SECTION**

# SECTION 16141

# WALL SWITCHES

**PART 1 GENERAL**

**1.01 WORK INCLUDED**

Wall switches

**1.02 RELATED WORK**

A. Section 16130 : Boxes

B. Section 16140 : Wiring Devices

C. Section 16050: Basic Electrical Materials and methods

* 1. **APPLICABLE CODES AND STANDARDS**

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.

**PART 2 PRODUCTS**

**2.01 ACCEPTABLE MANUFACTURERS AND/OR APPROVED EQUIVALENT**

1. Wandsworth Electric Co. Ltd.
2. Pass and Seymour Inc.,
3. Siemens

The listing of "Acceptable Manufacturers" above is intended to indicate the quality of the equipment or materials required and it is not intended that the Contractor be in any way restricted to obtaining tenders or ordering equipment or materials from these sources.

**2.02 MATERIALS**

A. 230/400 Volt Switches: Quiet slow make, slow break design, toggle handle, with totally enclosed case, rated 10 ampere or as indicated on the drawings, either 1-way, 2 way or Intermediate, ganged as indicated on the drawings.

1. Colour: Subject to approval of the Engineer
2. Submit material compliance sheet as to Specifications and Data Sheet as to manufacture.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Mount switches 1300 mm above finished floor level, to center of switch or switch assembly or as indicated on the drawings.

B. Coordinate switch mounting location with architectural detail.

**END OF SECTION**

# SECTION 16160

# ELECTRICAL - CABINETS AND ENCLOSURES

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

A. The Contractor shall furnish and install all cabinets and enclosures to house electrical equipments controls, instruments, terminal blocks, and similar devices as shown on the Drawings and specified herein.

B. Cabinets and enclosures shall conform to all applicable UL and NEMA standards. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Drawings.

1. Reference Section 16050, Basic Electrical Requirements and Division 13, Control and Information Systems.
2. Reference codes and standards as referred to in Section 16050.

**1.02 TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Test

Not required.

2. Shop Test

The cabinets and enclosures shall be given routine factory tests in accordance with the requirements of UL, NEMA, and the manufacturer's standards, provided that a set of the followed standard should be submitted to the approval of the Engineer..

3. Field Tests

Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.

**1.03 SUBMITTALS**

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer(s) and submit the following:

1. Shop Drawings

Each submittal shall be identified by the applicable specification section.

B. Submit materials compliance sheets with the specifications and the data sheet as to the manufactuerer, each separately.

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Material specifications and product data sheets identifying all materials used and methods of fabrication.

2. Complete assembly, layout, and installation drawings for each cabinet and enclosure with clearly marked dimensions.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

1. Cabinets and enclosures for non-hazardous locations shall be as manufactured by Hoffman Engineering Company, Rittal Corporation, The Austin Company, or equal. Enclosures for hazardous locations shall be as manufactured by the Appleton Electrical Company, Crouse-Hinds, O-Z/Gedney, or equal.

**2.02 CABINETS AND ENCLOSURES**

A. Ratings

1. Unless otherwise specified herein or shown on the Drawings, cabinets and enclosures shall be:

a. NEMA 1A (gasketed) when located in environmentally controlled spaces such as control rooms, electric rooms, and similar locations.

b. NEMA 12 when located in dry, indoor process areas.

c. NEMA 4X fiberglass or stainless steel (308 AISI min.) when located in damp/wet, indoor, corrosive process areas.

d. NEMA 4X stainless steel (308 AISI min.) for all outdoor locations.

1. Suitable for the specific Class, Division, and Group when located in hazardous locations.

B. Construction - Steel

1. Enclosures shall be fabricated from 14 gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.

2. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be stainless steel. A hasp and staple shall be provided for padlocking. Interior panels shall be provided. Each enclosure shall have a print pocket.

3. NEMA 1A and 12 enclosure finish shall be white enamel interior, light grey enamel, ANSI 61 exterior, over phosphatized surfaces. Interior panels shall be white enamel. Special finishes and colors shall be furnished as required.

4. NEMA 4X enclosures and enclosures suitable for hazardous locations shall be unpainted.

C. Construction - Fiberglass

1. Enclosures and cabinets shall consist of base and cover which shall be heavy-duty hot compression molded from fiberglass reinforced polyester compound containing not less than 25 percent fiberglass by weight. Transparent covers, where specified herein or shown on the Drawings, shall be polycarbonate. The enclosures shall be provided with cover hinges manufactured from nonmetallic materials. The cover latch system shall be nonmetallic, and space heators and internal lighting should be part of cabinets and enclosures.

2. The gasket system shall be of neoprene material cemented into a molded labyrinth on the cover.

3. NEMA 4X enclosures shall be unpainted.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Cabinets and enclosures shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

**END OF SECTION**

# SECTION 16181

# FUSES

**PART 1 GENERAL**

**1.01 WORK INCLUDED**

A. Low voltage fuses.

**1.02 RELATED WORK**

A. Section 16425 : Switchboards

B. Section 16445 : Panel Boards and Disconnect Switches.

C. Section 16182 : Circuit Breakers

D. Section 16480 : Motor Control Center - MCC

**1.03 APPLICABLE CODES AND STANDARDS**

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.

**1.04 SUBMITTALS**

1. Submittals shall be in compliance with Section 1300, Submittals.
2. Submit "Time/current," "I2t" cut off" characteristics of each type of fuse used.
3. Provide Manufacturer's descriptive literature.
4. Provide operation and maintenance data.
5. Submit materials compliance sheets with the specifications and separately data sheets as to manufacture.

**PART 2 PRODUCTS**

**2.01 ACCEPTABLE MANUFACTURERS**

A. Fuses to be supplied by recommended Manufacturers of switchgear or control gear.

**2.02 FUSES**

1. Time delay type fuses shall be cartridge type. They shall be used in three phase motor starters and in the main switchboard as back-up to the other protective devices down line. Fuses shall have a tested fault interrupting capacity of not less than 80 KA.
2. Type delay fuses shall be used in control circuits warranted by the high fault levels. They shall be plug-in type.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Fuses shall be installed where required.

B. Each fuse holder shall have a coloured spot, 8 mm diameter in clear view, to correspond with the phase.

C. Each fuse shall have mounted on it, an indicator, which will change appearance when that fuses blows.

D. It shall not be possible to replace cartridge-type fuses while the circuit is live.

**END OF SECTION**

# SECTION 16182

# CIRCUIT BREAKERS

**PART 1 GENERAL**

* 1. **WORK INCLUDED**

A. Molded Case Circuit Breakers (MCCB's)

B. Miniature Circuit Breakers (MCB's)

C. Ground Fault Circuit Breakers.

* 1. **RELATED WORK**

A. Section 16160 : Electrical – Cabinets and Enclosures.

B. Section 16425 : Switchboards

C. Section 16445: Panel Boards and Disconnect Switches

E. Section 16480 : Motor Control Centers - MCC

* 1. **APPLICABLE CODES AND STANDARDS**

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.

**1.04 SUBMITTALS**

1. Submittals shall be in compliance with Section 1300, Submittals.
2. Submit manufacturer's product data, technical literature and wiring diagrams.
3. Submit type test certificates from an approved International Test Organization that the equipment complies with the relevant standards.
4. Submit characteristic curves for all circuit breakers.
5. Submit materials compliance sheets with the Specifications.

**PART 2 PRODUCTS**

**2.01 ACCEPTABLE MANUFACTURERS**

Circuit breakers to be provided by the supplier of the appropriate main switch gear panel, distribution board, panel board or motor control centres.

**2.02 MOLDED CASE CIRCUIT BREAKERS**

A. MCCB'S shall be of the quick make, quick break type with trip free mechanism all enclosed in an insulated molded case of low hygroscopicity and high mechanical strength.

B. They shall be on the adjustable thermal magnetic type.

C. Where used for motor protection they shall have characteristic curves compatible with the motor curve.

D. MCCB's shall be provided with the following.

1) Visible indication on the enclosure front of “open”, “ closed” and “tripped”.

2) Two normally open and two normally closed auxiliary contacts.

3) Facility for locking in the `open' position.

4) Under voltage release and indication.

5) Shunt trip.

E. Where the prospective short circuit at the point of installation exceeds the breaker capacity, back up fuse protection shall be provided.

**2.03 MINIATURE CIRCUIT BREAKERS**

A. MCB's shall be of the plug-in or rail mounting type with bimetallic trip for over current protection and instantaneous electro magnetic trip for short circuit protection.

B. They shall be provided with visible indication of “open”, “closed” and “tripped”.

C. Where used for motor protection they shall have characteristic curves compatible with the motor curve.

D. Where the prospective fault current at the point of installation exceeds the breaker capacity, back up fuse protection shall be provided.

**2.04 GROUND FAULT CIRCUIT BREAKERS**

A. Ground fault circuit breakers shall be on the current operated type comprising a circuit breaker, and transformer unit mounted on a common base plate and enclosed in a molded case.

B. They shall be of the plug-in or rail mounted type as required.

C. They shall have a solenoid operated tripping mechanism and shall be provided with a test button to simulate operation of the device.

D. They shall have a rated tripping current of not greater than 30 milliamps.

**2.05 SPARE PARTS**

A. Provide spare parts for at least two years operation.

B. List all spare parts being provided at tender as recommended by the manufacturers.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Install circuit breakers in the appropriate distribution boards or motor control centres in accordance with the manufacturers recommendation.

B. Label all circuit breakers as specified in section 16075.

**END OF SECTION**

# SECTION 16205

# PACKAG E ENGINE GENERATOR SET

**PART 1 GENERAL**

**1.01 WORK INCLUDED**

Standby power system.

**1.02 RELATED WORK**

A. Section 01730 : Operating and Maintenance Data.

B. Section 16425 : Switchboards.

C. Section 16111 : Conduits

D. Section 16120 : Wires and Cables

E. Section 16122 : Armoured Cables

F. Section 16182 : Circuit Brakers

G. Section 16060 : Grounding and Bonding.

H. Section 16075 : Electrical - Identifications

I. Section 16181 : Fuses

J. Section 16480 : Motor Control Centers- MCC

**1.03 DESCRIPTION OF SYSTEM**

A. Provide Prime Power Diesel Generator Set for supply of power in event of failure of normal supply, consisting of power supply unit, liquid cooled, diesel engine directly coupled to ac generator complete with fittings, connections, auxiliaries, control panels, safety devices, meters necessary for complete operating system.

B. Provide fully automatic operation so that unit takes full load within 10 second after power failure. On resumption of normal power after time delay automatically retransfer load to normal power and automatically shut down generator, returning to starting condition ready for another operating cycle.

C. Capable of delivering the required load as shown on drawings at installed location after consideration of all applicable derating factors, such as temperature, altitude, etc.

D. Provide signal circuits to Elevator control panels to indicate failure of normal supply and activation of Generator.

E. The circuit breaker interlocking shall be provided by mechanical and electrical means.

**1.04 REQUIREMENTS OF REGULATORY AGENCIES**

A. Conform to the National Electrical Code and applicable inspection authority.

B. Generator to be manufactured to NEMA Standards.

**1.05 APPLICABLE CODES AND STANDARDS**

A. ANSI/NEMA MG2-1977: Construction and Guide for selection, installation and use of Electrical Motor and Generators safety standards.

1. IEC 34 : Rotating Electrical Machines.
2. All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.

**1.06 SUBMITTALS**

A. Submit shop drawings and product data in accordance with section 1300, submittal.

B. Submit full technical data service and parts facilities complete with manufacturer's published data.

C. Submit engine data with shop drawings:

1) Number of cylinders

2) Piston displacement

3) Break mean effective pressure

4) Piston speed

5) Aspiration

6) Engine type

7) Mainfold type

D. Submit manufacturer's installation instructions.

E. Submit manufacturer's descriptive literature, operating instructions, and maintenance and repair data.

F. Submit test reading made after installation.

G. Submit alternator data :

1. Alternator type

2) Alternator construction

3) Regulation (Volts Per Hertz)

4) Alternator efficiency at 100%, 75% and 50% full load.

5) Short circuit and overload characteristics.

1. Submit type test certificate for all components.
2. Submit factory test results prior to delivery.
3. Submit materials compliance sheets with the specifications.

**PART 2 PRODUCTS**

**2.01 ACCEPTABLE MANUFACTURERS OR APPROVED EQUIVALENT**

1. Caterpillar Tractor Company

U.S.A

1. Cummins Engine Company

U.S.A

1. O’Brien Machinery Ltd

Ireland

The listing of "Acceptable Manufacturers" above is intended to indicate the quality of the equipment or materials required and it is not intended that the contractor be in any way restricted to obtaining tenders or ordering equipment or materials from these sources.

**2.02 CONSTRUCTION**

A. The entire generator assembly shall be suitable in all respects for operation in the climatic conditions obtaining on site.

B. Engine and alternator shall be mounted on a common steel rail base with approved anti-vibration mountings between the rail base and the floor and semi-rigid couplings between the engine and alternator.

C. Means shall be provided for lifting and transporting the complete assembly without undue difficulty.

D. All moving and rotating parts shall be adequately and effectively guarded so as to afford maximum protection to personnel working on or near the unit. All guards shall be readily removable for maintenance and shall be simple and easy to reinstall.

E. Complete assembly shall be finished with a heavy duty enamel paint after rust proofing and priming, all to the approval of the Engineer.

**2.03 ENGINE**

A. Water-cooled `In Line' or `Vee' type, pressure charged, intercooled, four stroke cycle with multi cylinders designed to deliver the required output when running at rated speed.

B. A heavy electrical flywheel shall be fitted to the engine to ensure smooth running under all load conditions and it shall be provided with an approved flywheel guard.

C. Each engine shall be provided with Electronic speed sensing governor capable of isochronous frequency regulation from no load 10% overload.

D. Each engine shall be provided with the following:

1. Fuel oil filters.

2. Lubricating oil filters.

3. Intake air filters complete with pre-cleaner.

4. Sand filters on the intake air louvres.

E. Torsional vibration dampers shall be fitted to the free end of the crankshaft to ensure that all harmful vibrations are fully damped out.

F. The engine shall be capable of starting up in adequated time to allow the alternators to develop fully load within a period of not greater than 10 second.

**2.04 ALTERNATORS**

A. Brushless type with salient pole revolving field with an AC self exciter and three phase full wave diode rectifier.

B. Screen protected drip proof enclosure with a single end shield, self aligning roller bearings and shaft extension with semi rigid couplings for bolting to the engine.

C. Minimum Class F insulation in accordance with IEC 85.

D. Regulation shall be provided to + 2.5% of the rated voltage from, zero to 10% oveload for the full temperature range from cold to hot and for balanced and reasonably out of balance loads and for loads with a power factory varying from unity to 0.8.

E. Voltage shall be readily adjustable in the range +5% of rated voltage.

F. An adequately sized terminal box shall be provided on the left hand side of the alternator when facing the radiator end for the main cables.

G. The star point of the alternator windings shall be taken out to a terminal suitably insulated for connection of the neutral of the supply cable.

H. Suitable approved thermistors shall be provided for protection of the alternator windings. They shall be designed to disconnect the generator set in the event of too high a winding temperature.

**2.05 RADIO SUPRESSION**

The complete generator installation shall be supressed against radio interference in accordance with the recommendations of the International Committee on Radio Interference (CISPR).

**2.06 COOLING**

Provide engine mounted radiator complete with directly coupled fan and galvanized steel ductwork and flexible connections between the radiator and air louvres.

**2.07 SOUND ATTENUATORS**

A. Provide galvanized steel enclosed sound attenuators for the exhaust air louvre.

B. System shall be designed to provide a maximum noise level of 50 db at 1 metre from the generator room.

**2.08 AIR LOUVRES**

A. Provide adequately sized intake and exhaust air louvres in the wall of the generator room.

B. Louvres to be manufactured from heavy duty sheet steel finished stove enamel after rust proofing and priming colour to match doors.

C. Provide sand trap louvres on the inlet air.

**2.09 HEATING**

Engine shall be provided with the following engine mounted heaters with thermostatic control.

1. Electric water heater for the radiator.

2. Electric block mounted heater for the lubricating oil.

3. Electric jacket water heater.

**2.10 FUEL STORAGE**

A. Provide day storage tanks (8 hour capacity at full load) of the totally enclosed type with bolted and gasketted lid all manufactured from highest quality mild carbon steel and provided with all necessary

Supporting steelwork:The complete unit shall be rust proofed and painted with an approved oil resistant paint.

B. Provide bulk storage tank capacity of 30 m3. The tank shall be fabricated of steel plates, it shall not be less than 8 mm thick and the ends not less than 10 mm thick, it shall be fitted with stiffener to make the tanker very safe, not subjected to any damage during lifting or installation.

C. Each tank shall be provided with the following connections.

1. Oil fills line connection.

2. Oil returns line connection.

3. Outflow connection for the fuel line to the engine.

4. Emergency overflow connection (50 mm minimum).

5. Valve sludge connection (50 mm minimum).

6. Connections for level switches as listed below.

7. Dump line connection.

D. Each tank shall be provided with the following level switches.

1. Extra high-level switch to indicate an alarm condition in the event of the fuel transfer pump failing to stop.

2. High level switch to stop the fuel transfer pump.

3. Low level switch to start the fuel transfer pump.

4. Extra low level switch to indicate an alarm condition in the event of the fuel transfer pump failing to start.

E. Each tank shall be provided with a transfer pump set comprising two pumps (one run and one standby), with duty select, switch, and automatic changeover and pumps controlled by level switches mentioned above.

F. All starters, controls, etc., shall be located in the generator control panel and shall be so arranged that supply for the pumps can be taken from the generator control panel busbars when the generator is running and from the normal supply at all other times. The system shall be designed to ensure that it cannot be supplied from the two sources at any time and to automatically switch over to the generator supply in the event of failure of the main supply.

G. Provide for the supply and installation of a semi rotary hand operated fuel transfer pump.

H. Provide for a direct reading oil contents gauge on the tank.

I. Pipework between the main storage tank, day storage tank, fuel transfer pumps and the engine shall be provided by the generator supplier.

**2.11 EXHAUST SYSTEM**

The generator supplier shall include for the complete engine exhaust system comprising the following:

1. Stainless steel flexible pipe for connection to the engine manifold.

2. Hospital type silencer complete with all supporting steelwork.

3. Exhaust pipework complete with all necessary bends and supporting steelwork.

4. Stainless steel expansion bellows where the length of exhaust necessitates it.

5. Condensate traps complete with drain valves.

**2.12 CONTROL PANEL ENCLOSURES**

Enclosures shall comply with section 16160.

**2.13 BUSBARS**

Busbars shall comply with sections 16112 and 16160.

**2.14 STARTERS**

Starters shall comply with section 16480.

**2.15 CIRCUIT BREAKERS**

A. Circuit Breakers shall comply with section 16182: Circuit Breakers.

B. Up to 1000 Amp rating circuit breakers may be either of the Air Break or Moulded Case type.

1. Above 1000 amp rating circuit breakers shall be of the air break type.

**2.16 FUSES**

A. Fuses shall comply with section 16181.

**2.17 INSTRUMENTS AND TRANSFORMERS**

Instruments and transformers shall comply with sections 16461 and 16920.

**2.18 GENERATOR CONTROL PANEL**

A. Generator control panels shall be freestanding type suitable for bolting to the floor.

B. The generator control panel shall be provided with the following:

1. Main circuit Breaker with overload, short-circuit and earth fault protection.

2. 3 No. Ammeters of the panel mounted type complete with current transformers.

3. 1 No. Voltmeter complete with 6 pole selector switch for voltages between phases and between phases and neutral.

4. Kilowatt hour meter complete with current transformers.

5. Frequency meter complete with transducers.

6. Hours run meter with a maximum range of 100,000 hours.

7. Hand-off-Auto switch for selection of manual or automatic control.

8. Stop and start pushbuttons with generator `ON' indication and facility for remote pushbuttons and indication.

9. Heater control switches with heater `ON' indication. Thermostats shall be wired to over-ride the control switches.

10. Voltage Adjustment controller.

11. Voltage Gain controller (where applicable).

12. Reset pushbuttons as required.

13. Fuel oil transfer pump set control system comprising duty select switch, hand-off-auto switch, stop and start pushbuttons, starters, run and trip lamps, level switch relays and auxiliary contacts, overloads, fuses, etc.

14. Lamp test pushbutton.

15. Fuse monitoring.

16. Engine speed controller.

17. Panel mounted alarm sounder with outgoing terminals for a remote mounted siren.

18. Alarm mute switch with visible indication that alarm has been muted.

19. Normal supply healthy indication (Green Lamp).

20. Battery charger control switches and indicating lamps.

21. Facility for manually simulating failure of the normal supply using a key operated switch.

22. Alarm reset pushbutton.

23. Facility for remotely shutting down the generator in an emergency.

24. Facility for shutting off the oil supply to the day storage tank in the event of a fire. The system shall be designed to shut off the oil supply and to empty the day storage tank back into the main storage tank. All necessary valves, fusible links and controls shall be provided by the Generator Supplier.

**2.19 ALARM ANNUNCIATOR PANEL**

A. The Alarm Annunciator panel shall form part of the Generator control panel.

B. Facilities shall be provided for a remote mounted alarm annunciator panel to be located in the operator office. (Forms part of the plant Monitoring panel: see section 16920).

C. Audible and visible alarms to be provided shall be as detailed in 2.18 above 2.20.

D. Alarm circuits shall have a power supply available at all times. It shall be sized to maintain all the alarm indicators for a minimum period of six hours in the event of failure of the normal or generator supply. Alarm circuits shall operate at 24 volt D.C. with power derived via a battery/rectifier unit, supplied from the normal supply. It shall provide with a battery charger capable of recharging the batteries fully within twelve hours.

E. All audible alarm circuits shall feed to a common electronic sounder on the panel.

F. All alarm circuits shall be of the manual reset type.

G. Alarm mute switch shall be so arranged that it will silence the sounder for the specific fault causing the alarm, but will leave the system capable of receiving and sounding the alarm in the event of a further fault or faults.

Operation of the mute switch shall not cancel the visible indication of the fault.

H. Pre alarm indication shall be provided to indicate a state which might result in the generator failing to start. It shall be provided for the following:

1. Failure of Electric Heating Devices.

2. Low Lubricating oil level.

3. Low Radiator water level.

4. Low fuel oil level.

5. Extra low radiator water temperature.

6. Low battery level.

7. Battery charger malfunction.

8. Circuit Breaker open.

Pre alarm indicator shall illuminate regardless of whether a generator is operating or not or whether the normal supply is available or not.

**2.20 ENGINE INSTRUMENT PANEL**

A. The engine instrument panel shall be of the engine-mounted type.

B. The following shall be provided for each engine: -

1. Oil temperature gauge with high temperature alarm and shut down contact.

2. Oil pressure gauge with low pressure alarm and shut down contacts.

3. Water temperature gauge with high temperature alarm and shut down contacts and extra low temperature alarm contacts.

4. Engine speed indicator with over-speed alarm and shut down contacts.

5. Over-crank alarm and shut down contacts.

6. Cylinder temperature gauge with extra high temperature alarm and shut down contacts and high temperature alarm contacts.

**2.21 PLANT SHUT DOWN**

A. The system shall be designed to provide automatic shut down of the generator in the event of any of the following occurring.

1. High temperature in the Alternator windings.

2. High oil temperature.

3. High water temperature.

4. Engine overspeed.

5. Engine fail to start.

6. Extra high cylinder temperature.

7. Extra low oil level in the day storage tank.

B. The protection circuits for low oil pressure and high cooling water temperature shall only be operational on a time delay following engine start.

C. In the event of an overcurrent or earth fault the circuit breaker shall automatically trip and shut down the generator.

**2.22 STARTING**

A. An approved electric or air starting system shall be provided.

B. Power for electric starting shall be derived from heavy duty Nikle Cadimium of batteries 36 volt. Batteries shall be capable of starting the set successfully from cold at least six times without recharging. Means shall be provided for automatic disconnection of the starter motor for a pre-determined time, on failure to start after three attempts. An approved method for recharging the batteries shall be provided.

C. Batteries shall be provided complete with all necessary battery leads and shall be mounted on a rigid steel frame fixed to the engine under-base.

D. Air starting systems shall comprise diesel driven air compressor, air starting motor, starting valve, air receiver, pressure regulator, associated pipework, valves, etc., and any other equipment recommended by the engine supplier to ensure reliable operation.

* 1. **Main Failure Automatic Transfer Switch (A.T.S)**

1. Floor mounted, galvanised sheet steel cubicle of equal construction to control cubicle, comprising two main contactors and two main air circuit breakers and controls necessary for automatic transfer of power supply from normal source to stand-by source, voltage sensing control relay and time delay relays to signal generator start and stop, auxiliary switches and indicating lights etc. as necessary for the required operation of the system.
2. Operation

When voltage and/or frequency of any phase drops below an adjustable setting (60% - 90%) of normal supply, for an adjustable period of 1 - 300 seconds, power failure relay is to actuate engine starting control, whilst normal mains contractor is to open. After an adjustable period of 0 -10 seconds from sensing stabilised rated voltage and frequency of generator at the ATS, the emergency contactors is to close. Upon restoration of normal mains supply to above 95% of rated voltage and/or frequency, for and adjustable present period of 2 - 60 minutes, emergency contactors is to open and normal mains contactors is to close.

1. Mechanical And Electrical Interlocks

Are to prevent contactors/circuit breakers from being closed simultaneously at any time. Transfer mechanism is to be powered from the source to which the load is being transferred.

1. Selector Switch

Is to have the following positions :

off : both contactors open and remain open.

normal : contactors for normal power source closes and remain closed.

emergency: contactors for stand-by power source closes and remains closed.

auto : automatic transfer as described above.

1. Pilot Lights

Are to indicate which contactors is on.

1. Instruments

Are to include voltmeter and amperemeter with selector switches.

1. Contactors

Are to be to IEC 158-1, 3-phase, 4-pole, magnetic type, 600 V rating, capable of interrupting at least ten times rated current inductive or non-inductive loads under normal service conditions and are to have re-placeable main arcing contacts and arc quenching devices. Contactors are to withstand, without welding or burning of contacts, an inrush current of 20 times normal rating upon closing and the heaviest short-circuit of the system for period required by upstream protective switchgear to operate or a minimum of 3 seconds, whichever is greater. Three N.O. and three N.C. spare contacts are to be provided on each contactors.

1. Circuit Breakers

Two Air Circuit Breakers to be provided.

1. Wiring

Moisture and heat resistant, silicon rubber insulated, stranded copper conductors, modularly and neatly arranged on master terminal blocks, with suitable numbering strips and appropriate cartridge types fuses where required. Flexible wiring is to be used on all hinged/draw-out components.

1. Connections

Are to be made at a front terminal block with no live metal exposed. Power cables are to terminate on fixed insulated copper connectors suitably sized to receive specified cables. Cable glands and gland plates are to be provided.

1. Metal Cases

Of instruments, control switches, relays etc. are to be connected by flexible protective conductors, of not less than 2.5 mm2 section, to nearest earthing bar or terminal.

1. Earthing

Earthing bar is to be provided for connection of protective earthing conductors, using set-screw or bolted anti-turn pressure terminations.

1. Ferrules

Wire ends are to be fitted with numbered ferrules of approved type at each termination.

**2.24 TOOLS**

A. The supplier shall provide all tools necessary for the proper operation and maintenance of the sets.

B. The tools shall be mounted in a lockable stove enameled sheet steel cabinet adjacent to the generator set.

C. Details of tools being provided shall be submitted at tender stage.

**2.25 OPERATING AND MAINTENANCE**

A. The following shall be provided for the generator set:-

1. A checklist and guide to the correct operation, routine testing and maintenance of the set for the operator's use. ( In English and Arabic).

2. A coloured cutaway drawing shown the engine, alternator and all ancillary equipment with all items clearly indicated.

B. The layout of the above shall be submitted to the Engineer for approval prior to final printing.

C. After approval they shall be heat sealed on cardboard and mounted in a glazed hardwood frame which will be rigidly fixed to the wall adjacent to the control panel.

D. A spare plastic film negative of each of the above shall be handed to the Employer for his records.

**2.26 PANEL WIRING**

Panel wiring shall be carried out using PVC insulated cables in PVC trunking and in flexible conduit to door mounted equipment. Minimum cable size shall be 1.5sq.mm.

**2.27 SPARE PARTS**

Provide spare parts for at least two years operation. List spare parts being provided.

**PART 3 EXECUTION**

**3.01 CO-ORDINATION**

Co-ordination with all other works to ensure that there is not conflict and to provide an efficient and well co-ordinated layout.

**3.02 INSTALLATION**

A. Install generator complete and make operational in accordance with the manufacturer's instructions.

B. Install sound attenuators, louvres and sand trap louvres in accordance with the manufacturer's instructions.

C. Provide a copper drain line with draincock from the bottom of the silencer to the nearest floor drain.

D. Install engine exhaust system in accordance with the manufacturer's instructions and provide vibration insolation to prevent vibration transfer to the building structure components.

E. Install day storage tanks and associated pumps, level switches and pipework.

F. Install control panel in the location indicated on the drawings.

G. Label all components in accordance with section 16075.

H. Vacuum clean all panels prior to energising the system.

I. Repair all damaged paintwork in an approved manner.

**3.03 GROUNDING**

A. Ground generator frame and alternator star point using minimum 70 sq.mm ground.

B. Ground all panels, conduit, trunking, etc., in accordance with section 16060.

**3.04 WIRING**

A. Wire between alternator and generator control panel and Main Distribution Board, as indicated on the drawings.

B. Wire to all control devices, instruments, dampers, fans, pumps, etc., in accordance with the manufacturer's instructions using PVC insulated cables in conduit and/or trunking.

**3.05 NO LOAD START**

A. To prevent the generator running on no-load, sufficient contactors shall be provided at all lighting boards in the main building.

B. The contactor coils shall be energised from the generator control panel and the contactor contacts shall be connected across the local circuit switches and main contactor switches.

* 1. **LOAD TEST**

Are to be carried out at low loads to over load conditions, at various power factors. Measurements are to include voltage and frequency deviations and regulating time under various step loading conditions, temperature measurements and pressure measurements at various locations, and in accordance with an approved plan under conditions equal to worst site ambient conditions .

Tests to include :

* Full load test for 8 hours continuous , immediately followed by 10% overload test, without interruption.
* Insulation measurement.
* Functional tests for voltage sensing, automatic start and synchronisation, transfer of load and load-sharing as applicable.
* Operation of engine shut-down and alarm signalling and indication, under simulated fault conditions.
* Measurement of vibration transmission to building structure.
  1. **LOAD BANKS**

If actual loads are not made available at time of acceptance testing, provide load banks to carry out complete test cycle of the system under loading and switching conditions necessary to prove compliance with the Specification.

* 1. **TESTING**

A. Test all control panels in accordance with IEC439.

B. Test units at works prior to despatch and submit test results to the Engineer for approval.

C. Test units on site after installation as follows:-

1. Start up test combined with a full load test using a portable resistor bank. The test shall be run for six hours during which time the kilowatts, current, voltage, frequency, coolant temperature, oil pressure and room temperature shall be recorded at 30 minute intervals.

2. Six hour fuel consumption test carried out in conjunction with the full load.

3. 10% overload test for one hour.

4. Speed test to ensure that the variation is within the limits specified.

5. Voltage regulation test.

6. Operational test of all warning and cut out devices.

7. Battery charges test.

The results of the above tests shall be recorded on test sheets and submitted to the Engineer for approval prior to handing over the installation.

* 1. **DEMONSTRATION**

Demonstrate system operation.

**END OF SECTION**

# SECTION 16425

# SWITCHBOARDS

**PART 1 GENERAL**

* 1. **SCOPE OF WORK**

1. Furnish and install the 415/230 volts switchboards as specified and as shown on the Drawings.
2. Install metering equipment as indicated.
   1. **RELATED WORK**
3. Equipment mounting hardware shall conform to Section 05500.
4. Concrete for equipment pad is included in Division 3.
5. Section 16050: Basic Electrical Material and Methods.
   1. **SUBMITTALS**
6. Submit shop drawings and product data, in accordance with Section 16050 and 01300, as follows:
   1. Equipment shop drawings showing elevation and plan views, compartment arrangement, dimensions, weight, shipping splits, and metering layouts.
   2. single line diagrams, point-to-point compartment wiring diagrams for metering, relay, and control circuits. Show wire and terminal numbers.
   3. Bus material, ratings and insulation details.
   4. product data sheets and catalog numbers for circuit breakers and fused switches. List all options, trip adjustments, and accessories furnished specifically for this Project.
   5. Itemized bill of material for metering, protective relays, accessories, and control equipment.
   6. Show all the main and auxilliary contacts with their Nos. on the terminals and wires (for used of spare contacts) in very CB, contactor and relay on the lower part of each Drawing.
   7. Show clearly on the 1st pages of the wiring and control diagrams, the way how to read the control circuits thru all control panel wiring diagrams and sheets.
   8. Any No. on any wire should not at all repeated on any other wire in the same cubicle.
7. Submit bound operating and maintenance manuals in accordanced with Section 01702. Manuals shall include the following as a minimum:
   1. A comprehensive index.
   2. A complete “As Built” set of approved shop drawings.
   3. A complete list of the equipment supplied, including serial numbers, ranges, pertinent data manufacture name and address.
   4. Full specificaitons on each item.
   5. System schematic drawings “As built”, illustrating all components, piping, and electric connections of the systems upplied under this Section.
   6. Detailed service, maintenance, and operation intructions for each item supplied.
   7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
   8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
   9. Complete parts list with stock numbers, including spare parts.
8. Submit material compliance data sheets to comply with the specifications.
   1. **APPLICABLE CODES AND STANDARDS**
9. Switchboard shall be designed, built, and tested in accordance with the latest editions and evisions NEMA Standard PB-2, and Underwriters’ Lbroratories Standard No. UL-891 or other approved equal standard. Switchboard shall also comply with any applicable ANSI and IEEE Standards and the requirements of the Local Standards and Codes.
10. All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.
    1. **QUALITY ASSURANCE**

The equipment furnished under this Section shall be the product of a manufactuer who has produced this same type of equiment for a period of at least ten consecutive years.

* 1. **MANUFACTURERS’ SERVICES**

The switchboard manufacturer shall furnish the services of a factory trained engineer that has complete knowledge of proper operation and maintenance of the equipment furnished under this Section. Services shall be provided as outlined in Section 16050.

* 1. **SYSTEM DESCRIPTION**

Switchboards shall be rated and shall be provided with all equipment as indicated on the Drawings.

* 1. **SPARE PARTS**

1. Provide the following spare parts priced in a list in the quantities specified:
   1. One dozen each of cover bolts, spring nuts and door fasteners.
   2. One quart of touch-up paint.
   3. One spare main circuit breaker of each type furnished.
   4. One spare feeder breaker of each type furnished.
   5. One digital metering and protection module.
   6. one circuit breaker trip unit of each type furnished.
2. Spare parts shall be boxed or packaged for long term storage and clearly identified on the exterior of package. Identify each item with manufactuers name, description, and part number.

**PART 2 PRODUCTS**

* 1. **RATING**

1. Service: 415/230 volt, 3 phase, 4 wire, 50 Hertz.
2. The switchboards and protective devcices shall be integrally ratedfor a short circuit current of 50 KA rms symmetrical amperes. Systems employing series connected ratings shall not be used. Main and feeder devices shall be coordinated for selective tripping.
3. The manufacturer shall design the switchboard, including devices, for continuous operation at its rated current in a 50 degree C ambient temperature.
   1. **CONSTRUCTION**
4. Structure
   1. Switchboards shall be indoor type, free standing, rear accessible, completely metal enclosed and sectionalized to isolate and minimize the effects of internal short circuit currents. All sections shall line up front and rear.
   2. Completely isolated compartments shall be provided for all main and branch circuit protective devices and metering equipment. Feeder device shall be individually mounted. Incoming and outgoing cable connections shall be made in the rear of the switchboard.
   3. Incoming line compartment shall be isolated from the feeder compartments.
   4. Cable compartments shall be isolated from phase bus with barriers.
   5. All buses shall be totally enclosed with insulating materials. Bus joints shall have removable insulating covers or boots. Taped buses are not acceptable.
   6. Side and top covers shall be code gauge steel, bolted to 12 gauge frame structure membes. Front and rear doors shall be flush, hinged, with screw fasteners.
   7. Each main and feeder device shall be individually compartmented with an external operating handle located on the compartment front door.
   8. All metal surfaces shall be chemically cleaned and primed. The finishing coat of paint shall be ANSI Z55.1 No. 61 or other approved standard, light gray enamel.
5. Buses
   1. All buses shall be silverplated copper.
   2. Buses shall be braced for the specified equipmetn short circuit current rating.
   3. All joint connections shall be welded or shall be joined with bolts and Belleville washers.
   4. Provide a copper ground bus extending throughout the entire length of the switchboard, equipped with lugs for external ground connections, sized for cables shown on the Drawings.
   5. Unused spaces, shall include doors, bus, device supports or mounting plates and connections.
6. Main Section
   1. The switchboards shall include an auxiliary cable pull section if required, for transition from underground cable feed. Provide bus extensions and compresion lugs for number and size of incoming cable as shown on the Drawings.
   2. The main section shall also include a customer metering compartment as shown on the Drawings.
7. Main Circuit Protective Device
   1. Main circuit breaker shall be insolated case, 4-pole, 600 volt, 100 percent rated, stationary type unless otherwise indicated on the Drawings or in the Bill of Quantity, electrically operated with stored energy closing mechanism. Trip device shall be solid state with adjustable long time pickup, delay and timing light; adjustable short time pickup and delay; short time i2t switch; adjustable high range instantaneous, adjustable ground fault pickup and delay; overload, short circuit and ground fault indicator lights, ground fault delay and pickup trips for selective tripping. For more details see (Section 16182).
   2. Main device shall be equipped with contacts for remote status and trip indication. Device rating shall be as shown on the drawings.
   3. Main device shall have line side at top.
8. Feeder Protective Devices
   1. Feeder circuit brakers shall be molded case, 4 pole, 600 volt, 100 percent equipment rated, fixed type equipped with an adjustable, temperature insensitive, solid state trip device with adjustable instantaneous, short time, long time and ground fault delay and pickup trips for selective tripping.
9. Digital Metering and Protection Module (DMFM)
   1. The DMFM shaqll be a microprocessor based, solid state unit, door mounted, providing monitoring and protecting funcitons. The DMFM shall comply with ANSI Standard C37. 90.
   2. The DMFM shall provide a digital display of measured or calculated values for the units listed below and shall automatically range between units, kilo-units, and mega-units for all displayed values.
   3. AC amperes in each phase, 1 percent accuracy.
   4. Ac voltage, phase-to-phase, phast-to-neutral, 1 percent accuracy.
   5. Watts, 2 percent accuracy.
   6. Vars, 2 percent accuracy.
   7. Power fator, 4 percent accuracy.
   8. Frequency, 0.5 percent accuracy.
   9. Watt demand (5, 10, 15, 30 minute interval programmable or from utility synchronizing pulse) 2 percent accuracy.
   10. Watt hours, 2 percent accuracy.
   11. The DMFM shall provide the following adjustable protective features:
       1. voltage phase loss, if any phase is less than 50 percent of the nominal line voltage.
       2. Current phase loss, if the smallest phase value is less than 1/16 of the largest phase value.
       3. Line voltage phase unbalance, selectable from 5 to 40 percent of nominal in 5 percent increments.
       4. Voltage phase reversal.
       5. Overvoltage, selectable from 105 to 140 percent in 5 percent increments.
       6. Undervoltage, selectable from 95 to 60 percent in 5 percent inrements.
       7. Time delay (adjustable from 0 to 8 seconds in 1 second intervals) for overvoltage, undervoltage, and phase unbalance trip and alarm settings.
   12. Current transformers shall be provided.
   13. Synchronous pulse input shall be provided and when activated shall override the preset watt demand interval and let the utility control the demand window.
   14. The DMFM shall have separate trip and larm output contacts that actuate when a protective function exceeds its set point. The contact shall have ratings of 10A at 115/230 VAC and shall be NO/NC.
   15. A separte NO/NC contact shall be provided for a kilowatthour pulse. KWH pulse shall be field programmable.
   16. The DMFM face shall be membrance type and rated NEMA 12. The DMFM shall have a durable six digit LED display screen. The display screen and LED’s shall indicate both trip and larm conditions. The cause of a trip or alarm shall be indicated in the display window.
   17. The DMFM shall have an operting temperature range of 0 degrees C to 70 degrees C, and 0 to 95 percent relative humidity noncondensing.
   18. The DMFM shall allow the user to disable undersired values / functions and to later reactivate them if required.
   19. In the event of a trip or alarm condition, a built-in reset button shall allow a manual reset. The DMFM shall also be capable of being remotely reset via its communications port. Watthours and watt demand shall be resettable.
   20. Control power shall be from the monitored AC line terminal connections. A separate AC supply input shall not be required.
   21. The DMFM shall have non-volatile memory and not require battery backup. In the event of a power failure, the DMFM shall retain all preset parameters, acumulated watthours and watt demand. Data at time of power loss and cuase of trip shall be stored.
   22. Provisions shall be made for the future addition of an addressable communication card capable of transmitting all data, including trip dataover a compatible two wire local areas network to a central personal computer for storage and / or printout. The network shall also be capable of tranmitting data in RS232 format via a tanslator module.
10. Wiring
    1. Low voltage instrument and control wiring shall be copper, type SIS, flameproof switchboard wire identified with shrink-on marker sleeves at each end. Low voltage wiring terminal blocks shall have marking strips and shall be mounted vertically in an accessible location. All terminal lugs shall be of the full loop type.
11. Marking and Identification
    1. Marking and Identification shall be in compliance with Section 16075.
    2. Nameplates shall be provided on all hinged doors for unit load description and for each control or indicating device. Nameplates shall be engraved as shown on the Drawing or as directed, using lettering approximately 9.5mm high for unit identification nameplate and 6.5 mm high elsewhere. The nameplates shall be black and white laminated phenolic material. The engraving shall extend through the black exterior lamination to the white core. Nameplates shall be engraved in English language.
    3. A manufacturer’s plaque shall be fastened to the front of the switchboard. The plaque shall indicate model number, serial number, amperes, volts, short circuit rating, etc.
    4. Each switchboard shall be furnished with a sign marked “DANGER – 415 VOLTS KEEP OUT”. Letters shall be not less than 25mm high, 6.5mm stroke. Signs shall be adhesive backed mylar, OSHA approved. Sign shall be in both English and Arabic Languages.

**PART 3 EXECUTION**

* 1. **INSTALLATION**

1. Switchboards, shall be mounted on continuous 100mm structural steel channels furnished under this Section, set flush with the equipment pad and level in all directions. The switchboard shall be bolted to the channel with not less than 12mm bolts. Provide anchor bolts, shims, and hardware in accordanced with the details shown on the Drawings.
2. Installation shall be in accordance with the manufacturers’ instructions.
3. The switchboard shall be arranged so that the upper most operating handle shall not exceed 1900 mm from the floor when the switchboard is mounted on a 100m high equipment pad.
4. Field wiring shall be grouped by circuit and tie wrapped. Terminations shall not be stressed. Field wiring shall be slackened with sufficient lengths.
   1. **FIELD TESTING**
5. Make the following minimum tests and checks before energizing the equipment:
   1. Megger terminals and buses at two times rated voltage, phase-tophase and phase-to-ground after disconnecting devices sensitive to megger voltage.
   2. Remove all current transformer shunts after compelting secondary circuit.
   3. Check all mechanical interlocks for proper operation.
   4. Vacum clean all interior equipment.
   5. Adjust and test all circuit breakers and relays in accordance with Secton 16000 and 16050.
   6. Confirm and record all protective relays settings.
6. Submit megger test reports to the Engineer for approval.

**END OF SECTION**

# SECTION 16445

# PANELBOARDS AND DISCONNECT SWITCHES

**PART 1 – GENERAL**

**1.1 DESCRIPTION**

This section covers furnishing and installing of all panel boards and disconnect switches as specified herein as shall be indicated on the Submittal Drawings.

A. Related Work

1. General Equipment and Material Stipulations.

The general equipment and material stipulations shall apply to all equipment furnished under this section.

2. Work Specified Elsewhere.

Other items that relate to and are referenced in this section include, but are not limited to, the following section SUBMITTALS

**1.2 QUALITY ASSURANCE**

A. Applicable Codes and Standards

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050

**1.3 SUBMITTALS**

The Contractor shall furnish manufacturers' catalogue sheets marked for the items furnished and cross referenced with the Drawings and shall submit all Drawings, data sheet and compliance sheet for review and approval on accordance with Section 01300 SUBMITTALS.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

A. Lighting and Power Panels

Except as individually described, each lighting and power panel shall be dead front, circuit breaker, 400/230 Volts, 3 phases, 4 wire panel board type in accordance with the Drawings including the following:

1. Cabinet

The panel shall have a surface NEMA Type 1 enclosure. The enclosure shall have a door with latch and lock. A directory inside the door shall have the panel and all circuit identities neatly typewritten at completion of the Contract.

A ground stud bolt shall be provided through the cabinet with a removable 50 sq. mm (1/0 AWG) bond to the panel ground bus and an external clamp connector for a station ground cable.

Every cabinet shall have 20% of its space as a reserve space for future extra installation.

All indoor cabinets and panels shall be IP 54.

2. Circuit Breakers

In addition to what mentioned and specified in other related sections about CBs (Sec. 16182), circuit breakers shall be thermal-magnetic both adjustable according to the brand ratings permits, bolt-in, individually front replaceable, and shall indicate "ON", "OFF" and "Tripped". Breakers indicated as multiple pole shall be common trip. Breakers shall have interrupting ratings not less than 6,000 Amperes.

Breakers and provisions for future breakers shall be provided in the quantities, poles, and ampere ratings indicated on the drawings. Breakers shall be shown on the Submittal Drawings.

3. Buses

The panel shall have main and neutral buses insulated from the cabinet and a ground bus. Buses shall be copper with ampere ratings and main lugs for breaker as indicated. The ground bus shall be similar to a neutral bus and shall have a good ground connection to the cabinet, a removable bond to the neutral bus, clamp type lugs for the ground cable in each supply conduit, and connections for a ground cable in each load conduit.

B. Separately Enclosed Disconnects

Separately enclosed disconnects not furnished with equipment shall be provided, as indicated on the Drawings.

Disconnects shall be 4 poles (plus 2 No + NC Auxiliary Contacts) operated and indicated by lockable external handles. Disconnects shall be rated at least 600 Volts and 10,000 Amperes interrupting rating on circuits below 600 Volts. Disconnects enclosures shall be NEMA Type 4 for outdoor use and NEMA Type 1 for indoor use.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

A. The equipment shall be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used.

B. Equipments mounted on water-or earth- bearing walls shall be separated from the wall not less than 5 mm.

**END OF SECTION**

# SECTION 16461

# DRY TYPE DISTRIBUTION TRANSFORMERS

**PART 1 GENERAL**

**1.01 THE REQUIREMENT**

1. The Contractor shall furnish, install, and test transformers for power and lighting distribution systems as specified herein, as indicated on the Drawings, and as required to complete the electrical installations.
2. All equipment specified in this Section shall be furnished by the transformer manufacturer who shall be responsible for the suitability and compatibility of all included equipment.
3. Reference Section 16050, Basic Electrical Materials and Methods, and Section 09900, Painting.
4. Reference codes and standards as referred to in Section 16050.

**1.02 TESTING**

ِِِِِA. All tests shall be performed in accordance with the materials and methods of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

This shall be certified and signed by a 3rd party company (Liods, SES … etc) in the origin country of a well known nambe mut approved by the Engineer before testing.

2. Certified Shop Tests

a. The transformers shall be given routine factory tests in accordance with the requirements of the ANSI and NEMA standards or according to the standard which implied by the manufacturer for these types. Temperature rises may be certified from basic design.

b. As a minimum, the following tests shall be made on all transformers:

1. Ratio tests on the rated voltage connection and on all tap connections.

2. Polarity and phase-relation tests on the rated voltage connection.

3. Applied potential tests.

4. Induced potential tests.

5. No-load and excitation current at rated voltage on the rated voltage connection.

1. Field Tests
2. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.
3. After installation, the transformers shall be subjected to routine insulation resistance tests. The tests shall be made by the Contractor who shall also furnish the required testing equipment.
4. The Contractor shall also execute all the tests the Engineer shall see it necessary according to the needs or instructions of the Local Electric Company in the area or as the Company may recommends.

**1.03 SUBMITTALS**

A. In accordance with the procedures and requirements set forth in the General Conditions and Division 1, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Operation and Maintenance Manuals.

3. Spare Parts List.

4. Special Tools List.

5. Reports of Certified Shop Tests.

1. Each submittal shall be identified by the applicable specification section.
2. Submit materials compliance sheets that comply with the specifications

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein, and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

2. Drawings showing clearly marked dimensions for each transformer.

3. Sample equipment nameplate diagram.

D. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings.

1. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

**1.05 OPERATION AND MAINTENANCE MANUALS**

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

**1.06 TOOLS, SUPPLIES AND SPARE PARTS**

1. The transformers shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.
2. Spare parts lists, included with the Shop Drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
3. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.
4. All submitted spare parts prices after approval shall be included in the unit price of the Contract.

**1.07 IDENTIFICATION**

A. Each transformer shall be identified with the equipment item number indicated on the Contract Drawings and the accepted Shop Drawings. A nameplate shall be securely affixed in a conspicuous place on each transformer. Nameplates shall be as specified in Section 16075, Electrical Identification.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Dry type distribution transformers shall be manufactured by Square D Company, General Electric Company Type QL, Cutler-Hammer/Westinghouse Electric Corporation, or equal european company aproved by the Engineer.

**2.02 DRY TYPE TRANSFORMERS**

A. Furnish and install single-phase and three-phase general purpose, dry-type transformers, as specified herein and indicated on the Drawings. The transformers shall be 50 Hz, self‑cooled, quiet‑design insulated of the two winding type.

B. The transformers shall be Underwriters Laboratories, Inc. listed and shall bear the UL label, or to other international (approved by the Engineer) standards.

C. The primary windings shall be rated 415 VAC for use on 3‑phase, 3‑wire systems and connected delta unless indicated otherwise on the Drawings. KVA ratings shall be as shown on the Drawings. Furnish transformers with two 2‑1/2% primary taps above, and four 2‑1/2% primary taps below rated voltage for transformers 15 KVA and above, and two 2‑1/2% primary taps above, and two 2‑1/2% primary taps below rated voltage for transformers less than 15 kVA. All taps shall be full capacity rated.

D. The ratings of the secondary windings shall be as indicated on the Drawings.

E. Transformers shall be designed for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in IEEE 65 and ANSI C57.96. This performance shall be obtainable without exceeding 150 degrees Celsius average temperature rise by resistance or 180 degrees Celsius hot spot temperature rise in a 40 degrees Celsius maximum ambient and 30 degrees Celsius average ambient. The maximum coil hot spot temperature shall not exceed 220 degrees Celsius. All insulating materials shall be flame retardant and shall not support combustion as defined in ASTM Standard Test Method D 635. All insulating materials shall be in accordance with NEMA ST 20 Standard for a 220 degrees Celsius UL component recognized insulation system.

F. Transformer coils shall be of the continuous wound copper construction and shall be impregnated with nonhygroscopic, thermosetting varnish.

G. Transformers shall have copper windings.

H. All cores are to be constructed of high grade, nonaging, grain‑oriented silicon steel with high magnetic permeability and low hysteresis and eddy current loses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be tightly clamped and compressed with structural steel angles. The completed core and coil shall then be bolted to the base by means of vibration‑absorbing mounts to minimize sound transmission. There shall be no metal‑to‑metal contact between the core and coil assembly and the enclosure.

I. The enclosure shall be made of heavy gauge steel and shall be degreased, cleaned, primed, and finished with a baked weather-resistant enamel. See painting requirements specified in this Section.

J. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees Celsius. Transformers shall be furnished with lugs of the size and quantity required and suitable for termination of the field wiring.

K. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable NEMA, IEEE, and ANSI standards.

L. Transformers shall have core and coil assemblies mounted on rubber isolation pads to minimize the sound levels. The transformers shall not exceed the following ANSI sound levels:

0 to 9 kVA 40 dB

10 to 50 kVA 45 dB

51 to 150 kVA 50 dB

151 to 300 KVA 55 dB

301 to 500 KVA 60 dB

501 to 700 KVA 62 dB

701 to 1000 KVA 64 dB

1001 to 1500 KVA 65 dB

**2.03 PAINTING**

A. The exteriors of the transformer enclosures shall be painted as follows:

1. Factory painting: Surfaces shall be cleaned carefully and given a priming basic lead chromate. This shall be followed by two coats of an approved paint applied by brushing.

1. Field painting: After delivery and installation, but before transformers are placed in service, all factory-painted surfaces shall be carefully cleaned and all abrasions shall be repaired. All painted surfaces shall then be given one brushed-on coat of paint as specified for the fourth coat of machinery and equipment in Section 09900 - Painting. Color shall be ANSI #61.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. The transformers shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer.

B. Conduit routed to and from the transformer shall be arranged for easy removal of the transformer.

**END OF SECTION**

# SECTION 16480

# MOTOR CONTROL CENTRE

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers the 400 Volts class motor control centre to be furnished and installed as specified, and shall be indicated on the Submittal Drawings. The motor control centre shall be for use on a 400 Volts + 10%, 3 phases, 4 wires, 50 Hz system.

Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer.

The motor control centre assembly shall be a product of an industrial motor starter’s and circuit breaker equipment’s manufacturer who has an official local agent in the country and supplied such equipment both individually and together as feeder breakers, starters relays…etc, and combination starters for a period of not less than 15 years for the manufacturer and 5 years for the Agent.

**A. Related Work**

1. General Equipment and Material Stipulations:

The General Equipment and Material Stipulations shall apply to all equipment furnished under this section.

2. Work Specified Elsewhere:

Other items that relate to and are referenced in this section include, but are not limited to, the following section submittals

**1.2 QUALITY ASSURANCE**

**A. Applicable Codes and Standards**

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.

**B. Shop Tests**

The complete control centre shall be witness tested by the Engineer and the Employer (3 persons) at the factory. The Contractor shall pay all costs of transport with full accommodation and food. The Contractor per capita shall pay pocket money of US$ 150 per day as well the Nos. of days shall be from the 1st day of flight departure of the Engineer team to the last day they land their hope airport. All circuits, including power and control, shall be given dielectric tests in accordance with the NEMA procedures set forth in "TESTS FOR INDUSTRIAL CONTROL SYSTEMS', or equivalent BSS.

**1.3 SUBMITTALS**

**Manufacturer's Drawings and Data**

The Contractor shall furnish outline drawings and dimensional data which fully describe (1) the projected floor space required for the equipment, (2) the absolute minimum working space required at the front, rear, and sides of the equipment, (3) the equipment height, and (4) the equipment weight.

The Contractor shall furnish complete and accurate drawings of the equipment including plan, front and sectional or side views; base plans showing anchor bolt locations and base details; and schematics and wiring diagrams. All drawings shall be submitted for review in accordance with the clauses related to submittals in Section 16050.

Three copies of the following drawings shall be submitted for approval within one month of the date of order, and before manufacture commences:

1. General arrangement drawings showing the overall dimensions of the switchgear, the space required for the opening of doors, lids and withdrawal of circuit breakers, and sizes and positions of holding down bolts related to the cable trench. Any projection affecting the passage of boards through doors shall be shown.
2. Layout and sectional drawings showing positions of switchgear components, busbars, riser connections, contactors and cable gland plates.
3. Comprehensive power and control wiring diagrams showing all terminals, wires and ferrule numbers, the settings or ratings of all circuit breakers, fuses, contactors, overloads, timers switches, buttons and any other equipment.
4. Complete material lists identifying each item in the electrical diagrams, giving the name of the manufacturer and his address and origin, type or model number of the item and manufacturer’s reference number.
5. The wiring deagram shall also show all the following:

* All abreviations and symbols, on separate pages.
* A complete symbol of how to read each page in the wiring and control diagrams and drawings and to follow the control in other related sheets and drawings.
* Each C.B., Contactor, relay…. etc shall have alog underneath it down in the drawings showing the NO. & NC. contacts of the device and at what drawing or sheets they are located.
* Every wires in every drawings shall be numbered at its both start and termination and cary a specific No. Any specific No. of any wire should not be the same nor repeated on any other wire in the same control panel of the same partition or compartment.
* Each termination in open or close contacts, switches, devices …. etc shall be numbered exactly as they are on the related contact or device.
* Every sheet in the drawings shall have vertical and horizontal coordinates which shall be used for locating any device (contacts, contactors, CBs, relays …etc) and its related wired contacts.

**PART 2 - PRODUCTS**

* 1. **MATERIALS AND CONSTRUCTION**
     1. **General**

**A. Vertical Sections**

Each motor control centre shall consist of standardised free-standing vertical sections and special free-standing instrument sections bolted together to form a single dead front panel assembly containing combination motor control units, feeder breakers, lighting panels, metering, relaying interlocking, and miscellaneous control devices.

A vertical section shall be fabricated from sheet steel, not less than 2.0 mm thick, and formed steel members securely fastened to form a rigid self-supporting structure with integrally constructed floor mounting sills having two 16 mm bolt holes, one at centre front and one at centre rear.

Removable rear plates shall be sectionalised so that it is necessary to handle any plate greater than the section width or one-half the section height. Hinged rear doors shall be full height and full section width provided with not less than a three-point latch.

Each standardised vertical section shall be designed and fabricated so additional sections may be added.

**B. Compartment Units**

Each vertical section shall be of modular construction of various sized components, which are of some multiple dimension of the smallest compartment. The modular component design shall be such that a vertical section cannot accommodate any greater than six Size 2 full voltage combination motor starters.

Individual motor starter units, feeder breaker units, transformers, lighting panels, distribution panels, control device compartments, etc., shall be isolated from each other by metal barriers.

Each vertical section shall have a vertical wiring trough for power and control wiring, and two horizontal wiring troughs, one at top and one at bottom, which line up with adjacent sections to form wiring troughs the entire control centre.

All control sections; floor-mounted panels and boards shall be installed on a concrete base 10-cm height over finish floor level.

**C. Bussing**

The horizontal main bus and the vertical bus extensions shall be copper mounted on supports formed of high dielectric strength, low moisture absorbing, high impact material with ample creepage distance between phases. Both horizontal and vertical bussing shall be braced against forces resulting from fault current.

Vertical bus connecting an incoming power feeder cable shall be of the same rating as the main horizontal bus. Each vertical bus extension shall have a current rating of not less than 150 percent of the connected load specified for its respective vertical section.

A full capacity, copper, insulated neutral bus shall be furnished continuously through the control centre.

A copper ground bus, having a momentary and short time current rating at least equal to that of the largest circuit breaker, shall be furnished through the entire control centre and located where it will not interfere with pulling of external cable. All control equipment requiring grounding shall be connected to the ground bus. Grounding connections shall be conveniently accessible from the front. A solderless connector shall be provided on each end of the ground bus and located within each end section for connecting external grounding cables, sized for 70 sq. mm (2/0 AWG). All Bus-Bars (vertical and horizontal) shall be insulated.

**D. Isolation of Buses**

The main bus shall be isolated from the horizontal wiring trough by a removable steel barrier. Permanent insulation on or in front of vertical buses except at control unit connection points shall prevent front contact with the buses while the control units are removed.

1. **Terminals**

Suitable solderless terminals or lugs shall be provided for connection of all incoming and outgoing circuits. Terminals shall be provided for control cables shown by the one-lines and schematics on the Drawings as entering the control centre without connection to internal devices.

1. **Insulation Pad**

Every control and motor panel ( of more than 1.2m width and ground mounted) shall have its own rubber mat in front of it, the dimension of which shall be of

Length = Panel width+60 cm.

Breadth = 80 cm.

Thickness = 6 mm.

Color = Black.

* + 1. **Devices & Panel Elements:** 
       1. **Motor Starter with Electronic Soft Starter**

1. **General Requirement:**

The electronic soft starter shall have the following specifications:

The starters shall be suitable for squirrel cage induction motors with main supply: 3 phase, 400V, +15%, -10%, 47 upto 63 Hz.

Ambient temperature 50oC, IP 54

Set point facility for start up current respectively torque.

Ramp characteristic for starting up to preset rated value and the same for stopping sequence.

Power supply monitoring and protection (i.e phase loss and failure) on both input and output of the starter.

Two levels of starting current and respective torque (selectable).

Current limitation on starting, adjustable by a potentiometer (i.e. start with partial resettable load current).

Start voltage selectable between 0% up to 65%.

Current rise adjustable, time range adjustable 1 sec up to 60 sec.

With automatic and manual restart facility.

Acceleration and relay.

Run indication acceleration, start up complete indication.

Soft down capability up to stand still.

Connection and disconnection of line contactor shall be carried out under no load, and shall be supplied with by-pass contactor.

Energy saving continuously controlling the load when motor is partially loaded.

Pump controlled acceleration and deceleration of pump motor without feed back devices (in case of pump starters).

Start fault detection protection.

Temperature (over heating) fault protection for internal and motor protection.

Controlled soft start and controlled acceleration.

Motor stop control in case of failure (internal and external).

Over and under voltage protections.

The motor shall stop after a preset time – via delay timer- if the discharge control valve (in case of pump starters) does not close as it is scheduled.

Motor Starter Cubicle shall have:

* 1. Emergency stop – push button (stay push – keyed switched to reset mushroom red head type).
  2. The motor (via the starter) shall start only when the discharge control valve is fully closed, in case the valve did not open, the starter shall shut down after a preset time delay
  3. The soft starter shall have a by-pass contactor to short out the soft starter after completion of motor starting. This contactor shall be rated with AC3 catergory. The contactor of the starter shall go out when stopping and starting shall be through the starter, not through the contactor.
  4. The motor starter shall have provisions to wire the starter to a remote status or telemetry control.
  5. All the previous protections and operations shall have indication lamps on the starter cubicle front door, unless inapplicable for some of them.
  6. Thermal over load suitable for the motor rating shall be included in the starter cubicle.
  7. The soft starter shall be protected by a proper main circuit breaker, with adjustable magnetic and thermal protection.
  8. The soft starter and all the above mentioned components shall be enclosed in a standard panel, fitted with the control cabinet and subject to the approval of the Engineer.
  9. The motor starter cubicle in addition to the soft starter fans shall be well ventilated (by long life suitable industrial metallic fans) to keep the inside temperature of the panel guaranteed within the operational limits (35oC max), otherwise the Contractor shall execute what necessary even with A/C units with all arrangements, construction and installation facilities to acomplish this with no extra cost.
  10. The Contractor shall supply, install, commission, test and put into operation completely, the soft starter. He shall primarily early, submit complete technical data to the Engineer for approval before the supply of and ordering the starter.
  11. The Contractor shall completely put the soft starter (in numbers mentioned in BoQ) into operation. The Contractor shall also repair, rectify and procure all the necessary materials and make all the necessary maintenance for the soft starter if this fails or abruptly makes troubles or is functioning in an unacceptable manner, during any time within the maintenance period and within 24 hrs. of recall after malfunctioning of the soft starter. Otherwise the Employer will carry out the job, and the Contractor shall reimburse the cost plus 100% to the Employer.
  12. Each motor starter with rating (30 kW) and above shall be furnished with door mounted, Motor Protection and Monitoring unit (MPMU) approved by the Engineer.

Each starter shall have LCD for all control, monitoring and alarm functions included in the starter.

This device shall be equipped with all integral options needed to conduct all its function to protect the pump or the machine and the driving motor, if these options shall be installed inside the starters.

In case of supplying starters only (to stores or as spare starter) without installation on site, all wiring needs for this device to go out of the starter shall be terminated on a comprehensive full wire labeled terminal bars with a complete identification and wiring to other integral control devices installed on the pump and motor in conjunction with MPMU Unit. In this case the spare starter shall be tested on site as if it is for permanent operation before stored.

However all this protection device including the starter shall be labeled comprehensively for all wires, cables, devices…etc. with elastic rubber tireless and rigidly-fixed labeled terminal bars for the out going wires out of starters, all in approved execution of the Engineer.

* 1. The supplier shall provide with his bid a detailed list(s) of all components, whether major or minor, which shall be incorporated in his offer and in the starter. Failure to provide such list(s) shall result in the rejection of the bid.
  2. Complete circuit diagrams shall be provided together with service instructions, and spare parts list for all components used in the starter panel, and they shall be supplied in a transparent plastic case inside a metallic pocket welded on the backside of the panel door.
  3. The manufacturer should in the factory conduct the required tests on each starter as per IEC 439-1:1990 (clauses: 8.1.2, 8.3 and all its sub-clauses), and the test should be repeated and witnessed by the Engineer’s and Employer’s representatives at the site. The required tests are (but not limited to) the following:
  4. Visual Inspection.
  5. Mechanical inspection.
  6. Operation test.
  7. H.V. test: 2.5 kV for 1 min.
  8. Insulation (megger) test.
  9. Primary injection test.
  10. Secondary injection test (for measuring instruments and protection).

The manufacturer shall after that submit a complete tests report including the above mentioned tests and a (certificate) for each panel showing that the starters were completely tested, and setting of relays were adjusted. Setting values of all installed instruments and protections shall be submitted.

1. **Starter Construction:**

1. The motor starter shall be housed in a suitable factory built assemblies “ FBA” complying with IEC 439-1:1990, FBA shall be of cubical type the front of which shall have a smooth well finished surface.

2. The FBA shall be manufactured to a high standard from steel sheet minimum thickness 2 mm, and shall be adequately braced to give a rigid structure. Adequate removable eye bolts for lifting purposes shall be provided.

3. Access to the cubicles compartment for all normal routine maintenance shall be from the front by hinged and lockable doors secured with cam type fasteners and cylinder locks with removable key. Hinges shall be of substantial size and stops shall be provided to prevent doors touching adjacent cubicles. Other access shall be by means of bolted panels. The maximum width of any door shall be 800 mm.

4. Protection category of starters’ enclosures shall be at least IP54 according to IEC publication 529-10/91.

1. All cables and piping shall be made through glands in a plate covering the base of the cubicles.
2. The base plate shall be of non-magnetic material to avoid electric heating
3. All the wiring, instruments, devices and all parts of the panel shall be facing the front of the panels, i.e. it shall not be needed to go to the rear of the panels to do any thing to it, any time ( for dismantling, maintenance, reinstallation etc.)
4. Each starter panel shall enclose all related devices (i.e. equipment, contactors, relays, controls….etc. ), no devices related to the starter shall be installed outside the starter enclosure, unless otherwise specified.
5. Components shall be mounted in a way to prevent mechanical shocks transmitted from large components to small components and there by adversely affecting their proper functions. The components shall be so arranged to give adequate accessibility for maintenance and for removal of any one component with the minimum disturbance to the wiring. Plug-in connectors shall be used where possible.
6. All bolts, nuts, screws, hinges, handles, etc. shall of galvanized or stainless steal, cadmium plated steel, or chrome-plated steel as appropriate.
7. The internal wiring of all cubicles shall be completed before delivery.
8. Interlocks of a substantial mechanical type shall be provided in each cubicle between the door and the circuit breaker so that the door cannot be opened unless the circuit breaker is in the OFF position and all live parts, which can be accidentally touched, have been disconnected.
9. The whole busbars, including the conductors connecting the busbars to each outgoing unit shall be arranged to withstand a short circuit at any point.

The FBA shall be designed to withstand any external fault. In the event of any internal arcing fault on a functional unit, the damage should be confirmed to that unit so that the busbars and all other functional units remain fit for further service. However, the conductors connecting the busbars to the outgoing unit might be damaged by the internal arcing fault.

1. Starter's contactors interconnections (wiring): -

The maximum ampere loading for the power interconnectors shall not be rated more than (2.5) Amp/mm2, (the bigger cable or Busbar cross section shall be installed in case the computed cross section is not available).

1. For starters of power less than (200) kW, the input and output interconnectors shall be PVC insulated Cu cables.
2. Every starter panel with height less than 1600 mm shall have an empty metal base covered from the sides for a height not less than 30cm in which nothing shall be installed. There must be left additional 30cm over that base to install any connection bar or terminal bar cables to the control board and for the out-going cables to the motor.
3. For free standing enclosures with height 1800 mm and above, a 100-mm steel plinth shall be installed.
4. Each panel board shall be equipped with electric heater for condensation and thermostat to auto control the heater at a resettable temperature range.
5. The starter should have 2 x 10w flourescent lamps to light the starter panel interior by a door switch when opened directly and turn it off when closed.
6. **Controls, Indication & Alarms:**
7. Control, Protection and measurement equipment and devices shall be power supplied through isolation transformer.
8. The operating push buttons, switches, or handles of all circuit breakers, motor starters, isolators, etc. shall be located on the doors of the cubicles as much as practicable or according to the manufacturer recommendations, and there shall be visual indications of the “ ON “ and “ OFF “ positions.
9. All operations of fault and alarm circuits shall be clearly and individually indicated on the front of the switchboard by lamp operation.
10. Fault and alarm indication lamps shall remain ON until the cause has been cleared and the system has been manually reset.
11. The front of the starter panels shall contain the following signaling, controls and instruments: -
12. A set of “ ON “ and “ OFF” and “ FAULT” signals.
13. One voltmeter 0-500VAC with selector switch to monitor the 3 phases + neutral voltages (unless they are shown on LCD on the panel facia).
14. Three ammeters “ one per phase “ with double scale (unless they are shown on LCD on the panel facia).
15. One running hours recorder without resetting facility to record up to 9999 hours.
16. LED indication lamps to show the following:-
17. Motor “ ON ” and “ OFF ” and “ FAULT ”.
18. The motor is overloaded.
19. Dry run trip.
20. Low water level trip from suction side reservoir.
21. Motor winding high temperature trip
22. Soft starter faulty.
23. R-S-T indication lamps
24. High pressure trip.
25. Low pressure trip.
26. One operating pulses recorder or meter (digital type) for number-of-starts counts (unresettable).
27. One stay-put push button for emergency stopping with key switch to reset.
28. One audible alarm Re-settable buzzer for all faults.
29. High and low pr. switches with trip relays and signal lamps for each, incase of pump starters.
30. Indication lamps and push buttons shall be colored as follows:

|  |  |
| --- | --- |
| **Indicating Lamp** | **Colour** |
| ON | Green |
| OFF | Red |
| Fault | Amber |
| Alarms | Yellow |
| Heaters | Blue |

|  |  |
| --- | --- |
| **Push Buttons** | **Colour** |
| Start | Green |
| Stop | Red |
| Alarm Accept | Black or White |
| Emergency Stop | Red |
| Horn Silencer | Yellow |

1. Indication lamps test push button.
   * + 1. **Motor Starters with Auto Transformer Starter (ATST)**
     1. **General Requirements:**
2. The starters of (30)kW and above shall be of auto transformer unless otherwise stated, as required suitable for a squirrel cage induction motor 400 volts ± 10%, 50 Hz, 3 phase, the starting steps shall be such that the maximum starting current does not exceed two and half times the rated motor current and tapping 70%.
3. Each motor starter shall comprise the following:

Automatic circuit breaker 30 kA rated short circuit breaking capacity, (0.6-1.8 of rated motor current capacity) for electromagnetic protection adjustable and adjustable thermal protection range.

Starting, bridging, and running contactors as required.

A starting auto transformer with 70% tapping.

All controls for the pump sets as specified.

All alarm indication lamps for the pump set as specified.

Re-settable audible and visible alarm system for all faults.

LCD & MPMU for all control, monitoring and alarm functions included in the starter.

1. The main, step, and star contactors shall be selected in accordance with utilization category AC3 at 400 VAC, (110%, 70%, 35% of rated power respectively).
2. The thermal overload protection relay, of the suitable adjustable range, shall be installed between the running contactor and motor, (with current- TFs. According to situation). The overload range shall be approx. from (80%) – (120%) of the nominal current rating of the motor.
3. The starter shall be rated to stand a minimum of six starts per hour at an ambient temperature of 50º C.
4. The motor starter shall incorporate the following:
   * + Adjustable thermal overload protection.
     + Dry running protection relay (in case of pump starters).
     + Relay, Low water level in tank (in case of pump starters).
     + Relay, Low pressure in pump discharge line (in case of pump starters).
     + Relay, high pressure in pump discharge line (in case of pump starters).
     + Relay, no flow in pump line (in case of pump starters).
     + One power monitor relay which shall trip in case of:
       1. Incorrect phase sequence,
       2. Over voltage,
       3. Under voltage,
       4. Phase failure,

And it shall have additional features such as:

1. Adjustable trip time delay for over and under voltage up to 10 sec,
2. Sealable transparent cover.
   * + RTD motor protection module, to protect the motor, starter windings from over heating. The sensors provided in the motor starter winding are RTD resister sensors.
     + Thermistor protection relay or micro therm contact, to prohibit starting the motor when the Auto transformer is overheated, and to protect the Auto transformer.
3. The phase failure relay shall be wired via delay relays in two places; one at the main circuit braker of the starter, the other just before the inlet to the motor overload.
4. There should be wired a delay relay in the circuit of the under voltage protection with 0-30 sec. range adjusted to (10 sec.) to delay the effect of u.vge in the starting steps.
5. Separate current transformers shall be provided for protection and instrumentation duties. The rated burden shall be as needed by the instrumentation and/or protection, but not less than 10VA.
6. Fuses (if used) and links shall be grouped where appropriate according to their functions and shall be clearly marked both on panels and the associated wiring diagrams.
7. Auto transformer shall have the following features:
   * 1. Air cooled design
     2. The core and coil shall be twice impregnated under vacuum in high temperature grade.
     3. It shall be designed and tested to meet the requirements of IEC 292-4 for 50º C ambient temperature.
     4. Starts per hour 6 times, 10 min. each.
     5. Phases:3
     6. Transformation ratio: 400/280 Volt, tapping: 70%
     7. PTC resistor sensor or Micro-therm contact shall be inserted in the Autotransformer winding, to protect it against overheating.
     8. Insulation class: F
8. The starter shall be fully assembled by the same manufacturer, & where modifications such as a additions of extra protection devices or indications are required, these modifications shall be performed in a similar manner by the original equipment manufactures. In such case full details of modifications and circuit diagrams shall be provided.
9. Each starter (in case of pumps starters) shall have its own dry running sensor, low pressure switches (installed on the suction of its pump and its own high pressure switch installed on the discharge side of the pump i.e. each pump) and its own relays inside the starter panel. This protection shall be independent from that low water level or dry running installed in the reservoir, which shall be connected in series with them as a protection.
10. The main power circuits in the A.T.ST, shall be protected by molded case circuit breaker (MCCB) which has adjustable thermal, magnetic trip units and short circuit breaking capacity not less than 30 kA, unless otherwise specified else where, and shall comply with IEC publications 157-1, 292, and 947.
11. Control circuit in the A.T.ST. shall be protected by miniature circuit breakers (MCB) with current limiting feature, and I.C. not less than 6 kA according to IEC 157-1 P1, (or fuses if approved by Engineer).
12. Complete circuit diagrams shall be provided together with service instructions, and spare parts list for all components used in the starter panel, and they shall be supplied in a transparent plastic case inside a metallic pocket welded on the backside of the panel door.
13. The manufacturer should in the factory conduct the required tests on each starter as per IEC 439-1:1990 (clauses: 8.1.2, 8.3 and all its sub-clauses), and the test should be repeated and witnessed by the Engineer’s and Employer’s representatives at the site. The required tests are (but not limited to) the following:
    1. Visual Inspection.
    2. Mechanical inspection.
    3. Operation test.
    4. H.V. test: 2.5 kV for 1 min.
    5. Insulation (megger) test.
    6. Primary injection test.
    7. Secondary injection test (for measuring instruments and protection).

The manufacturer shall after that submit a complete tests report including the above mentioned tests and a (certificate) for each panel showing that the starters were completely tested, and setting of relays were adjusted. Setting values of all installed instruments and protections shall be submitted.

1. Starters of 15 kW shall be Auto-transformer starter type (unless otherwise stated) suitable for phase , 400 Volts + 10%, 50 Hz for the pump motors. They shall be housed in floor mounted steel (free standing) cubicles with 2 mm thick steel plate to IEC standard and IP54 protection with the following components at least:
2. Main incoming circuit breaker incorporating magnetic and adjustable thermal over load protection.
3. Starting, bridging and running contactors or circuit breakers.
4. Phase failure relay as specified earlier.
5. High motor winding temperature trip relay.
6. Three ammeters and three current transformers.
7. Voltammeter 0-500 volts with phase to phase and phase to neutral selector switch set.
8. Control fuses or MCB’s for protection of control circuits and protection relays
9. Illuminated push buttons as detailed in section C.
10. Indication lamps for R-S-T, phase, with Red-Yellow-Blue colours respectively
11. Push button as detailed in section C.
12. The starter shall be equipped with a visual, audible alarm, and reset systems.
13. All other specification mentioned in the technical specs. Of the autotransformer starters attached within this tender.
14. All switching circuit breakers shall have rupturing capacity not less than 50kA.
15. Each starter of power rating 150 kW and above shall have three thermal sensor (PTC) embedded in the auto transformer’s coils.
16. Each starter of power rating (30)kW and above shall be furnished with door mounted, motor monitoring and protection device (MPMU) as specified hereafter. It shall be of the type and manufacture approved by the Engineer.

In case of supplying starters only (to Employer stores) without installation on site, all wiring needs for this device to go out of the starter shall be terminated on a comprehensive full wire labeled terminal bars with a complete identification and wiring diagram, so as to complete all future connection for this outgoing wiring to other integral control devices installed on the pump and motor in conjunction with MPMU. In this case the spare starter shall be tested on site as if it is for permanent operation before stored.

However all these protection devices including the starter shall be labeled comprehensively for all wires, cables, devices…,etc with elastic rubber tireless and rigidly-fixed labeled terminal bars for the out going wires out of starters, all in approved execution by the Engineer.

1. The supplier shall provide with his bid a detailed(s) of all components (see please table -enclosure No. 1), whether major or minor, which shall be incorporated in his offer and in the starter. Failure to provide such list(s) shall result in the rejection of the bid.
2. ATST panels and MCC colour shall be RAL 7030 paint finish with metallic electrostatic paint method.
3. The starter should have 2 x 10w flourescent lamps to light the starter interior by a door switch when opened directly and turn it off when closed.
   * 1. **Starter Construction:**
     2. The motor starter shall be housed in a suitable factory built assemblies “ FBA” complying with IEC 439-1:1990. FBA shall be of cubical type, the front of which shall have a smooth well finished surface.
     3. The FBA shall be manufactured to a high standard from steel sheet minimum thickness 2 mm, and shall be adequately braced or bent to give a rigid structure. Adequate removable eye bolts for lifting purposes shall be provided.
     4. Access to the cubicles compartment for all normal routine maintenance shall be from the front by hinged and lockable doors secured with cam type fasteners and cylinder locks with removable key. Hinges shall be of substantial size and stops shall be provided to prevent doors touching adjacent cubicles. Other access shall be by means of bolted panels. The maximum width of any door shall be 800 mm.
     5. Protection category of starters’ enclosures shall be at least IP54 according to IEC publication 529-10/91.
     6. All cables and piping shall be made through glands in a plate covering the base of the cubicles, unless otherwise specified.
     7. The base plate if used shall be of non-magnetic material to avoid electric heating
     8. All the wiring, instruments, devices and all parts of the panel shall be facing the front of the panels, i.e. it shall not be needed to go to the rear of the panels to do any thing to it, any time ( for dismantling, maintenance, reinstallation etc.)
     9. The starter transformer shall be fixed in a way that its longitudinal axis should be parallel to the rear plate of the panel.
     10. Each starter panel shall enclose all related devices (i.e. equipment, contactors, relays, controls….etc. ), no devices related to the starter shall be installed outside the starter enclosure, unless otherwise specified.
     11. Unless otherwise mentioned elsewhere or approved by the Engineer, the minimum facial width of the starter shall not be less than (60) cm, and the depth shall not be less than (60) cm. The height shall be approved initially by the Engineer according to the power rating of the starter.
     12. Components shall be mounted in a way to prevent mechanical shocks transmitted from large components to small components and there by adversely affecting their proper functions. The components shall be so arranged to give adequate accessibility for maintenance and for removal of any one component with the minimum disturbance to the wiring. Plug-in connectors shall be used where possible.
     13. All bolts, nuts, screws, hinges, handles, etc. shall be of galvanized or stainless steal, cadmium plated steel, or chrome-plated steel as appropriate.
     14. The internal wiring of all cubicles shall be completed before delivery.
     15. Interlocks of a substantial mechanical type shall be provided in each cubicle between the door and the circuit breaker so that the door cannot be opened unless the circuit breaker is in the OFF position and all live parts, which can be accidentally touched, have been disconnected, unless otherwise specified.
     16. The whole busbars, including the conductors connecting the busbars to each outgoing unit shall be arranged to withstand a short circuit at any point.

The FBA shall be designed to withstand any external fault. In the event of any internal arcing fault on a functional unit, the damage should be confirmed to that unit so that the busbars and all other functional units remain fit for further service. However, the conductors connecting the busbars to the outgoing unit might be damaged by the internal arcing fault.

* + 1. Starter's contactors interconnections (wiring): -

The maximum ampere loading for the power interconnectors between main, step, and starter connectors shall not be rated more than (2.5) Amp/mm2, (the bigger cable or Busbar cross section shall be installed in case the computed cross section is not available).

* + 1. All the input interconnectors for the main, and starter connectors of power (200) kW and above shall be insulated copper busbars.
    2. For starters of power less than (200) kW, the input and output interconnectors shall be PVC insulated Cu cables.
    3. Every starter panel with height less than 1600 mm shall have an empty metal base covered from the sides for a height not less than 30cm in which nothing shall be installed. There must be left additional 30cm over that base to install any connection bar or terminal bar cables to the control board and for the out-going cables to the motor.
    4. For free standing enclosures with height 1800 mm and above, a 100-mm steel plinth shall be installed. (Notes in drawings prevail)
    5. Each panel board shall be equipped with electric heater for condensation. (operating when motor is off), with thermostat to auto control the heater at a resettable temperature range.
    6. **Controls, Indication & Alarms:**
    7. Control, protection and measurement equipment and devices shall be power supplied through isolation transformer.
    8. The operating push buttons, switches, or handles of all circuit breakers, motor starters, isolators, etc. shall be located on the doors of the cubicles, and there shall be visual indications of the “ ON “ and “ OFF “ positions.
    9. All operations of fault and alarm circuits shall be clearly and individually indicated on the front of the switchboard by lamp operation.
    10. Fault and alarm indication lamps shall remain ON until the cause has been cleared and the system has been manually reset.
    11. The front of the starter panels shall contain the following signaling, controls and instruments: -
        1. A set of “ ON “ and “ OFF” and “ FAULT” signals.
        2. One voltmeter 0-500VAC with selector switch to monitor the 3 phases + neutral voltages (unless they are shown on the LCD on the panel facia).
        3. Three ammeters “ one per phase “ with double scale (unless they are shown on the LCD on the panel facia).
        4. One running hours recorder without resetting facility to record up to 9999 hours.
        5. LED Indication lamps to show the following:-

1. Motor “ ON ” and “ OFF ” and “ FAULT ”.
2. The motor is overloaded.
3. Low water level trip from suction side reservoir.
4. Dry run trip
5. Low pressure trip
6. High pressure trip
7. Motor winding high temperature trip
8. Auto transforms winding high temperature trip.
9. R-S-T indication lamps
   * + 1. One operating pulses recorder or meter (digital type) for number-of-starts counts (unresettable).
       2. One stay-put push button for emergency stopping with key switch to reset.
       3. One audible alarm Re-settable buzzer for all faults.
       4. High and low pr. switches with trip relays and signal lamps for each
     1. Indication lamps and push buttons shall be colored as follows:

|  |  |
| --- | --- |
| **Indicating Lamp** | **Colour** |
| ON | Green |
| OFF | Red |
| Fault | Amber |
| Alarms | Yellow |
| Heaters | Blue |
|  |  |

|  |  |
| --- | --- |
| **Push Buttons** | **Colour** |
| Start | Green |
| Stop | Red |
| Alarm Accept | Black or White |
| Emergency Stop | Red |
| Horn Silencer | Yellow |

* + 1. Indication lamps Test push button.
    2. The control voltage all over the plant for circuit breaker, contractors and starters shall be 230 Volts. (Low control voltage as 24 Volts may be used specially for some instruments).
    3. The pumps shall be started and stopped manually in normal operation providing that there is sufficient water in the suction reservoir or sufficient pressure in the suction pipe. Low suction level or low suction pressure shall protect the pumps when on manual control.

A high impedance plug-in type relay with a 24 Volt DC coil shall be operated by the low level float switch.. Two spare (1No and 1NC) contacts shall also be provided.

Suction reservoir low level, or suction pipe line low pressure, alarms and indications, as well as discharge pipe and high pressure, alarms and indication lights, shall be provided on each motor control center.

* + - 1. **Motor Starters with Frequency Converter:**

In order to operate some equipments in certain locations (if appointed), for each motor a suitable switchgear combination including frequency converter has to be installed. These switchgear combinations have to be arranged in a way that provides following operating capabilities:

* Start of the motor with initial higher start-up (break loose) torque.
* Starting with limited motor current, so that during the supply e.g. with Diesel – Generator all necessary motors can start and run without overload problems.
* Manual operation of each motor including setting of variable speed.
* Software for automatic operation via the separately specified PLC to keep the equipment in fully automatic operation.
* Soft stop of the motors.
* Automatic restart (in ncase of Auto start) of the motors after power failure in the same mode as before power loss.
* Sequential start in all modes.
* Save emergency stop with complete isolation of the mains.

Each of the switchgear combinations must be additionally equipped with:

* Main mccb electro magneticuly and thermally protection (both adjustable).
* Central emergency Stop-Button, switches and controls for manual operation and fault reset, LED status indicators (Manual – Auto – Fault – Over-temperature – Leak – Control Voltage Fault), main contactor, semiconductor fuses, complete set of spare fuses, mains filter, motor filter, individual voltage power supply for control voltage, isolation amplifiers 0/4 …. 20mA, thermostat, cooling fan, etc…, selector switch (M-O-A) for manual, off and auto operation.
* Integrated relays and circuitry (to protect the pumps against dry running and leakage) protection relays and circuitry for motor over-temperature of frequency converter, including warning and alarm signals.
* MPMU unit for motor protection.
* Frequency Converter, fully digital, low-loss, constant link voltage, sinusoidal pulsc width modulation, for standard, 3-Phase motors, modular and easy serviceable, with:

1. Comprehensive self-diagnosis.
2. Non volatile memory for settings, status and fault signals incl. Timestamp
3. LCD-display and status indicators with key pad to show all control, monitoring and protections functions.
4. Automatic and manual programming at built in, removable control panel
5. Interface to connect to a computer complete with all required access to connect the drive with remote control, operation and supervision in the main control room.
6. Computer software for programming and diagnosis of the frequency converter
7. Outputs 0/4 … 20 mA for mains current and motor speed
8. Digital outputs for status signals
9. Control inputs

* The Frequency Converter must be resistant resp. must be protected against: Mains over-voltage; Mains under-voltage; Phase failure; Short circuit; Earth fault; Idling; Overload.
* Technical data of the Frequency Converter:

For Motor: up to 300 kW mechanical power (as specified else where)

Mains Voltage: 0.4 kV, 50Hz, 3 phase, + 10%

Cooling: forced air-cooling

Overload Capacity: 1.5 x Nominal Current for 60 Seconds

Protection Class: IP 44

* The frequency converters have to be completely delivered, installed, carefully programmed according to the connected machines, tested etc.. . The contactors, fuses, circuit brakers required to complete the circuitry of the switchgear assembly have all to be included in the service.
* The starter should have 2 x 10w flourescent lamps to light the starter interior by a door switch when opened directly and turn it off when closed.
  + - 1. **Combination Starters**

Unless otherwise specified, control centre starter shall be breaker combination, magnetic, direct-on line type as follows:

* + 1. Starters shall be 3 phases, 400 V. + 10% 50 Hz contractors with three phase thermal overloads, 230 Volts AC coil, and an adjustable-magnetic and thermal circuit breaker (0.6 – 1.8Ir)
    2. Contractors shall be AC3 and have 8 hour current rating in accordance with latest NEMA standards. Contactor of reversing or multi speed starters shall be mechanically and electrically interlocked.
    3. Spare interlock contacts, whether on the starter or a relay, shall be wired separately to the unit terminal board and shall be indicated on the Submittal Drawings.
    4. Larger starters shall occupy spaces which are multiples or half of the space occupied by Size 1 and Size 2 starters.
    5. Three-phase bimetallic thermal overload relay with external manual reset shall be furnished with each starter, and shall be ambient compensated at 50o C.
    6. All thermal over load release everywhere on circuit breakers or contractors shall be of the adjustable type and not of the heater coil fixed rate type.
    7. The control voltage all over the plant for circuit breaker, contractors and starters shall be 220 Volts. (Low control voltage as 24 Volts may be used specially for some instruments).
    8. Operating handle with provisions for up to three padlocks shall be provided on each starter. The access door shall be interlocked with the starter so the door cannot be opened while the breaker is closed except by an interlock override.
       1. **Manual Starters (Direct On Line – DOL)**

All manual starters not furnished with equipment and required for completion of control requirements shall be furnished and installed hereunder and according to the Drawings or if stated otherwise in the specification of this contract. All starters shall be provided with contactors and selector switches, and / or Push buttons and thermal overload protection properly sized for the motors served and unless otherwise specified shall be mounted in stainless steel enclosure NEMA Type 1 for indoor service and NEMA Type 4 for outdoor service.

* + - 1. **Motor Protection and Monitoring Unit (MPMU)**

For motors of power rating 30 kW and above, a micro-processor based MPMU shall be installed in the motor starter, which measures the motor voltage, current, and temperature, processes the measured values and performs arithmetical and logical operations in order to display the required information, and also to perform the necessary alarms and trips caused by failures and faults.

The device shall have low power consumption, adaptability, and possibility of self-supervision, fault diagnosis by means of data recording, flexible construction and selection of relay characteristics.

The operating, and setting of the device shall be by means of the device’s front panel push button, and all the measurements, messages, instruction, … etc, shall be displayed on an alphanumeric backlighted display with two lines, 32 characters.

Also the unit shall have free selectable parameter setting of 4 output relay’ functions (alarm tripping).

The unit shall comply with IEC 225 and the requirements of VDE-regulation 0435, part 0435.

The unit shall be equipped so as to be connected to remote PLCs or SCADA system.

The operating temperature range for the unit is: 0oC to +50oC.

The device shall hve non-volatile memory and not require battery backup. In the event of a power failure, the device shall retain the pre-set paramters.

The MPMU unit has the following features.

* + - 1. **Protection functions**

All protection functions are equipped with warning and tripping element.

**Voltage based protection**

* phase under voltage protection
* phase over voltage protection
* Phase loss protection
* Phase sequence protection

**Current based protection**

The unit is connected to three current transformers, and the earth fault protection, and the earth current measurement is done by Holmgreen connection or core balance CT.

* Overload protection with thermal capacity according to I2t characteristics with adjustable current/ time tripping characteristics.
* Thermal overload Pre-Alarm
* Load increase Alarm
* Locked Rotor / Stall protection
* 2 stage Undercurrent protection
* High Set Over current Protection
* Low Set Over current Protection
* 2 Stage Current Unbalance Protection
* Short – Circuit Protection
* Excess Starting Time Protection
* 2 stage Earth Fault Protection
* Excess No. of starts Protection

**RTD / Thermistor Base**

Temperature supervision: 5 PT100 sensors; 3 sensors inserted in the motor windings, one sensor senses the motor bearing, and one sensor senses the load bearing, or senses 3 PTC/NTC sensors (option to be selected through the key pad and the software. The MPMU shall trip the motor when the temperature of windings and bearings rises over predetermined value.

* 1. **Measured Data**

MMPU shall monitor and display the followings: -

Phase and Line Voltages, (phase to phase, phase to neutral, for all phase)

Phase Current

Earth Fault Currents, (for all phases)

Power kW, Power VA

Power factor

Winding temperature for every phase, front and rare bearings temperature.

* 1. **Calculated Data**

Motor load – percentage FLC

Thermal capacity used

Time of trip

Time to start

Unbalance current

* 1. **Logic Inputs Status**

Motor available indication

Individual status of all input contacts

* 1. **Statistical Data**

Motor hours run

Number of motor starts

Last start time

Last peak starting current

Number of motor trips

* 1. **Fault Data**

Last fault

Last alarm

Phast currents at time of trip

Earth fault at time of trip

Phase Volts at Time of trip

* 1. **Indications**

The unit shall have optical indication (LED) for

Motor running

Motor stopped

Watchdog the unit self-supervision for software and hardware.

* + - 1. **Power Mains DMFM**

Microprocessor based, door mounted, digital multifunctional meter (DMFM) shall be furnished and installed as described herein. DMFM shall be supplied in sizes and numbers indicated on the drawings. DMFM shall monitor as a minimum the following mains parameters:

1. Current (3-phases)
2. Peak Current (Apk)
3. Voltage (v)
4. Frequency (Hz)
5. Power factor (cosφ).
6. Power in KW.
7. Power in KVA.
8. Peak Power (WPK)
9. Temperature.
10. Unbalance ratio.
    * + 1. **Circuit Breakers**

Circuit breakers shall be Muller, Schneider, Siemens, GE, AEG, Alstom, ABB or approved equal.

* + - * 1. **Molded Case Circuit Breakers (MCCB’s)**

A. MCCB'S shall be of the quick make, quick break type with trip free mechanism all enclosed in an insulated molded case of low hygroscopicity and high mechanical strenth.

B. They shall be on the adjustable thermal magnetic type and of Type 2 coordination (to IEC 974-6-2).

C. Where used for motor protection they shall have characteristic curves compatible with the motor curve.

D. MCCB's shall be provided with the following.

1) Visible indication on the enclosure front of `open' closed and `tripped'.

2) Two normally open and two normally closed auxiliary contacts.

3) Facility for locking in the `open' position.

4) Undervoltage release and indication.

5) Shunt trip.

E. Where the prospective short circuit at the point of installation exceeds the breaker capacity, back up fuse protection shall be provided.

* + - * 1. **Miniature Circuit Breakers (MCB’s)**

A. MCB's shall be of the plug-in or rail mounting type with bimetallic trip for overcurrent protection and instantaneous electro magnetic trip for short circuit protection.

B. They shall be provided with visible indication of `open', closed and `tripped'.

C. Where used for motor protection they shall have characteristic curves compatible with the motor curve.

D. Where the prospective fault current at the point of installation exceeds the breaker capacity, back up fuse protection shall be provided.

* + - * 1. **Ground Fault Circuit Breakers**

A. Ground fault circuit breakers shall be based on the current operated type.

B. They shall be of the plug-in or rail mounted type as required.

C. They shall be provided with a test button to simulate operation of the device.

D. They shall have a rated tripping current of not greater than 30 milliamps.

* + - * 1. **Spare Parts**

Provide circuit breakers spare parts for at least two years operation as recommended by the manufacturers.

List all spare parts being provided at Tendering stage.

Spare parts and tools shall be in compliance with section 16050 requirements.

* + - 1. **Fuse switches**

Fuse switches shall be heavy duty, metal enclosed types conforming to BS 5419 and suitable for making or breaking load currents and shall be fitted with high rupturing capacity cartridge-type fuses rated to suit the connected load and conforming to the requirements of BS 88.

The hinged door of the fuse switch shall be interlocked with the switch to prevent access to fuses unless the switch is in the fully opened position.

* + - 1. **Contactors**

Contactors shall be as specified and approved and be of approved magnetically operated air break types conforming to the requirements of BS 5424 and IEC 158-1. For motors they shall be rated for uninterrupted duty, utilization category AC3, mechanical endurance Class III and the operating coil insulation shall be Class F. Pick-up and drop-off voltages shall be within the BSI limits. For lighting circuits they shall be AC5A for discharge lamps or AC5B for incandiscent lamps.

The contactors shall be klockner Moeller, ABB, siemens, Schnider, AEC, US marks or approved equal.

The fixed and moving contacts and the operating coils shall be replaceable from the front of the board, without removing the contactors. Auxiliary contacts shall be enclosed in dust proof transparent enclosures. The contactors contained in dust proof housings, shall be mounted within the switchboard behind doors and shall be readily accessible for maintenance and adjustment.

Performance data stated below are subject to the tolerances of BS 5424 : Part 1 : 1977 contactors shall conform to the following requirements:

Operating voltage 400V +/- 10%

Rated voltage 660V

Coil voltage 230V

Rated thermal current temperature rise shall not exceed the limits specified in BS 5424 Tables V and VI Clause 7.3.

Rated operational current shall be greater than 110% of the full load current of the motor connected to the contactor.

Rated frequency 50 Hz +/- 5%

Rated duty shall be for uninterrupted duty.

Rated making and breaking capacities shall be to BS 5424 Clause 4.3.6 Table II.

The utilization category shall be AC-3, Coordination Type 2.

Mechanical life shall exceed 3 million no load operating cycles.

Number of operating cycles per load shall be Class 3.

Control voltage shall be 230 AC +/- 10%

Coil insulation shall be Class F.

* + - 1. **Control Transformers**

Control transformers shall comply with BS 171. The transformers shall be of the dry type, continuously rated, and have dual windings and earth screens. The transformers shall have fuses on the primary side.

Live parts shall be shrouded and warning labels fitted where necessary.

* + - 1. **Fueses and Holders**

Fuses for control circuits or for power circuits shall be of the HRC cartridge-type to BS 88 mounted in fully enclosed holders for manual withdrawal.

The fuses shall have a rupturing capacity suitable for the specified short-circuit capacity. Where fuses are fed direct from power busbars the terminals of the fuse holder base shall be shrouded.

Fuses shall be of the indicating type, the indicators being visible without withdrawing the fuses. All fuses shall be mounted behind doors, within the switchboards and all control circuit fuses shall be marked with labels indicating their function and current rating.

Voltmeter fuses shall be 2Amp, control transformer primary fuses 6Amp, control circuits fuses 6Amp unless otherwise specified.

* + - 1. **Time Switches**

Time switches, where specified for the control of audible alarms shall be driven by self-starting synchronous motors, with 8 hour clockwork spring reserve, arranged to switch off and on once per day.

* + - 1. **Current Transformers**

Current transformers shall be to approval and rated as indicated in the Equipment Schedules and shall comply with BS 3938. Terminals shall be marked to approval and the markings indicated on the wiring diagrams. Ring type current transformers shall be marked to show “mains” and “load” side connections.

* + - 1. **Indicating Instruments**

Indicating instruments shall be to approval conforming to the requirements of BS 89 Industrial Accuracy Grade. They shall be rectangular switchboard types suitable for flush mounting, contained in approved dust proof, metal cases and provided with clear and un-obscured dials and provided with zero setting adjustment on the face of the cases. On panels containing main or incoming switches the nominal face size shall be 100 mm. Ammeters shall have a full scale reading equal to the associated current transformer rated primary current.

Ammeters connected to dual ratio current transformers shall have reversible scale faces of the scales may be numbered above and below the graduations, provided a reversible label is fitted to the face of the instrument to indicate which scale is in operation. Ammeters in motor circuits shall have a compressed over current scale. All ammeters in Motor Circuits shall have a red line painted on the scale corresponding to the connected motor full load current.

Voltmeters shall be of the suppressed-zero type, having the range of indication specified in BS 89.

* + - 1. **Thermal Overload Relays**

Overload and anti-single phasing relays for motor protection shall be of the molded case enclosed type with one thermal element per phase and incorporating a differential action between elements to provide anti-single phasing protection.

The relays shall conform with IEC 292-2 and VDE 0660. The relays shall be capable of being hand reset with the reset button mounted on the door of the starter compartment.

Relays shall be selected to suit the motor and adjusted on site to match the motor full load current before the starter circuit is energized.

* + - 1. **Auxiliary Relays**

Auxiliary relays for mounting in motor control boards shall be of the attracted armature instantaneous self resetting type, provided with approved operating coils and auxiliary contacts. They shall be equipped with an adequate number of 230V AC 10Amp rated circuit opening and closing contacts for the immediate and future requirements of the control system.

* + - 1. **Time Delay Relays**

Time delay relays of the synchronous motor type shall be self instantly resetting. The time setting shall be adjustable and the range shall be as specified. They shall be preferably of the plug-in type and fitted in dustproof cases on the chassis plate of the switchboard.

Time delay relays for controlling the operation of secondary contactors of the starters shall be of the 11 pin type (or approved equivalent).

* + - 1. **Thermistor Protection Relays**

Thermistor protection relays shall be actioned by the positive temperature coefficient probe with which it is associated. They shall conform to IEC 2929-2 with an insulation rating to IEC 158-1. They shall be provided with auxiliary contacts or relays as required by the control system, which shall be manually reset.

* + - 1. **Selector Switches**

Selector switches shall be of approved robust construction of the rotary multi-position, multi-bank, master switch type. Switches shall be mounted behind the front panels with their operating handles projecting in front of the board with the various positions clearly marked.

* + - 1. **Key Selector Switches**

Each starter shall be equipped (it stated in the Drawings and / or the BoQ) with its private cylinder key switch (2 Nos for every switch) to switch the starter into either manual or automatic telemetry control selection. The auto telemetry control selection shall allow the pumps to operate automatically as well as by remote manual control via the radio telemetry system. The key shall be removable in any position. A common master key to fit all key switches shall be supplied (with 3 Nos.)

* + - 1. **Hour Meters**

Hour meters shall be connected to the load side of motor control circuits through relays and suitably rated fuses in holders, to indicate the total running time of the pumps or the machine (in hours and minutes). They shall have cyclometer type dials with five whole digits and two decimal digits.

* + - 1. **Indicator Lights**

The indicator lights shall be LED (or neon, capacitor) lamps manufactured to BS standard with an IP 66 degree of protection on the pilot light head.

* + - 1. **Push Buttons**

Push buttons shall be manufactured to BS 4794 and provided with chromium plated metal bezel circular heads with an IP 65 degree of protection.

* + - 1. **Float Switches**

The Contractor shall furnish float switches for control and alarm, which shall be as indicated on the submittal drawings. For the automatic operation of all pumps, float switches of submerged corrosion-resistant and internal mercury-free type shall be suspended in the tank with a stabilizing weight integrated to the suspension cable above the float switch. The contact of the switch changes from open to close if the rising float passes its horizontal line.

The float switch shall operate in a liquid temperature between 0oCand +50oC and shall be of rugged design, completely watertight, covered with solid rubber, flexible vulcanized connection cable (15m with 3 wires), terminal box IP 68 and protecting PVC pipe of heavy gauge to prevent horizontal movement of the float.

The service includes the delivery and complete installation at the correct position of the respective location as shown on the Drawings, including all necessary mounting materials and adjustment. Float switches type FLYGT shall be installed with rating of 5 Amp at 230 Volts AC.

Aluminum channel shall be supplied and fitted to side or the roof of the reservoir next to the manhole access point, with the float switch cable secured to it to prevent them from becoming tangled. The channel shall be fixed so that it is removable for changing float switches when the reservoir is full.

The switches shall be connected with a cable to the Control System.

* + - 1. **Float Switch Control Relays**

Water reservoir float switches shall operate high impedance float switch control relays of the plug in type. They shall be supplied by a DC system and shall be designed so that the float switch can be located faraway from relay. The relay shall be connected to the float switch through a standard 1.5mm2 copper conductor PVC insulated SWA cable with the conductors for 6 float switches in one cable.

* + - 1. **Pressure Switches**

The pressure switches shall be manufactured to IEC Standards. They shall have separately adjustable set points and span and will be equipped with an integral IP65 terminal box with sufficient space for glanding of 1.5 mm2 PVC SWA PVC cable.

* + - 1. **Nameplates**

Each unit assembly, control switch, and instrument on the front of the control centre shall be provided with a suitable engraved nameplate. Standard, engraved nameplates with 5 mm high letters may be used on push-button type units. Other nameplates shall be in accordance with the General Equipment and Material Stipulations. Relays and special devices inside the control centre shall have permanent markings to match identification used on manufacturer's wiring diagrams. Nameplate engravings shall be indicated on the Submittal Drawings in English and Arabic.

* + - 1. **Finish**

Each structure shall be thoroughly cleaned inside and out after fabrication, then given a rust inhibiting metal primer coat. Two finish coats on interior and exterior shall be applied according to manufacturer's standard and of colour as approved by the Engineer unless otherwise indicated elsewhere in the specifications, drawings and / or in BoQ. One litres of each type of finish paint shall be furnished for touch-up.

* + - 1. **Foundation**

Bolt holes shall be provided in the base of each section and the control centre anchored to the floor channels. All bolts and nuts shall be galvanized or cadmium plated.

* + - 1. **Ratings**

The motor control centres shall have the ratings the same as that which and shall be listed in the descriptions indicated on the Submittal Drawings.

* + - 1. **Lamp Check Devices**

Each MCC is to be equipped with a sufficient number of push buttons to check all indicating and flashing lamps by diodes provided for each lamp.

* + - 1. **Fuse Control**

All fuses and automatic cut-outs shall be provided with a secondary contact, connected in series, which shall initiate an annunciation “fuse blown” by a flashing lamp (yellow).

* + - 1. **Internal Lighting, and Socket Outlets Voltage 230 V - AC**

The switchgear are to be equipped with 2 x 10 W fluorescent lamp and socket outlet for their internal lighting and power, and the light shall be operated automatically by limit switches installed at the door of each panel when it is opened.

* + - 1. **R****eactive Power Compensation**
* **General**

If the rated power of the pump motor is P > 22 kW, a power factor correction is to be provided. The equipment will be dimensioned for a power factor Cos ϕ = 0.95. Over compensation and resonance at part-load as well as self-excitation of the motor must be avoided. The capacitors shall be selected as PCB-free type.

* **Single Compensation of Pump Motors**

The motors will be connected to a capacitor bank with discharging resistor.

The equipment listed below is to be considered with the corresponding item of the BOQ:

1. circuit breaker with over current protection, installed in the capacitor bank;
2. 3-phase contactor;
3. capacitors, 3-phase type, 400 + % volt, 50 Hz, protecting class IP 43, installed a separate capacitor bank;
4. discharging resistors;
5. Cables terminals and connections between the circuit breaker, the capacitors and the discharging resistors.
   * + 1. **Direct Current System: (if Applicable):**

The control compartment shall be equipped with a 24 Volt DC uninterrupted power supply (UPS) designed to operate the level control and indication system for 16 hours without mains power.

The system shall consist of a suitably rated 110 Volt AC supply battery charger, a 24 Volt DC sealed Nickel Cadmium battery and a 24 Volt DC voltage regulator. All equipment shall be rated to operate at full load under all site conditions of temperature and humidity without forced cooling.

The charger current limiting characteristics shall match the battery so that under no circumstances may the battery recommended charging rate be exceeded or the battery gassed or damaged. The charger shall maintain battery voltage and load current under normal operating conditions and be able to fully charge a discharged battery whilst maintaining load current in 6 hours.

The voltage regulator shall maintain the system voltage within 5% of 24 volts DC at all times. Should the duration of loss of power exceed 6 hours the voltage regulator shall trip at any time after that and shall prevent the battery from being deep discharged or ruined. All motors selected to automatic control shall be stopped in the event of a DC power supply failure.

The system shall be protected by an AC supply circuit breaker and a DC output circuit breaker with a trip contactor and the following indications and alarms:

1. Charger fall and regulator fail audible alarm and indication light.
2. Loss of AC power indication light.
3. DC output voltage 72mm Voltmeter.

These alarms shall be connected in parallel and shall be separate to the motor trip alarms and level alarms.

In case of pumps, they shall be started and stopped in sequence on fall and rise of the discharge reservoir level providing that there is sufficient water in the suction reservoir or sufficient pressure in the suction pipe. The pumps shall also be automatically duty cycle between consecutive starts. Low suction level or low suction pressure shall protect the pumps when on manual or automatic control.

A high impedance plug-in type relay with a 24 Volt DC coil shall be operated by each float switch. One potential free contact shall be wired to the telemetry terminal rail for remote indication of reservoir level. Another shall be provided for pump control as required. Two spare (1No and 1NC) contacts shall also be provided.

Suction reservoir low level, or suction pipe line low pressure, alarms and indication, as well as discharge reservoir low level and high level, alarms and indication lights, shall be provided on each motor control center.

A 0-10 minute timer shall be provided to delay initiation of low and high level alarms until a continuous alarm condition has been received for the duration of the timer setting (To prevent spurious alarms from waves etc.).

A 500 meter range continuously rated, weatherproof, audible alarm siren shall be mounted outside, under the roof eaves of the pump station. The audible alarm circuit shall be provides with a 24 hour 7 day time switch with spring reserve, which shall be adjusted to prevent any audible alarm between sunset and sunrise, or at any time over weekends. The audible alarm shall have an accept push button. All alarm indication lights shall remain on until the alarm condition has been removed.

All spare cores in the multicore cables to reservoirs shall be wired to terminals in the telemetry rail of the motor control board.

* + - 1. **Un-Interruptible Power Supply (UPS)**

The system is shown in single line diagram on the corresponding drawing.

1. *Equipment to be included in the Switchgear*

The following components are to be provided:

1. 1 fuses with holder for the power feed 400 V + 10%, 50 Hz
2. 1 battery charger with sufficient capacity to charge the relevant battery in 10 with I/V – characteristics with control equipment for constant voltage. Forced ventilation is to be included.
3. Inverter
4. 1 switch, two pole type for 24 V – DC.
5. 2 fuses for the battery.
6. 1 Ammeter (with minus and plus range).
7. 1 Voltmeter 0 to 30 V – DC.
8. *Batteries*

The relevant items of the BoQ shall include the cable connection to the switchgear of NYY type and with a cross section, which limits the voltage, drop to 3% (0.72 V). The equipment necessary to maintain the battery is also to be included.

The 24 V DC battery system is to supply control, monitoring, alarm, and indication. The standard type of battery is maintenance free sealed Ni-cadmium Alkaline type, with capacity 50 AH for minimum 6 hours operation.

The charger shall have the capability to charge the battery, as boost charge after the main power has been cut off not more than 30 minutes. Under the normal condition the charger will charge in floating mode as reserve for the DC power supply.

The charger is to be of an electronic automatic control type as follows:

1. Static thyristor type volt.
2. Single phase / three phase.
3. Automatic voltage and current limitation regulation system.
4. Power supply 380/220.
5. Alarm signaling.
6. Voltmeter and ammeter.
7. Automatic mode and manual mode.
   * + 1. Each panel board shall be equipped with electric heater for condensation and thermostat to auto control the heater at a resettable temperature range. The heater in motor starter panels shall only operate when the motorisoff.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

Prior to installation of motor control centres, all applicable shop drawings and data shall have been submitted for review by Contractor and accepted by the Engineer.

The motor control centre shall be installed in the location of the Submittal Drawings.

Each floor channel shall be levelled before grouting and shall be securely anchored to the concrete equipment base. Each control centre shall be securely anchored to the channels either by bolting or welding at a minimum of two points for each vertical section.

Prior to initial acceptance, all scratches and blemishes shall be retouched with a touch-up paint provided with the motor control centres.

**3.2 INSTALLATION CHECK**

After the motor control centres have been installed and connected, the manufacturer's representative shall thoroughly inspect the installation and make all required adjustments and standard test stated in this section, in the specifications, drawings or elsewhere in the Contract and as approved by the Engineer.

**END OF SECTION**

# SECTION 16500

# LIGHTING & LIGHTIN FIXTURE

**PART 1 GENERAL**

* 1. **THE REQUIREMENT**

A. The Contractor shall furnish and install all lighting fixtures, labor, and material, in accordance with the preceding Specifications, the requirements of this Section, and as shown on the Drawings.

C. All wiring shall be placed in conduit and shall comply with the Specifications for conduit, outlet boxes, pull and junction boxes, wires and cables, grounding, and other Sections as set forth in these Specifications and as noted herein.

1. Reference Section 16050, Basic Electrical Requirements.
2. Reference codes and standards as referred to in Section 16050.
   1. **RELATED WORK**

1. General Equipment and Material Stipulations.

The General Equipment and Material Stipulations shall apply to all equipment furnished under this section.

2. Works Specified Elsewhere

Other items of work provided in this section include the following: -

Submittals

Electrical Materials and Methods.

**1.03 SUBMITTALS**

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

1. As Built drawing
   1. Each submittal shall be identified by the applicable specification section.
   2. Submit materials compliance sheets to comply with the specificaitons.
   3. All materials, equipment, and wiring diagrams, where applicable, shall be submitted for review. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment as follows: -
      1. Lamp fixture descriptive sheets shall show the fixture schedule letter, number, or symbol for which the sheet applies.
      2. Equipment and materials descriptive literature and drawings shall show the specification paragraph for which the equipment applies.

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor for resubmittal without review.

1. Shop drawings shall include but not be limited to:
2. Equipment specifications and product data sheets.
3. Catalog cuts for each fixture type showing performance and construction details of standard fixtures, and complete working drawings showing all proposed construction details of special or modified standard fixtures.
4. Photometric curves.
5. Lamp data.
6. Ballast information.
7. Catalog data including applicable coefficients of utilization tables, isolux chart of illumination on a horizontal plane, beam efficiency, horizontal and vertical beam spread, and beam lumens.
8. Shop drawings shall be submitted to the Engineer for review and acceptance for all fixtures before fixtures and poles are ordered. Substitutions will be permitted only if approved by the Engineer.
9. Manufacturer's catalog number and description in the fixture schedule on the Contract Drawings establishes a level of quality, style, finish, etc. The use of a catalog number describing the various types of fixtures shall be used as a guide only, and does not exclude all the required accessories or hardware that may be required for a complete installation.

**1.05 OPERATION AND MAINTENANCE MANUALS**

1. The Contractor shall submit Operation and Maintenance Manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

**1.06 TOOLS, SUPPLIES AND SPARE PARTS**

A. The light fixtures shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor. The following minimum spare parts shall be furnished:

1. A minimum of one (1) ballast for every ten (10) ballasts (of the same type) installed free of charge.

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.

D. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

* 1. **LIGHTING CONTROLS**

A. The lighting systems shall be controlled as specified herein and indicated on the Drawings.

1. Lighting contactors shall be furnished and installed for specific lighting control applications as specified herein and indicated on the Drawings.
   1. **JOB CONDITIONS**

All fixtures and accessories shall be suitable for use in 50o C ambient.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Lighting contactors shall be as manufactured by Culture -Hammer/Westinghouse Electric Corporation, Square D Company, General Electric Company, ABB, Siement, TE, or equal. Lighting contactors shall be heavy duty industrial type with 25A minimum rating, shall have coils with voltages 230 V. AC, and shall have the number of contacts required. Contactors shall be housed in enclosures with NEMA rating to match the environment. Contactor ampere rating shall be as required to suit the application. Contactors shall be the electrically held type. Any auxiliary relays, or other devices required for proper operation shall be included.

**2.02 FIXTURES**

1. Each fixture shall bear the manufacturer’s name. All lighting fixtures shall be furnished complete with lamps of the size and type as indicated on the Drawings and all fittings and hardware necessary for a complete installation. Lighting fixtures shall have all parts and fittings necessary to completely and properly install the fixtures.
2. Fixture leads shall be as required by NEC and shall be grounded by the conduit connection to the fixture.
3. All glassware shall be high quality, homogeneous in texture, uniform in quality, free from defects, of uniform thickness throughout, and properly annealed. Edges shall be well rounded and free from chips or rough edges.

Fluorescent fixtures shall be complete with housing, parabolic type louvers (if required), accessories and starters of the types and quantities specified herein and indicated on the Drawings.

All outdoor fixtures shall be IP65 and to be controlled by photocell and time switches.

**2.03 BALLASTS**

1. Where available, ballasts shall be as manufactured by the fixture manufacturer. Ballasts for fluorescent fixtures shall be rapid‑start, high efficiency and high power factor. Ballasts shall have copper windings. All ballasts for indoor fluorescent fixtures shall be equipped with an internal, thermally actuated automatic reclosing protection device. Ballasts shall be guaranteed against service failure for a period of two (2) years. Ballasts shall be rated "Class P" to agree with requirements of 410-73 (e) and other applicable articles of the NEC, to conform to the time schedule for this requirement, and shall be Class A sound rated.
2. Ballasts for HID fixtures shall have copper windings and shall be high power factor, constant wattage autotransformer (CWA) (i.e. lead type for high pressure sodium or peak lead type for metal halide), or constant wattage (CW). All ballasts for HID fixtures shall be Class "H" insulated, encapsulated for quiet operation, and shall have an integral thermal protector.
3. All outdoor fixtures and fixtures located in unheated areas shall be furnished and installed with ballasts rated for outdoor installation.
4. Fixtures shown or specified to be controlled by dimmers shall be furnished with suitable electronic dimming ballasts.
5. The following data of fluorescent lamp ballasts shall be furnished as specified in the "Lighting Fixture Schedule" on the Submittal Drawings. Fluorescent ballasts shall be supplied as an integral part of the luminaries.

Percent allowable

Line Voltage

Variation + 5 %

Type Rapid Start

Power Factor 0.9+

Percent Allowable

Line Voltage Dip 15-20 %

Low Ambient

Operating

Temperature 10o C

High Ambient

Operating Temperature 45o C - 50o C

* 1. **General**

The Ballast shall be capable of starting and operating the mercury vapour lamps from a nominal 230 Volts, 50 Hz power source within the limits specified by the lamp manufacturer. The ballast, including starting aid, must protect itself against normal lamp failure modes. The ballast shall be capable of operation with the lamp in an open or short-circuit condition for six months without significant loss of ballast life.

The luminaries shall be suitable for continuous service in an ambient temperature of 50o C with the ballast operating normally or in the short-circuit or open circuit mode.

* 1. **Lamp Wattage**

For nominal line voltage and nominal lamp voltage, the ballast design centre will not vary more than 5 percent from rated lamp watts for all ballast types.

* 1. **Regulating Type Ballast**

At any lamp voltage, from nominal through life, lamp wattage regulation spread at the lamp voltage shall not exceed 18 percent for plus or minus 10 percent line voltage variation.

* 1. **Lamp Current Crest Factor**

The lamp current crest factor shall not exceed 1.8 for plus or minus 10 percent (regulating type) line voltage variation at any lamp voltage, from nominal through life.

* 1. **Ballast Power Factor**

The power factor of the lamp ballast system shall not drop below 90 percent for plus or minus 10 percent (regulating type) line voltage variations at any lamp.

1. The ballasts may be of the conventional type or electronic type if specified elsewhere in the Drawings or in the BOQ.

**2.04 LAMPS**

A. The Contractor shall furnish and install lamps in all fixtures. Lamps shall be of the following types:

1. Fluorescent: Rapid‑Start, Low Level Mercury

2. HID: Mercury Vapor, High Pressure Sodium, Metal Halide

3. Incandescent: 230V

B. Lamps shall be as manufactured by General Electric Company, Sylvania Lighting Equipment, Phillips Lighting Company, or better Europlan origin equal or as approved by the Engineer.

**PART 3 EXECUTION**

* 1. **INSTALLATION**

1. Lighting fixtures shall be located symmetrically with building lines as shown on the Drawings. The Contractor shall furnish and install the lighting fixtures to allow "convenient" access for maintenance such as cleaning, relamping, and other activities.
2. The Contractor shall provide and install all inserts, conduit, structural supports as required, lamps, ballasts, poles, wiring, and any other items required for a complete system. Contractor shall properly adjust and test, to the satisfaction of the Engineer, the entire lighting system. The Contractor shall provide pigtails and flexible conduit connected to an outlet box where necessary or required resulting in a neat and complete installation.
3. The Contractor shall protect all fixtures at all times from damage, dirt, dust, and the like. Before final acceptance, all fixtures and devices shall be cleaned of all dust, dirt or other material, be fully re-lamped and in operating condition to the satisfaction of the Engineer.
4. Circuiting shall be as shown on the Drawings and as follows:

1. Bus loads in all panelboards shall be balanced between phases to within a tolerance of one (1) KVA. Convenience receptacles shall be distributed evenly among all phase buses as much as practical.

2. Voltage drop to the most remote lighting fixture shall be limited to 2 percent.

1. The Contractor shall furnish and install all pendant trapezes and pendant stem hangers with durable swivel or equivalent trapeze hanger permitting normal fixture motion and self‑alignment. Fixture pendants shall be flexible hanger at the fixture and supports and junction box with hub cover, or equal. Pendant lengths shall be adequate and adjusted to provide uniformity of installation heights above the reference datum. Stems shall be one‑piece, with matching canopies and fittings.
2. Fixtures located on the exterior of the building shall be provided with neoprene gasket and non‑ferrous metal screws finished to match the fixtures.
3. The finish or exposed metal parts of lighting fixtures and finish trims of all recessed lighting fixtures shall be as directed by the Engineer.
4. The Contractor shall furnish and install recessed fixtures with a separate junction box concealed and located as to be accessible when fixture is removed.
5. The Contractor shall furnish and install all boxes for lighting fixtures such that the box is not the sole support of the fixture. The boxes shall be offset to allow maintenance such that access to wiring within the box can be attained without having to consider supporting (holding) the fixture.
6. All lighting units, when installed, shall be set true and be free of light leaks, warps, dents, and other irregularities. All hangers, cables, supports, channels, and brackets of all kinds for safely erecting this equipment in place, shall be furnished and erected in place by the Contractor.
7. The Contractor shall install fixtures at mounting heights indicated on the Drawings or as instructed by the Engineer. In areas with exposed ducts and/or piping, installation of lighting fixtures shall be adapted to field conditions as determined by the Engineer.
8. The Contractor shall support each fixture securely. Each fluorescent fixture shall be secured to the building structure. The Contractor shall not secure fixtures to the work of other trades, unless specified or noted otherwise, and shall not support fixtures to plaster. The Contractor shall furnish and install all steel members and supports as required to fasten and suspended fixtures from the structure.
9. In all mechanical equipment areas, the Contractor shall install lighting fixtures on the ceiling after all piping and equipment therein has been installed. Exact locations for such fixtures may be determined by the Engineer on the site during the course of the work.
10. Upon completion of work, and after the building area is broom clean, all fixtures shall be made clean and free of dust and all other foreign matter both on visible surfaces, and on surfaces that affect the lighting performance of the fixture including diffusers, lenses, louvers, reflectors, and lamps.
11. All fixtures that require physical adjustment shall be so adjusted in accordance with the directions of the Engineer. The Contractor shall also adjust angular direction of fixtures and/or lamps, as directed.
12. Relamping access shall require no special tools. All optical control surfaces such as lenses and reflectors shall be safely and securely attached to fixtures and shall be easily and quickly removed and replaced for cleaning without the use of tools. No fixture part that may be removed, for maintenance, shall be held in place by metal tabs that must be bent to remove said part.
13. Poles shall be designed to withstand calculated wind force due to 100 mph [160kmph] winds with a 1.3 gust factor without structural damage.
14. Pole mounted fixtures shall be mounted on poles as designated in the fixture schedule or as indicated on the Drawings. All metal poles shall be bonded to the plant grounding system. Poles shall have adequate handholes and weatherproof receptacles where indicated. All anchor bolts and nuts shall be stainless steel.
15. The Contractor shall furnish and install a concrete foundation for the pole mounted fixtures as indicated on the Drawings and as required. Foundation shall be approved by a professional structural engineer. Pole structure/foundation shall be able to handle fixture/pole weight and withstand wind velocity of up to 100 MPH [160kmph] with a 1.3 gust factor. Provide calculations for review.
16. The Contractor shall furnish and install switches as indicated on the Drawings. Switches shall be single pole, double pole, 3‑way, or 4‑way as indicated on the Drawings and as required. Switches located outdoors or in wet indoor locations shall be installed in cast boxes complete with yellow, fiberglass weatherproof covers. Reference Section 16140, Wiring Devices.
17. The Contractor shall furnish and install time switches and photocells as specified herein or indicated on the Drawings. Time switches shall be provided with a manual bypass switch controlling the lights locally and remotely. Time switches shall control contactors, relays, or direct controlling of one, two, or three lighting circuits, as indicated. The Contractor shall furnish and install photocells as specified herein or indicated on the Drawings for automatic "ON/OFF" switching of outdoor lighting.
18. Fixture maintenance shall be continuous until the date of Taking-Over by the Employer. All fixtures shall be cleaned immediately prior to the Contractor leaving the work site unless otherwise directed by the Engineer.

Fixture locations indicated on the Drawings are approximate only and shall be co-ordinated with other work in the same area to prevent interference between lighting fixtures and piping or other equipment. Any fixture shall be relocated if, after installation, it is found to interfere with other equipment or is so located to prevent its practical and intended use.

Fixtures installed in rows shall be carefully aligned vertically and horizontally.

All outdoor lighting (streets and buildings) shall be lit via selector switch (H-O-A) as detailed in the Submittal Drawings.

A. Auto mode is actuated by photocells (The streets separated from buildings) wired with a contactor for the relevant circuit,

H. Hand mode can light the lamps manually via the contactor only,

O. Off position.

* 1. **TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

Not required.

2. Certified Shop Tests

The lighting fixtures shall be given routine factory tests in accordance with the requirement of ANSI, NEMA and Underwriters Laboratories standards or other equal or better standard approved by the Engineer.

3. Field Tests

Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16050, Basic Electrical Requirements.

**END OF SECTION**

# SECTION 16501

# LIGHTING FIXTURES INTERNAL AND EXTERNAL AREA

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section covers design furnishing, installing, and maintenance of lighting fixtures. This section shall include fixtures, lamps, starters, ballasts, poles, hangers, and accessories as required for a complete installation.

**A. Related work**

1. General Equipment and Material Stipulations.

The General Equipment and Material Stipulations shall apply to all equipment furnished under this section.

2. Works Specified Elsewhere

Other items of work provided in this section include the following: -

Submittals

Electrical Materials and Methods.

**1.2 QUALITY ASSURANCE**

***Applicable Codes and Standards***

All works shall be performed and all material and equipment shall be in accordance with the standards and codes referred to in Section 16050.

**1.3 SUBMITTALS**

All materials, equipment, and wiring diagrams, where applicable, shall be submitted for review. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment as follows: -

a. Lamp fixture descriptive sheets shall show the fixture schedule letter, number, or symbol for which the sheet applies.

b. Equipment and materials descriptive literature and drawings shall show the specification paragraph for which the equipment applies.

**1.4 JOB CONDITIONS**

All fixtures and accessories shall be suitable for use in 50o C ambient.

**PART 2 - PRODUCTS**

**2.1 LIGHTING FIXTURES**

Lighting fixtures shall be identified on the Drawings by a letter and symbol. Each fixture has a general description as to type, material of construction, wattage, and operating voltage.

**2.2 LAMPS**

Lamps shall be furnished for all fixtures. Immediate lamp replacement, whenever burnouts occur, shall be continuous until the date of initial acceptance by the Employer.

All lamps shall be replaced immediately prior to the Contractor leaving the work site unless otherwise directed by the Engineer.

All incandescent lamps shall be screw base extended life lamps of the wattage in the "Lighting Fixture Schedule" on the Submittal Drawings.

**Emergency Lighting**

Portable and fixed type emergency lighting with halogen 2 x 20-watt lamp and rechargeable battery for minimum 3 hours operation complete with charger automatically initiated when the main power fails.

In normal conditions, the lights will be connected to socket outlets and not lit.

**External Light**

External lighting shall be by photocell control by (M-O-A) S.S. (where ‘M’ for Manual, ‘O’ for Off, ‘A’ for Auto by the photocell) according to the drawings and Engineers approval.

**2.3 BALLASTS**

Ballasts shall be furnished for all fixtures. Immediate ballast replacement, whenever failure occurs, shall be continuous until the date of initial acceptance by the Employer.

The following data of fluorescent lamp ballasts shall be furnished as specified in the "Lighting Fixture Schedule" on the Submittal Drawings. Fluorescent ballasts shall be supplied as an integral part of the luminaries.

Lamp Watts 2-40 W

Line Watts 85 W

Line Volts 230 V

Percent allowable

Line Voltage

Variation + 5 %

Type Rapid Start

Power Factor 0.9+

Percent Allowable

Line Voltage Dip 15-20 %

Low Ambient

Operating

Temperature 10o C

High Ambient

Operating Temperature 45o C - 50o C

**A.** **General**

The Ballast shall be capable of starting and operating the mercury vapour lamps from a nominal 230 Volts, 50 Hz power source within the limits specified by the lamp manufacturer. The ballast, including starting aid, must protect itself against normal lamp failure modes. The ballast shall be capable of operation with the lamp in an open or short-circuit condition for six months without significant loss of ballast life.

The luminaries shall be suitable for continuous service in an ambient temperature of 50o C with the ballast operating normally or in the short-circuit or open circuit mode.

**B. Lamp Wattage**

For nominal line voltage and nominal lamp voltage, the ballast design centre will not vary more than 5 percent from rated lamp watts for all ballast types.

**C. Regulating Type Ballast**

At any lamp voltage, from nominal through life, lamp wattage regulation spread at the lamp voltage shall not exceed 18 percent for plus or minus 10 percent line voltage variation.

**D. Lamp Current Crest Factor**

The lamp current crest factor shall not exceed 1.8 for plus or minus 10 percent (regulating type) line voltage variation at any lamp voltage, from nominal through life.

**E. Ballast Power Factor**

The power factor of the lamp ballast system shall not drop below 90 percent for plus or minus 10 percent (regulating type) line voltage variations at any lamp.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

Lighting equipment, material, and wiring devices shall be installed according to the Submittal Drawings and Specifications and as required to provide a complete and operating system.

Each complete fixture shall be secured to its support assembly. This work includes but is not limited to all-special drilling, assembling, disassembling, reassembling, and wiring.

Fixture maintenance shall be continuous until the date of Taking-Over by the Employer. All fixtures shall be cleaned immediately prior to the Contractor leaving the work site unless otherwise directed by the Engineer.

Fixture locations indicated on the Drawings are approximate only and shall be co-ordinated with other work in the same area to prevent interference between lighting fixtures and piping or other equipment. Any fixture shall be relocated if, after installation, it is found to interfere with other equipment or is so located to prevent its practical and intended use.

Fixtures installed in rows shall be carefully aligned vertically and horizontally.

All outdoor lighting (streets and buildings) shall be lit via selector switch (H-O-A) as detailed in the Submittal Drawings.

A. Auto mode is actuated by photocells (The streets separated from buildings) wired with a contactor for the relevant circuit,

H. Hand mode can light the lamps manually via the contactor only,

O. Off position.

**END OF SECTION**

# SECTION 16502

# LAMPS

**PART 1 GENERAL**

**1.01 WORK INCLUDED**

A. Incandescent Lamps

B. Fluorescent Lamps

C. Discharge Lamp

D. Low voltage Lamps

**1.02 RELATED WORK**

A. Section 16500 : Lighting & Lighting Fixtures

B. Section 16511 : Luminaries

C. Section 16050: Basic Electrical Materials and Methods.

**1.03 REFERENCE STANDARDS**

A. IEC 64 : Tungsten Filament Lamps for General Service.

B. IEC 81 : Tubular Fluorescent Lamps for General Lighting Service.

C. IEC 662 : High Pressure Sodium Vapor Lamps.

**1.04 SUBMITTALS**

1. Submit manufacturers product data and technical literature.
2. Submit materials compliance sheet with the Specifications.

**PART 2 PRODUCTS**

**2.01 ACCEPTABLE MANUFACTURERS OR APPROVED EQUIVALENT**

A. Philips NV, Mazda, Thorn, GTE, DZ, OSRAM, IGUIZZINI … TRILUX, DIZANO, DIALUX ,…. Etc.

The listing of "Acceptable Manufacturers" above is intended to indicate the quality of the materials or equipment required and it is not intended that the Contractor be in any way restricted to obtaining tenders or ordering equipment or materials from these sources.

**2.02 INCANDESCENT LAMPS**

**A. GENERAL LIGHTING SERVICE (GLS) LAMPS :**

2500 Hour, 250 Volt, extended service type with either ES or BC caps as required for the particular Luminaire. Wattage of lamps shall be as indicated on the Luminary Schedule.

**LAMP WATTAGE LUMINOUS FLUX**

60 Watts 820 Lumens

100 Watts 1560 Lumens

150 Watts 2440 Lumens

**B. INTERNALLY SILVERED LAMPS (ISL) :**

2500 Hour, 250 Volt, 80mm diameter light diffused type with either ES or BC cap as required for the particular laminar.

**C. REFLECTOR LAMPS :**

2000 Hour, 250 Volt, PAR 38, pressed glass type either 100 or 150 Watt as required. They shall be of the wide flood type with a half value beam spread of 2 x 24 degrees.

**LAMP WATTAGE LUMINOUS FLUX**

100 Watts 960 Lumens

150 Watts 1500 Lumens

**2.03 FLUORESCENT LAMPS**

18000 hour, warm white switch start, bi-pin type with the following requirements :

**NOMINAL LUMINUOUS**

**WATTAGE TYPE SIZE FLUX**

20 Linear 610mm 1150 Lumens

40 Linear 1220mm 3070 Lumens

22 Circline 215mm dia. 1110 Lumens

32 Circline 310mm dia. 2080 Lumens

40 Circline 410mm dia. 2930 Lumens

**2.04 DISCHARGE LAMPS**

**HIGH PRESSURE SODIUM LAMPS :**

400 Watt, SON/T high pressure sodium lamps with a minimum luminuous flux of 48,000 lumens.

**2.05 LOW VOLTAGE LAMPS**

**A. EMERGENCY LIGHTING LAMPS :**

12 Watt, 12 Volt inside frosted type with ES cap, unless otherwise specified elsewhere in the Contract (e.g. Drawings & BOQ).

**B. SUBMERSIBLE FLOOD LIGHTS :**

24 Volt, 150 Watt, PAR 38 generally as described for 2.02C above.

**2.06 SPARES**

Provide at least 25% spare lamps of each type.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Install lamps in accordance with the manufacturers instructions.

B. Provide lamps for luminaries listed in the Schedule of Luminaries.

**END OF SECTION**

# SECTION 16511

# LUMINAIRES

**PART 1 GENERAL**

* 1. **WORK INCLUDED**

A. Interior Luminaires

B. Exterior Luminaires

* 1. **RELATED WORKS**

A. Section 16500: Lighting & Lighting Fixtures

B. Section 16502: Lamps

* 1. **APPLICABLE CODES AND STANDARDS**

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.

* 1. **SUBMITTALS**

A. Submit shop drawings and product data in accordance with Section 1300.

B. Submit samples of all luminaires prior to ordering.

C. Submit photometric data and polar curves for all luminaires.

D. Submit manufacturer's technical literature, and installation and maintenance instructions for all luminaires.

E. Submit photometric and heat dissipation reports from an independent test laboratory.

1. Submit air handling capacity and noise data for air handling luminaires.
2. Submit material compliance sheets with the specifications.
   1. **ELECTRICAL SUPPLY**

All Luminaires shall be suitable for use on a 230 volt single phase 50 Hertz supply.

**PART 2 PRODUCTS**

**2.01 REFERENCE MANUFACTURERS**

A. Reference manufacturers and associated luminaire catalogue numbers for the different Luminaires shall be as listed on the attached luminaire schedule (see part 3.03 below).

B. The reference manufacturers and associated luminaire catalogue numbers are intended to indicate the type and quality of the luminaire required and is not intended that the Contractor be in any way restricted to obtaining tenders or ordering the Luminaires from these drawings.

C. Where deviations occur between the referenced luminaire and the luminaire proposed by the Contractor, the following shall be submitted to the Architect/Engineer prior to the placing of any orders and the Contractor shall amend the Contractor drawings as necessary.

1. Manufacturers shop drawings indicating all physical characteristics and methods of construction.

2. Detailed photometric and heat dissipation data substantiated by test carried out by an internationally recognized test laboratory.

**2.02 FLUORESCENT LUMINAIRES**

A. Luminaires shall be constructed from 0.9mm thick sheet steel folded, and welded as necessary to provide a rigid, robust, dust and light-tight enclosure.

B. All cut edges and the edges of all punched and drilled holes shall be cleaned of all irregularities and burrs.

C. After cleaning and rush proofing, metal surfaces shall be given one primer coat with two finish coats of high reflectance baked white enamel to ensure a minimum reflectance of 85%.

D. Luminaire enclosures shall be sized to ensure adequate dissipation of heat under normal operating conditions so as to ensure optimum performance of lamps and central gear.

E. Ensure adequate ventilation of all Luminaires.

F. Protection classes (IPXX) for Luminaires, where given on the luminaire Schedule shall be in accordance with IEC 144.

G. Internal wiring shall be carried out using high temperature PVC or glass fiber insulated flexible cables with copper conductors rated for the maximum possible temperature inside the enclosure. Cables shall be arranged in a neat loom and shall be kept in place using nylon clips at not greater than 50mm on centers.

H. Provide 3-way fixed terminal adjacent to the main terminal which when connected to the system ground will effectively ground the complete fitting.

J. Control gear shall be of the high power factor type and unless otherwise indicated on the schedule all Luminaires shall be arranged for "Switchstart" operation (i.e rapid start.)

K. Lamp holders shall be of B1-Pin molded bakelite type with spring loaded contact.

L. Diffusers shall be of the one piece molded opalescent or prismatic type manufactured from 100% acrylic, or Plexiglas. They shall retain in position using corrosion resistant springs or clips so designed as to keep the diffuser tight to the enclosure.

M. Reflectors shall be of the open ended metal trough.

N. Louvers. See Part 3.03 below.

O. Recessed and semi-recessed Luminaires shall be provided with brackets for supporting the fitting from the ceiling.

P. Trunking mounted Luminaires shall be provided with suitable galvanized steel mounting brackets provided by the trunking manufacturer.

**2.03 INCANDESCENT LUMINAIRES**

A. Surface mounted Luminaires shall be provided with die cast aluminum or stove enameled white metal base plates as indicated on the schedule.

B. Bulkhead Luminaires shall be provided with clear vandal resistant glass diffusers fixed to the base plate by screws.

C. General surface incandescent Luminaires shall be provided with snap-on opal glass drum type diffusers.

D. Recessed incandescent Luminaires shall be of the pre rewired type with the terminal block forming an integral part of the luminaire and shall be provided complete with ceiling trim to suit the ceiling in which they are to be installed.

E. Down lighters and wall washers shall be provided with integral multi-groove black baffle to remove glare from the lamp.

**2.04 CORROSION PROOF LUMINAIRES**

Corrosion proof Luminaires shall be manufactured from impact resistant glass fiber reinforced polyester with clear acrylic or Plexiglas diffuser fixed to the enclosure using a minimum of six retaining clips.

**2.05 FLOODLIGHTS**

A. Floodlights shall have rugged die cast aluminum enclosures, polished aluminum reflectors and clear heavy-duty vandal resistant glass diffuser.

B. They shall be provided with suitable adjustable mounting brackets.

C. They shall be provided with remote mounted control gear.

**2.06 POLE MOUNTED LUMINAIRES**

A. Pole mounted Luminaires shall be of the "Post Top" type and shall be provided with suitable spigot for fixing to the pole.

B. They shall be provided with spherical diffusers as detailed in the Luminaire Schedule.

C. Where discharge lamps are specified, they shall be provided with integral control gear.

**2.07 EXIT SIGNS**

Self-contained, maintained, 3-hour duration type with cast metal frame and aluminum face plate, cut out letters and directional arrows and 8 Watt fluorescent tubes.

**2.08 SPARE PARTS**

A. Provide spare parts for all Luminaires for at least two years operation as manufacturer’s recommendations.

B. Detail spare parts being provided at tender stage.

Provide 10% spare Lamps of each type of luminaires.

**PART 3 EXECUTION**

**3.01 CO-ORDINATION**

A. Co-ordinate location of recessed Luminaires with the specialist ceiling contractor.

B. Co-ordinate location of all Luminaires with all other trades and other ceiling mounted electrical services.

C. Ensure all recessed Luminaires are provided with the necessary plaster frames trim rings and back boxes or back plates required.

D. Co-ordinate luminaire support systems with all other trades.

E. Co-ordinate size of recessed fluorescent Luminaires with ceiling systems.

**3.02 INSTALLATION**

A. Install Luminaires in accordance with the manufacturer's instructions and as indicated on the drawings.

B. Install recessed or semi-recessed Luminaires to permit easy removal from below.

C. Support recessed fluorescent Luminaires from the ceiling support grid using brackets supplied by the luminaire manufacturer for the purpose.

D. Install surface mounted Luminaires direct to the building structure using galvanized threaded rod (10mm diameter minimum) with lockouts and washers.

E. Install trunking mounted Luminaires using brackets provided by the trunking manufacturer.

F. Install external floodlights on the ground and protect them from damage after installation.

G. Ensure correct operation of all Luminaires prior to final acceptance.

H. Align all Luminaires and clean all diffusers prior to final acceptance.

**NOTES**

1. Recessed Luminaires to be installed in plaster ceilings are to be provided complete with plaster ceiling kits.

2. Addresses of reference Manufacturers listed above are, but not limited to, the following:

a. Trilux Lenze GMBH & Co. KG,

West Germany.

b. Concord Lighting Limited,

United Kingdom

c. Mentor Engineering Limited,

Ireland.

d. Hoffmeister-Leuchten GMBH,

West Germany,

e. Iris Lighting Limited,

France.

f. Wandsworth Electrical Company Limited,

United Kingdom

g. GEC (Lamps & Lighting) Limited,

United Kingdom.

h. Raak Lighting Architecture,

Netherlands.

i. Bega Jantenbrink - Lenchten OHG,

West Germany.

j. Thorn Lighting Limited,

United Kingdom.

**END OF SECTION**

# SECTION 16588

# POLES AND POSTS

**PART 1 GENERAL**

**1.01 WORK INCLUDED**

A. Provide and install poles, posts and standards

B. Provide base reinforcement and anchor bolts.

* 1. **APPLICABLE CODES AND STANDARDS**

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in section 16050

* 1. **RELATED WORK**

A. Section 16050 : Basic Electrical Materials and Methods

B. Section 03300 : Cast-In-Place Concrete.

C. Section 09900 : Painting

D. Section 16120 : Wire and Cable.

E. Section 16060 : Grounding and Bonding

F. Section 16501 : Lighting Fixtures Internal and External Area

G. Section 16502 : Lamps

H. Section 16511 : Luminaries

* 1. **SUBMITTALS**

1. Submittals shall be in compliance with Section 1300, Submittals.
2. Submit pole manufacturers recommended reinforcing for bases.
3. Submit materials compliance sheets with the specifications.

**PART 2 PRODUCTS**

**2.01 POLES**

A. Configuration : Conical octagonal, polygonal or circular hot dip galvanized steel poles according to the Drawings & BOQ and as approved..

B. Handhole : 450mm complete with removable cast iron weatherproof cover and frame.

C. Pole Top : Provide single and / or double arm to match luminary listed in luminary schedule and as shown in BOQ and Drawings and as approved.

D. Masts : Provide polygonal high masts of the multi-fit in or hinged type of hot dip galvanized steel as shown in the Drawings & BOQ and as approved.

**PART 3 EXECUTION**

**3.01 BASES**

A. Construct of concrete with minimum dimension of 600 mm x 600 mm x 1200 mm deep or as indicated on drawings and recommended by the manufacturer and approval of the Engineer.

**3.02 INSTALLATION**

1. Mount standards on bases plumb and true utilizing shims as necessary.
2. Touch up chips and scratches on poles upon completion.
3. Mount poles on walls where indicated.
4. Put on each pole an approved labeling with a sticker durable and fluorescence fascia material for the whole outside lighting system.

**END OF SECTION**

# SECTION 16610

# ELECTROMAGNETIC FLOW METERS

**PART 1 - GENERAL:**

**1.1 DESCRIPTION**

This section covers furnishing and installation of electromagnetic flowmeter.

**A. Related Work**

Other items of work that relate to and are referenced in this section include, but are not limited to, the following section :

Submittals.

**1.2 APPLICABLE CODES AND STANDARDS**

The submitted meters shall comply to relevant DIN, ISO, and BS standards with regard to design and performance.

**1.3 SUBMITTALS**

Complete outline and installation drawings, together with detailed specifications and data covering material used parts, devices and other accessories forming apart of the equipment furnished, shall be submitted in accordance to submittal section. Operation and maintenance manuals shall be submitted in accordance with submittals section.

**1.4 PRODUCT HANDLING**

The equipment furnished under this section shall be prepared for shipment, delivered, stored, and handled in accordance with the General Equipment and Material Stipulation.

**PART 2 - PRODUCTS:**

**2.1 ELECTROMAGNETIC FLOWMETERS:**

**2.1.1 Material of Components**

The bodies of the electromagnetic water Flow Meters shall be manufactured from the best quality cast iron with integrally cast flanges or stainless steel. The tubes shold be fitted with electrically insulating liner. Material in contact with water shall be non-toxic and shall not affect the quality of water. The metering tube shall be of stainless steel.

The lining shall have either of the following specifications, with all materials suitable for potable water use:

1. PFA-Perfluoro-alkoxy-UKWFBS
2. Elastomer-UKWFBS
3. Polypropylene-UKWFBS, listed for potable water,
4. Ebonite, Bonded FEP, Polyurethane and Neoprene,
5. Electrodes (including earthing electrodes) are to be field replaceable without removing the tube , stainless steel, Hastelloy “C” Titanium, Tantalum or Platinum Iridium.

Meters shall be designed for use in a tropical climate and for temperatures up to 50° C.

**2.1.2 Pressure Rating**

The minimum working pressure shall be to PN 25 and the meters shall comply with the relevant DIN, ISO and BS standards with regard to design and performance.

**2.1.3 Accuracy of Operation**

The meter shall be capable of achieving an accuracy of ± 0.2 % of reading within the specified flow range.

**2.1.4 Power Supply**

The power supply shall be as follows:

1. AC: 85-265 V, 45 to 400 Hz at 20 VA maximum, or
2. 11 to 40 V, at 20 VA maximum.

The transmitter display shall be a 32-character (2 line) high temperature LCD alpha-numeric type, capable of recording flow rates and total flow.

The field mounting shall be powder coated die-cast aluminium IP 68 output signals, 4 – 20mA, counting pulse, status output. Power supply, 230 VAC, 50 Hz.

The meter shall be either programmed before dispatch from the manufacturer and should be capable of being re-programmed on site to suit prevailing conditions.

**PART 3 - EXECUTION:**

**3.1 INSTALLATION**

The Electromagnetic flowmeter shall be installed at discharge main of pumping station as shown in drawings.

The Contractor shall submit a comprehensive specification regarding meter type, design performance and installation, including required lengths and straight pipe on either side of the meter.

**END OF SECTION**

# SECTION 16620

# POWER SUPPLY AND DISTRIBUTION

# STAND-BY/EMERGENCY POWER PLANT

**PART I: GENERAL**

* 1. **WORK INCLUDED:**

Standby/emergency power plant installation comprises the following: -

One diesel generating set, with associated auxiliaries, exhaust system, start-up system, cooling system, fuel system, batteries and charger etc.

Fuel storage and fuel transfer system.

Instrumentation, protection and control equipment

Manually operated overhead hoist.

Inter-plant cabling and wiring.

Earthing

* 1. **APPLICABLE CODES AND STANDARDS**

1. All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.
2. Equipment and component parts are to comply with ISO 3046, IEC 85 and CISPR, or equivalent NEMA, ANSI, IEEE, DIN and VDE Standards and recommendations of ABGSM (Association of British Generator Set Manufacturers) where such standards meet with or supersede the ISO and IEC Standards.
   1. **EQUIPMENT DATA & SUBMITTALS:**

Submit full technical data of equipment for approval including, but not limited to, the following:

General description and characteristics of engine-generating set, standards with which components comply, site rating and overload capability, overall efficiency, and fuel and lubricant consumption at 100%, 75%, 50% and 25% of rated load.

Description and operating criteria of engine; type, model, manufacturer, fuel and lubricating oil types and specific consumption, starting conditions and starting periods from cold to full-load pick-up, governor and response characteristics due to sudden load changes, super-charger, fuel injection system, cooling system and radiator, air filters, fuel filters, oil filters and pumps.

Description and operating criteria of generator, exciter and voltage regulator, with loading response and short-circuit characteristics, insulation, cooling and accessories.

Dimensions, weights and forces, mounting methods, vibration protection etc.

Battery type, make, charge/discharge characteristics, capacity and constructional features.

Battery charger, method of charging, equalising and trickle charging

Fuel tanks, pipes and accessories; materials and construction.

Exhaust system and silencers; materials and construction.

Control instruments, protection, alarms, cut-outs, indicating lamps, indicating instruments and all other devices or components.

Control gear.

Calculated noise levels in dB(A)at typical points within engine room and at various locations inside and outside.

The Contractor shall supply, in his offer for each electrical section, data sheets comprising all technical information about each equipment, machine, motor, Gen-set & its all components, devices, instruments, cables, computers, PABX, wireless PABX & its talk about units, monitors, luminaires, …etc. that he shall submit within that section covering all specification of that item or component.

The Contractor shall, during construction stage, submit to the Engineer, for each electrical or mechanical submittal of any item a complete comprehensive compliance sheet comprising several columns; one for identifying the item, the 2nd for tender specs. the 3rd for the submittal specs., the 4th for the deviations if there is any.

* 1. **ROUTINE AND SHOP TESTS:**

Fully assembled plant or equipment is to be tested at the factory, before shipping. The complete stand-by Generator-Set shall be witness-tested by the Engineer at the factory. The Contractor shall pay all costs of transport, accommodation and food. Pocket money of US$ 150 per day shall be paid by the Contractor as well the Nos. of days shall be from the 1st day of flight departure of the Engineer team to the last day they land their hope airport. Complete performance tests are to be carried out under site simulated conditions, in accordance with the Standards and as described in the Specification.

* 1. **SHOP AND CONSTRUCTION DRAWINGS:**

Submit drawings for approval including, but not limited to, the following:

Certified manufacturers' dimensional drawings, templates and installation instructions for equipment and accessories, showing weights and distribution of forces, location and size of cabling (power and control), piping connections to equipment, and other pertinent data.

Plans and elevations of all equipment.

Separate unit wiring diagrams, schematics and interconnecting wiring diagrams.

Constructional details of bulk fuel storage tanks and daily service fuel tank, including outline drawings showing piping arrangements, connections and dimensions.

Complete execution drawings of associated auxiliaries.

* 1. **SPARE PARTS:**

Provide manufacturer's recommended spare parts for 1,000 hours operation of the standby plant. Provide list of manufacturer's spare parts for 2,000 hours operation together with current prices. The prices shall be deemed to be included in the unit price of the Contract.

* 1. **TOOLS AND INSTRUMENTS :**

Provide tools (normal & special) and instruments required for normal routine inspection, testing, and operation and general maintenance, as recommended by the manufacturer. The prices shall be deemed to be included in the unit price of the Contract.

* 1. **APPROVED MANUFACTURERS :**

Obtain generator sets from one of the following :

Caterpillar (USA)

Onan (USA)

Volvo (Sweden)

or other equal and approved.

* 1. **WARRANTY :**

Provide two (2) years of warranty for equipment specified in this section.

* 1. **LOCAL REPRESENTATIVE :**

Provide evidence that proposed equipment manufacturer has a locally established and authorised organisation which can be called upon for professional advise and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy the Engineer may disqualify a manufacturer.

* 1. **MAINTENANCE CONTRACT :**

Obtain an undertaking by the equipment manufacturer and his authorised local representative to provide an annual maintenance contract, available after substantial completion of the work for two (2) years, covering routine service and emergency service by trained employees, and to ensure supply of necessary standard spare parts.

**PART 2: PRODUCTS**

* 1. **GENERATOR SET ASSEMBLY:**

Compact package type, with all equipment mounted on one rigid steel bed frame suitable for skidding. Radiator is to be mounted on the set as shown on the Drawings. Design is to permit easy operation, maintenance and repair.

* 1. **VIBRATION REDUCTION:**

Is to be achieved by appropriate design and careful balancing at factory. Compact set is to have approved anti-vibration isolators of steel spring or resilient neoprene between rotating equipment and bed-frame, limiting transmission of vibration to building to a maximum of 0.04 mm amplitude throughout the operating vibration frequency range. (i.e the vibration velocity shall not be less than very good.)

* 1. **NOISE REDUCTION :**

Is to be achieved by approved methods at source of noise, with sound level measured at 25 m limited to 78 dB(A) at 20 Hz down to 41 dB(A) at 10,000 Hz in accordance with ISO standards for residential areas.

* 1. **COLD STARTING:**

Engine is to be fully equipped to start and pickup initial load specified at specified minimum ambient temperature. Cold starting aids, such as engine jacket water heater, lubricating oil heater, intake-air heater, oversize standby battery and all devices, accessories, connections, thermostatic switches and off-duty disconnects with pilot lights and necessary protection, are to be supplemented as recommended by the manufacturer and approved.

* 1. **EQUIPMENT RATINGS:**

Are to be as shown on the Drawings or the next higher standard ratings provided by the manufacturer. Ratings are to be net continuous output to consumer, excluding fan and any auxiliaries, auxiliary drives and losses, delivered at specified frequency, voltage and power factor and under worst climatic conditions on site.

* 1. **DIESEL GENERATOR SET**
     1. **COMPONENTS:**

Set is to be basically consist of diesel engine, brushless synchronous generator with direct flexible coupling to engine and single or parallel control cubicle as required.

* + 1. **GOVERNING :**

Is to be AO to ISO 3046/IV or BS 5514, using electronic type governor with limits of speed control as specified.

* + 1. **STARTING AND STOPPING :**

When in the automatic mode the set is to start and stop automatically by a signal sensed through and auxiliary contact in the Priority transfer switchgear. The set is to stop, after an adjustable cool-down period (2-30 minutes).

* + 1. **DUTY :**

The set shall be capable to be loaded within (10-15) second maximum period at most from receiving its starting signal and shall be equipped with all devices and controls needed to take the load within this period of time.

Plant is to reach full speed within 10 seconds from start impulse and accept immediately 80% of net rated output (load being mixed, steady and inductive, with motor starting loads). Transient voltage variation is not to exceed 10% under any step-load application for which the system is intended, up to full rated load, recovering to within +/-2% within a few cycles.

The diesel generator shall be capable of maintaining speed at not more than (110%) by maximum load removal and not more than (115%) by all load removal.

* + 1. **FAILURE TO START:**

Should engine fail to start following a start impulse, the system is to come to rest for a few seconds. Two further starting attempts are to be automatically made with intermediate 20 seconds maximum periods of rest. Should the set fail to start after three attempts, an alarm is to sound and a 'start failure' signal illuminate.

* + 1. **HAND OPERATION:**

Is to be possible for testing or normal operation through a test/manual/off/auto selector switch.

* + 1. **REGULAR EXERCISING:**

While on 'auto', the set is to start regularly and automatically every week and is to operate for 30 minutes before stopping .

* + 1. **COOLING SYSTEM:**

Engine is to be water cooled with gear-driven water pumps. System is to be pressurised, with heavy duty tropical radiator cooled by reverse flow fan. Fan cowl and hand protection guard are to be fitted. Coolant temperature is to be controlled by one or more thermostats as determined by design of system. Radiator is to be sized for continuous performance at 110% rated load at worst operating ambient conditions with a 15° C temperature differential. Radiator is to be non-ferrous metal, incorporating pressure valve, radiator cap and drain cock and with integral expansion tank. Direct acting modulating thermostatic diversion valve is to control engine cooling water temperature. Under normal operation, by-pass is not to be fully closed. Treated or fresh cooling water and anti-corrosion and anti-freeze additives are to be used as recommended by manufacturer for specific conditions of installation.

* + 1. **COOLING AIRFLOW:**

Obstructions in path of cooling air flow (openings, louvers, grilles, mesh, ducts, bends etc.) are not to reduce air flow below that needed at full rated output. Fan and radiator characteristics are to be selected accordingly. Advise if additional booster fans are required and provide necessary control gear for automatic operation.

* + 1. **CYLINDERS:**

Are to have removable liners. Wet type liners are to have witness hole between line sealing rings of each cylinder for early detection of coolant or oil leakage. Each cylinder is to have drilled and tapped hole and valve for connections of pressure indicator.

* + 1. **LUBRICATING OIL SYSTEM:**

Pressurised circulating type, using two engine-driven, gear type lubricating oil pumps with full flow filters and replaceable elements and lubricating oil heat exchanger. Filter system is to have spring loaded by-pass valve to permit oil circulation if filters become clogged. Audible and visual alarms are to cut-in when valve starts opening. Lubricating oil cooler is to be shell and tube heat exchanger with water from engine radiator as the cooling medium. Direct acting thermostatic diversion valve is to control oil temperature. Under normal operation by-pass is not to be fully closed.

* + 1. **FUEL SYSTEM:**

Is to have injection pump and injectors that are easily removable and replaceable for servicing. Engine is to have integral, gear type, engine driven transfer pump to lift fuel against a head of 2.5 m and supply it through filters to injection pump at constant pressure. Fuel filter elements are to be easily replaceable.

* 1. **EQUIPMENT AND ACCESSORIES**

**DIESEL ENGINE AND AUXILIARIES**

* + 1. **DESIGN:**

Diesel engine is to be designed for type of load and application required. Engine and governor are to be selected to meet operating requirements and response specified.

* + 1. **ENGINE TYPE:**

Compression-ignition type with direct solid-injection, turbo-charged for ratings, over 100 kW, water cooled, with air-cooled radiator, 4-stroke cycle, inline or V-type cylinder arrangement, 1,500 rpm, operating on BS 2869 class A diesel oil, suitable for direct coupling to driven machine. Flywheel is to be suitably sized for type of service and constraints specified, and capable of being rotated at 125% of rated speed without failure. Torsional vibration dampers are to be provided.

* + 1. **ENGINE RATING:**

Is to be such that alternator can deliver net specified continuous rated output, and is to withstand 10% overload for one hour in any period of twelve hours continuous operation at full load, with temperature rise not exceeding rise allowed by the Standards.

* + 1. **ACCESSIBILITY :**

It is to be possible to:

Remove rocker-box covers without disturbing fuel injection pipes or other components.

Remove and replace pistons and piston rods, liners, big and small end shells and caps without dismounting engine.

Bar engine over by hand for spill timing check and adjustment.

* + 1. **MEASURING INSTRUMENTS :**

Engine mounted instruments are to include, at least, water temperature gauge, lubricating oil temperature gauge and pressure gauge, tachometer and running time meter. It is to be possible to measure, with extra instrumentation, coolant temperature at lower end of radiator, air depression after air filter, air boost and temperature using methods recommended by manufacturer. Instrument accesses are to be normally sealed by threaded blanking caps.

* + 1. **EXHAUST SYSTEM:**

Is to be complete with flanged, bolted, galvanised, seamless steel pipe sections, long sweep elbows, flexible expansion sections, clean-outs, residential silencer, wall thimbles and supporting steelwork. Silencer is to be independently supported. Indoor hot exhaust parts are to be insulated with approved insulation, not less than 100 mm thick, with anti-condensation overlap and sheet metal covers to protect insulation. Exhaust system is to be designed to reduce back pressure to below maximum specified by the manufacturer, in relation to exhaust pipe length shown on the Drawings. The exhaust pipe outside the building shall be supported vertical up over the building edge at least 1m, with a conic cover wide enough over the outlet of the exhaust chimney pipe to prevent rain from entering the pipe.

* + 1. **AIR INTAKE SYSTEM:**

Plant room is to have heavy duty air-filter of the locker panel, all metal, cleanable, viscous impingement type, complete with duct and frame, as shown on the Drawings. Engine air filter is to be either dry filter with replaceable paper filter elements or oil-bath filter with dipstick and provision for adding oil while engine is running. Filters are to be capable of removing particles 10 microns and larger.

* + 1. **ELECTRIC STARTING SYSTEM:**

Engine starting is to be manual by push-button or automatic through control system at control panel. System is to consist of heavy duty 24 V D.C. starter motor, heavy duty battery and battery charger. Cranking motor and battery are to be rated for cranking the engine when cold and at lowest temperature recorded. Starting pinion is to automatically disengage when engine fires.

* + 1. **STORAGE BATTERY:**

Alkaline, sealed-in-plastic type, complete with battery rack and intercell connectors. Battery is to have sufficient capacity to provide minimum four cranking periods.

* + 1. **BATTERY CHARGER:**

To be 25% over-rated, solid state, full-wave rectifier type, adequate to fully recharge depleted battery in not more than 8 hours and to automatically control rate of charge (providing a high-charge rate to a depleted battery and reducing to a trickle-charge rate when battery is fully charged). Ammeter is to be provided to indicated charging rate, which is to be adjustable. Battery charger is to be mounted in control cubicle, unless otherwise approved. The charger shall have 2 LED’s signal lamps, one for boost and one for trickle charging positions.

* + 1. **ELECTRONIC GOVERNOR :**

Is to provide isochronous governing, paralleling and load sharing of generator sets. Governor is to have zero percent (isochronous) setting and adjustable droop from zero percent to 10% droop. System is to include power supply unit, magnetic speed pick-up, control module and actuator using fast response D.C. motor drive or equally approved alternative. Governor is to be designed for fast-response and high-precision of speed (frequency) control, automatic paralleling and load-sharing and is to include speed adjustment to +/-5% of normal, while running, and with remote control interface. Frequency deviation under 25% sudden load change is not to exceed 0.5 Hz, recovering to stable speed condition of +/-0.1 Hz in 0.5 seconds.

* + 1. **GOVERNOR OVERSPEED TRIP:**

Is to automatically close fuel pump racks in event of engine OVERSPEED. Device is to be separate and independent from governing mechanism.

* + 1. **PROTECTIVE SYSTEM :**

Is to comprise automatic engine shut-down and generator trip with visual and audible alarm in event of overspeed, low lubricating oil pressure, high cooling water temperature and over cranking.

* 1. **GENERATOR (ALTERNATOR) :**
     1. **TYPE :**

Synchronous, low reactance, high efficiency, revolving field type, with brushless exciter and flexible coupling, sized to pick up effective load without exceeding transient and steady-state voltage deviation limits specified up to its full nominal rating and designed for the performance stipulated in the Specification. It is to be two bearing construction with bearings of the sleeve or sealed ball type.

* + 1. **LEADS AND CABLES ;**

Phase leads are to be brought out fully insulated to a terminal cable box of heavy gauge sheet steel, protection IP 44. Control and protection cables are to be brought out to a separate terminal box.

* + 1. **MAXIMUM VOLTAGE DIFFERENCE :**

Between the three phases at 100% balanced load is not to exceed 1%. With unbalanced load up to 30% on one phase at unity power factor and zero load on other phases, the line-to-neutral voltages are not to differ by more than 5%.

* + 1. **CHARACTERISTICS:**

number of phases : 3

rated voltage,

frequency : 400/230 Volts + Hz

rated power factor : 0.8

winding connection : reconnectable with ends brought out and fully insulated.

unbalanced load

current with none of

the phase currents

exceeding rated

current : 30% minimum

Overload : 10% nameplate rating for 1 hour every 12 hours.

rotor : salient pole type, incorporating damping grid.

excitation : brushless, with rotating armature rectifiers and discharge resistors

voltage regulator : automatic, with readily accessible controls for voltage level.

insulation : class H for stator class H for rotor and exciter Both shall be further protected with 100% epoxy impregnation and an over coat of resilient insulating material on end costs to reduce possible fangus and abrasion deterioration.

enclosure : drip proof and screen protected (IP 23 to IEC 144).

cooling : built-in centrifugal fans.

* + 1. **VOLTAGE REGULATION :**

Overall voltage deviation within normal speed variations is to be within limits specified from no-load to full-load, from hot to cold and with load power factor form 0.8 lagging to unity. Regulator is to automatically reduce voltage if load exceeds capacity of generator. Voltage build-up is to be positive and rapid even when full load is suddenly applied. Line-to-line voltage wave-form deviation factor is not to exceed +/-5%. Total harmonic content is not to exceed 5% and that of one harmonic not to exceed 2%. Radio interference suppression is to be within the limits set by the Standards, grade (N).

* + 1. **EXCITER:**

Armature is to be 3-phase, directly mounted to generator shaft and connected to generator field windings through six solid state, hermetically sealed, silicon rectifiers, accessible for maintenance or repair. Exciter is to have field suppression system to eliminate any source of diode failure resulting from high inductive loads and surges. Exciter field windings are to be stationary. Exciter-regulator combination is to maintain output voltage within limits specified for any load up to 110% generator rating and under any sudden load changes specified.

* + 1. **VOLTAGE REGULATOR :**

Solid state, volts/Hz type, utilising silicon semi-conductor devices in control and power stages, with built-in electro-magnetic interference suppression and designed for single or parallel operation. Manual adjustment to +/-5% of regulated voltage level is to be possible by a potentiometer at control panel. All components are to be sealed, moisture and heat resistant, with a suitable environmentally protected enclosure. Voltage regulator is to automatically reduce voltage if load exceeds capacity of generator and is to sustain a 3-phase short-circuit current at the generator terminals for the period for which the short-circuit protection operates and at least for 3 seconds. Voltage regulator power is to be supported by generator voltage and current to maintain excitation field power.

* + 1. **TWO POSITION SWITCH :**

Is to be provided for selection of manual or automatic mode of regulated voltage control.

* 1. **INSTRUMENTATION, PROTECTION AND CONTROL EQUIPMENT:**

**GENERATING SET INSTRUMENTS, PROTECTION AND CONTROLS:**

* + 1. **Engine‑Generator Set Control:**

The generator set shall be provided with a microprocessor-based control system, which is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

The control shall be UL508 listed, CSA282‑M1989 certified, and meet IEC8528 part 4. All switches, lamps and meters shall be oil‑tight and dust‑tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts. The controls shall meet or exceed the requirements of Mil‑Std 461C part 9, and IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions. The entire control shall be tested and meet the requirements of IEEE587 for voltage surge resistance.

The generator set mounted control shall include the following features and functions:

* + 1. **Three-position control switch labeled RUN/OFF/AUTO:**

In the RUN position the generator set shall start, and accelerate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

* + 1. **Red “mushroom‑head” push‑button EMERGENCY STOP switch:**

Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.

* + 1. **Push‑button RESET switch:**

The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

* + 1. **Push‑button PANEL LAMP switch:**

Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

* + 1. **Generator Set AC Output Metering:**

The generator set shall be provided with a metering set including the following features and functions:

2.5‑inch, 90 degree scale analog voltmeter, ammeter, frequency meter, and kilowatt (kW) meter. These meters shall be provided with a phase select switch and an indicating lamp for upper and lower scale on the meters. Ammeter and kW meter scales shall be color coded in the following fashion: readings from 0‑90% of generator set standby rating: green; readings from 90‑100% of standby rating: amber; readings in excess of 100%: red.

Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output kW, kW‑hours, and power factor. Generator output voltage shall be available in line‑to‑line and line‑to‑neutral voltages, and shall display all three-phase voltages (line to neutral or line to line) simultaneously.

* + 1. **Generator Set Alarm and Status Message Display:**

The generator set shall be provided with alarm and status indicating lamps to indicate non‑automatic generator status, and existing alarm and shutdown conditions. The lamps shall be high‑intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on a digital display panel:

low oil pressure (alarm)

low oil pressure (shutdown)

oil pressure sender failure (alarm)

low coolant temperature (alarm)

high coolant temperature (alarm)

high coolant temperature (shutdown)

Engine temperature sender failure (alarm)

Low coolant level (alarm or shutdown—selectable)

fail to crank (shutdown)

over crank (shutdown)

over speed (shutdown)

low DC voltage (alarm)

high DC voltage (alarm)

weak battery (alarm)

low fuel‑day tank (alarm)

high AC voltage (shutdown)

low AC voltage (shutdown)

under frequency (shutdown)

over current (warning)

over current (shutdown)

short circuit (shutdown)

earth fault (shutdown)

over load (alarm)

emergency stop (shutdown)

In addition, provisions shall be made for indication of two customer‑specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non‑automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

* + 1. **Engine Status Monitoring:**

The following information shall be available from a digital status panel on the generator set control:

Engine oil pressure (psi or kPA)

Engine coolant temperature (degrees F or C) both left and Right Bank temperature shall be indicated on V‑block engines.

Engine oil temperature (degrees F or C)

Engine speed (rpm)

Exhaust temperature (optional)

Number of hours of operation (hours)

Number of start attempts

Number of operations

Battery voltage (DC volts)

The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

* + 1. **Control Functions:**

The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and number of start cycles. Initial settings shall be for 3 cranking periods of 10 seconds each, with 10-second rest period between cranking periods.

The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.

The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

The control system shall include time delay start (adjustable 0‑300 seconds) and time delay stop (adjustable 0‑600 seconds) functions.

The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual fault conditions.

* + 1. **Alternator Control Functions:**

The generator set shall include an automatic voltage regulation system, which is matched, and prototype tested with the governing system provided. It shall be immune from miss-operation due to load‑induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three‑phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque‑matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of (48/49 or 58/59 HZ). The voltage regulator shall include adjustments for gain, damping, and frequency roll‑off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. The voltage regulation system shall include provisions for reactive load sharing and electronic voltage matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.

Controls shall be provided to monitor the output current of the generator set and initiate an alarm when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator.

Controls shall be provided to monitor the kW load on the generator set, and initiate an alarm condition when total load on the generator set exceeds the generator set rating for in excess of 5 seconds.

Controls shall include a load-shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.

An AC over/under voltage monitoring system, which responds only to true RMS voltage conditions, shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 Vdc. During engine starting, the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a “weak battery” alarm shall be initiated.

When required by National Electrical Code or indicated on project drawings, the control system shall include a ground fault-monitoring relay. The relay shall be adjustable from 100‑1200 amps, and include adjustable time delay of 0‑1.0 seconds.

* + 1. **Control Interfaces for Remote Monitoring:**

All control and interconnection points from the generator set to remote components shall be brought to a separate connection box. No field connections shall be made in the control enclosure or in the AC power output enclosure. Provide the following features in the control system:

Form “C” dry common alarm contact set rated 2A @ 30VDC to indicate existence of any alarm or shutdown condition on the generator set.

One set of contacts rated 2A @ 30VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.

A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.

A fused 20 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.

The control shall be provided with a direct serial communication link for the LonWorks communication network interface as described elsewhere in this specification and shown on the drawings.

* + 1. **PROTECTIVE GEAR :**

Is to ensure orderly engine stop or shutdown with reset relays, as required for safety and operational reliability, and is to include the following :-

Output circuit breaker for over-current and external earth fault protection.

Over-voltage protection with voltage and time lag adjustment.

Loss-of-field protection.

Breaker is to be (for ratings up to 800A): moulded case circuit breaker (MCCB) with solid-state trip unit, (electrically tripped by shunt release).

For ratings above 800A: power air circuit breaker (PACB) with solid-state trip (electrically operated and electrically tripped by shunt release).

Negative phase sequence protection.

For generators above 500 kVA provide a restricted earth fault protection, with current adjustable settings between 0 and 20% of rated current, and time adjustable settings 0.3 seconds.

* + 1. **CONTROL AND PROTECTIVE GEAR CUBICLES :**

Generator set mounted instrument and/or control cubicles are to be resiliently mounted, preventing transmission of vibration to the components. Separately mounted instrument and control cubicles are to be self-supporting, floor mounted and free-standing. Cubicles are to be sheet steel construction, ventilated indoor type, vermin and dust-proof, (IP 42 to ICE 144), with lockable hinged doors and instrument panels, separate compartments for control devices, protective relays, circuit breaker(s) and neutral earthing device. Inner and outer surfaces of steel enclosures are to be cleaned , phosphatized, primed with heavy duty rust inhibiting primer and finished with two coats of enamel. Wiring is to be 600 V, modularly arranged, with connections made at front terminal blocks with no live conductors exposed. Wires are to have approved numbered ferrules at each terminal. Printed circuit plug-in boards, where applicable, are to be of industry standards, accessible and withdrawable, mounted in standard windings.

Every control and motor panel ( of more than 1.2m width and ground mounted) e g. MDB.,ATS., SMDB-INC…etc.and others shall have its own rubber mat in front of it, the dimension of which shall be of:

Length = Panel width+60 cm.

Breadth = 80 cm.

Thickness = 6 mm.

Color = Black.

* + 1. **RELAYS:**

Front adjustable, sealed type, with dust-tight enclosures, removable covers, test terminal blocks and plugs for testing relay without removal from case. Removal from casing is to automatically short-circuit respective current transformer secondary windings.

* + 1. **INSTRUMENTS:**

Are to be housed in enamelled metal cases for switchboard flush installation, with scales and markings protected and sealed. Indicating meters are to be minimum 76 mm square. Accuracy is to be within 2% unless otherwise specified. Voltmeters and ammeters are to be moving iron type for D.C. measurements.

* + 1. **CURRENT TRANSFORMERS:**

Class 2 for measuring and protection.

* + 1. **VOLTAGE TRANSFORMERS:**

Single phase, dry type, 0.5 accuracy class.

* + 1. **kWH-METER :**

3-element type for unbalanced 3-phase, 4-wire loads, fitted with 6-digit cyclometer.

* + 1. **FUEL STORAGE AND TRANSFER**

1. Provide day storage tanks (10 hour capacity at full load) of the totally enclosed type with bolted and gasketted lid all manufactured from highest quality mild carbon steel and provided with all necessary

Supporting steelwork:The complete unit shall be rust proofed and painted with an approved oil resistant paint.

1. The Contractor shall arrange and construct all facilities, test and operate it to supply the D-Genset with fuel from the bulk tank of Diesel fuel inside the Tank Farm Facility Area with all needed work and equipments.
2. The daily Fuel tank shall be provided with the following level switches.

1. Extra high level switch to indicate an alarm condition in the event of the fuel transfer pump failing to stop.

2. High level switch to stop the fuel transfer pump.

3. Low level switch to start the fuel transfer pump.

4. Extra low level switch to indicate an alarm condition in the event of the fuel transfer pump failing to start.

1. The Daily Fuel tank shall be provided with a transfer pump set comprising two pumps (one run and one standby), with duty select, switch, and automatic changeover and pumps controlled by level switches mentioned above.
2. All starters, controls, etc., shall be located in the generator control panel and shall be so arranged that supply for the pumps can be taken from the generator control panel busbars when the generator is running and from the normal supply at all other times. The system shall be designed to ensure that it cannot be supplied from the two sources at any time and to automatically switch over to the generator supply in the event of failure of the main supply.
3. Provide for the supply and installation of a semi rotary hand operated fuel transfer pump.
4. Provide for a direct reading oil contents gauge on the tank.
5. Pipework between the main storage tank, day storage tank, fuel transfer pumps and the engine shall be provided by the generator supplier.
   * 1. **FUEL LINES:**

Heavy gauge, black seamless steel, to ISO/R65 or equal, treated internally with corrosion resistant paint and with joints sealed with PTEE tape. Plumber's twine or gasket sealing compound are not to be used.

Fuel feed line to daytank is to have bypass with stop-cock. Size of fuel return line from daytank to main fuel tank is to be to manufacturer's recommendations.

Filling line of main fuel tank is to be at least as fuel-line-size & external diameter, entering tank at opposite end to drain plug. Main tank fill and sounding line connections are to have hinged, lockable caps with female threaded bottom inlets.

* + 1. **EXPANSION JOINTS :**

Stainless steel, packless bellows type, suitable for working pressure and temperature of service, of same size as pipe on which installed, with screwed ends for pipe sizes not exceeding 50 mm and flanged ends for sizes over 50 mm.

* + 1. **VALVES GENERALLY :**

125 psi steam working pressure rating and 200 psi cold water non-shock pressure rating and type that can be repacked under pressure.

* + 1. **PIPE HANGERS AND SUPPORTS :**

Galvanised steel.

* 1. **MISCELLANEOUS REQUIREMENTS**
     1. **LIFTING EQUIPMENT**

1. Works To be Included

The Works to be included in this section shall comprise the design, manufacture, works witness testing, delivery, storage, installation, site testing commissioning and maintenance of brand new (not more than 2 years before Tender’s year) complete electrically operated traveling bridge crane.

1. Location of Works

The electrically operated traveling bridge crane shall be installed in the Diesel – Generator powerhouse.

1. Detailed Description of Lifting Equipment

The Contractor shall include for the delivery and complete erection of the lifting equipment, as required by the Engineer. The Contractor shall provide all necessary tackles for the erection and testing of the lifting equipment.

The lifting capacity of the equipment shall be as mentioned in BOQ and / or in Drawings.

Ball or roller bearings shall be employed on all motions, and the load hook shall revolve on a ball swivel. All gears shall be machine cut and runway wheels for the bridge crane shall be machined and be of the double flanged type.

A load chain collection box shall be incorporated on all bridge cranes and pulley block units.

A reliable braking and locking arrangement shall be incorporated.

1. Detailed Description of Bridge Crane

The Contractor shall provide a traveling bridge crane complete with tracks, track support beams and all accessories including slings for installation on the support columns in the Genset room.

The bridge tracks and track support beams shall be provided, jointed and fixed to the concrete support columns. The Contractor for jointing sections of runway beams shall supply fishplates; the number of joints shall be kept to a minimum. The joints shall be so executed that the carriage rides smoothly over the joints. Suitable designed end stops or limit switches shall be provided to stop the carriage (On both sides) from touching the walls and limit switches for the hook (on up and down stopping).

The crane shall comprise of end carriages and bridge unit as separate units bolted together on site during erection.

The crane shall be of the single or double girder motorized traveling type and have a geared motorized traveling trolley. The traveling trolley shall run on bridge rails which shall be securely fixed to the bridge girders. All wheel treads and flanges shall be machined to correct profile to suit the runway.

All drive motors of the electrically operated bridge crane shall be squirrel cage totally enclosed induction Type fan cooled, 2 speeds, 1500 rpm max, IP 54 AC 400V. 3 phase / 230V. single phase, 50Hz mains.

Longitudinal and cross traverse motions shall be provided on the crane and shall be such that the operation is speedy without impairing safety in working. They shall be operated by means of hand-held control pendant which shall extend to within 600mm of the operating floor. The hook and load chain shall be such that the hook will reach to the lowest floor or duct level.

The load steel-rope shall be capable of reaching the ground level with also limit switches on both directions for this motion.

The crane shall bear a permanent inscription readily legible from floor level stating the safe working load expressed in kilograms.

The whole crane (trolley, bridge, beams, and electricals … etc) shall be of the same supplier (manufacturer) and have one general serial number in addition to each equipment serial numbers (for motors, gears … etc).

The crane must include an electrical control box installed on trolley. Power feeding may be of forced brush and insulated copper bus or the zig-zag flexible cable type suspended near along the bridge and the side beam.

The crane must have a control box including mainly the main CB of the crane in exposed metallic box near the door or as approved.

The crane shall have 3 motions (6 directions) each have its own motor/s, (each direction shall be 2 speeds. All motions and crane on-off buttons shall be controlled by and in the pendant control device. The pendant control shall be held by another steel rope to prevent loading of the pendant cable.

The Contractor shall supply all accessories and ancillary equipments and devices to make the unit works in perfect running conditions. He shall also submit a complete original set of technical catalogues for the proposed type including all electro mechanical components, Drawings and complete numbered parts lists detailed in exploded views in Drawings. and in lists in English or Arabic only with the address of the manufactures.

A 3rd party certificate shall be supplied with the submitted type (After approved by the Engineer and the Employer on the crane and the 3rd party). The manufacturer of the whole crane must be of not less than 10 years of certified experience in this field, and of minimum 5 years of applying these types in Jordan with nominating 5 separate sites using these cranes as hole (not as individual parts of crane) with their general serial Nos. that are fixed on them.

The Contractor shall equip the over head crane with all electrical panels, motors, cables, wires, control boxes, feeding cables, steel ropes, channels, rails, beams, end stoppers, limit switches, … etc. needed to complete the job.

1. Name Plates

Each unit (The whole crane, motors, gears, trolley … etc) shall has a name plate including the following or part of them according to the M/C type (electrical, Mechanical … etc):

The Manufacturer, Type, Serial No. Weight, Year, Vge, Hz, speeds, Amps, Insulation Class, Ip Degree, Lifting Weight, Brake Type … etc.

1. Runway Beams

All runway beams shall be designed to BS. 2853 and fabricated in accordance with BS.449 or approved (By the Engineer) if by other standards. In rating the beam size, it should be assumed that the beam will be supported as shown on the Drawings and shall comply with the design of the building structure.

The contractor shall also comply and install end stops on all runway beams.

1. Painting

All mechanical parts (beams, hooks, trolleys … etc) shall be yellow color painted. All electrical parts (boards… etc) shall be gray or bluish color painted. All paints shall be applied at the Factory; it shall be of the best type and application. After completion of erection and also after testing, touch paint shall apply if necessary up to Engineer decision and approval.

1. Test

All lifting equipment parts shall be submitted and approved by the Engineer before ordering. The lifting equipment shall be tested at the supplier’s works (by submitting a certificate) and at Site following completion of installation by exact loading as designed and specified.

The Contractor shall be responsible for the provision at site of all necessary test weights.

The Safe Working Load shall be clearly marked in large print on the units in Arabic and English after final painting of the installation has been completed and stencils should be supplied with each unit for the site painting.

* 1. **POWER AND CONTROL EQUIPMENT :**

To comply with the specification.

* 1. **EARTHING EQUIPMENT :**

To comply with Section 16450 of the Specification.

* 1. **MAIN FAILURE AUTOMATIC TRANSFER SWITCH (ATS) :**

Floor mounted, galvanised sheet steel cubicle of equal construction to control cubicle, comprising two main contactors and two main air circuit breakers and controls necessary for automatic transfer of power supply from normal source to stand-by source, voltage sensing control relay and time delay relays to signal generator start and stop, auxiliary switches and indicating lights etc. as necessary for the required operation of the system.

* + 1. **OPERATION :**

When voltage and/or frequency of any phase drops below an adjustable setting (60% - 90%) of normal supply, for an adjustable period of 1 - 300 seconds, power failure relay is to actuate engine starting control, whilst normal mains contractor is to open. After an adjustable period of 0 -10 seconds from sensing stabilised rated voltage and frequency of generator at the ATS, the emergency contactors is to close. Upon restoration of normal mains supply to above 95% of rated voltage and/or frequency, for and adjustable present period of 2 - 60 minutes, emergency contactors is to open and normal mains contactors is to close.

* + 1. **MECHANICAL AND ELECTRICAL INTERLOCKS :**

Are to prevent contactors/circuit breakers from being closed simultaneously at any time. Transfer mechanism is to be powered from the source to which the load is being transferred.

* + 1. **SELECTOR SWITCH :**

Is to have the following positions :

off : both contactors open and remain open.

normal : contactors for normal power source closes and remain closed.

emergency : contactors for stand-by power source closes and remains closed.

auto : automatic transfer as described above.

* + 1. **PILOT LIGHTS :**

Are to indicate which contactors is on.

* + 1. **INSTRUMENTS :**

Are to include voltmeter and amperemeter with selector switches.

* + 1. **CONTACTORS :**

Are to be to IEC 158-1, 3-phase, 4-pole, magnetic type, 600 V rating A C3, coordination type 2, capable of interrupting at least ten times rated current inductive or non-inductive loads under normal service conditions and are to have re-placeable main arcing contacts and arc quenching devices. Contactors are to withstand, without welding or burning of contacts, an inrush current of 20 times normal rating upon closing and the heaviest short-circuit of the system for period required by upstream protective switchgear to operate or a minimum of 3 seconds, whichever is greater. Three N.O. and three N.C. spare contacts are to be provided on each contactors.

* + 1. **CIRCUIT BREAKERS:**

Two Air Circuit Breakers to be provided.

* + 1. **WIRING:**

Moisture and heat resistant, silicon rubber insulated, stranded copper conductors, modularly and neatly arranged on master terminal blocks, with suitable numbering strips and appropriate cartridge types fuses where required. Flexible wiring is to be used on all hinged/draw-out components.

* + 1. **CONNECTIONS :**

Are to be made at a front terminal block with no live metal exposed. Power cables are to terminate on fixed insulated copper connectors suitably sized to receive specified cables. Cable glands and gland plates are to be provided.

* + 1. **METAL CASES :**

Of instruments, control switches, relays etc. are to be connected by flexible protective conductors, of not less than 2.5 mm2 section, to nearest earthing bar or terminal.

* + 1. **EARTHING :**

Earthing bar is to be provided for connection of protective earthing conductors, using set-screw or bolted anti-turn pressure terminations.

* + 1. **FERRULES :**

Wire ends are to be fitted with numbered ferrules of approved type at each termination.

**PART 3: EXECUTION**

* 1. **FIELD AND INSTALLATION WORK :**
     1. **EQUIPMENT BASES :**

Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawing sand equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.

* + 1. **BUILT-IN ITEMS :**

Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases or building structure are provided as and when required and that they are properly installed.

* + 1. **TOOLS :**

Use only tools recommended by equipment manufacturers for installations, particularly in making connections and adjustments.

* + 1. **SUPERVISION :**

Carry out equipment installation under the direct supervision of a qualified technician, licensed by and trained at the factory. Final adjustments and putting into satisfactory operation are to be made by a specialist delegated by the factory.

* + 1. **GENERATING SET :**

Install to maintain alignment and minimise engine and generator stresses. Protect instrumentation and control equipment including engine-mounted instruments from machine vibration. Mountings and method of mounting are to be as recommended by the manufacturer and approved by the Engineer.

* + 1. **ENGINE EXHAUST PIPING**

Is to be slightly sloped away from engine to avoid condensation returning to engine and is to have drain plugs or clean-out at lower end as required.

* + 1. **ENGINE HOT-AIR EXHAUST DUCT:**

Install approved canvas duct with metal frames between radiator and louvered opening in wall for radiator exhaust air.

* + 1. **PIPE HANGERS AND SUPPORTS:**

Fasten securely to building structure with approved masonry expansion bolts, minimum 20 mm diameter and install in accordance with manufacturer's instructions.

* + 1. **EARTHING:**

Install earthing system (special for the genset) in accordance with Section 16450 of the specification. The earthing resistance shall not be more than 2 OHM.

* 1. **INSPECTION AND TESTS ON SITE**
     1. **EQUIPMENT:**

Inspect equipment upon delivery to site and report specified any loss or damage to the Engineer.

* + 1. **EARTHING RESISTANCE TESTS:**

Are to be carried out to verify specified requirements.

* + 1. **LOAD TEST:**

Are to be carried out at low loads to over load conditions, at various power factors. Measurements are to include voltage and frequency deviations and regulating time under various step-loading conditions, temperature measurements and pressure measurements at various locations, and in accordance with an approved plan under conditions equal to worst site ambient conditions.

* + 1. **TESTS:**

Are to include:

- Full load test for 8 hours continuous, immediately followed by 10% overload test, without interruption.

- Insulation measurement.

- Functional tests for voltage sensing, automatic start and synchronisation, transfer of load and load sharing as applicable.

- Operation of engine shutdown and alarm signalling and indication, under simulated fault conditions.

- Measurement of vibration transmission to building structure.

* + 1. **LOAD BANKS:**

If actual loads are not made available at time of acceptance testing, provide load banks to carry out complete test cycle of the system under loading and switching conditions necessary to prove compliance with the Specification.

* + 1. **PIPING SYSTEM:**

Using carbon dioxide or nitrogen from pressurised cylinder, test each system to 1.5 times normal operating pressure. Do not subject equipment, apparatus or devices to pressure exceeding prescribed test pressure obtained from nameplate data or from manufacturers' published data. Apply tests before connecting piping to equipment. Remove or disconnect and blank off relief valves, instruments and devices that might be damaged by test pressure. Maintain test pressure on system for 24 hours during which time there is to be no noticeable drop in pressure. Check for leaks using soap solution. Isolate source of pressure during testing.

**END OF SECTION**

# SECTION 16902

# ELECTRIC CONTROLS AND RELAYS

**PART 1 GENERAL**

* 1. **THE REQUIREMENT**

A. The Contractor shall furnish, install, test, and place in satisfactory operation all electric controls and relays as specified herein and indicated on the Drawings.

B. Electrical control and relay systems shall be assembled using NEMA rated components.

C. Motor control circuits shall be wired in accordance with the requirements specified herein or indicated on the Drawings.

1. Reference Section 16050, Basic Electrical Requirements and Section 16075, Electrical Identification.
2. Reference codes and standards as referred to in Section 16050.
3. The Contractor shall furnish and install, as specified herein and indicated on the Drawings, all motor control components and wiring for all motor‑operated equipment furnished under this Section and all other Sections as indicated. The Contractor shall review the entire Contract Drawings to be totally familiar with his responsibilities.
4. The Contractor shall furnish and install all external power and control wiring to control panels of prewired packaged equipment, unless indicated otherwise.
5. Control wiring requirements are indicated in electrical schematics and descriptions on the Drawings, and in equipment manufacturer's equipment data. The Contractor shall furnish and install all control wiring in accordance with these Contract Documents. The Contractor shall provide all control circuits and wiring for a particular item of equipment in accordance with requirements as set forth by the manufacturer of the particular item of equipment.
6. As specified herein and indicated on the Drawings, furnish and install instrumentation wiring and connections to instrumentation equipment furnished under all Contracts of this Specification. Unless indicated otherwise, motor control switches, pilot lights, relays, and other control equipment for mounting in instrumentation panels shall be furnished, installed, and wired by the Contractor.
7. Where annunciators or other types of alarm systems are indicated as being furnished by others, the Contractor shall furnish and install the wiring and make connections to the alarm initiating device or contacts and to the annunciator. Where annunciators or alarm systems are indicated or specified in the Contract, the Contractor shall furnish and install the equipment and the complete wiring.
8. Where pumps provided by others are furnished with solenoid valves or other devices for control, the Contractor shall wire these valves or devices.
9. Unless otherwise specified herein or indicated on the Drawings, motor controllers shall be wired to drop out and remain dropped out on loss of power to the line side of the controller. Operator action shall be required to restart the motor unless the motor is intended to automatically restart.
10. Motor control components and control wiring shall conform to NEMA Specifications ISC-1970 (Revised, 1975), Industrial Controls and Systems.
11. Where devices are installed on the doors of NEMA 4, 4X, or 3R enclosures, devices shall be selected and installed to maintain the NEMA rating of the enclosure.
12. Wiring in all starters, panels, junction boxes, and similar equipment shall be brought out to numbered terminal strips for interconnection. The Contractor shall be responsible for documenting terminal numbers for all starters, controls, panels, and similar equipment provided under the Contrract. At the completion of the project, the Contractor shall submit a complete set of record drawings showing and/or listing all terminals in boxes, panels, starters, and similar equipment in a single, complete bound package for the equipment and control supplied under the Contract. Reference the General Conditions, Section 01300 - Submittals and Section 01710 - Project Closeout.
13. The Contractor is responsible for coordinating the electrical work under the Contract with all equipment starters, controls, and instruments provided under the Contract. The Contractor shall verify and coordinate with the Contract process equipment power supply and voltage, process equipment control power supply and voltage, and details of installation and interconnection.
14. Electrical control schematic diagrams drawn using a ladder-type format in accordance with JIC standards shall be submitted for all electrical equipment which is being provided under the Contract.
15. Record drawings shall be provided in accordance with requirements in the General Conditions, Section 01300 - Submittals, and Section 01710 - Project Closeout. One complete set of record wiring diagrams encased in plastic or plexiglass envelopes shall be provided for each starter, panel, and similar equipment. The diagrams shall include wire color codes showing connections from numbered terminal blocks to external equipment.
16. Where space or strip heaters are provided within the enclosures for electrical equipment, the Contractor shall make connections to these heaters from an appropriate power source and operate the heaters with temperature control as necessary until the equipment is installed and operated according to its intended use.
17. Control stations shall be furnished and installed at each motor and at all other controlled devices (e.g. solenoid valves) as specified herein and indicated on the Drawings.
    1. **TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

Not required.

2. Field Tests

Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division I, and Section 16050, Basic Electrical Requirements.

* 1. **SUBMITTALS**

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Spare Parts List.

3. Operation and Maintenance Manuals.

1. Each submittal shall be identified by the applicable specification section.
2. Submit materials compliance sheets with the specifications
   1. **SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

* 1. **OPERATION AND MAINTENANCE MANUALS**

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

* 1. **TOOLS, SUPPLIES AND SPARE PARTS**

A. The electrical control and relay systems and accessories shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Employer by the Contractor.

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Employer.

D. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Term such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

**PART 2 PRODUCTS**

* 1. **CONTROL COMPONENTS**

A. Pushbuttons (PB) and selector switches (SS) shall be Type E34 as manufactured by Cutler-Hammer/Westinghouse Electric Corporation, Type SK as manufactured by Square D Company, General Electric Company or equal. Pushbuttons and selector switches shall be 30.5 mm, heavy‑duty, oil tight NEMA 4X corrosion resistant with legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Pushbuttons and selector switches shall be non‑illuminated. Pushbuttons shall include a full guard. Panic stop/alarm pushbuttons shall be red mushroom type with manual-pull release.

B. Pushbuttons and selector switches for all electrical equipment shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

C. Pushbuttons, selector switches, and other pilot devices for pump control panels shall be as specified herein.

D. Engraved nameplates shall be securely fastened to the front of each pushbutton station, disconnect switch, and motor starter remotely located from the motor control center. If adequate space is not available, the nameplate shall be mounted below the push button station. Nameplates shall be as specified in Section 16075, Electrical Identification. Identify all switches, control stations, and motor controllers as to their respective equipment.

E. Pilot lights shall be Cutler Hammer/Westinghouse Electric Corporation, Type E34, Square D Company Type SK, General Electric Company equivalent, or equal. Pilot lights shall be of the proper control voltage, LED type, heavy‑duty, corrosion‑resistant NEMA 4X with legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Pilot light lens colors shall be as follows:

Red - "Run", "On", “Open”

Green - "Off", “Closed”

Amber - "Alarm", "Fail"

F. Pilot lights for all electrical panels shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

G. Pilot lights for pump control panels shall be round with custom engraved legend plates for each pilot light.

H. Control Relays (CR) shall be Type KU as manufactured by Square D Company, Potter‑Brumfield equivalent, Allen-Bradley equivalent, or equal. Relays shall be general purpose plug-in type with coil voltage as shown on the Drawings and sealed 10 ampere contacts. All relays shall have three SPDT contacts rated 230 VAC and 28 VDC minimum. Machine tool relays shall be provided when the contact burden exceeds 10 amperes. Miniature type or "ice cube" relays are not acceptable.

I. Timing Relays (TR) shall be the general purpose plug-in type, Type JCK as manufactured by Square D Company, Cutler-Hammer/Westinghouse Electric Corporation equivalent, Allen-Bradley equivalent, or equal. Timing relays shall be electronic type with 230 VAC coils unless otherwise specified or indicated on the Drawings. Timers shall be provided with two SPDT timed output contacts. Contact ratings shall be the same as for control relays as specified above.

J. Control Stations (CS) shall be as manufactured by Cutler-Hammer/Westinghouse Electric Corporation, Square D Company, General Electric Company equivalent, or equal. Control stations shall be furnished and installed complete with pushbuttons, selector switches, and other pilot devices as specified herein or indicated on the Drawings. Stop pushbuttons shall be furnished with a lock-out device as specified herein and indicated on the Drawings.

Control station enclosures shall be cast aluminum with gasketed cover for all indoor dry areas. Control station enclosures shall be NEMA 4X stainless steel or non-metallic with gasketed cover for all indoor damp/wet process areas. Control station enclosures shall be NEMA 4X stainless steel with gasketed cover for all outdoor applications.

Control stations located in hazardous locations shall be suitable for the Class, Division, and Group to suit the application. The pilot devices shall be the factory sealed type mounted in enclosures as specified above.

K. Selected motors are indicted as requiring elapsed time indicators. Provide Eagle Signal Type HK210A6, General Time Catalog #ED27NR, Allen-Bradley equivalent, or equal, elapsed time indicators for 230 VAC volt operation mounted flush in the respective motor starter compartment door. Where clearance is not obtainable for compartment door closing, mount timers in a separately mounted enclosure, with each timer nameplated. Wire elapsed time indicator to operate when the respective motor operates.

L. Terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the enclosure or cabinet subpanel. Terminals shall be tubular screw type with pressure plate for wire size #22 - #8 AWG (0.5mm2 – 10mm2).

Power terminal blocks shall be single tier with a minimum rating of 600 volts, 30A. Signal terminal blocks shall be single tier with a minimum rating of 600 volts, 20A. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. There shall be a sufficient quantity of terminals for the termination of all spare field conductors.

Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for incoming field conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's pre-engineered and prefabricated wiring termination system may be acceptable.

The terminal blocks shall be as manufactured by Phoenix Contact, Inc., Wieland, Inc., Square D Company, or equal.

M. Alarm horns shall be as manufactured by Federal Signal Corporation, Edwards Signaling Company, EST (Edwards Systems Tech) or equal. Alarm horns shall be made for surface, flush, or semi-flush mounting on walls, panels, enclosures, or on square outlet boxes. Alarm horn sound output level shall be of 100 dB (nominal) at 10 feet.

**PART 3 EXECUTION**

* 1. **CONFIGURATION OF CONTROLS AND EQUIPMENT**

A. All controls including wiring, control switches, pushbuttons, indicating lights, control interlocks and similar devices, shall be provided at the control voltages specified herein or indicated on the Drawings. Each motor starter shall be provided with a control power transformer mounted in the starter unit. Primary wiring to the control power transformer shall be tapped to two (2) poles on the load side of the circuit breaker or fusible switch. Both primary wires shall be fused with 10- ampere, slow-blow fuses. The fuse on the ungrounded secondary side shall be capable of handling 100 percent to 125 percent of the rated control transformer secondary current. Control power transformers shall be provided with volt-ampere (VA) ratings equal to a minimum of 125 percent of the volt-ampere (VA) load connected to the transformer.

B. All equipment, cabinets, and devices furnished under the Contract shall be heavy‑duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models which are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.

C. All equipment shall be designed to operate on a 50 Hz alternating current power source at a nominal 230 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided.

D. All switches shall have double‑pole, double‑throw, contacts rated at a minimum of 600 VA, unless specifically noted otherwise.

E. Materials and equipment used shall bear a U.L. label wherever such labeling of equipment and materials are available.

F. Unless otherwise specified or indicated on the Drawings, all equipment shall be designed, furnished, and installed so that in the event of a power interruption, the equipment must be restarted manually after a power failure.

G. All power terminals shall be insulated and identified.

H. All instruments shall operate at 10 to 125 degrees F (-13 to 50°C) unless otherwise specified.

I. Internal wiring within all starters, panels, instruments, junction boxes and similar equipment, shall be brought out to numbered terminal strips for interconnection and field wiring.

J. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries' standard practices. All internal components shall be identified with suitable plastic or metal engraved tags attached with drive pins adjacent to (not on) each component identifying the component in accordance with the Drawings, Specifications, and supplier's data.

K. Unless otherwise noted, the Contractor shall provide all interconnecting wiring and conduit for complete control systems. The Contractor shall make all connections to equipment devices, instruments, and all components.

L. The shield on each instrumentation cable shall be continuous from source to destination and shall be grounded as directed by the manufacturer of the instrumentation equipment. In no case shall more than one ground point be employed for each shield. The ground point shall be as specified in Section 16920. All analog control functions shall utilize 4‑20 mADC control signals, unless otherwise specified. All analog transmission shall take place within shielded twisted cables which are not susceptible to interference or noise.

M. Lightning/surge protection shall be provided to protect the instrumentation and control system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and shall be maintenance free and self‑restoring. Equipment shall be housed in a suitable metallic case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and, where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the enclosure or in a separate NEMA 4 junction box coupled to the enclosure.

N. Reference Section 16920 Equipment control and Instrumentations.

* 1. **FIELD TESTS**

A. The Contractor shall conduct field tests prior to operation of the equipment. The Engineer shall witness all field testing. Field testing shall be conducted at a time approved by the Engineer. Field tests shall be conducted for all hardware components and shall include a functional check of all items. Field tests shall include a functional check of all instruments and control equipment. All equipment shall be connected and fully operational for field testing. Field tests shall demonstrate that the controls perform according to the Contract requirements and that all equipment, valves, switches, controls, alarms, interlocks, indicating lights, and similar equipment function properly. Based on the results of field tests, the Contractor shall make any required corrections to equipment and controls and shall make any adjustments required to the control logic and control settings to achieve the specified operation or operation otherwise directed by the Engineer. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. The Contractor shall make modifications and adjustments to the controls as directed by the Engineer for optimizing operation of the overall system. All costs in connection with field tests of equipment provided under the Contract shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of all motor starters and controls during the tests.

**END OF SECTION**

# SECTION 16920

# EQUIPMENT CONTROL AND INSTRUMENTATION

**PART 1 - GENERAL**

**1.01 DESCRIPTION**

This section covers furnishing and installing the plant flow metering and recording equipment, the unit for transmitting the flow signal intelligence and associated appurtenances, any electrical metering, lighting and signing required for the control panels, the level control (float) switches required to control the operation of the water pumps.

Supplementing this section, the Drawings indicate locations and arrangement of instruments and controls and provide functional diagrams and schematics regarding connection and interaction with other equipment. This section also covers the services of technical representatives of the instrumentation and control equipment supplier in Section 01600 GENERAL EQUIPMENT AND MATERIAL STIPULATIONS.

**A. Related Work**

**1.** Section 01600 General Equipment and Material Stipulations:

The general equipment and material stipulations shall apply to all equipment and material furnished under this section.

**2.** Work Specified Else where:

Other items of work that relate to and are referenced in this section include, but are not limited to, the following sections:-

Submittals

Electrical Sections

**1.02 QUALITY ASSURANCE**

1. **Applicable Codes and Standards**

All works shall be performed and all material and equipment shall be in accordance with standards and codes referred to in Section 16050.

1. **Supplier's Qualifications.**

The system shall be designed, coordinated and supplied by a major instrumentation manufacturer or his recognized and authorized agent who is regularly engaged in the business of designing and building instrument and control systems. An authorized agent will be required to prove his qualifications by submitting the following:

1. Authorization of agency from the major instrument manufacturer.

2. That he has the required financial capability.

3. The names of manufacturers whose products are normally supplied and the type of business relationship with each.

4. That he maintains a qualified technical staff and design office.

5. That he has the physical plant and fabricating personnel to complete the work specified.

6. That he has and will maintain competent service personnel to service the equipment furnished.

7. That he has successfully provided similar work for at least 5 years.

8. The names of at least three references who are users of similar equipment designed, fabricated, and furnished by the agent.

**1.03 SUBMITTALS**

**A. Drawings, Data and Manuals**

Complete assembly and installation drawings, together with detailed specifications and data covering materials used, parts, devices and other accessories forming a part of the equipment furnished shall be submitted in accordance with the Engineering Information and Requirements Sections.

The coordinating supplier shall prepare systems and installation drawings for all interconnecting wiring and piping between components of the systems furnished and for all interconnecting wiring and piping between the related equipment and the equipment furnished under this section. All interconnecting piping and wiring shall be appropriate for the service and shall result in a properly functioning metering of control system.

The drawings shall indicate the mounting elevations for all process connected instruments; the direction of piping, upward or downward; the amount of slope toward the instrument; and the provisions for shutoff, bypass, vent, or drain as recommended by the manufacturer for proper operation and maintenance.

Panel and sub-panel drawings shall include overall dimensions, metal thickness, door swing, mounting details, and front of panel arrangement to show general appearance with spacing and mounting height of instruments and control devices.

System drawings shall be cross-referenced with detailed drawings and engineering data. For example, a flow metering system shall show each component and its related equipment marked with a suitable identification number or letter for cross-reference to any additional drawings or engineering data submitted for those components.

**PART 2 - PRODUCTS**

**2.01 GENERAL REQUIREMENTS**

All equipment furnished under this section shall be expressly selected by the equipment suppliers for its superior quality for its intended performance and shall be installed in accordance with the manufacturer's instructions. Equipment and materials used shall be subject to review and shall comply with the following requirements:

**A.** **Power and Instrument Signals**

Unless noted otherwise, electrical power supply to the instrumentation equipment will be 230 volts, 50 Hz, single phase, at the locations noted on the one-line and functional diagrams. The transmitted electronic analog instrument signals shall be 4-20 mA dc, unless noted otherwise, and shall be linear with the measured water flow rates.

**B. Operating Environment**

All instrumentation devices, panels, etc.., shall be suitable for operation over an ambient temperature range of 0oC to + 50oC and a relative humidity of 10 to 100 percent. Sunshields shall be provided where required to protect outdoor mounted instrumentation.

**2.02 PANEL FABRICATION**

The following paragraphs describe general fabrication requirements for the electrical panels:

**A. Wiring**

All internal instrument and component device wiring shall be as normally furnished by the manufacturer. Except for electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be not less than 600 Volts, with a moisture and heat resistant material and flame-retardant nonmetallic covering.

Terminal blocks for external connections shall be fabricated complete with marking strip, covers, and pressure connectors. A terminal shall be provided for each conductor of external circuits plus one ground for each shielded cable. All wiring shall be grouped or cabled and firmly supported to the panel. Not less than 100 mm of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. All electronic circuits shall be shielded. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be located for easy maintenance.

**B. Device Identification**

All devices mounted on or within the panel shall be permanently identified. The device and terminal identifications shall agree with those shown on the Drawings.

Nameplates shall be provided on the face of the panel on the individual device as required. Panel Nameplates shall have approximate dimensions and legends as indicated on the Drawings and shall be made of laminated phenol material having engraved letters approximately 5 mm high extending through the white face into the black layer. Nameplates for field mounted equipment shall be provided with engraving similar to their related panel mounted controls. Nameplates shall be secured firmly to the panel.

Nameplates engravings shall be as indicated on the drawings in English.

**C. Painting**

The panel shall be thoroughly cleaned, sanded, and given not less than one coat of rust inhibitive both inside and out. The panel interior shall be given not less than one coat of white enamel or lacquer. All pits and blemishes in the exterior surface shall be filled. Exterior surfaces shall be smoothed and given not less than two coats of enamel or lacquer of manufacturer's standard finish color. Two liters of finish color paint shall be furnished with the panels to cover future scratches.

**D. Factory Test**

The panel shall be factory tested electrically and pneumatically by the panel fabricator before shipment.

**E. Construction**

Panel construction shall be an indoor, dust-tight, completely enclosed cubicle formed from steel structural members and steel plates. Base shall be formed of heavy channel iron, with flanges up, and with 10 mm holes drilled at 200 mm spacing so that it may be bolted to the floor or welded to embed floor channels. Welds, seams, and edges on all exposed surfaces shall be ground smooth. Suitable lifting facilities shall be provided for handling and shipment.

Panel structure shall be suitably braced and of sufficient strength to support all equipment mounted on or within, to withstand handling and shipment, to maintain alignment, and to be rigid and freestanding. Top, sides, and rear shall be fabricated from steel plates not less than 3 mm thick designed for rear access hinged rear door.

The front shall be stationary, with mounted instruments and control devices, fabricated from 5mm steel plate. The panel front shall be suitably reinforced between mounting cutouts and drilling to support instruments and devices without deformation and shall be free from waves and other imperfections. The panel front shall not be recessed at the base.

Doors shall be essentially full height, having turned-back edges and additional bracing to assure rigidity and prevent sagging, and shall be mounted with strong continuous piano type hinges. Positive latches, acting from a common door handle, shall hold doors securely compressed at top, side, and bottom against rubber gaskets.

The bottom shall be open, and components shall be arranged for external wiring conduit and piping to enter from below.

**F. Size and Arrangement**

Panel dimensions and general instrument arrangement shall be as shown on manufacturer's shop drawings, approved by the Engineer.

**G. Interior Lighting**

A ceiling-mounted lamp fixture shall be provided inside of each panel. The fixture shall be 2 x 20 Watts fluorescent lamps with an ON-OFF switch near the door. A receptacle shall be provided inside the panel for maintenance. The lighting and receptacle circuit shall be fused separately from the instrumentation equipment. The receptacle shall be 230 Volt, three pin type BS 1363.

**H. Indicating Lights**

Indicating lights shall be heavy-duty, 18mm, oil tight type, which utilizes a low voltage LED lamp and a built in transformer. Legends shall be engraved on the lens or on a legend faceplate. Lamps shall be easily replaceable from the front of the indicating light. Indicating lights shall be the Push-to-Test type.

**2.03 INDIVIDUAL DEVICE SPECIFICATIONS**

The following specifications shall apply to the equipment items in the instrumentation system: -

All instrumentation has to be solidly installed with and to corrosion free fittings. It must be mounted in an appropriate way using a mounting structure made of high-grade steel (material 1.4541/V2A), so that the devices can easily be removed for maintenance or repair. In areas affected by corrosion instead of the said steel other materials that are long lasting and corrosion free have to be used.

All measuring transmitters and signal processors must be equipped with over voltage protection for all power and signaling lines, cable inlets have to be water tight and must fit to the cable size.

All measuring transmitters shall be installed together with the over voltage protection to a mounting including cable duct with protective roof and housing to protect the device against Sunlight and weather (material1.4541/V2A).

The life span and reading of displays must not be disturbed by Sunlight.

The distance between the measuring sensor and the measuring transmitter responsible signal processor has to be as short as possible but with enough cable length for easy maintenance of the sensor. Extra lengths of cables have to be orderly arranged on cable holders next to the measuring transmitters.

The service includes all accessories and materials that are necessary for the correct operation of the measurements, as well as adjustments and on site calibration, by a representative of the original manufacturer.

The overall accuracy of each instrument has to be 0.5% of the measuring range.

Each measured value has to be indicated at the relevant LV Control-Room by an instrument in order to allow the personnel to run the system in manual mode. The indicating instrument including calibration, over voltage protection, isolating amplifier for the connections of the recording equipment and complete installation have to be included within the price of each measuring instrument.

For automatic control and monitoring the system, all the following instruments must be completely supplied, installed, calibrated, tested, commissioned and documented.

**2.3.1 Indicator for voltage**

Front dimensions: 96 mm x 96 mm, range 0 to 500v. The Voltmeter-meter shall be connected to a selector switch has positions: “L1L2, L1L3, L2L3, off”.

**2.3.2 Indicator for current:**

Front dimension 96 mm x 96 mm. Scale with 100% over current range. The transformers are to be included, if they are necessary.

**2.3.3 Indicators for flow rate, water level and Pressure:**

Front dimension: 72 mm x 144 mm; as edgewise indication meters, input 4 to 20 mA.

Power supply 24 VDC; Inscription according to the respective function.

**2.3.4 Timer**

Electronic time relays, according to its function with delayed dropout or delayed pull-off contact.

**2.3.5 Limit Signaler**

Input 4 to 20 mA, with one or two independently adjustable floating contacts; power supply 24 V – DC

**2.3.6 Multi-coupler and Load Transducer**

They are to be included if the output of the primary element if the measurement is not sufficient for the connected instrumentation. Input 4 to 20 mA; output electrically insulated 4 to 20 mA not connected to the grounding system; power supply 24 V – DC

**2.3.7 Accessories (Parts and measuring Instruments)**

The Contractor shall supply the following and the price shall be deemed to be included in the price of the contract.

1. Chart pens (and ink if needed) enough for two years.
2. Charts enough for two years.
3. Signal calibrator (with DC mA, V, mV readings)
4. Digital high-grade amp/voltmeter (AVO meter) reads (AC, DC, V, mV, A, mA, Hz, Ohm, transistor test, temperature measurement, audible continuity check). Universal or approved equal.
5. Digital high-grade clamp meter /voltmeter reading up to 1000A, 750V, AC, and 0-500 kilo-Ohm with peak and peak hold push button facility.
6. Digital Migger 500 & 1000 V.

*2.3.7.1 Signal Calibrator Specification*

An instrument calibrator with digital read-out shall be furnished and handed over to the Client at the start of the commissioning to calibrate the electronic instruments and the price shall be deemed to be included in the price of the contract. The calibrator shall be capable of measuring, generating, and simulating milli-amperes, milli-volts and volts. The calibrator shall be completely solid state and shall have a 4 - ½ digit LED display. The calibrator shall operate from rechargeable nickel cadmium batteries and be provided with a charger that operates from 230 Volts AC, 50 Hz.

The calibrator shall have measurement capabilities as follows:

|  |  |  |
| --- | --- | --- |
| Voltages | | |
| Ranges | Accuracy | Input Impedance |
| 0 – 110 mV,  0-11V | 0.12 per cent | 2 mega ohms (minimum) |
| Current | | |
| Ranges | Accuracy | Input Impedance |
| 0 – 22 mA,  0 – 54 mA, | 0.18 per cent | 100 ohms (maximum) |
| The calibrator shall have generating capabilities as follows: | | |
| Voltage and Current | | |
| Ranges | Accuracy | Output Impedance |
| 0 – 110 mV,  0 – 11 v | 0.12 per cent | 25 ohms (maximum) |
| 0 – 222 mA, | 0.18 per cent | 0-500 ohms  (External load) 0 – 54 mA, |

The calibrator shall be capable of simulating a 2 – wire transmitter operating from a supply voltage of 22 to 100 Volts DC.

The calibrator shall be protected on all ranges against misconnection and over voltage. Battery life shall be at least 2 - ½ hours for 50 mA continuous output or 3 - ½ hours for 20 mA continuous output. The calibrator shall be supplied with a set of batteries, carrying case, power cord, instruction manual, and test leads.

**2.3.8 Emergency-Off Switch**

An emergency-off switch will be provided for each

1. Pump motor,
2. Compressor.

An encased switch of protection class IP 55 will be provided with a red push button “off”. Release of the switch must be by key.

This push button is effective generally and independent of other conditions in the system.

The activation of the emergency-off triggers an alarm at the control panel. The voltage of operation is 400 V + 10% AC.

Non-corrodible fixing materials shall be included within the relevant items of the Bills of Quantities.

**2.3.9 Controlling Device with Binary Contact (Digital output)**

*2.3.9.1 General Requirements*

All controlling devices, which are described herein, must be equipped with a binary output as a floating changeover contact for the control voltage 48 V-AC fed by the respective switchgear. The current carrying capacity of the contact must be 1.0 Amp minimum.

Protection class: IP 54 for all electrical parts, which are not encased in switchgear.

The non-corrodible materials for fixing and connecting are to be included with the item of the switch.

*2.3.9.2 Float Switch*

The Contractor shall furnish float switches for control and alarm, which shall be as indicated on the submittal drawings. For the automatic operation of all pumps, float switches of submerged corrosion-resistant and internal mercury-free type shall be suspended in the tank with a stabilizing weight integrated to the suspension cable above the float switch. The contact of the switch changes from open to close if the rising float passes its horizontal line.

The float switch shall operate in a liquid temperature between 0oCand +50oC and shall be of rugged design, completely watertight, covered with solid rubber, flexible vulcanized connection cable (15m with 3 wires), terminal box IP 68 and protecting PVC pipe of heavy gauge to prevent horizontal movement of the float.

The service includes the delivery and complete installation at the correct position of the respective location as shown on the Drawings, including all necessary mounting materials and adjustment. Float switches type FLYGT shall be installed with rating of 5 Amp at 230 Volts AC.

Aluminum channel shall be supplied and fitted to the side or the roof of the reservoir next to the manhole access point, with the float switch cable secured to it to prevent them from becoming tangled. The channel shall be fixed so that it is removable for changing float switches when the reservoir is full.

The switches shall be connected with a cable to the Control System.

*2.3.9.3 Pressure Gauge*

Pressure gauges oil filled diaphragm type with magnetic snap action contacts.

Dial face diameter : 160 mm

Accuracy class : 2.5

Contacts adjustable over the full measurement range;

Connected to the pipe with a three-way cock and screw joints R ½”

All gauges shall be oil filled diaphragm type with magnetic snap action contacts. Orifice shall be used in line of gauge to depress vibrations.

*2.3.9.4 Pressure Switches*

The pressure switches shall be manufactured to IEC Standards. They shall have separately adjustable set points and span and will be equipped with an integral IP65 terminal box with sufficient space for glanding a 1.5 mm2 PVC SWA PVC cable.

*2.3.9.5 Flow Switch or sensor*

The flow sensor installed within the suction pipe shall be connected by a swivel arm to the outer part of the switch. The switch is connected to the pipe by a socket with female thread R1".

It must be suitable and have watertight connections for an internal pressure. Only one flow direction is possible. All parts, which are in contact with the water, must be of non-corrosion material.

*2.3.9.6 Thermometer*

Thermometers are provided to indicate the air temperature of the room. They are to be wall-mounted type, dial face diameter 160 mm, and range 0 to 60°C, with three magnetic snap action contacts separately adjustable over the entire range.

*2.3.9.7 Thermistor Protection Relays*

Thermistor protection relays shall be actioned by the positive temperature coefficient probe with which it is associated. They shall conform to IEC 2929-2 with an insulation rating to IEC 158-1. They shall be provided with auxiliary contacts or relays as required by the control system, which shall be manually reset.

**2.3.10 Controlling Device with Analogue Signal Output**

*2.3.10.1 General Requirements*

All equipment that is described under this chapter must be equipped with an analogue output 4 to 20mA, electrically insulated and not connected to the grounding system.

The admissible load of the output should be adjusted to the instrumentation, which is provided in the loop, but should not be less than 500 ohm.

Protection class: IP 68 for all electrical parts, which are not encased in switchgear.

A four-wire system with power supply 230 V-AC is required.

The cables and cable connections from the control equipment to the switchgear are to be quoted with the items of the controlling devices. The lengths are as shown in the relevant drawings.

The control cables carrying the signal 4 to 20mA shall be installed at a suitable distance to the power cables to prevent an influence by electromagnetic fields. It is not possible, shielded cables are to be provided; the screen is to be connected to the grounding systems.

The non-corrosion material for fixing and connecting as well as the activities for the adjustment and calibration is also to be quoted with the items of the controlling device

*2.3.10.1 Flow Rate Measurement Device*

Electromagnetic flow meters are required. The primary element shall be installed in the pipe, connected with flanges. The transmitter is to be installed at the wall close to the primary element. The cables from the primary element to the transmitter are to be included in the items of the measurement device.

Design features: -

Liner material of the primary element: hard rubber

Electrodes : removable, of stainless steel, 4571

Max. interior pressure : as the pipe line pressure connected to it

Accuracy : 0.5% of the measured value

Low flow-out off : programmable from 0 to 10 % of the measured range.

Scaled pulse output : pulse height 24; load > 15 Ohm

Pulse weighting : 1 pulse per 1 m3

Additional to the analogue output 4 to 20 mA the transmitter has two further outputs:

Scaled pulse output : Pulse height 24 V Load > 150 Ohm

Weighting 1 pulse per 1 m3 for volume counting.

Binary output : reversed flow.

The measurement is designed for one flow direction; if the flow reverses, the above-mentioned signal is to be formed by a floating contact

The digital indictor, chart recorder (folded chart type), non resettable totalizer and the electronic counter shall be in one box and located in the control room in wells or the pump houses as approved by the Engineer.

The transmitter shall be packaged in rugged enclosure, waterproof and weatherproof to IP 68.

*2.3.10.2 Ultrasonic Water Level Meter*

The primary element is required as a continuos ultrasonic water level sensor, complete with controller and transmitter.

The wall-mounted transmitter is to be encased for the protection class IP 68. The cable connection from the primary element to the control panels of Lesotho Sun Reservoir and Treated Water Reservoir (at the inlet of New P.S), are to be provided as a shielded and armored cables to be quoted with the item of the measurement device.

The ultrasonic sensor should provide:

* Integrated temperature sensor for compensation
* Temperature range: -20o - +80o C
* Measuring range: 0 – 10 m
* Degree of Protection: IP68
* Connection to transmitter: via cable

The measuring transmitter should provide

* Digital display for momentary level (m,%) and volume (m3, %)
* Permanent measurement of the water level
* Field mounted housing IP 68
* Outgoing signal, 4 – 20 mA, status contact, potential free
* Power supply, 230 VAC, 50 Hz

The installed meters shall be resistant against gases, humidity, so that the function of the meter should not be affected by these phenomena.

Any fitting inside the tank must not disturb the measuring ultrasonic signal, in order to get reliable results. All fittings must easy to access and remove for maintenance or repair. All mounting material is also included.

Unit shall employ an admittance level measurement technique, using a low power RF signal to measure the level of the water and produce an output signal linearly proportional to the level of the water. The system shall consist of a sensor and mounting-track, ground plate, interconnecting cable and termination box, and transmitter.

Sensor shall be flush mounted in a track on the wall of the tank presenting minimum disturbance to the water level. Sensor shall contain no moving parts and shall be easily removable for maintenance. Sensor and interconnecting cable shall be intrinsically safe in accordance with NFPA 493. Sensor shall be characterized to produce output linear with level of the water and shall have length as required for noted scale range.

Transmitter electronics shall be solid state, mounted in a NEMA 4 enclosure suitable for wall mounting, unless otherwise noted. Transmitter shall be intrinsically safe in accordance with NFPA 493 for Class 1, Groups C and D, Division 2, and Class 2, Groups E, F, and G, Division 2, unless otherwise noted. Provide 0 to 30 seconds of internal signal dampening. The system shall be designed to operate with water conductivity’s below 500 micromhos / cm when noted.

Output signal shall be linearly proportional to the level of the water within plus or minus 2 percent of actual level.

*2.3.10.3 Pressure Gauge*

Pressure gauges oil filled diaphragm type and with function angle transmitter, connected to the pipe with three-way cock and screw joints R½.

Dial face diameter : 160 mm

Accuracy class : 1.6

All gauges shall be diaphragm and oil filled. Orifice shall be used in line of gauge to depress vibrations.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

Experienced and competent supervision and qualified piping and electrician labor shall be provided for installation of the equipment in full accordance with the Drawings and instructions of the coordinating supplier.

**A. Field Wiring**

Field wiring materials and installation shall be in accordance with the Electrical Section.

**B. Field Piping**

Field piping materials and installation shall be in accordance with the appropriate sections of these specifications. Reference Section is 16111.

**C. Miscellaneous**

Any signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, or isolation requirements shall be furnished and installed as required for the equipment to perform properly.

**D. Field Calibration**

A technical representative of the coordinating supplier shall calibrate the flow measuring equipment at 5, 25, 50, 75, 95, 100 percent of span and shall provide a written calibration report indicating the results and final tuning adjustment settings. The adjustments of the calibrated instrument shall be sealed or marked, insofar as practicable so that further adjusting by unauthorized personnel is discouraged. Instrument calibration shall be accomplished prior to a check-out of the operations of a system.

**E. Systems Check**

A technical representative of the manufacturer shall participate in the checkout of metering and control system. If interrelated devices furnished by other suppliers, such as valve operators, motor controls, chemical representative shall use suitable test equipment to introduce simulated signals to and/or measure signals from those devices as may be required to locate the source of trouble of malfunction. A written report regarding the results of such tests shall be furnished, as necessary to resolve a question of responsibility for corrective measures.

**F. Installation Test Equipment**

The Contractor shall provide all necessary test equipment for calibration and check of system components.

**END OF SECTION**

# SECTION 16921

# TELEMETRY AND SCADA SYSTEM

**PART 1 - GENERAL**

**1.01 DESCRIPTION**

This section covers furnishing and installing the plant Telemetry and SCADA equipment, supplementing this section, the Drawings indicate locations and arrangement of instruments, if it is not clear or not shown in the drawings, then the Contractor shall propose a system covers all locations in all facilities of the project and to the approval of the Engineer. The central SCADA monitoring station shall be in the main control room, unless otherwise approved or mentioned in other proposed place in the Drawings or elsewhere. Controls and component providing functional diagrams and schematics regarding connection, and interaction with other equipment. This section also covers the services of technical representatives of the instrumentation and control equipment supplier in Section GENERAL EQUIPMENT AND MATERIAL STIPULATIONS.

**A. Related Work**

**1.** General Equipment and Material Stipulations:

The general equipment and material stipulations shall apply to all equipment and material furnished under this section.

**2.** Work Specified Else where:

Other items of work that relate to and are referenced in this section include, but are not limited to, the following sections:-

Submittals

Electrical Sections

**1.02 QUALITY ASSURANCE**

**A. Supplier's Qualifications.**

The system shall be designed, coordinated and supplied by a major instrumentation, components and software manufacturer or his recognized and authorized agent who is regularly engaged in the business of designing and building Telemetry and SCADA instruments and control systems. An authorized agent will be required to prove his qualifications by submitting the following:

1. Authorization of agency from the major instrument manufacturer.

2. That he has the required financial capability.

3. The names of manufacturers whose products are normally supplied and the type of business relationship with each.

4. That he maintains a qualified technical staff and design office.

5. That he has the physical plant and fabricating personnel to complete the work specified.

6. That he has and will maintain competent service personnel to service the equipment furnished.

7. That he has successfully provided similar work for at least 5 years.

8. The names of at least three reference who are users of similar equipment designed, fabricated, and furnished by the agent.

**1.03 SUBMITTALS**

**A. Drawings, Data and Manuals**

Compliance sheets and complete assembly and installation drawings, together with detailed specifications and data covering materials used, parts, devices and other accessories forming a part of the equipment furnished shall be submitted in accordance with the Engineering Information and Requirements Sections.

The coordinating supplier shall prepare systems and installation drawings for all interconnecting wiring and piping between components of the systems furnished and for all interconnecting wiring and piping between the related equipment and the equipment furnished under this section. All interconnecting piping and wiring shall be appropriate for the service and shall result in a properly functioning metering of control system.

The drawings shall indicate the mounting elevations for all process connected instruments; the direction of piping, upward or downward; the amount of slope toward the instrument; and the provisions for shutoff, bypass, vent, or drain as recommended by the manufacturer for proper operation and maintenance.

Panel and subpanel drawings shall include overall dimensions, metal thickness, door swing, mounting details, and front of panel arrangement to show general appearance with spacing and mounting height of instruments and control devices.

System drawings shall be cross-referenced with detailed drawings and engineering data. For example, PLC system shall show each component and its related equipment marked with a suitable identification number or letter for cross-reference to any additional drawings or engineering data submitted for those components.

**PART 2 - PRODUCTS**

**2.1 TELEMETRY & SCADA SPECIFICATION**

**2.1.1 General**

Data transmission will be required between Reservoirs. The data to be transferred are required for proper operation and control of the all facilities of the project as described above.

The following I/Os lists is considered as the minimum which shall be monitored and controlled by the SCADA system through the SCADA software.

**PUMPING STATION I/Os LIST**

**Local PLC Unit, Input Signals**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Signal** | **Designation** | **Type** | **Qty** | **Remarks** |
| 1 | Supply voltage, mains | Not available | DI | One per unit |  |
| 2 | DMFM | Fault | DI | One per unit |  |
| 3 | DMFM | General Alarm | DI | One per unit |  |
| 4 | Control voltage | ON/OFF | DI | One per unit |  |
| 5 | Control voltage | Fault | DI | One per unit |  |
| 6 | Battery charger | Fault | DI | One per unit |  |
| 7 | Inverter | Fault | DI | One per unit |  |
| 8 | UPS | Fault | DI | One per unit |  |
|  |  |  |  |  |  |
| 9 | Main Pumps | Status(ON/OFF) | DI | One per unit |  |
| 10 | Main Pumps | Remote/Local | DI | One per unit |  |
| 11 | Main Pumps | Trip | DI | One per unit |  |
| 12 | Emergency - Off Switch | Off | DI | One per unit |  |
| 13 | MPMU | Fault | DI | One per unit |  |
| 14 | MPMU | General Alarm | DI | One per unit |  |
| 15 | Starters | General Alarm | DI | One per unit |  |
| 16 | Sump Pump | Status(ON/OFF) | DI | One per unit |  |
| 17 | Sump Pump | Remote/Local | DI | One per unit |  |
| 18 | Sump Pump | Trip | DI | One per unit |  |
|  |  |  |  |  |  |
| 19 | Motorized Butterfly Valves | 0-100% | AI | One per unit |  |
| 20 | Motorized Butterfly Valves | Trip | DI | One per unit |  |
| 21 | Flow meter, 4-20 mA | 0-100% | AI | One per unit | Also alarms for flow levels shall be programmed through PLC |
| 22 | Pressure Transmitter, 4-20 mA | 0-100% | AI | One per unit | Also alarms for Pressure levels shall be programmed through PLC |
| 23 | Electrical Float Switches | High /Low | DI | One per unit | For ground reservoir . |
| 24 | Ultra-sonic level meter | 0-100% | AI | One per unit | Also alarms for levels shall be programmed through PLC |
| 25 | Fire Alarm Panel | Status (ON / OFF) | DI | One per unit |  |
| 26 | Fire Alarm Panel | Faulty | DI | One per unit |  |
| 27 | Fire Alarm Alert | Alert | DI | One per unit |  |

**Local PLC Unit, Output Signals**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Signal** | **Designation** | **Type** | **Qty** | **Remarks** |
| 1 | Main MCCB | ON / OFF | DO | One per unit |  |
| 2 | Main Pumps | ON / OFF | DO | One per unit |  |
| 3 | Sump Pump | ON / OFF | DO | One per unit |  |
| 4 | Motorized Valve | ON / OFF | DO | One per unit |  |

**Reservoir With Water Tower I/Os List**

**Local PLC Unit, Input Signals**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Signal** | **Designation** | **Type** | **Qty** | **Remarks** |
| 1 | Supply voltage, mains | Not available | DI | One per unit |  |
| 2 | DMFM | Fault | DI | One per unit |  |
| 3 | DMFM | General Alarm | DI | One per unit |  |
| 4 | Control voltage | ON/OFF | DI | One per unit |  |
| 5 | Control voltage | Fault | DI | One per unit |  |
| 6 | Battery charger | Fault | DI | One per unit |  |
| 7 | Inverter | Fault | DI | One per unit |  |
| 8 | UPS | Fault | DI | One per unit |  |
|  |  |  |  |  |  |
| 9 | Booster Pumps | Status(ON/OFF) | DI | One per unit |  |
| 10 | Booster Pumps | Remote/Local | DI | One per unit |  |
| 11 | Booster Pumps | Trip | DI | One per unit |  |
| 12 | Emergency-Off Switch | Off | DI | One per unit |  |
|  |  |  |  |  |  |
| 13 | MPMU | Fault | DI | One per unit |  |
| 14 | MPMU | General Alarm | DI | One per unit |  |
| 15 | Starters | General Alarm | DI | One per unit |  |
|  |  |  |  |  |  |
| 16 | Sump Pump | Status(ON/OFF) | DI | One per unit |  |
| 17 | Sump Pump | Remote/Local | DI | One per unit |  |
| 18 | Sump Pump | Trip | DI | One per unit |  |
|  |  |  |  |  |  |
| 19 | Motorized Butterfly Valves | 0-100% | AI | One per unit |  |
| 20 | Motorized Butterfly Valves | Trip | DI | One per unit |  |
| 21 | Fire Alarm Panel | Status(ON/OFF) | DI | One per unit |  |
| 22 | Fire Alarm Panel | Faulty | DI | One per unit |  |
| 23 | Fire Alarm Alert | Alert | DI | One per unit |  |
| 24 | Chlorination System | Status(ON/OFF) |  |  |  |
| 25 | Chlorination System | Remote/Local |  |  |  |
| 26 | Chlorination System | Trip | DI | One per unit |  |
| 27 | Chlorine Residual Analyzers | 0-100% | AI | One per unit |  |
| 28 | Chlorination Room Fans | Status(ON/OFF) | DI | One per unit |  |
| 29 | Chlorination Room Fans | Remote/Local | DI | One per unit |  |
| 30 | Chlorination Room Fans | Trip | DI | One per unit |  |
| 31 | Motive Water Pumps | Status(ON/OFF) | DI | One per unit |  |
| 32 | Motive Water Pumps | Trip | DI | One per unit |  |
| 33 | Gas Detector in chlorination Room | Alarm | DI | One per unit |  |
| 34 | Flow meter, 4-20 mA | 0-100% | AI | One per unit | Also alarms for flow levels shall be programmed through PLC |
| 35 | Pressure Transmitter, 4-20 mA | 0-100% | AI | One per unit | Also alarms for Pressure levels shall be programmed through PLC |
| 36 | Electrical Float Switches | High /Low | DI | One per unit | For ground reservoir and elevated reservoir |
| 37 | Ultra-sonic level meter | 0-100% | AI | One per unit | Also alarms for levels shall be programmed through PLC |

**Local PLC Unit, Output Signals (Commands)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Signal (Command)** | **Designation** | **Type** | **Qty** | **Remarks** |
| 1 | Main MCCB | ON/OFF | DO | One per unit |  |
| 2 | Booster Pumps | ON/OFF | DO | One per unit |  |
| 3 | Sump Pump | ON/OFF | DO | One per unit |  |
| 4 | Motorized Butterfly Valves | 0-100% | DO | One per unit |  |
| 5 | Chlorine Residual Analyzers | 0-100% | AO | One per unit |  |
| 6 | Fans Chlorination Room | ON/OFF | DO | One per unit |  |
| 7 | Gas Detector | Silent Alarm | DO | One per unit |  |

**Reservoir Without Water Tower I/Os List**

**Local PLC Unit, Input Signals**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Signal** | **Designation** | **Type** | **Qty** | **Remarks** |
| 1 | Supply voltage, mains | Not available | DI | One per unit |  |
| 2 | DMFM | Fault | DI | One per unit |  |
| 3 | DMFM | General Alarm | DI | One per unit |  |
| 4 | Control voltage | ON/OFF | DI | One per unit |  |
| 5 | Control voltage | Fault | DI | One per unit |  |
| 6 | Battery charger | Fault | DI | One per unit |  |
| 7 | Inverter | Fault | DI | One per unit |  |
| 8 | UPS | Fault | DI | One per unit |  |
|  |  |  |  |  |  |
| 9 | Sump Pump | Status(ON/OFF) | DI | One per unit |  |
| 10 | Sump Pump | Remote/Local | DI | One per unit |  |
| 11 | Sump Pump | Trip | DI | One per unit |  |
|  |  |  |  |  |  |
| 12 | Control Valves, 4-20 mA | 0-100% | AI | One per unit |  |
| 13 | Control Valves, 4-20 mA | Trip | DI | One per unit |  |
|  |  |  |  |  |  |
| 14 | Chlorination System | Status(ON/OFF) |  |  |  |
| 15 | Chlorination System | Remote/Local |  |  |  |
| 16 | Chlorination System | Trip | DI | One per unit |  |
| 17 | Chlorine Residual Analyzers | 0-100% | AI | One per unit |  |
| 18 | Chlorination Room Fans | Status(ON/OFF) | DI | One per unit |  |
| 19 | Chlorination Room Fans | Remote/Local | DI | One per unit |  |
| 21 | Chlorination Room Fans | Trip | DI | One per unit |  |
| 22 | Motive Water Pumps | Status(ON/OFF) | DI | One per unit |  |
| 23 | Motive Water Pumps | Trip | DI | One per unit |  |
| 24 | Gas Detector in chlorination Room | Alarm | DI | One per unit |  |
| 25 | Flow meter, 4-20 mA | 0-100% | AI | One per unit | Also alarms for flow levels shall be programmed through PLC |
| 26 | Electrical Float Switches | High /Low | DI | One per unit | For ground reservoir . |
| 27 | Ultra-sonic level meter | 0-100% | AI | One per unit | Also alarms for levels shall be programmed through PLC |
| 28 | Fire Alarm Panel | Status(ON/OFF) | DI | One per unit |  |
| 29 | Fire Alarm Panel | Faulty | DI | One per unit |  |
| 30 | Fire Alarm Alert | Alert | DI | One per unit |  |

**Local PLC Unit, Output Signals (Commands)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Signal (Command)** | **Designation** | **Type** | **Qty** | **Remarks** |
| 1 | Main MCCB | ON/OFF | DO | One per unit |  |
| 2 | Sump Pump | ON/OFF | DO | One per unit |  |
| 3 | Control Valves, 4-20 mA | 0-100% | AO | One per unit |  |
| 4 | Chlorine Residual Analyzers | 0-100% | AO | One per unit |  |
| 5 | Fans Chlorination Room | ON/OFF | DO | One per unit |  |
| 6 | Gas Detector | Silent Alarm | DO | One per unit |  |

**2.1.2Design Criteria**

Each SCADA and telecontrol station consists of the following components:

1. wall cabinet IP54
2. power supply
3. signal amplifiers
4. modem for the signal transmission
5. receiver plug-in cards
6. transmitter plug-in cards
7. over voltage precision protection
8. coupling relays (if required)
9. PLC
10. SCADA software.
11. Communication media.
12. Personal computers (in SCADA center room only): Two complete sets (tower cases, 21 inch LCD monitors, key boards, mouses, licensed SCADA Software, Licensed Microsoft Office Software… etc.). Both sets shall operate in hot redundancy mode.
13. The Telecontrol station compromises all above mentioned components except the personal computers and all related items.

The data transmission time, the communication failures time and the response time of any change in the information in the whole system in the whole project (all stations ) must not exceed ( 5 seconds) at any case.

The data interchange between the two stations shall be processed as directed general interrogation with a serial data stream.

The information is to be transmitted in the form of frequency modulated - Frequency Shift Keying (FSK) or more efficient keying-method like Phase Shift Keying (PSK)…etc signals in a two-wire half-duplex mode of operation. The system shall operate as point-to-point traffic (although it has the ability to work in an integrated multi point SCADA system).

Each telecontrol link from the control station to a substation shall be monitored automatically to check that it is functioning properly. A disturbance will be sent to the PLC and processed with a flashing lamp.

All fire alarm systems in all facilities shall be monitored on SCADA system to give alarm on the SCADA monitor when any fire alarm in any FAP (Fire Alarm Panel) is established (occurred) or any fault happened in any FAP which lead to miss-operation in that panel.

The SCADA center, Computer N.W. center shall each be fed from its own 230v.AC. socket outlet branched from the main UPS. In the SCADA room.

**2.1.3 Telemetry Functionality**

* Telemetry system and components shall be based on prevalent industry standard.
* It shall be scalable to support wide spectrum of system sizes (dimensions to be according to BS standard).
* System shall be simple to install, use, program and needs no complicated equipment and high expertise.
* Have wide temperature ranges (hot/cold).
* Have protection against surge, lightning, condensation, power fluctuation, and corrosive vapor.
* Electronics to be packaged in rugged enclosure implying Electromagnetic Compatibility (EMC) against Electromagnetic Interference and Radio Frequency Interference (EMI/RFI).
* Have uninterruptible power supply of 220Vac 50 Hz (UPS) with low consumption (mA/hour) of 1.5 times the SCADA system power needs enough for 6 hrs working with NiCad non-maintenance battery with automatic charger and float –boost – off switch and A,V DC meters and LED signal lamps for all functions and Fan ventilated system 50 AH rating minimum. The UPS shall be for 50oC ambient minimum.
* Have build-in back-up battery.
* Have the option to operate either in stand-alone (transmission and reproduction of singles in their original form) or in integrated mode with SCADA systems providing telemetry in serial port of PC’s, Programmable Controllers (PLC’s), and Distributed Control System (DCS).
* Have a development software to add, delete or modify any further or existing images or program or system to the existing.
* Have flexible construction.
* Adaptability of self-supervision and fault diagnosis by means of data recording.
* Have the option to operate in point-to-point as well as in multi-points networks.
* Supporting old tone telemetry in addition to its advance telemetry system.
* The site-based equipment (the Remote Terminal Unit- RTU or DAS unit -Data Acquisition System) should imply the following:
* It should have adequate ID code size to fit further addressing in future extensions.
* It shall be of intelligent type having local data processing abilities for real-time application.
* Event storage with time/date tagging for adequate period during communication interruption. Stored data will be up loaded to the master station as soon as communication link is restored.
* RTU to be equipment with alphanumerical Liquid Crystal Display LCD showing all instructions, messages and settings and keypad from where operator can completely manipulate all parameters and calibration. (All changes are automatically reported to the master station).
* RTU access shall be password protected.
* It should have EMC casing and enclosure.
* Have long period records of data (100 days minimum).
* Ability for data logging and curve presentation.

**2.1.4 Alarm Processing**

* All faults, failures and alarms to be reported to the master station.
* Intrusion and hazardous alarms shall have hi-priority.
* Alarm management to delay unnecessary alarms.
* Same alarm repetition suppression.
* Root cause and important alarms rather than symptoms alarms to be identified and represented to the operator via intelligent and combinatorial techniques for filtering alarms.
* Annunciates system problems without using I/O’s.
* Operator queries and filtering of alarms/data should be executed with an easy-to-use, intuitive on-line query feature.
* Alarm sensor fault alert.
* Alarm battery fault alert.
* The system to have communication link monitoring to isolate, with no delay, the faulty facility causing communication jamming.
* The system should have a preventive and trouble shooting maintenance measures by means of condition monitoring in order to minimize unscheduled shutdowns and improved system reliability. The preventive and troubleshooting maintenance schedule should be submitted directly after the approval of the Engineer for the SCADA system and before primary taking over with enough time to be approved.

**2.1.5 Signal Directions**

The system is to be designed to have the ability for interchanging of binary messages and analogue signals in both directions.

*2.1.5.1 Messages*

(01) The input signal for a message from the local PLC to the telecontrol sub-station shall be transmitted as a continuous contact with self-holding device in the local PLC. The contacts in the PLC get the potential of the telecontrol system.

(02) The output signal for a message from the telecontrol central station to the local PLC shall be transmitted as a self-wiping contact (closed for about 50 ms) and repeated in adjustable intervals. The catching-up device (self-holding) is to be installed in the local PLC. The contacts of the telecontrol central station get the potential (48 V-DC) of the local PLC.

*2.1.5.2 Analogue Signal*

Multi-coupler (analogue signal isolator) with separate electrical power supply will electrically insolate the incoming and outgoing analogue signals which is 4 to 20 mA.

**SCADA Software**

This software to be installed in the personnel computer connected to the telemetry system.

* Object-Oriented Architecture, to implement full animation, control and alarming, data logging, Statistical Process Control (SPC) and Structured Query Language (SQL) without scripting, writing programs, or compiling.
* Use of standard ANSI “C” language or “VB” for uniformity, portability, and ease maintenance.
* It should be full Graphical User Interface (GUI).
* Have programming abilities for remote control.
* On-Line Configuration with any changes to the application without ever shutting the process down for even a second.
* Monitor abilities of dynamic visualization on screen with (GUI) interrogation via mouse clicks and other PC input devices.
* Event-Driven Performance (scanning of changing events), using no CPU time until an event occurs (e.g. changing level, pressure, speed, temperature,...etc). When object inputs are not changing, they remain quiescent, using no processor time.
* Batch processing tools such as recipe management, sequential execution and reporting, so the operator can import, modify, download, export recipes, step through procedures, and log modified recipe and batch data, as well as events.
* It must be purely open system and have connectivity with, virtually, all protocol driven PLC’s or RTU’s.
* Support industry standards like TCP/IP, ICCP, X/Windows MOTIF, and MS Windows NT, and having interoperability, security, and connectivity between windows, Linux and other environments.
* Support working in conjunction with, virtually, all PC-based operator software (e. g. Lookout, Web, Fix, Genesis, Intouch, Onspec, RS View … etc.).
* To include rich set of graphic tools, for example to provide full X-Y motion, dynamic resizing and visibility, dynamic graphic sequencing and dynamic coloring.
* Software shall be equipped with a comprehensive graphics library including 3-dimensional pipes, valves, pumps, motors, tanks, indicators, controls…etc.
* Software shall have the facility to convert AutoCAD drawings, digital photographs, maps or other image to graphics used by/within the software.
* Facility for capturing historical data and logging it (fore not less than 100 days) to disk and to manipulate files of data using common data base and spread sheet programs such as Microsoft Excel or equivalent.
* T o include powerful set of charts tools like, but not limited to:

1. Statistical Process Control (SPC) Charts
2. Control Chart to enable tracking the process and determine if it is about to go out of control and needs corrective attention.
3. Pareto Charts (or equivalent): for the display of frequency distribution of event occurrences, stored by category, so the most frequently occurring anomalies or defects in the process can be identified.

* To include the following set of built-in alarm processing features :

1. Trigger alarms when complex combinations occur.
2. The ability to play recorded voice massage.
3. The ability to dial out to digital pagers.
4. Alarm summary lines to be presented always at the bottom of the screen.
5. Graphic Panel automatically pop-up when certain alarms activate.
6. Alphanumeric massage to an operator’s pager when an MCC trips.
7. Announcing alarms over loudspeakers.
8. To maintain alarm and event history logs and prints reports based on these logs.

* Security shall be built into the software for adequate number of operator accounts, with options of equal or several levels of security (10 or more levels).

**2.1.7 Communication and Input/Out (I/O)**

The communication and I/O shall imply the following:

* Compatible with spread spectrum radios, radio moderns and fiber-optic.
* System should apply Multiplexing technique for both analogue and digital signals.
* It should support communication with industrial standard I/O protocol and modes like PROFIBus, MODBUS, TM 16000XC, TRSII, JBUS, DATABUS, SOFTBUS, TEC, PERAX, and VIDEOTEX …etc.
* It should be BI-directional valuable I/O systems.
* Have adequate I/O capacity for redundancy and future extensions.
* Have isolated I/O’s and lightning protection.
* Have status output.
* Require no power supply for analog loop (build-in).
* Compatible with solar batteries (if require for remote sites).
* Eliminate of ground looping and protection against faults.
* Eliminate interposing relays.
* Have I/O accuracy to 0.1 %.
* Communicate via PSTN Telephone lines, direct cables, and radio.

Any Additional equipment to achieve a signal at both ends of the telemetry cable shall be quoted in the price of the telemetry cable in the BoQ.

When radio communication is implemented, data transmission will be required between remote stations and master stations. The data to be transferred are required for proper operation and control of the pumping stations as described above.

The contractor shall study the Topology of the projects carefully to design the telemetry system. Clear signal from all remote stations and master station should be responded as fast as possible from all electrical equipment.

The contractor have to co-ordinate with the authority having the jurisdiction for issuing the license to use the radio frequency required to operate the telemetry system.

The radio modem combination shall be an integrated unit or multi separate unites, (digital data modem that has an RTU connection and a radio transmitter receiver and an antenna connector).

The radio telemetry system shall be a point to multi point (broadcast) half duplex, the master station shall contain a full duplex master radio and the remote stations shall contain half duplex remote radios.

The master radio modem shall be capable of full duplex operation since a full duplex radio modem has a transmitter that is separate from the receiver; this provides shorter RTS (request to send) – to – CTS (clear to send) delays with each master station data transmission.

The radio modems for the remote stations shall have a transceiver which limits modems to only half – duplex operation, since they can only send or receive data at one time. Therefore, with each remote station transmission, the RTS – to – CTS delay is longer, since the transceiver takes time to switch from receiver operation to transmitter operation, this time delay lets the transmitter fully power up.

This master station shall be set in a full redundant configuration (Communication and SCADA), because if the master station goes down, the whole communication system is down where as, when a remote station radio modem goes down only communication to a single remote stations is lost.

**2.1.8 The Programmable Logic Controller (PLC)**

It should fulfil the following:

* To have low consumption of power and wide operating temperature.
* Incased in an Electro-Magnetic Compatibility (EMC) enclosure to afford tough conditions of Electromagnetic Interference and Radio Frequency Interference EMI/RFI
* Durable enclosure undergoing wide span of weather fluctuation.
* Dimensions to be according to BS standards.
* To have alphanumerical Liquid Crystal Display (LCD) display showing all parameters.
* To have input keypad accessing all functions and parameters.
* Easy configuration features.
* Have automation capacity and storage memory.

*2.1.8.1 Performance and Functionality*

* It should include Boolean functions (AND, OR, NAND, XOR, … etc.) for digital data manipulation, and Arithmetic functions (sum, difference, multiplication, and integration) for Analogue variables.
* Selection between two Analogue variables.
* To have adequate number of Input/Output (I/O) terminals or extension blocks to fit 25% further extensions.
* Have high and low thresholds with hysteresis.
* Regulation by plus and minus with dead band.
* Measurement proportional sharing.
* Hourly and daily time-sharing.
* Time delay ON-OFF and monostable.
* Carryout time and pulse counting.
* Detection of daily minimum and maximum in addition to daily average calculation.
* Average pulse frequency calculation.

*2.1.8.2 Communication Features*

* Time clocking at acquisition.
* Support bilateral flow and transfer of data.
* The ability to communicate with PC, modem, Minitel, or printer.
* The ability to be interrogated via dedicated lines, public service telephone network (PSTN), computers though RS232 or 485 standards, and via radio links with standard communication protocols.
* Support immediate/delay transmission and function of the data emergency.
* Support network communication among PLC’s group.
* Ability to dialogue multi-standard protocols like ProfiBus, MODBUS, TM 16000XC, TRSII, JBUS, DATABUS, SOFTBUS, TEC, PERAX, and VIDEOTEX …etc.

*2.1.8.3 Input/Output (I/O) features:*

* Gain adjustment of an analogue value.
* Filtering of analogue variable oscillations.
* Probabilities control of the analogue measurement.
* Logical variables debouncine filtering.
* Logical variables inhibitions.
* Positive/Negative security selection.
* Support CMOS/TTL. I/O’s

*2.1.8.4 SCADA Printer:*

* Front dimensions: 144 x 166 mm
* Power Supply: 24 V.DC
* Input: Six analogues signal 4 – 20 mA.
* The Printer has to include the time

**2.1.9 Personal computer:**

The computer set and all its accessories shall be brand new of the latest year update type of manufacture and as approved by the Engineer, the following are minimum requirement prepared in the design stage early before Tendering and should be submitted updated:

1. Pentium 4 – 3.6 GHz processor. LGA 775 supports high threading technology FSB 166 / 800MHz. 1MB internal cache.
2. 512MB RDRAM with 800MHz Bus speed.
3. 120 GB SATA HDD,
4. 3D accelerated graphic card with driver software, G-Force 4 256MB MX 800
5. 2 serial & 4 parallel ports.
6. Minimum 6 USB with 3 fast ports at least
7. Microsoft PS2 mouse and A/L keyboard
8. Combo drive (CD writer + DVD)
9. 21in. LCD monitor as duty and 21in. monitor as hot backup redundant.
10. 8 GB internal type drive and 10x Tape media (or 2GB internal Jaz drive and 10x Jaz media)
11. 3.5in FDD and 50 x 3.5 in diskettes
12. Full multimedia 32 bit sound card and 200W speakers
13. PCI 56k internal modem for connection to PSTN/US Robotics
14. 10/100/1000 MB PCI fast Ethernet Card
15. ATX case W/450 watt minimum
16. Windows XP Pro. operating system, legal and registered license
17. Microsoft Office 2003 Professional edition, legal and registered license
18. SCADA telemetry software 500 I/O points capacity, runtime and development modules. Legal and registered license with Open Database Connectivity (ODBC), Dynamic Data Linkage (DDL) and other software modules for integration with Windows operating system and Office 2000 applications. With enough pages in the PC to show all Facilities with their elements for monitoring and control. The PC shall have a memory for 100 days for retrieving to be printed and analyzed with time hourly.
19. PCL configuration and setup software.
20. Colored Laser printer of the following specs:

* A4 & A3 600DPI, 22 Page/minute minimum
* HP High Quality or better equivalent.
* 32 MB memory with memory enhancement technology
* TMO adjustable trays for A4, letterhead, envelope, labels, transparencies, customized media, post card and larger paper.
* Updated PCL printer language and fonts.
* Energy saving and economic printing facility.
* ECP parallel port, local talks port, infrared ports and USB port.

1. Mod-bus or RS485 connection to PLC network.

Complete setup, configuration, testing and operating the PLC’s and SCADA package to include 2 weeks training for 3 engineers.

**2.1.10 Telecontrol Cable**

*2.1.10.1 Cable Type*

Telecontrol cable of double shielded PE insulated type with moisture barrier sheath (Alum/PE) according to IEC Standards is to be provided. It should be multipair X 0.8 mm2 wire c.s. of twisted colored pairs or numbered on each wire. The No. of pairs is 6 minimum unless otherwise specified elsewhere or on the Drawings.

If the telecontrol cable is buried underground, then it should be galvanized steel wire armored. The outersheatr of the cable may be PVC or PE. The depth of the trench should not be less than 50 cm.

For the telecontrol system cable pair/s, the internal telephone communication pair/s, and spare cable pairs shall be according to the telemetry and control drawing and the concerned Engineer approval.

For the telecontrol system, one or more pairs of cable cores will be used. Another pairs may be used for internal telephony. Other pairs are spares.

*2.1.10.2 Laying of cable*

(01) Cable trench:

Cable will be laid in the same trench provided for the water main from reservoirs.

(02) Cable laying:

The preparation of the trench’s bottom, the embedding of the cable with sand (free of stones) and the covering by bricks is to be quoted with the unit rate of the respective cable.

Locations where cable runs crossing roads or streets, it shall be laid inside a 10-cm. Diameter galvanized steep pipes of a length (2m + street width + 2m) and sand embedded all the way. In case of crossing any water or wastewater lines the cable shall be laid in 10 cm. Diameter galvanized steep pipes and encased with concrete for the total pipe length of (1m + water pipe Dia + 1m). In both cases the cost of the galvanized steel pipe and concrete encasements shall be deemed to be included in the unit price of the Contract. Both ends of the pipe should be tightly closed after cable laying.

(03) *Cable connections:*

All the cable cores (under or over ground) both ends of the cables are to be connected by soldered joints to the soldering lugs of the terminal boxes. The tightening of the wall duct of the cable by cable sealing compound and the fixing inside the building is to be quoted with the item of the cable connection.

* + 1. **Terminal Boxes**

The over ground telecontrol cables are to be connected to a terminal box, which are to be installed inside the buildings. These terminal boxes shall be class equipped with soldering lugs for each incoming and outgoing telecontrol cable core. It provides the plug terminals to connect the control cable in-going from the switchgear and all necessary cross connections. The terminal box shall include the over voltage protection for all cable cores of the connected underground cables and the respective connection to the grounding system. The terminated box shall be minimum P 66.

The telecable laid underground shall be one piece length and for the whole route without connections for the whole length. In case the total length can not be one-piece length of the cable, then the Contractor shall search and submit minimum 3 offers (locally and foreignly) from various manufacturers proving that each cannot produce one-piece length for the total length, then approved by the Engineer.

In case of more than one piece is used and to be connected then the Nos. of pieces should minimum (using the maximum possible produced lengths) according to the best approved offer.

For pieces connections, the standard underground connection boxes (kits), and as approved by the Engineer shall be used and installed of IP 68 and totally isolated and immersed in solid insulation – epoxy or better – materials as approved according to the standards and Engineer before ordering. The connected similar care terminals shall be soldered then insulated and according to the connection box (it) manufacturers.

In case of connection presence, then an approved – by the Engineer- reinforced concrete marker over / under ground shall be installed. The prices of the connections and marker shall be deemed to be included in the unit of the Contract.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

Experienced and competent supervision and qualified piping and electrician labor shall be provided for installation of the equipment in full accordance with the Drawings and instructions of the coordinating supplier.

**A. Field Wiring**

Field wiring materials and installation shall be in accordance with the Electrical Section.

**B. Field Piping**

Field piping materials and installation shall be in accordance with the appropriate sections of these specifications.

**C. Miscellaneous**

Any signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, or isolation requirements shall be furnished and installed as required for the equipment to perform properly.

**D. Field Calibration**

A technical representative of the coordinating supplier shall calibrate the flow measuring equipment at 5, 50, and 95 percent of span and shall provide a written calibration report indicating the results and final tuning adjustment settings. The adjustments of the calibrated instrument shall be sealed or marked, insofar as practicable so that further adjusting by unauthorized personnel is discouraged. Instrument calibration shall be accomplished prior to a check-out of the operations of a system.

**E. Systems Check**

A technical representative of the manufacturer shall participate in the check-out of metering and control system. If interrelated devices furnished by other suppliers, such as valve operators, motor controls, chemical representative shall use suitable test equipment to introduce simulated signals to and/or measure signals from those devices as may be required to locate the source of trouble of malfunction. A written report regarding the results of such tests shall be furnished, as necessary to resolve a question of responsibility for corrective measures.

**F. Installation Test Equipment**

The Contractor shall provide all necessary test equipment for calibration and check of system components.

**END OF SECTION**

# SECTION 16999

# SPARE PARTS AND TOOLS

**PART 1 - GENERAL**

The Total Contract Price is deemed to include the Mandatory and Recommended spare parts and tools for 2 years operation and maintenance.

The Contractor shall provide detailed schedules in duplicate of all Mandatory and Recommended the spare parts and tools to be supplied. During commissioning all spare parts shall be checked against the schedule and against the recommended maintenance programme. Any shortfall in the provision shall be provided by the Contractor.

All spare parts supplied shall be new, and strictly interchangeable with the parts for which they are intended to be replacements, and shall be treated and packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container and a detailed list enclosed.

All cases, containers and other packages shall be marked and numbered in an approved manner for purposes of identification.

All cases, containers or other packages are liable to be opened for such examination as maybe required and packing shall be designed to facilitate opening and thereafter repacking.

**PART 2 - MANDATORY SPARES AND TOOLS**

In addition to the spares described in the preceding Clause, the Contractor shall provide the following mandatory spares and tools as a minimum requirements for the works. The spares shall be delivered with the plant. The contractor should complete the schedule of spares, including the following items:

* 1. **Instruments**

• One spare set of arithmetic units, transducers, buffers, indicators, displays, buttons, switches etc. of each type and size provided

• Recorders – (Three spare pens nib and 5 tapes) for each instrument type (in addition to manufacturer's listed spares)

* 1. **MCCS, Distribution Boards (DBs) and Controls**

1. ***Fuses***

• One set of electric spares for each panel type with minimum of 15 % spares of relays (one No. min.of each type), 100 % spares of common fuses and 200 % of special fuses

1. ***Low Voltage MCCs & DBs***
   * Minimum of 20 % spare of each type and size of low voltage circuit breakers & contactors. 1 No. min. of each type, which ever the more.
   * Lamps Minimum of 20% spare lamps of each type and capacity. (4 No. min.) which ever the more.
   * 4 sets of moving and fixed contacts and coils for each for each type of the 3 main contactors for all ATST.

One set means the number of parts installed in each machine and equipment. The Employer's Representative will determine the amount to be deducted from the Contract Price in respect of the Contractor's failure to deliver all spare parts defined by this clause.

1. ***Electro-technical tools***

The Contractor shall supply all the following brand new electrical tools as specified hereinafter and as in the BOQ and after approval of the Engineer. Part 1, General of this section shall also be applied for the tools as practical as possible. These tools shall be handed over to the Employer via the taking over committee during the taking over of the project before the issuing of the substantial taking over certificate of the project.

These tools are as follows:

1. **CLAMP AVO METER: With electronic digital display.**

**Qty=4**

A= 0~2000 A (ranges) AC

V= 0~1000 V (ranges) AC

O = 0~Infinity ohm (ranges)

DCV= 0~250 V (ranges)

Temp = 0~500 deg. C (ranges) by probe and adaptor (Preferred)

Hz = 0~200 HZ (ranges)

Diodes and thyrestor measures

dB measures with accessories.

Sonar conductivity measures.

Hold and peak button measures facility.

Fused protection+ probes and leather case.

KW- by clamp measure.

1. **AVO METER: With electronic digital display.**

**Qty= 4**

A= 0~2000 A (ranges) AC

V= 0~1000 V (ranges) AC

O = 0~Infinity ohm (ranges)

DCV= 0~250 V (ranges)

Temp = 0~500 deg. C (ranges) by probe and adaptor.

Hz = 0~200 KHz (ranges)

Capacitence =1- 500uF.

Diodes and thyrestor measures .

Sonar conductivity measures.

Hold and peak button measures facility.

Fused protection+ probes and leather case.

1. **TACHO – METER: (RPM)**

**Qty = 2**

**Mechanical Type:**

Mechanical, multi-range (0 ~ 10000 rpm) adjustable, dial type with small divisions and hold button. All metallic parts are of stainless steel or anti-rust metal. The meter shall be supplied with all accessories, peripheral and wheel adapters (all to be in one case).

1. **Electrician Mechanical Tools:**

Mechanical Tool set comprises the following in one metalic case wheelable: (6 whole sets):Each comprise of :

Hammers (steal): 1000, 500, 200, 100 gm set 1.

Hammers (rubber): big, medium, small, set 1.

Hacksaw: adjustable to 8, 10, 12 inch blades with six blades from each kind set 1.

Ring spanner (Double end): 4 mm –36 mm set 1.

Open spanner (Double end): 4mm –36 mm set 1.

L- Keys set: 1mm – 10m in one case set 1.

Adjustable wrench (for bolts) 12 pcs (chrome) Pc 1.

Screw drivers (in one case) chrome steel

Flat and Philips 6 sizes set 1.

Socket spanner 4m – 36 mm chrome forged steel with

Short & long arms, auto ratchet key, Hexockits adapter set 1.

Inter locking pliers: large, medium, small set 1.

Needle nose pliers: straight and bent insulated set 1.

Cutting pliers: insulated 2 sizes (chr. steel) set 1.

Combined cutting and grip insulated pliers: small, medium, (chr. steel) set 1.

Files: medium size six pieces (smooth) set 1.

(Flat, circ, flat-circ, (smooth and coarse), square,

Triangle. (High Quality steel) set 1.

Vice-grip: 10”, 5” (chr. Steel) set 1.

Puller: 3-jaws complete sizes: small, medium and large set 1.

Calliper (vernier): metric & inches for inside, outside or depth

measurements with clamp lock side and fine adjustments.(chr. steel) 1set

Safety glasses 2 Nos

Eear protectors: 360o head band (ANSI 224.22) 2 Nos

Eear corks (formable; malleable pieces) 20Nos

1. **Grease gun:**

**Qt = 3**

2- way fill gun, lever type with cast iron pump head, vet valve for purging air from gun, handle grip, variable stroke and pressure with variable 3 nipples and 6,18 in hoses.

1. **Portable Cable Reel:**

**Qt = 2**

Manual rewind 3 ph + N with socket outlet and plug, 30m-extension cable, on metallic spool, steel powder coated paint finish, with (4 x 4mm2 Cu/PVC) flexible cable.

1. **Portable Cable Reel:**

**Qt= 2**

Manual rewind 1ph + N with socket outlet and plug 30m-extension cable, (3 x 4mm2 Cu/PVC flexible cable) on metallic spool, steel powder coated paint finish.

**PART 3- RECOMMENDED SPARES AND TOOLS**

1. The contractor shall propose and furnish spare parts and tools for 2 years operation and maintenance.
2. The Recommend Spares and Tools shall cover all items not covered in Part 2 of this section of the Specifications, Mandatory Spares and Tools, like (level, pressure, flow, temperature) switches, transmitters, meters, transducers, DMFMs, MPMUs, relays, contactors, protections, circuit breakers, control switches, indications lamps, lighting fixtures, sockets, etc.
3. The proposed Recommended Spares and Tools shall cover all sections of the Electrical and Instrumentation Specifications.
4. The Contractor shall submit a detailed schedule of Recommended Spares and Tools at the time of the bid.

**END OF SECTION**