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مشروع تنمية الثروة السمكية

EGYPT AQUACULTURE PROJECT

For: The Ministry of Agriculture, A.R.E.
Sponsor: U.S. Agency for International Development

DESIGN DEVELOPMENT SPECIFICATIONS

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EGYPT AQUACULTURE PROJECT
DESIGN DEVELOPMENT SPECIFICATIONS

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DESIGN DEVELOPMENT SPECIFICATIONS

DIVISION 2 - SITEWORK

SECTION 02110 - CLEARING

A. CLEARING shall consist of the removal of all natural growth, trees, abandoned culverts and drainage structures, and any other objects deemed detrimental to or in the way of construction. Grubbing shall consist of the removal and disposal of topsoil, loose rock, stumps, roots, and other organic or metallic debris not suitable for the water impoundment and foundation purposes, below the original level of the ground.

SECTION 02220 - EXCAVATION AND BACKFILL

A. POND AREAS shall be excavated to the required depth and the material will be deposited in stockpiles to induce further draining of the silty-clay soil. The stockpiles may require reworking to achieve near-optimum moisture content before placement. The drained soil shall be used to construct all berms by placement in horizontal layers not to exceed 0.30 meter (m) in depth and each layer shall be compacted to a dry density equal to 95 percent of the ASTM D 1557, Method D, maximum dry density. Working and placement of soil to grade in building areas will use the same procedures as for ponds.

SECTION 02221 - TRENCHING, BACKFILL, AND COMPACTION

A. PIPE BEDDING AND BACKFILL - GENERAL. Determination of the source of materials for bedding and backfill shall be the responsibility of the Contractor. Native material may be used for any or all of the material classifications, provided it conforms to the specified requirements. Similarly, approved imported material may be used for all material classifications.

1. The foundation under a pipeline must be strong enough to hold the pipe on grade under its full backfill load and uniform enough to avoid load concentration that would cause "beam action" failure or "punching." Soft native material must be removed and replaced with a ballast layer thick enough to adequately distribute the load on the soft material beneath.

2. Where bedding is required due to unstable foundation conditions, the bedding support shall be provided uniformly along the pipe allowing a small degree of clearance under all joints to prevent "beam action" in rigid pipe and to avoid deflection out of round in flexible pipe.

B. BEDDING MATERIAL shall consist of well-graded, granular material containing no muck, roots, sod, or other deleterious material. It shall consist of no more than 5% by weight of particles passing the No. 200 sieve, and all material shall pass a 2 cm sieve.

C. BACKFILL. Initial backfill shall consist of select material containing no muck, roots, sod, or other deleterious material.

D. GRAVEL SURFACING MATERIAL shall be as specified in Section 02511.

E. DEWATERING. Provide, maintain and operate sufficient dewatering pumps or well points, headers and pumps to keep all excavations free from water at all times.

F. CRIBBING AND SHEETING. Contractor shall provide all cribbing and sheeting needed to protect the work, existing property, roadways, etc., and to provide safe working conditions in the trench. Such cribbing and sheeting shall be according to the Contractor's design which shall comply with applicable safety codes.

1. Removal of any cribbing and sheeting from the trench shall be accomplished in such a manner as to fulfill the above requirements and prior to backfilling except as otherwise noted on the drawings.

2. Damages resulting from improper cribbing or from failure to crib shall be the sole responsibility of the Contractor and paid for at his expense.

G. REMOVAL OF UNSUITABLE MATERIAL. Cross-sectional dimensions and depths shown shall be subject to change. Unsuitable materials encountered shall be removed and replaced with granular materials.

H. EXCAVATION AND TRENCHING. The Contractor shall do all excavation of whatever substance encountered to the lines and grades shown on the drawings. All material suitable for use as backfill shall be piled in an orderly manner a sufficient distance from the bank of the trench to avoid overloading and to prevent sliding into the trench. The Contractor shall do such grading as is necessary to prevent surface water from entering the excavation. All operations shall be carried out in an orderly fashion.

I. BACKFILL AND BEDDING includes the bedding and backfilling for all piping, whatever size or kind for the entire project. See typical details on the drawings for depth and detail description of bedding.

J. FINAL TRIMMING AND CLEANUP shall consist of all work as follows:

1. All irregularities shall be made smooth, washouts shall be filled, slopes made uniform, slightly rounded at top and bottom, and the entire area of the fill compacted and completed to the required lines, grades and cross sections.

2. When work is completed, the Contractor shall remove and dispose of all surplus material including stumps, trees and brush.

3. Cleanup and repair: The Contractor shall maintain his operations in a neat and orderly manner causing as little inconvenience as possible. All excess excavation shall be removed from the trench side and disposed of at the Contractor's expense. The work area shall then be thoroughly cleaned.

K. TESTING

1. Compaction supporting pipe, roads, or structures shall be compacted to 95% of maximum dry density as determined by ASTM D 1557, Method D. Other compaction shall be not less than 90% of the maximum dry density as determined by ASTM D 1557, Method D.

2. In the event that the tests do not comply with the requirements of the specifications, additional compaction shall be performed or the fill shall be replaced with fill that will comply.

SECTION 02400 - DEWATERING

A. PRIOR TO any clearing or excavation operations, the Contractor shall dewater the entire site. The site will be dewatered by blocking off all supply canals that do not interfere with the existing government fish farm operation. Existing embankments will be punched through to allow draining of any water impoundment, and drain canals/channels will be cleared and/or deepened to allow full draining of the site.

SECTION 02510 - ROADWAY AND PARKING PAVING

A. THE VISITOR AND SERVICE access roads, as well as the parking area, will be constructed to conform with Class B standards of the General Roads and Bridges Organization. The roads shall consist of 6-m-wide asphaltic surfacing over crushed rock and asphalt courses, and 1-m-wide soft shoulders.

SECTION 02511 - CRUSHED STONE SURFACING

A. THE PERIMETER AND CENTER roads shall be crushed stone as shown on the drawings, consisting of a top course of 19 mm - minus material and a base course of 50 mm - minus material.

SECTION 02730 - WATER WELLS

A. WELL HOLE shall be 300 mm diameter by 50-meter hole (presently being drilled).

B. CASING shall be 250 mm Schedule 40 steel pipe extending to a depth of approximately 25 meters. Approximately 5 meters from the ground surface shall be sealed with a surface casing and/or grout.

C. WELL SCREEN shall be 150 mm diameter stainless steel approximately 25 meters in length with a solid bottom plate. Screen size and gravel jacket specification will depend upon soil gradation of aquifer.

D. PUMP shall be as specified in Section 15100.

SECTION 02743 - SEPTIC TANKS

A. THE SEPTIC TANK shall be installed as indicated on the drawings. The tank shall be designed and constructed to withstand any loads possible in both the filled and unfilled conditions. The tank shall be designed to prevent vertical movement due to bouyant forces created by groundwater when the tank is empty. The tank shall be precast or cast-in-place reinforced concrete.

B. PIPING shall conform with Section 15060.

C. DRY WELL discharge shall be fabricated from cast-in-place or precast concrete manhole, or from brick manhole.

DIVISION 3 - CONCRETE

SECTION 03100 - CONCRETE FORMWORK

A. GENERAL

1. Forms shall be rigid and constructed of materials that will result in finished products conforming to the shape, lines and dimensions shown on the contract drawings.

2. Forms may be of wood or metal, or any other suitable material, at the option of the Contractor.

B. STEEL FORMS will be used for the interior side of all concrete tanks and raceways.

SECTION 03200 - CONCRETE REINFORCEMENT

A. STEEL BAR AND WELDED WIRE-FABRIC REINFORCING. Unless specified otherwise, all bars for concrete reinforcement shall be deformed, standard mild steel, Type "37," strength (fs) 1,400 kg/cm^2.

SECTION 03300 - CAST-IN-PLACE CONCRETE

A. CONCRETE CURING. Moisture curing for cast-in-place concrete.

B. CONCRETE

1. All concrete work shall be cast-in-place concrete construction unless otherwise indicated.

2. All cast-in-place concrete shall consist of portland cement, coarse aggregate, fine aggregate and water, etc. The various components and their proportionate combination, shall result in 28-day strengths as follows:

   a. Reinforced concrete: 225 kg/cm^2

   b. Unreinforced concrete: 180 kg/cm^2

SECTION 03340 - LOW DENSITY CONCRETE

A. LOCATION. Sloped roof fill, over waterproof membrane.

B. LOW-DENSITY CONCRETE. Portland cement, water and special low-density aggregate to produce concrete with the following properties:

1. Dry density: 640 to 1,100 kg/m^3.

2. 28-day compressive strength: 30 kg/cm^2, minimum.

C. PLACING. Slope drain at minimum of 2% slope.

D. FINISH. Hard, dense steel-trowel finish.

SECTION 03341 - INSULATING CONCRETE

A. LOCATION. Roof, under waterproof membrane.

B. INSULATING CONCRETE. Portland cement, water and special low-density aggregate to produce concrete with the following properties:

1. Dry density: 320 to 400 kg/m^3.

2. 28-day compressive strength: 7 kg/cm^2, minimum.

3. Conductivity (k-value): 0.25 $kcal/mh^oC$, minimum.

DIVISION 4 - MASONRY

SECTION 04100 - MORTAR

A. CEMENT, LIME MORTAR, AND GROUT. For masonry 125 kg/cm^2 minimum 28-day compressive strength.

Premixed mortars: may be used in lieu of item above.

SECTION 04200 - UNIT MASONRY

A. EXTERIOR WALLS, TYPICAL. 25 cm thick, English bond (header every second course).

B. INTERIOR WALLS AND EXTERIOR WALLS SHOWN 12 CM THICK ON DRAWINGS. 12 cm thick (single wythe), running bond.

C. BRICK UNITS. Fired red clay, 25- by 12- by 6-cm, nominal dimensions.

DIVISION 5 - METALS

SECTION 05500 - METAL FABRICATIONS

A. BOLTS. Anchor bolts, expansion bolts and steel work, where indicated on the drawings, shall be hot-dip galvanized (zinc-coated) after fabrication.

B. HANDRAILS AND RAILINGS shall be galvanized steel pipe or aluminum tubing unless otherwise shown.

C. GRATINGS

1. Gratings shall be all aluminum-serrated bar grating, swage-locked type.

2. Galvanized steel grating seats and return angles shall be used to support grating and protect concrete edges.

D. LOOSE LINTELS FOR MASONRY shall be galvanized steel angles. Minimum fc, 2,500 kg/cm^2.

E. SCREEN FRAMES shall be fabricated from structural steel shapes conforming to ASTM A 36.

F. SHUTOFF GATES AND BAFFLES shall be fabricated from aluminum plate, ASTM B 308, grade 6061-T6.

G. GATES. Welded steel plates 0.6 cm x 5 cm spaced at 6 cm o.c. vertically with cross bars at top, bottom, and third points. Provide heavy-duty hinges and lock mechanism.

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DIVISION 6 - WOOD AND PLASTICS

SECTION 06200 - FINISH CARPENTRY

A. MILLWORK. Standing and running trim, casework and shelving.

1. Standing and running trim and casework shall be hardwood and hardwood veneer-faced plywood suitable for paint finish. Provide plastic laminate countertops unless indicated otherwise.

2. Shelving will be 25 mm thick plywood with solid wood edges.

3. Countertops:

   a. Plastic Laminate: 1.6 mm thick, phenol-formaldehyde resin laminate, matte-finish, uniform color. Bond with waterproof adhesive to 25 mm thick plywood with 0.8 mm thick plastic laminate backing sheet.

   b. Acid-Resistant: Cast epoxy resin or specially formulated cement/asbestos/resin finish laboratory countertops, 25 mm thick.

   c. Stainless Steel: ASTM A 167 Type 304, 1.6 mm minimum thickness, all joints welded and ground smooth, No. 4 finish (brushed).

SECTION 06600 - PLASTIC FABRICATIONS

A. FIBERGLASS (FRP) TANKS, GATES AND BAFFLES shall be fabricated of fiberglass-reinforced polyester using glass mat and woven roving, where necessary, over a rigid polyurethane core.

1. Manufacturer: A firm specializing in the manufacture of FRP construction of the types required for the project.

2. Standards: Conform to the provisions of Product Standard 15-69, published by the U.S. Department of Commerce, National Bureau of Standards.

3. Submittals: Submit shop drawings, installation instructions, and structural calculations for all FRP items.

4. Structural Requirements:

   a. Tank Sidewalls: Maximum deflection 25 mm under full hydrostatic load.

   b. Walkways: Maximum deflection 6 mm under 250 kg/m^2 (50 pst) uniform live load.

   c. Gates and Baffles: Maximum deflection 12 mm under full hydrostatic load.

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5. Provide tank outlet screens and outlet piping as shown on the drawings.

B. POND SCREENS shall be fabricated from polyethylene/polypropylene similar to Conwed Plastic Netting XM-1670 (for 3 mm opening) and XM-4348 (for 20 mm opening). Install in steel frames specified in Section 05500.

DIVISION 7 - THERMAL AND MOISTURE PROTECTION

SECTION 07150 - DAMPPROOFING

A. BITUMINOUS DAMPPROOFING. Walls below grade.

B. BITUMEN/CEMENT/SAND MORTAR DAMPPROOFING. Top of foundation walls and where indicated.

SECTION 07200 - INSULATION

A. ROOF. Refer to Section 03341, Insulating Concrete.

B. COLD ROOMS. Loose vermiculite fill, treated for water repellancy. Comply with ASTM C549 or urethane board insulation.

SECTION 07500 - MEMBRANE ROOFING

A. ROOFING. Two-ply, asbestos felt roofing with heavy bituminous top coating. Surface with lightweight concrete and precast concrete pavers.

SECTION 07900 - SEALANTS AND CALKING

A. SEALING. Use sealing compounds at exterior and interior surfaces of exterior wall penetrations and at the following:

1. Joints and recesses formed where frames and subsills of doors, louvers, and vents adjoin concrete, or metal frames.

2. Expansion and control joints.

3. Openings where items pass through exterior walls.

4. Metal-to-metal joints where sealing or calking is shown or specified.

5. Bottoms of exterior doorway frames.

6. Glazing.

7. Other conditions as detailed or required.

B. BOND PREVENTIVE MATERIALS OR JOINT FILLER BACKUP. Polyethylene closed-cell foam, either in rod stock or rectangular.

DIVISION 8 - DOORS AND WINDOWS

SECTION 08100 - METAL DOORS AND FRAMES

A. STEEL DOORS AND FRAMES. 6 mm thick steel plate.

1. Locations: Wet areas, production areas, exterior doors, and all doors at Serrow.

2. Provide glazed openings, and louvered openings as indicated.

B. GLAZED ALUMINÚM DOORS. Extruded aluminum sections, 44 mm thick, 100 mm wide stiles and top rail, 150 mm wide bottom rail.

1. Glass: 6 mm thick clear tempered glass.

2. Finish: Clear anodized.

3. Location: Entry at RTP.

SECTION 08200 - WOOD DOORS

A. DOORS. Oak panel wood with relights shall be used.

1. Location: All swing doors not specified as steel or aluminum.

SECTION 08300 - SPECIAL DOORS

A. ROLLING GRILLS. Aluminum, composed of horizontal 6 mm round rods at 5 cm O.C. and pressed aluminum links vertically at 23 cm spacing. Operation: Manual. Finish: Mill.

B. ROLLING DOORS shall be manually operated, aluminum-slat doors with galvanized-steel frames. Passage doors shall be provided where called for on drawings.

C. FOLDING DOORS. Side coiling, folding or stacking metal door assembly. Aluminum slats or panels, mill or clear anodized finish.

D. COLD STORAGE DOORS. Prefabricated door and frame units. Doors with galvanized steel face and vapor-sealed urethane insulation, 10 cm thick.

SECTION 08500 - METAL WINDOWS

A. EXTERIOR WINDOWS shall be aluminum window systems with double glazing. 4 cm by 10 cm tubular aluminum section.

B. ROLL-UP METAL SHUTTERS shall be provided where indicated.

SECTION 08700 - HARDWARE AND SPECIALTIES

A. FINISH HARDWARE shall be stainless-steel satin finish.

B. WEATHERSTRIPPING AND SEALS shall be provided.

C. THRESHOLDS shall be aluminum.

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SECTION 08800 - GLASS AND GLAZING

A. EXTERIOR GLAZING shall be clear plate glass. Obscure (translucent) glass may be provided.

B. TEMPERED GLASS OR WIRE GLASS shall be used for glazing doors where light size exceeds 0.6 m^2.

DIVISION 9 - FINISHES

SECTION 09010 - ROOM FINISH SCHEDULE

A. FINISH SCHEDULE, ABBREVIATIONS AND SCHEDULE OF ROOM FINISHES appear on the drawings.

SECTION 09200 - PLASTER

A. TYPES AND TYPICAL APPLICATION:

1. Stucco: Exterior surfaces.

2. Cement Plaster: Interior wet areas.

3. Gypsum/Cement Plaster: Other interior ceilings.

4. Lime/Cement Plaster: Other interior wall surfaces.

B. APPLICATION. Scratch coat, undercoat and finish coat. Overall thickness, 2 cm.

C. FINISHES

1. Exterior work, where indicated: sprayed finish coat, "trowel-touch" finish.

2. Other surfaces: smooth trowelled.

D. SKIRTING (BASE). Interior plastered walls to receive precast cement skirting 20 cm by 15 cm high by 3 cm thick, unless indicated otherwise.

SECTION 09300 - CERAMIC TILE (All projects except Serrow)

A. TILE. 15 cm by 15 cm, glazed ceramic tile.

1. Wainscots shall be thin-set ceramic tile, 1.5 m high.

2. Floors shall be "mud-set" and grouted.

SECTION 09330 - QUARRY TILE

A. TILE. Fired clay tiles, as selected by Architect for color and chemical resistant properties.

1. Size: 15 by 15 by 2 cm.

SECTION 09360 - PRECAST CONCRETE TILE

A. "PATIO BLOCKS." 20 by 20 by 2 cm.

B. ROOF TILES. 20 by 20 by 1.5 cm.

SECTION 09370 - STEELCRETE TILES

A. TILE. Concrete tile with top 8 mm of cement, sand and nonrusting metal shavings. Cure by water immersion.

1. Size: 20 by 20 by 2.5 cm.

SECTION 09421 - TERRAZZO TILE

A. MARBLE AGGREGATE TILE (RTP Only)

1. Aggregate: marble chips, color as selected by Architect.

2. Matrix: color as selected by Architect.

3. Size: 30 by 30 by 3 cm.

B. TERRAZZO TILES

1. Matrix and aggregate: as selected by Architect from manufacturer's standard selection.

2. Size: 20 by 20 by 2.5 cm typically, 15 by 15 by 2.5 cm where indicated.

SECTION 09510 - ACOUSTICAL CEILING (RTP)

A. EXPOSED GRID SUSPENSION SYSTEM. Steel with white enamel finish, "lay-in" system.

B. ACOUSTICAL TILE. Mineral fiber boards 120 by 60 by 1.5 cm nominal dimensions, fissured pattern, white washable finish.

SECTION 09680 - CARPETING

A. LOCATION. Director's office, RTP.

B. CARPET. As selected by Architect.

SECTION 09900 - PAINTING

A. MATERIALS: see finish schedule for applications.

1. Lime/glue paint.

2. Plastic (acrylic copolymer) paint

3. Oil (alkyd enamel) paint:

a. Interior and exterior steel door frames, steel relight frames, metal shelving, miscellaneous steel, wood shelving, and wood cabinets in shop.

b. Walls and ceilings of areas as indicated on finish schedule.

c. Provide primers compatible with substrates to be painted.

DIVISION 10 - SPECIALTIES

SECTION 10100 - CHALKBOARDS AND TACKBOARDS

A. CHALKBOARDS. Hardboard core with special paint surface.

B. TACKBOARDS shall be 6 mm thick cork tile with vinyl edge.

SECTION 10200 - LOUVERS

A. LOUVERS. Extruded aluminum, stationary type or manually operable at Serow, weatherproof, with extrusions not less than 2 mm thick.

1. Bird Screen: 1.2 cm square mesh, 0.6 mm diameter aluminum wire in removable aluminum frame, mill finish.

2. Louver and Frame Finish: Factory prime, ready to receive finish specified in Section 09900.

DIVISION 15 - MECHANICAL

SECTION 15010 - GENERAL PROVISIONS

A. SCOPE. The work covered by this section consists of furnishing all labor, materials and equipment for the installation of all piping and mechanical equipment, plus equipment to provide a plumbing system as shown on the drawings and as specified.

B. CODES AND STANDARDS. All equipment, apparatus and systems shall be furnished and installed in complete accordance with the latest edition or revision of the following applicable codes and standards.

1.	ASME	American Society of Mechanical Engineers
2.	ASTM	American Society of Testing Materials
3.	AWWA	American Water Works Association
4.	NBFU	National Bureau of Fire Underwriters
5.	NEC	National Electric Code
6.	NEMA	National Electric Manufacturers Association
7.	UL	Underwriters Laboratories, Inc.
8.	ANSI	American National Standards Institute
9.	AISI	American Iron and Steel Institute
10.	AFBMA	Anti-Friction Bearing Manufacturer's Association

Where conflicts arise between the plans and code requirements, the latter shall prevail, unless the plans are more stringent.

C. FLANGES AND PIPE THREADS. Unless otherwise noted, all flanges on equipment and appurtenances provided under this section shall conform in dimensions and drilling to ANSI B16.1, Class 125. All pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit. Bolted flanges shall be located away from walls and floors to provide for disassembling with standard tools.

D. GUARDS. All exposed moving parts shall be provided with guards. Guards shall be fabricated of 12-gage steel and expanded metal screen to provide visual inspection of moving parts without removal of the guard. Guards shall be galvanized after fabrication and shall be designed to be readily removable to facilitate maintenance of moving parts.

E. BEARINGS. Unless otherwise specified, all equipment bearings shall be oil or grease lubricated, ball or roller antifriction type of standard manufacture. Bearings shall be conservatively designed to withstand all stresses of the service specified. Each bearing, except when otherwise noted, shall be rated in accordance with the latest revisions of AFBMA Methods of Evaluating Load Ratings of Ball and Roller Bearings for one of the following classes of B-10 rating life: Class M1, 8,000 hours of operation; Class M2, 20,000 hours of operation; Class M3, 50,000 hours of operation; Class M4, 100,000 hours of operation. Bearings shall be not less than Class M3 unless otherwise noted.

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All grease lubricated bearings, except those specified to be factory lubricated for life, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be the standard hydraulic type.

Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 40 degrees C and shall be equipped with a filler pipe and an external level gage.

During transportation, bearings shall be suitably blocked or otherwise suitably protected to avoid work hardening or "Brinelling" damage from vibration. Bearings shall be separately packed if necessary to comply with this requirement.

F. SHAFT COUPLINGS.

1. General: Shaft couplings for direct connected electric motor-driven equipment 1/2-kW or larger shall be Type I or Type II as specified herein. Where requirements of the equipment dictate specialized features, the manufacturer may substitute the coupling normally supplied for the service. All couplings shall be nonlubricated type, designed for not less than 50,000 operating hours life.

   Coupling sizes shall be as recommended by the manufacturer for the specific application, considering horsepower, speed of rotation, and type of service. The use of couplings as specified herein shall not relieve the Contractor of his responsibility for precision alignment of all driver-driven units.

2. Type I Couplings: Reversing equipment or equipment with high torque loads shall be connected to their drivers by flexible couplings which can accommodate angular misalignment, parallel misalignment, and end float, and which cushions shock loads and dampens torsional vibrations.

3. Type II Couplings: Type II couplings shall be employed on normal torque, nonreversing applications. Type II couplings shall be of the pin and preloaded neoprene cylinder type, designed to accommodate shock loading, vibration, and shaft misalignment or offset. Stub shafts shall be connected through collar or round flanges, firmly keyed to their shafts, to neoprene cylinders held to individual flanges by through pins. Couplings with cylinders pinned to both coupling flanges will not be acceptable.

G. SPECIAL WRENCHES. Furnish any special wrenches or hand tools required for maintenance or operation of the equipment supplied.

H. WATER STOPS shall be provided on all pipe and fittings where shown on the drawings.

I. SPARE PARTS. Where spare parts are required by the specifications, they shall be wrapped in waterproof containers and shall be properly tagged and labeled "Spare Parts" followed by the name and number of the piece of equipment involved. Spare bearings shall be encapsulated in airtight plastic film.

J. LUBRICANTS. The Contractor shall furnish all mechanical equipment with supply and relief lubricant fittings and with its proper supply of correct lubricant for starting, testing and adjustment. The Contractor shall provide the Engineer with 3 copies of a list showing the proper lubricants for each item of mechanical equipment.

Unless other wise noted, all grease lubrication fittings shall be the standard hydraulic type.

K. STORAGE. All equipment shall be stored in a warm, dry, ventilated enclosure which shall afford complete protection against the elements and ensure that cleaned surfaces remain clean. All bearing capsules and housing shall be filled with fresh lubricant. All piping connections shall be plugged, blind flanged or capped to prevent the entrance of foreign objects and all space heaters in control panels shall be connected to a suitable power source.

These same storage precautions will be observed once the equipment has been installed on its foundations and will continue until the area is completely free of possible contaminants or other environmental hazards.

L. INSTALLATION

1. The Contractor shall supply and install all materials and equipment shown on the contract drawings and specifications unless otherwise noted.

2. All materials and equipment shall be installed in strict accordance with these specifications or manufacturer's recommendations subject to approval of the Engineer.

3. All equipment shall be installed straight and true with respect to the building or structure to which it attaches or the surrounding structures.

M. TESTING AND OPERATION. Operational and hydrostatic tests are specified in Section 15050 and applicable system specification sections.

N. SITE INSPECTION. The Contractor shall verify layout and check excavation and condition of trenches for underground work. Clearances, sleeving and proposed supports for above ground work shall be inspected. Preparation shall be made for any cast-in-place components. With respect to work relating to the water delivery piping and to the hatchery building, the Contractor shall have satisfied himself concerning all grades, levels, and true conditions under which the work is to be done.

O. SHOP INSPECTION. Work being done in the shop whether it be the Contractor's onsite shop or a subcontractor's facility shall be subject to inspection by the Engineer.

P. COORDINATION. The Contractor shall coordinate all work with the Engineer so work of other trades can be made without delays.

Q. ELECTRICAL WORK. Where special control panels are required or included as an integral part of a specific equipment item package the service and control wiring between these special panels and pieces of equipment shall be installed by the Electrical Contractor with coordination by the Contractor supplying the equipment.

The Electrical Contractor shall also be responsible for all electrical systems up to and including the junction boxes or local disconnect switches and wiring into the above mentioned special panels.

R. DEFECTIVE OR INCOMPLETE WORK shall be corrected at the Contractor's expense.

S. CLEANUP AND REPAIR

1. The Contractor shall maintain his operations in a neat and orderly manner causing as little inconvenience as possible.

2. Cleaning of Water and Air Lines: After installation testing has been completed and before insulation is applied, all lines shall be cleaned by flushing or other suitable means that will remove all foreign matter from the lines.

SECTION 15050 - BASIC MATERIALS AND METHODS

A. SCOPE. This section specifies all miscellaneous material, and procedures used for Division 15 work. General characteristics or requirements common to all motors, pumps, installation and testing methods are also specified in this section. The particular type of material and characteristics unique to each item such as type of valve to be used, pump capacity, motor RPM, test pressure requirement, and the like, will be specified in the system or equipment sections with a reference back to this section if required.

B. QUALITY ASSURANCE. Compliance with standards and requirements of the regulatory bodies called out in the system and equipment sections herein shall be met. Materials supplied shall be the product of manufacturers of established reputation regularly engaged in the fabrication of such equipment.

C. PIPE shall be as specified in Section 15060.

D. VALVES are specified in Section 15100.

E. MECHANICAL SUPPORTIVE DEVICES. All hangers and supports shall be galvanized and shall meet the requirements of Standard Practices SP-58 and SP-69 as approved by the Manufacturer's Standardization Society of the Valve and Fittings Industry, Inc.

F. PUMPS are identified and specified in Section 15140.

G. MOTOR AND ELECTRICAL REQUIREMENTS

1. General: All electrical requirements, except for motors driving mechanical equipment, are described in Division 16. Motors specified in this section shall be in accordance with the following, unless otherwise noted in the detailed specifications of a particular piece or type of equipment.

2. Standards: Motors shall be constructed in accordance with the latest standards of NEMA and ANSI and to the requirements of these specifications. They shall be the product of a nationally recognized electric motor manufacturer.

3. Type:

   a. Unless otherwise noted, all motors, 1/2 kW and larger, shall be three-phase, squirrel-cage induction type, connected and rated for operation on a 380-volt, 50 Hz, alternating current system.

   b. Unless otherwise noted, all motors smaller than 1/2 kW shall be standard single-phase capacitor-start, or repulsion-start, induction type, designed for operation on 220 volts, 50 Hz alternating current system. Small fan motors may be split-phase or shaded-pole type as standard with the drive.

4. Service Factors: Pump motors shall be non-overloading at all points of the pump curve. Use of the motor service factor during normal operation will not be allowed. Under operating conditions, no motor shall exceed 1/1 load. After installation, during start-up and testing, the actual load current of each motor will be measured and compared with the full load rating stamped on the motor name-plate. In no case shall the actual input exceed the nameplate rating. Deviation from this requirement shall be sufficient grounds to reject the equipment as not meeting the requirement of these specifications.

5. Motor Submittals: The following data shall be submitted for approval of each motor:

   a. Manufacturer's type and frame designation

   b. Kilowatt rating

   c. Time rating (per NEMA MG 1-10.36)

   d. Ambient temperature rating

   e. Temperature rise

   f. RPM at rated load

   g. Frequency

   h. Number of phases

   i. Rated-load amperes

   j. Voltage

   k. Service factor

   The foregoing data shall also be verified after installation and shall be included with the information to be furnished in the maintenance manuals.

H. VIBRATION ISOLATION. Vibration isolation equipment shall be furnished and installed by the Contractor in accordance with manufacturer's recommendations.

I. BOLTS. Unless specified otherwise, all exposed bolts including anchor bolts shall be non-ferrous, galvanized steel, or stainless steel.

J. GAGES

1. Pressure gages shall have 120mm diameter dial if mounted within 2 meters of floor or a 150mm diameter dial if mounted higher than 2 meters, stainless-steel bourdon tube, phenol case, double strength glass lens, balanced adjustable design pointer, accuracy within 1/2 of 1% of full range, 10mm NPT male bottom connection suitable for mounting on the wall or direct on the pipe unless specified otherwise.

Service	Full Range	
L.P. Air	0 - 100	K pascals
H.P. Air	0 - 1000	K pascals
Water	0 - 200	K pascals
Water	0 - 400	K pascals
Water	0 - 700	K pascals

2. Temperature gages unless specified otherwise shall have 120mm diameter dial, geared stainless-steel movement, phenol case, double strength glass lens, balanced adjustable design pointer, accuracy within 1% of full range, 10mm NPT male bottom connection.

K. HYDROPNEUMATIC TANK. The hydropneumatic storage tanks will be of the sizes shown on drawings. The tanks shall be designed to a working pressure of 125 psi (860 Kpa) and shall conform to ASME codes as applicable. Material shall be steel with suitable protective finish applied internally and externally. Coating applied to wetted surfaces shall be non-toxic to humans and aquatic life. Approved epoxy-type material may be used. Tank shall be furnished complete with the following:

1. Pressure gage 0 to 125 psi (0 to 860 Kpa).

2. Bronze relief valve set at 75 psi (515 Kpa).

3. Excess air valve for automatic bleed of excess air.

4. DPDT pressure switch adjustable range 20 to 80 psi (140 to 550 Kpa).

5. Supply and discharge connection screwed or flanged.

6. Sight glass with ball check and drain.

L. INSTALLATION

1. All materials shall be installed in strict accordance with manufacturer's recommendations and/or specifications and in the best commercial trade practice. Any special tools required for installation, laying, jointing or cutting shall be supplied by the Contractor and properly used.

2. All material and equipment for which no location dimensions are shown shall be installed in a neat and workmanlike manner in accordance with the best trade practice. It shall be the Contractor's responsibility to lay out properly all miscellaneous piping to clear obstructions and larger sized pipes.

3. All installations shall conform to lines and grades as shown on the drawings. Valves and special fittings shall be placed where shown on the drawings unless their location is changed by the Engineer. In the event field conditions dictate deviation from the plans, no change shall be made without written authorization of the Engineer.

4. Prior to starting work, the Contractor shall arrange for the manufacturers of equipment and pipe to furnish initial instructions on proper installation. These instructions shall in no way be construed to assume all or any part of the Contractor's, Engineer's, or Owner's responsibility for proper design, installation and inspection.

5. All equipment permanently base mounted on concrete floors shall be installed on a 140mm-high concrete base and shall be leveled and aligned. Grout shall be placed between the concrete base and the equipment base after alignment. All concrete and grout shall be neatly trimmed and finished, and all spatter shall be completely cleaned from all surfaces.

M. TESTING

1. General:

   a. The Contractor shall furnish all labor, tools and equipment for testing, including pressure pumps, piping, gates, temporary caps and supports. He shall make all arrangements and pay all costs incidental to furnishing and conveying water for testing purposes. Any damage resulting from or caused by these tests shall be repaired at the Contractor's expense.

   b. Test instruments shall be tested for accuracy prior to use to ensure accuracy of tests.

2. Hydrostatic Testing:

   a. Upon completion of installation of pipe, fittings, and valves, but prior to covering of joints, the Contractor shall hydrostatically test each system as specified herein.

   b. The Contractor shall install adequate blocking or other means of resisting test pressure where required.

c. Allow a minimum of 15 minutes after filling systems for natural absorption before starting tests. Clean up and dispose of surplus water after test.

d. Water used for testing shall be clean and free of contaminating material.

e. Testing of piping shall be accomplished as near as possible in complete runs or to a convenient cut off. Selection of the test sections shall be approved by the Engineer to assure that the desired test coverage is obtained.

f. A record of test sections shall be maintained by the Contractor. This shall include:

(1) Identification of test section or item listed.
(2) Test pressure obtained (if applicable.)
(3) Date of test.
(4) Signature of inspector.
(5) Leakage rate of section (where applicable and allowed).

3. Piping Above Ground:

a. Tests shall be made between valves where possible.

b. Equipment which cannot sustain test pressure shall be isolated or bypassed.

c. Test pressure and leakage shall be as specified in applicable system section. Pressure shall be maintained for a period of one hour minimum while all piping, joints, valves, fittings and hydrants are inspected for leakage. Where leaking joints are found, they shall be remade and a retest conducted.

4. Operational tests for systems will be as specified in applicable system sections. Tests requiring the operation of interfacing systems shall not be conducted until hydro testing and cleaning of the interfacing system has been completed.

5. Defective Work: All work found to be defective prior to or after testing, or otherwise not in accordance with the intent of the Contract Documents, shall be removed and replaced with proper work, all at the expense of the Contractor.

N. PAINTING AND CORROSION PROTECTION

1. Ferrous piping for buried installation shall be factory-coated with a bituminous coating unless otherwise specified herein. All joints, couplings and appurtenances shall be completely coated with a bituminous coating in the field after jointing is complete.

2. Ferrous Piping for Above-ground Installation:

   a. Field painting shall be by the General Contractor according to Section 09900 - Painting, unless otherwise specified herein.

      (1) A color code system will be used to identify piping systems including all components.

      (2) All pressure testing shall be done prior to any finish painting or coating.

      (3) All hangers and appurtenances shall be completely painted.

3. All exterior ferrous surfaces of equipment shall have factory-applied rust preventing primer. Verify with the Engineer the type of primer to be used before shipment. See Section 09900.

   a. Contractor shall provide identification labels and tags as follows:

      (1) Nameplates for motors, pumps, tanks, filters, and the like.

         (a) Engraved, brass nameplates with black enamel background.

         (b) The description, name and number to be the same as identified on the drawings.

         (c) Fasten with brass rivets or hang with brass chain as directed.

         (d) Characters shall be helvetica medium, upper and lower case and shall not be smaller than 7mm.

         (e) Final letter size to be selected by the Engineer.

      (2) Name tags for valves. Engraved, laminated plastic nameplates, white characters with black background, hung from brass chain. The minimum letter size shall be 7mm.

      (3) Labels for Pipes

         (a) Label shall be painted on all pipes with description as shown on the drawings. Direction of flow shall be indicated.

         (b) Markers shall be placed so that each exposed pipe can easily be identified for type and direction of flow. Markers shall be placed about every 8 meters on continuous pipe runs of 15 meters or more, and where most observable on shorter runs.

         (c) Every type of flow will be labeled at least once in every space through which a pipe passes.

(4) Pipe which shows corrosion or peeling of coating shall be sandblasted and resurfaced before installation. Pipe shall not be sandblasted while on hangers.

SECTION 15060 - PIPE AND PIPE FITTINGS

A. SCOPE. This section specifies piping material, methods and testing requirements for all pipe required for this project including that pipe to be used in the well water supply system.

B. MANUFACTURERS shall be of established good reputation, regularly engaged in the fabrication of such equipment. Unless otherwise noted, any equipment offered shall be current modifications which have been in successful regular operation under comparable conditions.

C. PIPING SCHEDULE

Designation	Pipe Materials
Culverts, pond inlet and outlet pipes	Reinforced concrete
Well, pump, and storage tank	Ductile iron steel
Potable water	Galvanized steel Ductile iron, cast iron PVC Asbestos cement
Well process water and Canal process water	Ductile iron, cast iron PVC Asbestos cement
Domestic and Process Wastewater	PVC ABS Asbestos cement Vitrified clay
Air supply	PVC Galvanized steel

D. STEEL PIPE AND FITTINGS

1. Piping:

a. Black pipe shall meet ASTM Standard A 53-76 Grade B, of standard weight conforming to ANSI B36.10 and shall have threaded ends or plain ends for welded joints and mechanical couplings.

b. Galvanized pipe shall be of standard weight and meet ASTM Standard A 120-76.

c. Protective coating for buried black steel pipe.

- For pipe 80mm and larger use a cement mortar lining to conform with AWWA standard C 205 and an exterior coal-tar enamel coating meeting AWWA Standard C 203, with a wrapping of asbestos coal-tar saturated felt and kraft paper.

- For pipe less than 80mm use one coat of coal-tar primer and two coats of coal-tar enamel conforming to AWWA C 203.

2. Fittings:

a. Factory made welded and flanged fittings for 100mm and larger steel pipe shall be seamless carbon steel conforming to ASTM A 234. Dimensions, tolerances, marking and welding bevel requirements shall conform to ANSI B16.9, Schedule 40. Flanges shall be 1,000 K pascals carbon steel complying with ASTM A 181 Grade I, and standard dimensions per ANSI B16.5. The joints shall develop the full strength of the pipe.

b. Field made fittings for steel pipe 100mm inches and larger shall be in accordance with AWWA Standard C 208-59. Protective coating material same as that for pipe.

c. For galvanized steel pipe less than 100mm, the screwed fittings shall conform to ANSI Standard B16.3.

d. For black steel pipe less than 100mm, fittings shall conform to ASTM A 105-76, ANSI B16.11 screwed connection 1,000 K pascals pressure. Protective coating materials shall be the same as those specified for pipe.

e. Dielectric Fittings: Provide insulating joints between nonthreaded ferrous and nonferrous metallic fittings and/or pipe. Dielectric fittings shall be installed between threaded ferrous and nonferrous metallic pipe.

3. Couplings:

a. Couplings shall provide a tight, flexible joint under all conditions such as pipe movement, minor variations in the trench gradients or traffic vibrations.

b. Couplings shall be any standard product as required for the intended service.

c. Push-on Joints: The couplings rated working pressure shall be not less than the service rating of the pipe in which it is installed. Middle ring shall have a minimum thickness of 10mm and follower ring a minimum thickness of not less than 5mm. Gaskets shall be as recommended by coupling manufacturer and middle and follower rings and bolts shall receive a shop coat of rust inhibitive primer.

d. Grooved end joint couplings may be used in lieu of flanged, welded or screwed joints for steel pipe, provided they meet all provisions required.

When used, mechanical grooved couplings and fittings shall be cast of malleable iron conforming to ASTM A47-74 or ductile iron ASTM A536-72. The coupling shall be of the grooved, mechanical type which engages grooved or shouldered pipe ends. The coupling shall be cast in two or more parts per manufacturer's standard. Coupling gasket shall be of molded synthetic rubber EPDM Grade "E" conforming to ASTM D2000 designation 2CA615A15B44F17Z. Bolts and nuts shall be heat treated carbon steel conforming to ASTM A183-68, minimum tensile 750,000 K pascals and oval neck track head type. Fittings shall be of grooved or shouldered end design to accept grooved mechanical couplings without field preparation. Flanges for connecting flanged components into the grooved system shall be as recommended by the manufacturer.

On steel pipe, grooving shall be in accordance with manufacturer's specifications. Pipe sizes 20mm through 600mm may be cut grooved except that pipe with wall thickness less than the minimum recommended by the manufacturer shall be roll-grooved without the removal of any metal.

Collared or shouldered end pipe shall be in accordance with manufacturer's recommendation and Engineer approval.

D. DUCTILE IRON PIPE AND FITTINGS

1. Pipe and fittings shall be ductile-iron conforming to AWWA C 150, 151 and ANSI A21.51 with cement mortar lining conforming to ANSI A21.4 and rated for 1,000 K pascals water working pressure except pipe with threaded or grooved ends which shall be Class 53.

2. Fittings shall be ductile or cast iron conforming to ANSI A21.10 (AWWA C 110) except end preparation shall be different for grooved end-joint couplings as specified herein.

3. Joints shall be flanged, mechanical, push-on, or grooved end as shown on drawings or specified herein and designed for 1,000 Kpascals water working pressure.

   a. Flanged joints shall have ductile or cast-iron flanges conforming to ANSI B16.1, Class 125, good for 1,700 K pascals water working pressure. Threads for flanges and pipe barrel shall conform to ANSI B2.1. All bolts and nuts shall be hot-dip galvanized ductile iron or steel. Flanged joints shall have full-face factory-formed rubber gaskets.

   b. Mechanical joints shall conform to ANSI A21.10 (AWWA C 110) and ANSI A21.11 (AWWA C 111). All bolts and nuts shall be hot-dip galvanized ductile iron or steel.

c. Push-on joints shall conform to ANSI A21.10 (AWWA C 110) and ANSI A21.11 (AWWA C 111).

d. Grooved end joint coupling for non-buried pipe shall be of the grooved, mechanical type which engages grooved pipe ends. The coupling shall be cast in two or more parts per manufacturer's standard. Coupling gasket shall be of molded synthetic rubber flush seal type conforming to ASTM D 2000 designation. Bolts and nuts shall be heat-treated carbon steel conforming to ASTM A 183, minimum tensile 750,000 K pascals and oval neck track head type. Fittings shall be of grooved or shouldered end design to accept grooved mechanical couplings without field preparation. Grooving shall be "rigid radius cut grooved" per manufacturer's standard unless otherwise directed by Engineer. Victaulic Style 31, Smith-Blair 472 ME-PRE-GRUV or equal. Grooved end joint couplings and fittings may be used in lieu of flanged joints shown on the drawings at Contractor's option provided they meet all provisions required.

E. COPPER TUBING AND FITTINGS

1. Tubing: Copper tubing shall comply with ASTM B 88 annealed Type L above ground. Brass pipe for nipples shall comply with ASTM B 315.

2. Fittings:

a. Fitting for water systems shall be soldered cast bronze complying with ANSI B16.18 or wrought copper or bronze complying with ANSI B16.22 and ASTM E 75

b. Copper tubing not to be used for process water.

F. PLASTIC PIPE AND FITTINGS

1. PVC Schedule 80:

a. Plastic pipe, 80mm and smaller, shall be high impact Polyvinyl Chloride (PVC), Schedule 80. Pipe shall conform to dimensions, tests and requirements of ASTM D 1785-74.

b. Material to be PVC 2112.

NOTE: Potable water use. Pipe and fittings that are intended for transport of potable water shall be evaluated for this purpose by a laboratory recognized by the public health profession and regulatory bodies having jurisdiction. The seal or mark of the laboratory making this evaluation shall be included in the marking of the pipe that is intended for potable water transport.

2. Drain, Waste and Vent Pipe:

a. These pipes, when made from plastic, shall be either ABS (Acrylonitrile Butadiene Styrene) or PVC (Polyvinyl Chloride) in accordance with the following standards:

ABS - ASTM D 2261-76; Commercial Standard CS-270-65.
PVC - ASTM D 2665-76; Commercial Standard CS-272-65.

b. Material:

(1) ABS - Type 1.
(2) PVC - Type 1, Grade 1.

3. Flanges: Material shall be the same as pipe with drilling to ANSI B16.1, 125-pound (860 Kpa) flat face.

4. Gaskets: Neoprene, full face, 3mm thickness or as recommended by pipe manufacturer.

5. Fittings and Bends:

a. General:

(1) Fittings shall conform to standard ANSI long-radius type fittings and as indicated in the manufacturer's standard literature.

(2) I.D. of all pipe fittings shall be consistent with the I.D. of the pipe.

(3) Pipe bends, where used, shall have a minimum bending radius of 5-pipe diameter. Minimum tangent length shall be as indicated in the manufacturer's standard literature.

b. PVC Schedule 80 threaded in accordance with ASTM D 2464-74. Material same as pipe. Socket joints may be used where called out in system specification or shown on the drawing.

c. DWV. ABS-type fittings shall be socket joint, solvent welded in accordance with ASTM D 2661-76 and Commercial Standard CS 270.

PVC-type fittings shall be socket joint, solvent welded in accordance with ASTM D 2665-76 and Commercial Standard CS 272.

6. Design Characteristics:

a. Pipe and pipe fittings shall be designed for use according to accepted piping practice. The ultimate physical properties shall be as follows:

	ASTM TEST	K PASCALS @ 25°C
Ultimate Tensile Strength	D 2105-67	61,800 min.
Modulus of Elasticity	D 2105-67	2.2×10^6
Hydro Burst Hoop Strength	D 1599-74	206,000 min.

b. Maximum operating temperature shall be 38°C. at maximum working pressure of 1,700 K pascals. Pipe also subject to -34°C temperature with no internal pressure.

c. Pipe inside diameter shall not be less than the nominal pipe size indicated on the drawings.

7. Bolting: Zinc-plated steel or nonferrous.

8. Solvents: Solvents used shall be compatible with the piping system used and conform to the following:

ASTM D 2235-73 for ABS
ASTM D 2564-73a for PVC

G. CONCRETE PIPE AND FITTINGS

1. Reinforced concrete, low head pressure pipe, shall be manufactured in accordance with the provisions of ASTM C 361 (AWWA C 302-74) with steel bell-and-spigot joint surfaces and shall be Class B-100. Reinforcement shall be circular with minimum wall thickness of 7.5 cm.

Reinforced concrete, noncylinder type, low head pressure, pipe and fittings shall conform to current provisions of AWWA C-302. Bell-and-spigot joint rings shall be coated with a 10-mil, three-coat Amercoat 83-84 system. The exterior joint space shall be mortar-grouted and the interior joint space shall be mortar-painted. Fittings, specials and closures for use with this concrete pipe shall be of the same design as the pipe with which they are used. Fittings shall have plate reinforcement as may be required.

The Contractor shall submit, for approval by the Engineer, details of reinforcing steel, details of joints, harnesses, and specials that may be required.

The Contractor shall furnish detailed drawings of the connection between the steel pipe and concrete pipe if used. Particular attention shall be made to the flexible joints or couplings which shall have the capability of withstanding a 40mm differential settlement within 2 meters of the wall.

2. Reinforced concrete gravity sewer pipe shall be bell-and-spigot type with rubber gasket joints. Pipe shall be manufactured in accordance with ASTM C 76, Class IV. Rubber gasket and joints shall be manufactured in accordance with ASTM C 443.

Wyes, if required, shall be shop fabricated from reinforced concrete pipe conforming to ASTM C 76, Class II. The thickness of the graft shall be at least as thick as the largest pipe and reinforcing steel shall be equivalent to pipe reinforcing. Joints shall be as shown on the plans. The Contractor shall submit design and method of manufacture for approval by the Engineer.

3. Nonreinforced concrete pipe shall be bell-and-spigot type with rubber gasket joints. Pipe shall be manufactured in accordance with ASTM C 14 and shall be Class II. Rubber gasket and joints shall be manufactured in accordance with ASTM C 443.

H. ASBESTOS CEMENT PIPE shall conform to ASTM C-428, Class 2400 for sewer and drain pipe and AWWA Standard C400 for water pipe.

I. VITRIFIED CLAY PIPE shall conform to ASTM C-700 and shall be installed in accordance with ASTM C-12.

J. FLEXIBLE COUPLING ADAPTERS

1. Follower flanges shall be made of:

   a. malleable or ductile iron
   b. rolled steel

2. Flanges shall conform to AWWA C 207-55, Class D or ANSI B 16.1.

3. Gaskets per ANSI A21.11.

4. "O" Ring - Neoprene.

5. Bolting - Zinc-plated steel.

6. Middle and follower ring and bolts shall receive a shop coat of Koppers Inertol Rust Inhibitive Primer No. 621.

K. REMOVABLE TEST PLUGS. Removable test plugs shall be the product of the pipe manufacturer.

L. GENERAL PIPING INSTALLATION

1. Routing:

   a. Piping shall be run parallel and square with the lines of the structures unless otherwise indicated.

   b. Wherever possible, runs and rises shall be grouped and kept parallel. It shall be the Contractor's responsibility to lay out properly all miscellaneous piping to clear obstructions such as passageways, equipment, and larger sized pipes.

2. Joining of Pipe Sections:

   a. Before joining, all scale shall be removed from steel pipe.

   b. Piping shall be accurately aligned. No section shall impose stress on an adjoining section due to misalignment or incorrect length. Flexible couplings shall not be used to compensate for misalignment.

   c. Flanged Joints:

      (1) Flange adaptors or Dresser-type couplings shall be installed in all mechanical joint piping to facilitate the removal of sections for maintenance or repair.

(2) Flanged joints shall be made up true and square so that there is no strain on pipe or valve. Bolts shall be tightened uniformly around the joint.

(3) Flanged pipe shall be installed using full-facing rubber gaskets between each pair of mating flanges. Gaskets shall be factory-formed. All bolts shall be installed in flanged pipe but shall not be tightened until the complete run of piping has been installed and aligned. Bolts shall be tightened uniformly.

d. Threaded Joints:

(1) Thread joints shall be neatly cut with sharp tools.

(2) After cutting, all pipe shall be reamed.

(3) All pipe shall be screwed together with an application of approved pipe compound applied to all male threads and once a joint has been screwed up, it shall not be backed off unless the threads are recleaned and new compound applied. This application shall be neatly made and all compound and dirt shall be thoroughly wiped off the outside of every joint. Compound used shall not be toxic to aquatic life.

(4) Unions shall be installed in all threaded joint piping to facilitate the removal of sections for maintenance and repair. All such unions shall be included in the bid price whether shown on the drawings or not. Connections between pipes of dissimilar metals shall be made with insulating unions (dielectric). This shall include cast-iron valve connections to adaptors for copper pipe.

3. Pipe Supports:

a. All piping, valves, and fittings shall be securely fastened to the structure with hangers, supports, guides, anchors or sway braces to maintain pipe alignment, prevent sagging and straining due to uncontrolled movement. All supports shall support the weight of pipe, fittings, valves and contents without exceeding the maximum recommended load for the pipe support.

b. Pipe supports shall be as called out on drawings. If no pipe support is called out, support shall be selected in accordance with Section 15050.

c. Pipe supports shall be installed to support pipes at all pump connections and changes in direction.

d. Contractor shall provide special supports under the pipe where fixtures such as valves, and the like, are to be supported by the pipe. No attempt is made to show all of these supports or hangers on the drawings but the Contractor shall be required to include such supports and bracings and they shall be installed in a manner which would be considered as good practice in the trade and in compliance with the requirements of the Engineer.

e. Pipe supports shall be spaced generally as shown on the drawings, but in no case shall support spacing exceed that recommended by the pipe manufacturer for the service intended. Vertical pipes shall be anchored at floor level by suitable galvanized steel straps. No straps or hangers of plumber's tape shall be acceptable.

f. Contractor shall provide additional supports which may be determined necessary by the Engineer for the proper suspension, bracing, or support of the pipe.

g. Hanger rods shall be threaded on ends only. No all-thread rods will be accepted.

h. Pipe supports shall be installed with anchorage adequate to hold the maximum recommended load of the pipe support.

i. Pipe to be embedded in concrete shall be secured in place to prevent displacement during concrete placement. Do not weld embedded pipe to reinforcing steel. Embedded pipes without seep collars may, at the Contractor's option be grouted into blockouts. Grouting shall be in accordance with Section 03300.

4. Buried Pipe:

a. Before any length of pipe is placed in the trench, a careful inspection shall be made of the interior of the pipe to see that no foreign material is in the pipe. In order to properly remove any foreign material, a swab of necessary length and diameter is to be available at all times. The pipe shall be kept clean until accepted in the completed work.

b. In distributing the material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench. All pipe and fittings shall be loaded and unloaded piecemeal by hand or in bundles by lifting with hoists or skidding so as to avoid shock or damage. Under no circumstances shall such materials be dropped. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground. Care shall be taken during placement of coated pipe to avoid abrasion of the pipe coating.

c. All pipe shall be lowered carefully into the trench, properly aligned and jointed by use of suitable tools and equipment, in such a manner as to prevent damage to water line materials and protective coatings and linings.

d. Under no circumstances shall materials be dropped or dumped into the trench. The pipe and fittings shall also be inspected for the purpose of determining if they are sound and free from cracks. Laying of pipe shall commence immediately after excavation is started.

e. No pipe shall be laid in water or when, in the opinion of the Engineer, trench conditions are unsuitable. When pipe laying is stopped at night or for any other reason, water-tight plugs shall be used to exclude dirt, water and small animals.

f. Under no conditions shall the pipe be laid against wall of trench. The minimum distance for exterior of pipe to trench wall shall be 23cm unless indicated otherwise on the drawings. Extra precaution shall be taken to prevent rocks or other large objects from lodging against the pipe during backfill.

g. Pipe shall be laid with bell ends facing in the direction of the laying, unless the main is being laid down a steep incline, in which case the bell ends shall face uphill.

h. Wherever a pipe passes from concrete to earth, a bell-and-spigot joint or a flexible coupling shall be installed. Particular care shall be taken to ensure a full support of the pipe in the earth between and beyond the joints.

i. All piping to be buried below structures, foundations or slabs shall be installed with extreme care. When all joints have been made, the Contractor shall demonstrate to the Engineer's satisfaction that all piping is watertight and that all lines are clear before proceeding with any work above this piping. It shall also be the Contractor's responsibility to see that these lines are kept clear until final acceptance of the project, providing suitable tight wooden bulkheads or plugs for open-end pipes.

j. Exterior surfaces at all joints, couplings, and all scraped or bare spots on buried pipe shall be field-coated with a bituminous coating of coal-tar or asphalt-base material with minimum thickness not less than original factory coating.

5. Thrust Restraints:

a. Where indicated on the drawings, piping joints shall be restrained by tie rods or thrust blocking to prevent slippage of the joints.

b. When used, poured concrete blocking, consisting of concrete having a 28-day compressive strength of not less than 20,600 K pascals, shall be placed after all piping included in the test section is in place. The concrete shall be poured against undisturbed soil and against the fitting or pipe, care being taken that no joints are covered. The concrete shall be allowed to set at least seven days before filling with water or subjecting to any pressure.

6. Low Point Drains: All low points in overhead piping shall have 25mm drain valves. The drain shall be routed to the nearest wall, or as directed by the Engineer. The drain valve shall be located as directed by the Engineer.

M. IRON PIPE INSTALLATION

1. General:

   a. Grooved end-joint pipe be installed in strict accordance with the manufacturer's recommendations.

   b. Ductile-iron pipe joints above ground shall be flanged or mechanical grooved end coupling as shown on drawings or if not shown, the joint shall be as directed by Engineer.

   c. Ductile-iron pipe joints below ground shall be mechanical joint or push-on type as shown on drawings. Joints not shown on drawings or otherwise designated shall be as directed by Engineer.

   d. Flanged pipe shall be installed using full-facing rubber gaskets between each pair of mating flanges. Gaskets shall be factory-formed.

   e. Laying of Pipe on Curves: Maximum deflections at pipe joints and laying radius for various pipe lengths shall be as found in the standard for Ductile-Iron Pipe, push-on joint, AWWA C 600-64.

   f. Gasket shall not be unpacked until the joint is prepared and ready to be made up.

2. Preparation:

   a. Each length of pipe or fitting shall be inspected before it is laid. All pipes with cracks or other defects shall be replaced at the Contractor's expense.

   b. Field Cuts: Avoid field cutting of pipe if at all possible. If pipe must be cut in the field, the cut end shall be conditioned so that it can be used to make up the next joint. Bevel the outside of the cut at an angle of approximately 30 degrees to prevent damage to the gasket.

   c. All lumps, blisters and excess coating shall be removed from the joint of each pipe; and the outside and inside of all joints shall be wire brushed and wiped clean and dry and free from oil and grease before the pipe is laid.

   d. Remove all foreign matter from the socket, making sure the gasket seat is clean.

   e. The gasket shall be wiped clean with a clean cloth, flexed and properly placed in the socket for a snug fit in the retainer seat.

   f. Apply lubricant furnished by the pipe manufacturer on the surface of the gasket, which will come in contact with the plain end of the pipe to be laid.

g. Clean the plain end of the pipe and apply a thin film of lubricant about 25mm back from the end. Keep the pipe free of ground or trench sides to avoid foreign matter from clinging to the lubricant.

h. Mark the plain end of the pipe to indicate when the proper depth will be reached during make-up of the joint.

i. Just prior to slipping the plain end of the pipe into the socket, the pipe and gasket surface which it contacts shall be brushed with a soap and water solution.

3. Joint Make-up:

a. The plain end of the pipe should be aligned and carefully entered into the socket until it just makes contact with the gasket. This is the starting position for the final assembly of the joint.

b. Joint assembly should then be completed by jacking the plain end of the entering pipe past the gasket (which is thereby compressed) until it makes contact with the bottom of the socket. A system of marking the pipe shall be used to make certain the assembled joint is at the proper depth.

c. All bolts shall be installed in flanged pipe but shall not be tightened until the complete run of piping has been installed and aligned. Bolts shall be drawn up to a uniform torque of from 70 to 80 newton-meters for 15mm bolts, 80 to 120 newtonmeters for 20mm bolts, 95 to 135 newtonmeters for 22mm bolts and 160 to 200 newtonmeters for 25mm bolts. Bolt threads and nut-bearing surfaces shall be lubricated before tightening. Bolts shall be tightened gradually so that the gland is brought up evenly, maintaining at all times a uniform distance between the gland and the face of the flange all around. If, under test, leakage occurs at the joint, this shall not be corrected by further tightening the bolts, but the joint shall be completely disassembled, and reassembled after thorough cleaning.

4. Joint protection exterior surfaces of all joints and all scraped or bare spots or buried pipe shall be field-coated with a bituminous coating of coal-tar or asphalt base material with minimum thickness not less than original factory coating.

N. COPPER TUBE INSTALLATION. Joints for tubing shall be made with solder type fittings. Tubing shall be cut square with burrs removed inside and out. Outside of tube where engaged in the fitting and inside of fitting in contact with the tube shall be cleaned with an abrasive material before sweating. Joints shall be made with a noncorrosive paste flux and solid wire solder. Core solder will not be permitted.

Threaded joints for copper pipe shall be a thread joint compound applied to the male threads before making the joint. No more than three threads shall show after the joint is made. All copper embedded in concrete shall be covered with heat shrink sleeves or plastic tape.

O. PLASTIC PIPE INSTALLATION. Piping shall be installed in accordance with piping system manufacturer's recommendations as to joint make-up. Fittings, pipe and solvent shall be a system of one manufacturer. Do not mix ABS and PVC in the same piping system.

Pipe shall be supported with pipe supports spaced according to the pipe manufacturer's recommendation for working pressure of pipe system. Pipe supports shall be as detailed on the drawings and where not shown, in accordance with manufacturer's recommendations and/or this specification.

Socket-welded fittings or lap-welded joints shall be installed with cementing materials as recommended by the pipe manufacturer and without projection of the cementing material into the interior of the pipe.

All materials used in the system shall be compatible with live fish after material has cured. Curing period shall be completed prior to completion of contract.

P. CONCRETE PIPE INSTALLATION. Reinforced concrete pipe sections shall be carefully fitted together without damaging the bell-and-spigot. The rubber gaskets shall be fitted properly in place and lubricated as necessary, and the pipe units shall be fitted together in a manner to avoid twisting or otherwise displacing or damaging the gaskets. The pipe sections shall be drawn together so that the bells and spigots are as fully engaged as practicable. Laying operation shall be with the bell end of the pipe facing the direction of laying and generally in an uphill direction.

Bell-and-spigot joints shall be made in accordance with the instructions of the manufacturer. The joint surfaces shall be cleaned of all dirt and the pipe is lowered into the trench. The gasket and inside surface of the bell shall be lubricated with a suitable vegetable compound soap, and the rubber gasket then properly installed. The spigot shall then be inserted and seated in correct position by use of a joint puller or other approved method. After seating, each joint shall be checked with a feeler gage to ensure that the gasket is not twisted and that the spigot is seated to the proper depth. Any improper joints shall be taken apart and correctly made.

Q. HYDROSTATIC TESTING

1. Upon completion of installation of pipe, fittings, and valves, the Contractor shall hydrostatically test piping to applicable system requirements. The tests shall be made between valves and as far as practicable in length as may be directed by the Engineer.

2. Fluid lines shall be tested as follows:

Line(s)	Test Pressure
Canal water supply and service	860 K pascals
Well water supply and service	860 K pascals
Drains	—

3. Leakage shall not exceed a rate of 4 liters per 25mm of diameter per 30 meters in 24 hours. Minimum testing period shall be as specified by the Engineer, but shall be no less than 15 minutes.

SECTION 15100 - VALVES, GATES AND OPERATORS

A. SCOPE. The work covered by this section consists of furnishing all labor, materials and equipment necessary for storage, installation and required fabrication of all valves, sluice gates and associated operating devices.

B. QUALITY ASSURANCE - GENERAL. All valves shall conform to the dimension, weight and tolerance indicated on submitted drawings. Valves shall meet ASTM/ ANSI/AWWA Specifications as required herein.

C. GENERAL. Contractor has option to select from the materials of construction listed herein for the valve only, if no material of construction is called out on the drawing. All valves shall be manufacturer's standard design unless otherwise specified and shall be furnished with operating handles. A union or flanged connection shall be provided within 0.5 M of each threaded end valve unless the valve can be otherwise easily removed and such technique of removal is approved by the Engineer.

D. BALL VALVES. Valves, 100 mm and smaller.

1. Plastic body, ball and stem with Teflon seats and Viton seals. Valves shall be union end socket type design (single or double entry).

2. 316 stainless-steel body, ball and stem with Buna N seal and seat. Valves shall be screwed connection below 50 mm, wafer or flanged ANSI B 16.5, for sizes above 50 mm.

3. Ball valves used in pump suction lines shall be full port valves.

E. BUTTERFLY VALVES. Valves, 100 mm and larger.

1. General

a. Valve shafts shall be one piece, Class 18-8, Type 316SS, extending full size through the valve disc and bearings; stub shafts are not acceptable.

b. All butterfly valves shall be of the tight-closing, resilient seat type with seats which are bonded to the valve body. No metal-to-metal sealing surfaces are permitted. Valves shall be bubble tight at 1,700 K pascals rated pressures with flow in either direction and shall be satisfactory for applications involving valve operation after long periods of inactivity. Valve discs shall rotate 90 degrees from the full-open position to the tight-shut position. Valve bearings shall be sleeve-type corrosion-resistant and self-lubricating with load not to exceed 17,000 K pascals. All butterfly valves shall be either flange or wafer-type with drilling to ANSI B16.1, 1,700 K pascals.

c. Butterfly valves 150 mm and smaller may be furnished with notch plate lever-type handles.

2. Metal Body Valves

   a. Bodies shall be constructed of cast-iron ASTM A 126-73, Class B.

   b. Discs shall be constructed of ASTM A 436-72a, Ni-Resist, Type 1 or 2.

   c. Seats shall be a Buna-N simultaneously molded in, vulcanized and bonded to the valve body; seat bond must withstand 335 newtons pull under test procedure ASTM D 429-58, Method B; seats affixed to disc are not acceptable and ring-type rubber seats not permanently affixed to body are not acceptable.

3. PVC body valves shall have PVC body and disc, Buna-N or Viton seat.

4. All valve nuts, bolts and studs shall be nonferrous or galvanized steel.

5. Buried valves shall be specially designed for buried service and meet the design requirements of AWWA Standard C 504-70, Section 13.4.

F. VALVE BOXES, INDICATORS AND OPERATORS

1. Valve operators shall be designed to hold disc in any intermediate position between full open and fully closed without creeping or fluttering. They shall be totally enclosed, lifetime lubricated, fully gasketed and designed to withstand submersion of water to 70 K pascals when used for buried applications.

   Valve operator shall be travelling-nut type designed to withstand 400 newtonmeters of input torque at full open or closed positions without damage to the valve or operator. Valves shall open with a counter-clockwise rotation of a standard handwheel, crank or AWWA nut and shall require a maximum of 30 turns to move from fully open to fully closed. Extension operator supports shall be provided as required and where shown on the drawings. All above-ground operators shall be furnished with indicators attached to operating shaft to show the actual position of valve disc.

2. For buried installation, valve boxes of sufficient length to permit operation of the valves shall be supplied with the valves. The valve box shall be of the extension type, with length sufficient to extend from the pipeline up to the surface of the finished grade, provided with a detachable iron lid of at least 150 mm in diameter.

   The boxes shall have a surface-mounted valve position indicator with adaptor that is installed directly in the valve box and will show disc position, direction of rotation and the number of turns from the full-open to the full-close position.

   Castings for cast-iron parts of valve boxes shall conform to the requirements of the Standard Specifications for Gray Iron Castings, ASTM Designation A 48-74.

   All bolts, nuts or studs shall be nonferrous or galvanized.

G. GLOBE VALVES. Valves shall be bronze with bronze disc, 860 K pascals service, screwed connection.

H. CHECK VALVES

1. Check valves, 60 mm and smaller, shall be iron body and bronze disc, 860 Kpa service, with screwed connection.

2. Check valves, 80 mm and larger, shall be 860 Kpa all-iron construction swing check, flanged connections.

3. Check valves for fire service system shall be 1,200 Kpa working pressure, cast-iron body with bronze trim, UL listed. Valves shall be flanged and drilled to ANSI B16.1 860 Kpa. These valves shall be of the swing check design.

I. GATE VALVES, 50 mm and smaller, shall be bronze with bronze trim, nonrising stem, wedge disc, 860 Kpa service, screwed connection.

J. PETCOCKS shall be bronze with threaded connection.

K. HOSE BIBBS installed inside structures shall be all bronze with composition disc and screwed connection and shall be 20 mm unless otherwise noted.

L. RELIEF VALVES/COMBINATION AIR VALVE

1. Definitions

a. Air Relief Valve: A valve designed to allow exhaust of small pockets of air from the line while in use shall be installed where shown on the drawings or directed by the Engineer.

b. Combination Air Valve: Combination air release valves (single body, double orifice) allow large volumes of air to escape out the large air vacuum orifice when filling a pipeline and to close watertight when the liquid enters the valve. During large orifice closure, the small air release orifice will open to allow small pockets of air to escape automatically and independently of the large orifice. The large air vacuum orifice shall also allow large volumes of air to enter through the orifice during pipeline drainage to break the vacuum.

2. Materials: Air relief and combination valves shall be cast-iron body, cover and baffle with stainless-steel float ball. Miscellaneous components and operating mechanism shall be bronze. The valves shall have screwed connections for sizes below 80 mm.

M. SQUARE-HEAD COCKS shall be all bronze for 860 Kpa service with screwed connection.

N. STRAINERS shall be Y-pattern, bronze body, 860 Kpa with 20 mesh monel screen. Strainers shall have screwed connection.

O. PREFABRICATED SLIDE GATES shall be Armco Model 10-00 or equal. Frames and fasteners shall be galvanized steel, gates and stems shall be painted carbon steel. Gates will not be watertight and some leakage will occur even in the fully closed position.

P. LEVEL CONTROL GATE shall be an AVIO Model 90/63, constant downstream level gate, as manufactured by Alstham Atlantic Company.

Q. INSTALLATION. All valves and gates shall be installed in accordance with AWWA standards or in accordance with the manufacturer's recommendations. Alignment and adjustments shall be verified after installation. Tee wrenches and operators shall perform freely, without binding or other interferences.

1. Valves shall be cleaned and Contractor shall touch up all previously primed surfaces to repair damages. Contractor shall make visual check of operating parts for proper and satisfactory operation.

2. Buried valves shall be installed in a vertical position and be provided with a cast-iron valve box. The valve boxes shall be set to position during backfilling operations so they will be in a vertical alignment to the valve operating gear shaft. The lower casting of the unit shall be installed first in such a manner as to be cushioned and to not bear directly upon the body of the valve or upon the water line. The upper casting of the unit shall then be placed in proper alignment at such an elevation that its top will be at final grade.

   Buried valves shall be bedded and backfilled according to the requirements of the pipe that they are attached to and Section 02221.

3. Gates: All gates shall be installed in strict accordance with the manufacturer's specifications and the drawing details. Gates mounted and anchored directly to concrete surfaces shall be installed with extreme care to avoid warping or distoring the gate frame preventing proper sealing or operation of the gate slide. After proper alignment, the frame shall be sealed at the wall with a two-part polysulfide sealant conforming to FS TT-S-00227E, Type II, Class A.

R. TESTING. The Contractor shall furnish all equipment, material and labor to perform the required tests. Any defects which become evident during the tests shall be corrected by the Contractor at his expense and the test re-run. The Contractor shall notify the Engineer prior to performing any tests.

1. Valves: All valves shall be tested and proven satisfactory with the pipeline they are attached to and at the pipeline pressure specified in the respective pipe sections herein. In addition to the pressure test, all valves shall be given an operational test by completely opening and closing the valve satisfactorily a minimum of 4 cycles against the maximum differential of pipeline test pressure required on one side and 0 pressure on the other side of the disc.

2. Gates and operators shall be adjusted and tested by operating through 4 complete cycles of closing and opening. Gates shall be adjusted so that they operate freely and leakage around the periphery shall be held to a minimum amount consistent with the intended use.

3. Records shall be maintained by the Contractor of all tests indicating date of test, item tested, test pressure passed, and inspector's name.

SECTION 15140 - PUMPS

A. SCOPE. The work covered by this section consists of furnishing all labor, materials and equipment necessary for a complete and satisfactory installation of the stationary pumps.

B. QUALITY ASSURANCE. The pumps shall conform to all dimensions and tolerances indicated on the submitted drawings. The pump manufacturer shall factory test all pumps in accordance with applicable portions of ANSI B58.1 and furnish to the Engineer 5 copies of the pump curve designated for each pump showing compliances with specification requirements. The curves shall indicate capacity, head, efficiency, horsepower, and net positive suction head. Pump manufacturer will be responsible for complete working pump assembly. This, in all cases, shall include the motor, see Section 15050.

C. PUMPS - GENERAL

1. All pumps supplied for this project shall be the manufacturer's standard design.

2. Pump designation and characteristics shall be as shown on the pump schedule as specified herein.

3. Pumps shall operate at optimum efficiencies to produce the most economical pumping system under the conditions encountered.

4. All pumps shall have mechanical seals and shall be water lubricated from the discharge line unless otherwise specified.

D. HORIZONTAL CENTRIFUGAL PUMPS

1. Mounting: Each horizontal centrifugal pump and its drive motor shall be integrally mounted on a cast-iron base with drip rim and drain connection.

2. Installation: Pump motor assemblies shall be installed on a concrete housekeeping pad at least 140 mm above the floor. After pump installation and alignment, grouting shall be placed between the base plate and the concrete pad in accordance with Section 15050. Minimum grouting thickness to be 20 mm.

3. Coupling: Pumps shall be direct driven through a flexible coupling of the rubber insert type.

4. Horizontal centrifugal pumps shall be end-suction type.

E. VERTICAL TURBINE PUMPS

1. Mounting

a. Pumps mounted on concrete curbs shall be mounted on a sole plate with minimum thickness equal to the pump mounting flange. After installation and alignment, grouting shall be installed between the sole plate and the concrete in accordance with Section 15050.

b. Vertical pumps without concrete curbs shall be mounted on structural steel with a dielectric washer separating the pump from the support steel.

c. Structural steel supports not sized on the drawings shall be designed by the Contractor.

2. Vertical pumps shall be as follows:

Designation	Location	Type	Discharge Characteristics
P-1, 2	RTP Building Pump Station	Vertical Turbine Peerless 9LA 4-Stage, or equal	1,045 LPM @ 27 m
P-3	Well/Storage Tank	Vertical Turbine Peerless 9LA 7-stage, or equal	1,300 LPM @ 47 m
P-4, 5	Serow Pump Room	Vertical Turbine Peerless, 3-stage, or equal	760 LPM @ 23 m
P-6	Serow Pump Room	Horizontal Centrifugal Booster Pump	760 LPM @ 35 m
P-7	MCS Pump Station	Vertical Turbine S.S. materials for saltwater	1,200 LPM @ 24 m
P-8, 9	MCS Pump Station	Vertical Turbine	900 LPM @ 6.7 m
P-10	MCS Administration Building	Horizontal Centrifugal Booster Pump	

F. INSTALLATION. Pumps shall be mounted off the floor on a house cleaning pad or as indicated elsewhere in these specifications, or the drawings, or as recommended by the manufacturer. Pumps shall be mounted true in the horizontal and vertical position.

G. TESTS

1. The Contractor shall operate the pump following installation and adjustment for a minimum of 1 hour at the head and capacity specified herein. The pump systems shall be put through a minimum of three operational cycles wherein only automatic control of the pumps has occurred. The test results shall verify that the pumps have been installed in conformance with applicable parts of ANSI Standard B58.1, and that all controls function properly. All tests and lengths of test periods shall be approved by the Engineer.

2. Deficiencies identified during testing shall be corrected at the Contractor's expense. The deficiencies shall be reported to the Engineer and a retest conducted if the Engineer so directs.

SECTION 15180 - THERMAL INSULATION FOR MECHANICAL SYSTEMS

A. SCOPE. This section covers the general requirements for field-applied insulation.

B. SUBMITTALS. For record purposes, Contractor shall submit an insulation schedule indicating manufacturer, system and thickness used on each piping or duct system.

C. MATERIALS

1. The materials used for piping and duct insulation shall be standard products. They shall be UL listed or labeled.

2. Fire hazard rating not to exceed 25 for flame spread and 50 for fuel contribution and smoke developed for insulation used on mechanical systems.

3. The insulation shall be a minimum of 25 mm thick.

D. LIST OF MANUFACTURERS

1. Johns-Manville

2. Owens Corning

3. Mobay Chemical Corporation

E. INSTALLATION

1. The potable/domestic water (hot and cold) piping shall have insulation applied inside buildings where heat transfer is detrimental to the function of the system.

2. The insulation shall be installed in accordance with manufacturer's recommendations as to thickness and application unless specified otherwise in the specifications. The manufacturer's entire system for any particular type of insulation shall be used, i.e., insulating material, adhesives, joint make-up method.

3. Exposed piping shall be finished with white pigmented lagging and pointed.

F. INSPECTION. The Contractor shall inspect all insulation and verify that it is continuous and without damage in all areas where application of insulation has been specified. The insulation shall be maintained and protected from damage until completion of the project.

G. DEFECTIVE OR INCOMPLETE WORK shall be corrected at the Contractor's expense.

SECTION 15370 - BASIC WATER SUPPLY SYSTEMS

A. SCOPE. The work covered by this section consists of furnishing all labor, material and equipment necessary for the construction of the following described water system to transport:

1. Canal process water from the El Wadi - El Quadim Canal throughout the pond system and through the RTP Building.

2. Well water, including both process well water to the RTP Building and potable water to the RTP Building, NAC Housing, MHC Housing, and MHC Fish Processing.

3. Canal water from the Navigation Canal to the Serrow Hatchery.

4. Canal water from the Main Drain No. 1 to the MCS facility.

5. Well water (salt water) to the MCS facility.

B. SUBMITTALS

1. Shop drawings shall include catalog cuts, pump curves, parts lists, operating instructions, detail drawings and other items necessary for the Engineer to check and approve the item.

2. Operating and Maintenance Manuals: The Contractor shall furnish the Engineer with five (5) separately bound copies of operating, maintenance and lubrication instructions, including complete parts list of all equipment furnished under this contract. The material shall be submitted to the Engineer for review, comment and correction prior to shipment.

C. PRODUCTS

1. Canal Water Concrete Structures: The canals and ponds shall comply with Division 3, Concrete.

2. Pre-fabricated slide gates shall comply with Section 15100.

3. Level control gate shall comply with Section 15100.

4. Shutoff gates and baffles in the ponds shall be fabricated from aluminum, plywood, or fiberglass-reinforced polyester as specified in Sections 05500, 06200, and 06600, respectively.

5. Pond screens shall be fabricated from structural steel frames per Section 05500 and plastic screen material per Section 06500.

6. Intake screen located at the RTP Building Pump Station shall be wedge wire screen, Profile B-9, with wire spacing of 3mm, as manufactured by Hendrix, or equal.

7. Pumps shall be as specified in Section 15140.

D. PRESSURE FILTERS

1. General: The filter station shall be by Baker Filtration Company and shall consist of multiple filter tanks, one influent (raw water) pipe header, one effluent (filtered water) pipe header, one backwash (wastewater) pipe header, and all valves required for backwashing each filter independently while keeping the others in operation. The control panel and all accessories shall be mounted on the wall where shown on the drawings.

2. Design Criteria: Each filter shall be capable of filtering raw water and removal of 98% of 20-micron or larger particles, at a flow rate of approximately 15 gpmsf. During backwash operation the on-line filters may operate up to 20 gpmsf and a rate of flow valve shall be supplied to restrict the backwash discharge line rate. Normal operating pressure as designed, is 40 psig with maximum pressure 60 psig.

   All materials in contact with the water shall be harmless to aquatic life.

3. Filter Tanks: Each filter tank shall be ASME code designed and stamped for a working pressure of 60 psi. Dished and flanged heads shall be fitted to each end.

   An 11-inch by 15-inch manhole complete with flange, steel cover, gasket, bolt and yoke shall be located in the top head of each filter tank.

   Filter tank shall be supported by pipe legs. All pipe connections shall be flanged 125-pound ANSI.

   A combination media dump port and drain complete with a stainless-steel media strainer and victaulic-type closure shall be provided.

Support brackets shall be provided for upper distributor and lower collector headers on the interior of the tank opposite the connections to the influent and effluent nipples.

4. Tank Lining: All interior, wetted surfaces of the filter tank and tank penetrations shall be sandblasted to white metal and the first coat of the tank lining shall be applied within 3 hours to prevent oxidation of the prepared surfaces.

   Tank lining shall be epoxy resin as recommended by filter manufacturer and shall be applied to all wetted surfaces of the tank and tank penetrations in two successive coats. Twelve hours curing time shall be allowed between coats, and the minimum thickness shall be 12 mils. The resin shall be non-toxic and tested by means of bioassay to be shown harmless to aquatic life.

5. Internal Distribution System: Filter internal equipment shall include filter manufacturer's standard upper distribution system and lower collection system, hydraulically balanced to prevent turbulence and/or displacement of the media during filtration.

   The upper distribution system shall include injection-molded Cycolac diverter lenses and lexan laterals located uniformly over the filter bed. They shall be jointed to the influent connection by means of a Schedule 80, PVC pipe header and Schedule 80 PVC pipes.

   The lower collection system shall consist of a Schedule 80, PVC pipe header and specially molded Lexan laterals designed to retain filter media with minimum head loss. The internal distribution system shall be designed to promote media bed circulation during backwash.

6. Filter media shall consist of uniformly graded silica sand which shall be free from limestone or clay. Media shall be selected in accordance with filtration requirements and shall have a uniformity coefficient not greater than 1.5. Working media depth and support media depth shall be proportioned for optimum filter efficiency.

7. Accessories: One each manual and automatic air vent valve on each tank.

   One pressure sight glass, design pressure 100 psi, on the backwash line.

   Dual 4-1/2-inch-diameter pressure gages shall be provided.

   Air filter/regulator/lubricator for pneumatic valve operation and control.

8. Pipe: Piping, fittings and flanges shall be cast-iron per Section 15062 of this specification. Piping coming into filter unit and leaving filter unit must be flanged to match piping in the rest of the mechanical room.

All necessary bolts, nuts, and gaskets shall be supplied.

9. Valves: Butterfly valves shall be per Section 15100 of this specification except they shall have Buna-N lining and stainless-steel trim.

   Raw water inlet valves and backwash valves shall be butterfly valves equipped with pneumatic actuator. Valve opening and closing time shall be 5 seconds. Air pressure available 100 psi.

   Filter water outlet valves shall be equipped with handles for manual isolation of each filter.

   Rate of flow valve shall be 8-inch Griswold flow control valve, No. 4378, cast-iron body and stainless-steel internal working parts set at desired discharge flow rate.

10. Control Panel: One fully automatic control system consisting of timers, step switches, relays, and selector switches and indicator lights mounted in a NEMA 4 enclosure shall be provided. All items shall be standard products from nationally recognized manufacturers. All automatic control components shall be mounted on the fabricated assembly and shall be tested in the factory ready for field connection to 220-volt power and 100 psi air.

    Initiation of filter cleaning cycle shall be by means of a differential pressure switch set at 15 psi. A pushbutton shall be provided for manual start of the filter cycle. Timer shall reset to zero during the cleaning cycle.

    Operation of the filter cleaning cycle shall be carried out by means of pneumatic valve actuators and four-way electro-pneumatic solenoid valves. During filtration of a station, the solenoid valves shall be de-energized and shall maintain all station valves in the "filtering position."

    Dialco pilot lights for each solenoid circuit, plus alarm and status condition lights shall be provided as specified and as recommended by the manufacturer.

11. Painting: The exterior surfaces of filter, piping and valves except PVC parts, and fabricated steel skid shall be painted with one coat of zinc chromate primer after thorough cleaning of mill scale, grease following factory testing. Finish painting shall comply with Section 09900, Painting.

E. WELL WATER

1. Well shall be installed as specified in Section 02580.

2. Pump shall be as specified in Section 15140.

3. Piping shall be as shown on the drawings and specified in Section 15060.

4. Storage tank shall be constructed from concrete as specified in Division 3.

5. Chlorinator shall be a liquid-type direct feed. Unit shall consist of a water meter, chlorine solution feed pump, and chlorine solution tank. Unit shall be similar to a Wallace and Tiernan Model A-429, water-meter driven.

F. SYSTEMS shall be tested as per manufacturer's recommendation with all discharge water bypassing the RTP Building and Serow Hatchery until the filters have been accepted without leaks and as functional.

SECTION 15400 - PLUMBING

A. SCOPE. The work covered by this section consists of furnishing all labor, material and equipment required for the plumbing work as shown on the drawings and as specified. Work under this section includes all of the potable water systems, drainage systems and vent systems.

B. MANUFACTURERS shall be of established good reputation, regularly engaged in the fabrication of such equipment. Unless otherwise noted, any equipment offered shall be current modifications which have been in successful regular operation under comparable conditions.

C. SUBMITTALS. Selection of materials and submittal of shop drawings shall be performed in accordance with Section 01300, Submittals. Where additional, more detailed submittals are necessary, those requirements are included in this section.

D. PIPING for the plumbing system shall be in accordance with Section 15060, with the following supplemental requirements:

1. Buried Pipe:

a. Pipe under floor slab shall be service weight, cast-iron soil pipe and fittings, or A.B.S. pipe and fittings, shall be first quality, smooth inside and out, of standard dimensions, free from cracks or sand-holes, coated with coal-tar pitch.

b. Buried pipe to 1.5 meters outside of building shall be service weight, cast-iron soil pipe and fittings, or A.B.S.

2. Pipe Out of Ground: Piping above floor in building shall be service weight, cast-iron soil pipe and fittings. Tyseal or No-Hub piping systems are acceptable. Pipe 50mm and under may be schedule 40 galvanized steel pipe, with cast-iron drainage fittings. DWV copper pipe and fittings or A.B.S. are acceptable.

3. Vents shall be DWV copper pipe of nominal sizes with wrought or cast solder fittings; service weight cast-iron soil pipe; Tyseal, No-Hub or A.B.S. piping systems are acceptable. Vents 50mm and under may be Schedule 40 galvanized steel pipe, with cast-iron fittings or A.B.S.

4. Acid-resisting pipe and fittings shall be Duriron, "GSR Fuseal", Kimax or Pyrex, acid waste systems. Install in accordance with the manufacturer's recommendations. Include installation instructions with submittal.

E. DRAINS

1. Floor drains shall be cast-iron body with polished nickel bronzetop. Strainer diameter 150mm, open area 60cm^2 minimum and "P" trap.

F. CLEANOUTS

1. Floor Cleanouts: Top shall be adjustable to the finished floor. Round top recessed for tile areas.

2. Wall Cleanouts: Countersunk plugs, with smooth round access cover, stainless steel.

3. Yard Cleanouts: Yard cleanouts shall be wye fittings of the same material as the piping connected thereto and be provided with plugs.

G. ELECTRIC WATER HEATERS shall be 200 liter capacity with glasteel lining, magnesium anode, thermostat, tinned copper element for 2,000 watts, 220 volts, 50-Hz, single-phase. Unit to be fiberglass insulated, white enamel painted metal case. Heater to carry five-year minimum tank warranty. Tested to 2,000 K pascals hydrostatic pressure and guaranteed to 1,000 K pascals working pressure.

H. FIXTURES. Plumbing fixtures include all sanitary fixtures, fixture carriers, supports, fitting appurtenances and accessories required to complete the plumbing installation. All plumbing fixtures, unless otherwise noted, are listed and illustrated in American Standard Plumbing Products Catalog P 72/73-HI Catalog. Fixture color shall be white. Fixtures of Crane or Kohler of similar model and quality will be acceptable.

1. The general arrangements and location of piping, fixtures and apparatus, shall be as shown on the drawings. All units shall be installed in accordance with the drawings except for minor changes as may be acceptable to the Engineer.

2. Fixture Schedule:

a. Water Closet: Elongated "Cadet" with elongated siphon jet action bowl (3089.018), vitreous china. Seat to be open front, commercial weight heavy-duty solid plastic, stainless-steel check hinge, white, 5320.114.

b. Urinal: "Maybrook," vitreous china, wall-hung washout urinal with flushing rim, 3/4-inch (20 mm) top spud, and 1-1/2-inch (40 mm) outlet with integral strainer.

c. Lavatory: Vitreous china, 20 by 18 inches (50 by 46 cm) for concealed arms, front overflow, faucet holes 4-inch (10 cm) centers, Scotian 0361.055. Faucet, aerator, with pop-up drain, Aquarian 2179.018. (Faucet, single control, aerator, grid drain, Moen No. 4600.) Carrier floor-mounted with concealed arms, Zurn Z-1231, Smith 700, or equal.

d. Laboratory Sink: Eighteen-gage, stainless-steel, self-rimming sink, sound dampened, Elkay DLFR-2519-10 with trap, supplied with stops, 8310.070 gooseneck faucet with lever handles.

e. Wall Hydrant: Standard design with 20mm male hose connection.

I. WASH-DOWN WATER HOSES. The Contractor shall furnish the following hose and fittings:

Sixteen 15-meter sections of 20mm diameter, flexible light-duty discharge hose. Each hose section shall be furnished with one male and one female coupling.

J. INSTALLATION

1. All horizontal runs of pipe in building and under floor slab shall have a grade down in direction of flow of 20mm per meter. If it is absolutely impossible to maintain a grade of 20mm per meter, piping may slope to a minimum grade of not less than 10mm per meter.

2. Support all horizontal runs of cast-iron soil pipe in building not to exceed 2.5 meter intervals and at each change of direction, and provide a support at the base of vertical risers with intermediate supports as required. All No-Hub and Tyseal shall be adequately braced to prevent motion, per manufacturer's recommendations.

3. Provide cleanouts in an accessible location at base of all risers in soil and waste piping and at each change in direction in horizontal runs of pipe. In long straight runs, provide a cleanout at least every 15 meters.

4. Joints in copper to be as specified in Section 15060.

5. Joints in cast-iron soil pipe shall be as specified in Section 15060.

6. Test system by closing all openings in pipe ends except in a vertical stack of at least 3 meters long; fill system with water to overflow. Water level shall remain constant for a period of 4 hours.

7. Provide a vent for each trap or as shown on the drawings.

8. Each vent shall rise vertically to a point not less than 150mm above the extreme overflow level of the fixture served before offsetting horizontally. Whenever two or more vent pipes converge, each such pipe shall rise to a point at least 150mm in height above the top of the plumbing fixture it services before being connected to any other vent.

9. Vents shall extend through the roof a minimum distance of 150mm, and shall not terminate closer than 5 meters horizontally from open windows, doors, or air intakes, and closer than 1 meter above such openings.

10. All vents shall be increased two (2) pipe sizes but not necessarily over 150mm where they pass through the roof.

11. Vents shall be flashed and counter-flashed. Flashings shall not be less than 45cm square. Prefabricated lead counter-flashing is required.

SECTION 15406 - COMPRESSED AIR SYSTEMS

A. DESCRIPTION OF WORK. The work covered under this section consists of furnishing all labor, materials and equipment for installation of the High Pressure and Low Pressure Air Compressor Systems.

B. QUALITY ASSURANCE. Compressors shall be factory tested, and certified performance curves furnished prior to shipment.

All dimensions, tolerance and interface shall be as shown on manufacturer's submitted drawings. Pressure vessels shall comply with ASME Code. Installation requirements/drawings and electrical schematics shall be furnished prior to shipment of compressors.

C. SUBMITTALS. Submit shop drawings showing dimensions of proposed equipment, materials of construction, and specific interface information.

D. PRODUCT DELIVERY AND STORAGE. Deliver, store, and handle all components and equipment in a manner to prevent damage. Store air compressors under cover in a dry and clean area. All components shall be tagged with system name, part name, and the like.

All damaged, broken or defective materials will be rejected.

E. HIGH PRESSURE AIR COMPRESSORS shall be factory assembled, complete unit with dual oil-less air compressors mounted on 60-gallon (240 L) vertical ASME coded tanks and accessories as specified herein.

Compressor shall be single stage for 100 psig (690 Kpa) continuous operating pressure and 120 psig (690 Kpa) intermittent usage. Compressor unit shall be equipped complete with safety valve, intake filter with muffler, internal pulsation chamber, aftercooler, automatic compressor switch, centrifugal pressure and moisture unloader, check valve, pressure gage, shutoff valve on tank outlet, automatic tank drain and tank mounting legs. Set compressor controls to energize motor at 110 psig (760 Kpa) and de-energize motor at 125 psig (860 Kpa).

1. Motor shall be 220-volt, single-phase, 50-cycle AC unit.

2. Compressor shall be air cooled and have a capacity of 1.7 cfm (8 L/sec.) each, Ingersoll-Rand, Powers Regulator Company, or Bell and Gossett.

F. BLOWERS. Provide 6 rotary positive displacement blowers, each having a capacity to deliver 50 scfm (236 L/sec.) against a discharge head of 5 psig (35 Kpa) and having a rotative speed not in excess of 2,200 feet per minute (11 m/sec.) measured at the pitch line of the timing gears.

Blowers to be rated for not less than 12 psig (80 Kpa) continuous service.

G. BLOWER CONSTRUCTION. All blowers shall be rotary lobe positive displacement type, of the 2-lobe involute design, and furnished by one manufacturer. The impellers, impeller casings and end plates shall be of a close-grained, high-strength cast-iron, i.e. meehanite.

The blower shall have removable nozzles to allow inspection of lobes without removal of inlet or discharge piping. The blower and motor to be mounted on soleplates and furnished with anchor bolts and sleeves.

The impellers shall be accurately, statically and dynamically balanced and permanently secured by means of a shrink fit and key to one piece stepped through shafts. The impellers shall be balanced to .01 inch ounces after profiling by metal removal and not by adding counter weights. The shafts shall be of 4,140 alloy steel and shall run in antifriction bearings, having a B-10 life expectancy of at least 100,000 hours. The impellers shall operate without rubbing or liquid seals or lubrication and shall be positively timed by a pair of accurately machined, matched, hobbed, shav d, crowned and nitrited helical gears, shrunk and pinned to the shafts.

The rear bearings and gears shall run in a splash oil-type housing. The front bearings shall be lubricated by a splash-oil system, contained within one oil reservoir. Front and rear covers to be removable.

The seals on the drive end and driven end bearing housings shall be of the piston ring labyrinth type and shall have air vents incorporated in the end plates to prevent oil penetration into the air chamber, and relieve excessive pressure on the seals. The seals shall have internal viton "O" rings.

The end covers shall be complete with amply sized oil sight glasses for observation of the oil levels.

H. MOTORS. Electric motors shall be of the squirrel-cage induction type and shall be TEFC suitable for 380/220 volts, 50-cycle, 3-phase power. The motors shall be 1,500 rpm, horizontal with a 1.1 service factor. Motors shall have sufficient power to drive the blowers at their maximum required capacity and operating pressure and also, the motors shall have sufficient power to discharge full blower capacity through the relief valve.

The motors shall be capable of delivering full rated power continuously throughout that range and the motors shall not operate within the service factor.

The motors shall be built in accordance with the current NEMA standard insofar as it applies. Insulation of the motors shall be Class B. Motor bearings shall be extra-duty, antifriction type and shall be suitable for B-10 rating of 100,000 hours.

I. DRIVE. Each blower shall be furnished with a V-belt, or flexible coupling drive, and belt, or coupling guards of sheetmetal and expanded mesh conforming to OSHA and applicable safety codes.

The V-belt drive shall be of the high-capacity matched belt, multiple-groove type, oil and heat resistance and static dissipating with a 1.5 service factor. The pulleys shall be of the split hub taper lock design dynamically balanced.

The coupling shall be a flexible all-steel, dynamically balanced coupling equal to Falk steelflex and shall provide for axial movement and shaft misalignment.

J. INTAKE AIR FILTERS. The manufacturer shall provide inlet filters. The filters shall be arranged for bottom connection to an ASA pipe flange. The filter elements shall be of the dry, washable, synthetic media type, selected to filter 99% of 10 micron and above particles. The filter shall be complete with a filter restriction indicator. There shall be a minimum of two filter elements and each unit shall be provided with two spare elements.

K. INLET SILENCERS. The manufacturer shall provide an inlet silencer for each blower. The silencers to be of the chamber-absorption type and shall be complete with matching drilled flanges and shall be of an all-welded steel construction.

L. DISCHARGE SILENCERS. The manufacturer shall provide a discharge silencer for each blower. The silencers to be of the chamber-absorption type and shall be complete with matched drilled flanges and shall be of an all-welded steel construction.

M. PRESSURE RELIEF VALVES. The blowers shall each be provided with a spring-loaded, or weighted type, pressure relief valve, set at 7 psig (50 Kpa) above the maximum working pressure and capable of discharging total blower output with 10% pressure accumulation.

N. CHECK VALVES. Each blower discharge line shall be furnished with a wafer split disc-type, or counter-weighted swing disc-type, check valve, designed for heavy on-duty type shutoff service. The valves shall be located approximately 8 pipe diameters downstream from the blowers.

O. BUTTERFLY VALVES. Each blower discharge shall be provided with a lever-operated butterfly valve, flanged or wafer, per blower manufacturer's recommendations.

P. FLEXIBLE CONNECTIONS. Each blower suction and discharge line shall be provided with ASA flanged single-arch type, multiple-ply, rubber or synthetic elastomer, reinforced flexible connector, suitable for 150°F (65°C) service. The flexible connection shall be complete with steel backing rings.

Q. INERTIA BASES. Each blower shall be complete with a floating inertia base, mounted on steel vibration isolators at each corner. The vibration isolators shall be of the spring type, suitably sized and properly placed, to eliminate vibration being transmitted into the supporting structure. The vibration isolators shall be securely attached to the inertia base. The base to be of open-channel construction with reinfocing rods on each lateral, and complete with a sheetmetal

bottom for concrete fill purposes. The base shall be complete with soleplates and anchor bolts in sleeves for insertion in the concrete. The soleplates shall be levelled and grouted in position to ensure proper blower and motor alignment as recommended by the equipment manufacturer.

R. HIGH TEMPERATURE SWITCH. Each blower shall be furnished with a high temperature cutout switch. The switch shall be general-purpose type NEMA 4 and include a remote 3/4-inch (20 mm) IPS stainless-steel bulb with well control, a vapor pressure-actuated brass bourdon tube, tilting-type sealed mercury contact external adjustment with locking device, visible setpoint dial and contact, wall-mounting bracket, back connection and sufficient length of copper capillary tubing.

S. THERMOMETERS. Thermometers shall be 90°F (32°C) back-angle with a 7-inch (17.8 cm) aluminum scale and with black etched figures, one with a range graduated from -50° to 100°F (-46° to 38°C) and a second with a range graduated from 80° to 300°F (27° to 150°C), a red reading, hand calibrated tube, a 3/4-inch (20 mm) stem including male pipe thread and a stainless-steel bulb.

T. PRESSURE AND TEMPERATURE GAGES. Each blower shall be furnished with one inlet and one discharge temperature gage and one discharge pressure gage. Gages shall be 4-1/2-inch (11.5 cm) dial-face type with MPT fittings for pipe insertion.

U. PRESSURE-REDUCING VALVES shall be industrial standard design for compressed air service. The valve shall be automatically self-adjusting to maintain the desired reduced pressure as indicated on the drawings. The valve shall have semi-steel or cast-steel body with stainless-steel trim, pressure rating 125 psi at 300°F (860 Kpa at 150°C). Pressure gages and shutoff valves shall be installed on both upstream and downstream of the valve, and a bypass line with globe valve shall be provided.

V. INSTALLATION

1. Air Compressors: The Contractor shall install the high-pressure and low-pressure air compressors at locations shown on the drawings. Compressors shall be installed in strict accordance with manufacturer's recommendations and the provisions of Section 15050.

2. Piping: The piping above and below ground shall be installed in accordance with the requirements of Section 15050.

W. TESTING. The entire high-pressure air system shall be tested to 135% of the operating pressure. The Contractor shall furnish all necessary test equipment and caps/plugs. A record of the test shall be maintained. Test pressure shall be maintained for a minimum of 60 minutes and no leakage is allowed. A solution of soap and water shall be applied to all joints to serve as a leak detector.

The low pressure system shall be tested and the Contractor shall provide all necessary test eqiupment to perform the test. A record of the test shall be maintained. The test shall be accomplished by charging the system with air to 15 psi (96.5 Kpa). An inspection of all joints shall then be made using suitable fluid wiped on the joints (i.e., soapy water) to indicate leakage. No leaks allowed.

All work found to be defective during the course of testing or otherwise not in accordance with the intent of the contract documents shall be corrected or replaced at the expense of the Contractor.

SECTION 15601 - GENERAL PROVISIONS: VENTILATING AND AIR CONDITIONING

A. SCOPE OF WORK. The work covered by this section consists of furnishing all labor, materials, and equipment for a complete and satisfactory installation and operation of the ventilating and air conditioning system as shown on the drawings and as specified in Section 15810.

B. CODES AND STANDARDS. All equipment, apparatus, and systems shall be fabricated and installed in complete accordance with the latest edition or revision of the following applicable codes and standards:

1. ARI. Air Conditioning and Refrigeration Institute.
2. ASHRAE. American Society of Heating, Refrigerating, and Air Conditioning Engineers.
3. ASME. American Society of Mechanical Engineers.
4. ASTM. American Society of Testing Materials.
5. NFPA. National Fire Protection Association.
6. NEC. National Electric code.
7. NEMA. National Electric Manufacturers Association.
8. SMACNA. Sheet Metal and Air Conditioning Contractors National Association.
9. UL. Underwriters Laboratory, Inc.
10. AABC. Associated Air Balance Council.

Where conflicts arise between the plans and code requirements, the latter shall prevail, unless the plans are more stringent.

C. SUBMITTALS. Contractor shall submit to the Engineer, full information of all materials proposed for use on the project 30 days prior to scheduled commencement of works. Submittals shall include material specifications, dimension drawings, catalog data and such descriptive data as may be requested in each

subsection or by the Engineer. No materials shall be purchased or installed until approved for use by the Engineer.

D. BEFORE FINAL ACCEPTANCE of the project the Contractor shall furnish to the Engineer 5 copies each of operating manuals, maintenance manuals, and parts lists for each specific model of equipment furnished.

1. Operating Manual shall be furnished by Contractor for inclusion in Operating and Maintenance Manual.

2. Maintenance Manual shall be furnished by Contractor. Maintenance Manual shall include the following:

   a. Description of routine maintenance required for each component.

   b. Suggested frequency of maintenance.

   c. List of lubricants recommended.

   d. Parts list.

   e. Supplementary drawings for required itemized servicing of maintenance points.

3. Binders shall be black, heavy loose-leaf with plastic tab sheets.

4. Manual must be submitted to the Engineer at least 5 normal work days prior to operating and instruction period of Contracting Agency's representative.

5. Operational Instruction Period: At the completion of the project, when systems are fully operational and at such time as designated by the engineer, a one-half-day systems operational instruction period for Contracting Agency shall take place. Contractor shall have his superintendent, and/or the foreman of various subcontracted portions of project present during this entire period. All operational and maintenance instructions shall be fully prepared and posted at this time. Complete item-by-item instructions shall be presented under direct supervision of the Engineer.

6. Final Inspection: Upon evidence of and operational test of facility per Paragraph H, Testing and Balancing, completion of above items and correction of items on final inspection list, the Engineer will recommend approval of the ventilating and air conditioning system installation.

E. MECHANICAL-ELECTRICAL WORK

1. Scope: Electrical work in connection with ventilating and air conditioning installation systems carrying over 24 volts shall be provided by the Electrical Contractor as indicated on drawings and specified. Equipment and installation shall conform to applicable paragraphs of electrical specifications. Coordination between the Ventilating and Air Conditioning Contractor and Electrical Contractor shall be required.

2. Material and Equipment: All motors shall be of the type required by equipment manufacturer, and of the size indicated in the schedules without using service factor. Each motor shall be compatible with motor starters furnished under Electrical Division and must be capable of developing starting torque without excessive starting current. All single-phase motors shall be capacitor-start type. All integral horsepower motors, unless otherwise specified, shall operate with ball- or roller-type bearings. Fractional horsepower motors may have wick-packed sleeve bearings. Motors less than 1/2 horsepower (1/2 kw) shall be single phase and motors 1/2 horsepower (1/2 kw) and larger shall be 3-phase unless otherwise noted. All motors 1/2 horsepower (1/2 kw) and larger shall be supplied by the Electrical Contractor unless specified otherwise.

3. Control wiring, conduit and wiring devices shall be as specified in Section 16100.

F. WARRANTY. The equipment specified under this division shall be covered by the manufacturer's standard warranty or guarantee on the new equipment. In all cases, the equipment shall be guaranteed for one year after acceptance and as further protected by the manufacturer's standard warranty.

G. INSTALLATION

1. All equipment shall be installed in strict accordance with the manufacturer's specifications. All equipment permanently mounted on concrete shall be installed on a base or curb as detailed in the drawings or as recommended by the manufacturer and shall be leveled and aligned.

2. Magnetic motor starters, unless furnished as an integral part of mechanical equipment, shall be furnished by Electrical Contractor complete with thermal overload relay in each phase. Packaged or integral starters furnished by ventilating and Air Conditioning Contractor shall also have overloaded protection for each phase.

   a. Power wiring shall be by Electrical Contractor.

   b. Control wiring circuits under 24 volts shall be installed by Ventilating and Air Conditioning Contractor.

   c. Ventilating and Air Conditioning Contractor shall provide all electrical controls.

   d. Ventilating and Air Conditioning Contractor shall furnish Electrical Contractor with a list of all motors under 1/2 horsepower (1/2 kw), showing all motor nameplate data, and shall be responsible to verify voltage and phase provided for motors prior to ordering.

   e. Wiring diagrams for installation purposes shall be furnished by the control manufacturer.

H. TESTING AND BALANCING

1. Balancing: Upon completion of Contractor's testing, balancing shall be performed by Balancing Contractor. Ventilating and Air Conditioning Contractor shall pay the cost of balancing and cooperate in the following manner:

   a. Provide sufficient time before final completion date so that tests and balancing can be accomplished.

   b. Provide immediate labor and tools to make corrections when required without undue delay.

   c. The Contractor shall put all ventilation and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing.

   d. The Ventilating and Air Conditioning Contractor shall include the costs of dampers, pulley and belt changes in his contract.

   e. Balancing shall be performed in complete accordance with AABC Standards for Field Measurements and Instrumentation Form No. 81266, Volume One, as published by the Associated Air Balance Council. Contractor shall submit written description of intended procedure and copies of all proposed forms to the Engineer for approval prior to commending any work.

2. Installation shall not be complete until final report is submitted to the Engineer.

SECTION 15810 - VENTILATION AND AIR CONDITIONING

A. SCOPE. The work covered by this section consists of furnishing all labor, materials and equipment necessary for the satisfactory and complete installation encompassing ductwork, exhaust fans, air conditioners and other items required for the distribution of air at low velocities and pressures, including fabric connectors, dampers, vanes, access panels, grilles, diffusers, registers, roofing curbs and specialties.

B. AIR CONDITIONING SYSTEM

1. Ductwork shall conform to SMACNA "Low Velocity Duct Construction Standards."

2. All ductwork shall be constructed of galvanized sheetmetal with internal duct insulation. Ductwork shall be roof mounted and weather tight.

3. Ductwork shall be supported at all fittings and changes in direction. For straight runs support every 2 meters.

4. Volume dampers shall be manually operated and provided as shown on the drawings and as necessary for the proper balancing of the air handling system(s). Dampers shall be single blade. Dampers shall be fitted with quadrant with position indicator and locking device.

5. Flexible connections between equipment and ductwork shall be waterproof, air tight, heat resistant, neoprene coated, fabric.

6. Grilles and Registers:

   a. Performance of all units shall be based on tests conducted in accordance with ADC Standard 1062 R2, "Air Diffusing Equipment Test Code," and ASHRAE Standard 36B, "Method of Testing for Rating and Acoustic Performance of Air Control and Terminal Devices and Similar Equipment." Air terminals shall be provided with gaskets.

   b. Sizes are shown on the plans with horizontal dimension given first and do not include borders. Net free area shall not be less than 60% of the area of duct attached thereto. Grilles and registers shall be provided with separate mounting frame. Finish shall be prime coat unless otherwise noted. Register and grille connections shall be in accordance with SMACNA Standards.

7. Square ceiling diffusers shall be provided and installed by the Contractor and shall be located as indicated on the Plans. Diffusers shall be of the fixed pattern type with stepped down core and 4-way horizontal air pattern. Diffusers shall be constructed of steel with baked enamel finish. Color to be selected by the Engineer. All square ceiling diffusers shall be furnished and installed with distributing grid and damper. Diffuser connection shall be in accordance with SMACNA Standards.

8. Air extractors shall be provided at all branch takeoffs.

9. Louvers: See Section 05500.

C. POWER ROOF EXHAUSTERS shall be roof curb mounted with capacities as shown on ventilation schedule on the drawing.

Power roof exhausters shall be a self-contained, internally vibration-isolated centrifugal forward-curved fan in a full housing constructed of fiberglass. The housing shall be hinged for easy access to fan unit, weatherproof, and symmetrical in shape. The fan unit shall be all-aluminum, belt drive, with adjustable motor sheaves and adjustable pulley centers. The impellers shall be statically and dynamically balanced with self-aligning, lubricatable impeller shaft bearings designed for thrust load. The motors shall be as indicated on the fan schedules and of the totally enclosed type. Power roof exhausters shall be "Pace" Sky-Cap, Penn Ventilator Company, Inc., or ILG Industries, Inc.

D. AIR CONDITIONERS

1. Rooftop Air Conditioner:

a. Air conditioner shall be Carrier 50 YH-042, single-package cooling unit or equal, with capacity as shown on the schedule. This unit shallbe a one-piece, factory-assembled, precharged, prewired, tested and ready-to-operate unit and be listed by Underwriters' Laboratories, Inc.

b. Compressor shall be a welded hermetic type with internal vibration isolation. Coils shall be of nonferrous construction with mechanically bonded plate fins. Factory-installed capillary tube shall provide refrigerant control.

c. Evaporator fan shall have a centrifugal forward-curved direct-driven blower. Condenser fan shall be direct-driven propeller type.

d. Controls shall be factory wired. Compressor and fan motors shall have both thermal and current sensitive overload devices. Control circuit transformer shall be factory installed.

e. Cabinet shall be a single, enclosed, weatherproof casing constructed of galvanneal steel bonderized and finished with baked enamel. Cooling section shall be fully insulated. Side panels and top cover shall be removable for service access.

f. Accessories shall include thermostat and subbase, colid-state pressure control for condensing fan motor control, and compressor restart time delay.

2. Through-the-Wall Air Conditioners:

a. Air conditioners shall have capacities as shown on the Air Conditioning Schedule on the drawings. Units shall be designed for single room use.

b. Units shall be equipped with 3-speed fan and air direction control. Units shall have air exhaust control.

c. Controls shall be concealed with an adjustable thermostat.

d. Units shall be factory assembled and tested complete with rigid filters.

E. DUCTWORK INSTALLATION

1. Ducts shall conform accurately to dimensions indicated which are net inside dimensions. Ducts shall be anchored securely to building and shall be installed so as to be completely free from vibration under all conditions of operation. Duct installation shall be in strict accordance with manufacturer's specifications and shall comply with SMACNA Low-Velocity Duct Construction Standards.

2. Air terminals shall be selected for type of construction and module of ceiling in which they are mounted.

3. Dampers: Damper rods opposite quadrant shall be fitted tightly in duct. Use hub plate. Dampers shall be provided where indicated and at all branches.

4. Deflecting dampers shall be installed at all supply branches. When deflecting dampers are adjusted for desired air delivery they shall be secured to ductwork.

F. POWER ROOF EXHAUSTER INSTALLATION. Power roof exhauster units shall be curb mounted and flashed as detailed on the drawings. Care shall be taken to ensure a watertight installation.

G. TESTING. Upon completion and prior to acceptance of installation, Contractor shall subject ventilating and air conditioning systems to such operating tests as may be required by Engineer to demonstrate satisfactory functional and operating efficiency. Functional tests shall be performed prior to balancing.

DIVISION 16 - ELECTRICAL

SECTION 16010 - GENERAL PROVISIONS

A. DESCRIPTION OF WORK. The work included under this division consists of furnishing all labor, materials, services, tools and other equipment necessary for the construction, installation, connection and testing of all electrical work for this project as shown on the drawings or specified herein.

B. INTENT OF DRAWINGS AND SPECIFICATIONS

1. One-line and control diagrams are schematic only and shall not be scaled to obtain exact locations.

2. The electrical drawings do not show complete details of the building construction. The Contractor shall check actual conditions and shall refer to architectural, structural and mechanical drawings.

C. COORDINATION OF WORK

1. The Contractor shall plan his work so that it proceeds with a minimum of interference with other trades.

2. The Contractor shall field verify all dimensions of equipment to be installed or provided by others so that correct clearances and connections may be made between the work installed by the Contractor and equipment installed or provided by others.

3. The Contractor shall arrange all conduit runs light fixtures and other equipment so that they do not interfere with duct work, structural members, etc.

4. No extra payments will be allowed where obstructions in the work of other trades, or work under this contract require offsets in conduit runs.

D. SUPERVISION. The Contractor shall maintain adequate supervision of the work and shall have a responsible person in charge at the site during all times that work under this contract is in progress, or when necessary for coordination with other work.

E. CODES. Work shall conform to the National Electrical Code and other applicable codes, even though not specifically mentioned for each item. These shall be regarded as the minimum standard of quality for materials and workmanship.

F. PORTABLE OR DETACHABLE PARTS

1. The Contractor shall retain in his possession and shall be responsible for all portable and detachable parts or portions of installations such as fuses, key locks, adaptors, blocking clips, and inserts until completion of his work.

2. All equipment shall be demonstrated to operate in accordance with the requirements of this specification and the manufacturer's recommendation.

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G. SUPPORT BACKING. Provide any necessary backing required to properly support all fixtures and equipment installed under this contract. This work will include all necessary hangers, supports and mounting brackets.

H. CUTTING, PATCHING AND FRAMING

1. The Contractor shall determine in advance the locations and sizes of all sleeves, chases, and openings necessary for the proper installation of his work.

2. Whenever practical, inserts or sleeves shall be installed prior to covering work. Cutting and patching shall be held to a minimum. All required holes in concrete construction shall be made with a core drill and patched with cement grout.

3. Cutting, fitting, repairing and finishing of carpentry work, metal work, or concrete work, etc., which may be required for this work shall be done by craftsmen skilled in their respective trades. When cutting is required, it shall be done in such a manner as not to weaken walls, partitions, or floors; and holes required to be cut in floors must be drilled without breaking out around the holes.

I. TESTS

1. The Contractor shall furnish all power, labor, material, instruments and tools to make all connections for testing of the electrical and instrumentation installation. All equipment shall be demonstrated as operating properly prior to the acceptance of the work. All protective devices shall be operative during testing of equipment. All deficiencies or unsatisfactory conditions shall be corrected by the Contractor.

2. After visual inspection of joints and connections and the application of tape and other insulating materials, all sections of the entire wiring system shall be thoroughly tested for shorts and grounds. A log of results for each circuit shall be kept by the Contractor and presented to the Engineer.

3. A phase rotation check shall be made to demonstrate that all power receptacles, service feeders, and main power feeders have the same A-B-C phase rotation.

4. Equipment shall be tested by operating all electric motors, relays, switches, heaters, etc. sufficiently to demonstrate proper installation and electrical connections. Control and emergency conditions shall be artificially simulated where necessary for complete system or subsystem tests.

5. Insulation resistance measurements of each 380-volt circuit shall be made with loads connected and contactors, if any, blocked closed to give complete circuits. Insulation resistance of complete circuit shall be measured from the circuit breaker load terminals with the breaker open. The Engineer shall witness these tests. A log of complete results shall be prepared by the Contractor and presented to the Engineer. Values of resistance shall be 10 megohms or greater.

SECTION 16100 - BASIC MATERIALS AND METHODS

A. DESCRIPTION OF WORK. All electrical materials, equipment and devices shall comply with the content of this section.

B. QUALITY ASSURANCE.

1. Standards: Equipment and materials for this contract shall be approved for installation in accordance with the National Electric Code and/or all appropriate local codes.

2. Each major component of equipment shall have the manufacturer's name, catalog number, capacity and rating on a nameplate securely affixed on the equipment in a conspicuous place.

C. MATERIALS. All contract materials shall be new, of proven quality, without imperfections and blemishes. All material not specifically detailed in the contract documents required to accomplish the completion of this contract shall be of comparable quality to the items specified and be approved by the Engineer. All materials shall be products of manufactures regularly engaged in production of such equipment and shall be of the manufacturer's latest design.

Where two or more units of the same classes of equipment are required, these units shall be of the same manufacturer.

D. RACEWAYS AND FITTINGS

1. RACEWAYS shall be a minimum 3/4-inch (22 mm) trade size and conform to the following:

a. Rigid metal conduit shall be steel, hot-dipped galvanized, conforming to UL No. 6, or equivalent.

b. Electrical metallic conduit (EMT) shall be electrogalvanized and shall conform to UL No. 797, or equivalent.

c. Flexible metal conduit shall conform to UL No. 1, or equivalent.

d. Liquidtight flexible metal conduit shall conform to UL No. 1, or equivalent.

e. Nonmetallic conduit shall be polyvinyl chloride (PVC) schedule 40.

2. FITTINGS

a. All metal fittings for rigid conduit shall be hot-dip galvanized. Terminations shall be by means of threaded hubs or double locknuts and insulating or grounding bushings. Unions shall be Erickson couplings or Crouse-Hinds UNY series or Appleton or Pyle-National equivalents. Running threads or set screw connectors will not be permitted.

b. EMT coupling and connectors shall be compression-ring type, rain and concrete tight. Crimp type, die-cast or set screw connectors will not be permitted.

c. Locknuts shall be heavy-duty steel for sizes 3/4 inch to 2 inches (22 to 50 mm) and malleable iron for sizes 2-1/2 inches (65 mm) and larger, as manufactured by Appleton, Thomas and Betts, or Gedney.

d. Insulating bushings shall be molded bakelite type "A" as manufactured by OZ Manufacturing Company or Thomas and Betts or Gedney equivalents.

e. Grounding bushings shall be galvanized steel or malleable iron with insulated throat as manufactured by OZ, Thomas and Betts, or Gedney.

3. BOXES AND CABINETS

a. Junction and pull boxes for use in indoor finished areas shall be fabricated from sheet steel and have set-in lip for flange-type cover and shall be standard NEMA 1 construction. Box and cover shall be primed and painted with two coats of grey semi-gloss enamel inside and outside after fabrication. Cover mounting screws shall be cadmium-plated, located no further than 6 inches (150 mm) apart. Box sizes and gages shall be in accordance with the fill requirements of the NEC unless otherwise noted on the drawings.

b. Outlet boxes, junction boxes, mountings for use in unfinished or wet locations shall be cast metal and gasketed weathertight. Outlet and switch boxes for concealed work shall be pressed steel, plated or galvanized, sized for conductor fill per the NEC. Minimum size shall be 4 inches (100 mm) square or octagonal equipped with plaster or extension rings to suit conditions. Boxes and covers for EMT runs may be pressed steel in dry locations.

E. WIRE AND CABLE

1. Wire and cable shall conform to the latest requirements of the NEC and shall meet IPCEA specifications. Wire and cable shall be new and shall have size, insulation type, voltage and manufacturer's name permanently marked on the outer covering at regular intervals. Feeder conductors and all wire No. 8 AWG (10 mm^2) and larger shall be stranded. Branch circuit wire No. 10 AWG (6 mm^2) and smaller may be solid. Wire for power and lighting service shall be factory color coded with a separate color for each phase, neutral and ground to be used consistently throughout the system. Conductors No. 4 AWG (25 mm^2) and larger may have black insulation with a minimum of six (6) half-lapped wrapped layers of colored plastic tape for color coding purposes.

2. Building interior wire shall be soft-drawn copper, type THW 600-volt insulation and of minimum No. 12 AWG (4.0 mm^2) size, except as otherwise noted or specified herein.

3. Direct burial wire shall be soft-drawn copper, type USE 600-volt insulation and of minimum No. 12 AWG (4.0 mm^2) size, except as otherwise noted or specified herein.

4. Wire terminations shall be accomplished as follows:

   a. Branch circuits shall utilize 3-M "scotch-locks," Ideal or Thomas and Betts equivalents for splices and connections to fixtures.

   b. Control wiring shall utilize tool-applied pressure, indent connectors as manufactured by Thomas and Betts, Burndy, or Buchanan. Both connector and tool shall be specifically cataloged for the wire size being used.

   c. Lugs for wire sizes larger than No. 6 AWG (16.0 mm^2) shall be pressure-type solderless connectors as manufactured by Burndy, Thomas and Betts, or Anderson.

F. OVERCURRENT PROTECTIVE DEVICES. Thermal-magnetic circuit breakers shall have quick-make, quick-break toggle mechanisms, and shall be trip free on overload and short circuit. Multiple pole breakers shall have common trip with a single handle. The breaker handle shall indicate the open, closed, or tripped position.

G. SAFETY SWITCHES. Safety switches or disconnect switches shall be of the nonfusible type and shall be horsepower rated. They shall be of the current rating required by the load served and rated at 400 volts, 2 or 3 pole, heavy duty. The switches shall be safety interlocked with provisions for padlocking as manufactured by Square D, General Electric, Westinghouse, or ITE.

H. WIRING DEVICES

1. General:

   a. Wiring devices shall be specification grade and of the configuration shown on the drawings.

   b. Device mounting height shall be as indicated below or as shown on the plans. Dimensions shall be taken from the finished floor elevation or final grade to the center of the device.

   c. Devices shall be installed to present a neat symmetrical appearance, plumb and square with the structure.

2. Switches:

   a. Wall switches shall be tumbler-type, rated at 250 volts, 6 or 10 ampere, AC. Switches shall be single pole, two pole, or three way as indicated on the drawings. Mounting height shall be 1.2 meters.

   b. Weatherproof switches for wet locations and process areas shall be the same as above except they shall be installed in a cast metal box with a gasketed, hinged, spring-return cover.

3. Receptacles:

   a. Receptacles shall be parallel post type rated at 250 volts, 10 amperes, as shown on the drawings. Mounting height shall be 23 cm.

b. Weatherproof receptacles shall be installed in a cast-metal box with a gasketed, hinged, spring-return cover.

4. Cover plates shall be of the type and size indicated for all wiring and control devices. Plates shall be anodized aluminum. When devices are installed in exposed conduit boxes the plate or cover shall be of a type designed specifically for the box used. Covers in wet areas shall be gasketed.

I. SUPPORTING DEVICES. Conduit supports shall be by means of galvanized, malleable iron, one-hole straps. Conduits may be suspended from the structure on rods with suitable beam clamps and pear clamps or channel trapeze. Anchors for concrete shall be drilled lead anchors.

J. GROUNDING MATERIALS. All metallic fittings, boxes, cabinets, panel boards and other equipment shall be bonded into one electrically continuous grounded system either by means of a metal interconnecting conduit system, a bare No. 6 (16 mm^2) copper bonding wire, or a combination of both. The system shall be solidly grounded at the electrical service and at other points as necessary.

K. INSTALLATION

1. Trenching and Backfill: The Contractor shall provide all required trenching and backfill necessary for the installation of his work. Buried conduits shall be installed a minimum of 0.5 m below grade and direct burial conductors shall be installed a minimum of 0.6 m below grade. Except as noted, backfill shall be compacted to 95% compaction in layers of no more than 15 cm. Conduits and conductors shall be bedded in fine sand placed at the bottom of the trench. Burial depths may be deviated from, with the Engineer's approval, if obstructions such as sharp rocks are encountered. Care shall be exercised with bedding materials so that any changes in elevation result in gradual slopes. A yellow plastic tape with black letters reading "CAUTION - BURIED ELECTRIC CABLES" shall be placed approximately 20 cm above cables prior to completing backfill. Contractor shall be responsible for correcting all settlements of his backfilling and all other related damage within the guarantee period.

2. Conduit:

a. Conduits in finished areas shall be concealed wherever practical. All other conduits shall be surface mounted.

b. Rigid galvanized steel conduit shall be installed for the following conditions:

(1) Concrete slabs, below slab on grade, or in above grade concrete walls or ceilings.

(2) All embedded or underground conduits in other areas.

(3) All conduits 5 cm PS and above.

(4) All conduits in exterior or damp locations or in production areas.

(5) Exposed locations below 1.2 m and wherever conduit is not protected from mechanical injury.

c. Flexible conduit may be used for final connection to all vibrating or rotating equipment.

d. EMT may be used in all conditions except those listed above.

e. Exposed conduit shall be run in straight lines parallel to column lines, walls, or beams. Where conduits are grouped, bends and fittings shall be installed to present an orderly appearance. Unnecessary bends or crossing shall be avoided.

f. Conduit shall be grouped wherever possible and supported by means of wall brackets or trapeze installations consisting of 12 gage (3 mm) preformed channels.

g. Supports for conduit runs shall be provided every 5 feet for 3/4-inch (1.5 m for 2 cm) and not less than every 8 feet for 1 inch (2.4 m for 2.5 cm) and larger. Conduit shall be supported no further than 30 cm from terminal boxes, pull boxes or fittings. Supports shall be secured by means of toggle bolts on masonry, expansion inserts in concrete or brick, machine screws to tapped holes in metal surfaces, or wood screws to wood surfaces.

h. Conduit shall be securely fastened to metal boxes and cabinets with a locknut and bushing inside the box and a locknut outside. The conduits shall be of such length that when the bushings are screwed tight against the ends of the conduits, no appreciable space will be left between the bushing and the locknut, with the locknut tightened against the box in such a manner as to assure a continuous ground connection. All conduit in panelboard enclosures shall have insulating grounding bushings connected to the ground bus.

i. Conduit joints and connections shall be made thoroughly watertight and rustproof by means of thread compound which will not insulate the joint.

j. Structural members shall not be cut or drilled to avoid interference. Structural steel members may be drilled and tapped for support bolts, providing the prime or finish coat is maintained in its former condition. Structural prestressed concrete members may be drilled for anchors only in locations specifically approved by the Engineer.

3. Boxes: Terminal, junction, pull and outlet boxes shall be installed in general on the surface, level and plumb and affixed to the surface with appropriate sized anchors. Outlet boxes on exterior surfaces shall be installed flush with the surface, level and plumb.

L. WIRING METHODS

1. All conductors shall be sized per the NEC or appropriate local standard for the load serviced. Larger sizes may be installed at the Contractor's option to utilize existing stock sizes provided conduits are increased where necessary to conform to the NEC and providing the wire has been manufactured within 2 years from the time of installation.

2. Splicing shall be minimized, and shall be accomplished only in outlets, junction or cabinet boxes. Splicing will not be allowed in power or control wiring except as specifically approved by the Engineer.

3. Wire pulls by powered mechanical means will not be permitted except where approved by the Engineer. Pulls in general shall be by hand. Conduit shall be thoroughly cleaned of all foreign material just prior to pulling wire or cable. Lubricants shall be compounds specifically prepared for cable pulling and shall not contain petroleum or other products which will affect cable insulation.

4. Splicing of conductors No. 10 AWG (6.0 mm^2) or smaller shall be by pre-insulated spring-pressure connectors. All uninsulated splices, joints and free ends of conductors shall be covered with rubber and friction tape or high dielectric strength plastic tape.

5. Circuits shall be identified by wire markers, E-Z code, Brady or Thomas and Betts, at the following locations:

   a. All power and lighting branch circuits and feeders at fixtures, outlets, motors, etc. shall be marked with markers indicating panel and circuit number at which each circuit or feeder originates.

   b. All branch circuits shall be marked in the panelboard gutters. Markers shall indicate corresponding branch circuit numbers.

   c. All signal and control wires shall be marked at all termination points, such as cabinets, terminal boxes, equipment racks, control panels, consoles, etc. Marking shall be in accordance with approved schedules prepared by the equipment manufacturer or by the Contractor.

   d. All receptacles and junction boxes used to terminate circuits shall be labeled with panel designation and circuit numbers.

6. Direct burial cables may be used at building exterior locations, 1.5 m beyond the outside edge of the building foundation. Where direct burial cables cross under roads, driveways, parking areas, etc., they shall be run in rigid metal conduit for the entire length of such crossing.

7. All underground electrical cables and conduits shall have routing identified as exactly as possible on the as-built drawings. In addition, a concrete monument, flush with grade, shall be provided at each change of direction of underground wiring. These monuments shall be identified and located by station on the as-built drawings.

8. Safety Disconnects: The Contractor shall provide safety disconnects for all motors and equipment that are not so equipped by the manufacturer, in addition to the disconnects indicated on the drawings.

M. GROUNDING

1. All conduit systems, supports, cabinets, switchboards, equipment cases and motor frames shall be permanently and effectively grounded. Continuity of equipment grounds shall be maintained throughout the system. Grounding fittings shall be of the type specifically designed for grounding. Where the ground conductor is enclosed in conduit, the ground clamp shall be of the type which grounds both the conductor and conduit. Copper clad strap metal or perforated strap will not be permitted for grounding or bonding purposes.

2. The neutral of each separately derived AC system shall be grounded at a single point to the ground grid.

3. Insulating grounding bushings shall be installed to bond all conduits 1-1/4-inch (32 mm) and larger to the ground bus and/or panel enclosure at both ends of the runs. Jumpers or bonds shall be a minimum of one trade size smaller than the ungrounded feeder conductor provided that it shall not be smaller than No. 6 AWG (16.0 mm^2) nor larger than No. 4/0 AWG (95 mm^2) copper. A double locknut and plain insulating bushing may be used for conduit attachments of 1-inch (32 mm) trade size and smaller.

SECTION 16200 - STANDBY GENERATORS

A. DESCRIPTION OF WORK. The work included under this section consists of furnishing and installing electric generating sets as specified herein and shown on the drawings. The sets shall consist of diesel engine-driven alternators rated at 1,500 rpm, 380/220-volt, 3-phase, 4-wire, 50 Hertz.

B. GENERAL REQUIREMENTS

1. Materials and Workmanship:

   a. Materials and parts comprising the generating sets specified herein shall be new, unused, of current manufacture and of the highest grade, free from all defects.

   b. Workmanship shall be of the highest grade, in accordance with modern practice.

2. Warranty: The units offered under these specifications shall be completely covered by the manufacturer's standard warranty.

3. Experience: The units offered under these specifications shall be the product of a firm regularly engaged in the manufacture of this type of unit. A unit assembled at the distribution level will not be acceptable. The units shall be manufactured by Onan, Caterpillar, or Kohler, or other approved supplier.

4. Parts and Service: Bidders shall specify nearest location of permanent parts depots from which replacement parts may be obtained in necessary quantities at any time, day or night. Service facilities and personnel shall be equally available.

5. Information to be Furnished: Contractor shall furnish the following data in one complete package.

   a. Scale drawings, dimensioned, or the generating set proposed, including foundation requirements, floor penetrations and vibration isolators.

   b. Interconnecting wiring diagrams and schematic drawings with specification sheets describing all electrical characteristics of the units.

   c. Drawings and/or literature completely describing all auxiliary equipment to be furnished.

   d. Mechanical data in tabular form including make of engine, number of cylinders, bore in inches, stroke in inches, total piston displacement, number and type of bearings, fuel and lubrication oil consumption, catalog data for governor, rating and catalog data for jacket water heater, exciter type and drive, and power at rated load.

6. Definitions: The specified rated KW, as shown on the drawings for each unit, shall mean the guaranteed net electric output which is obtainable continuously from the set when it is operating at rated conditions.

C. ENGINE. The engine shall be a compression-ignition engine, two- or four-cycle, solid-injection engine of either in-line or V-type. The continuous power output capacity of the engine for standby applications shall not be less than 1.5 bhp/kw (1.2 kw/kW) at synchronous speed, corrected to the specified application.

1. Governor: Engine speed shall be governed by a governor capable of maintaining engine speed such that generator output frequency is held to within 3% of the 50 cycles per second from no load to full load. The frequency at any constant load, including no load, shall be maintained within a steady-state band width of $\pm$ 0.25% of the 50-Hz rated frequency. The governor shall not permit frequency modulation (defined as the number of times per second that the frequency varies from the average frequency in cyclic manner) to exceed one cycle per second.

2. Fuel System: The engine shall be capable of satisfactory performance on a commercial grade of distilled petroleum fuel oil such as No. 2 fuel oil. The system shall include a fuel transfer pump to lift the fuel from the oil storage tank to the day tank and a replaceable element fuel filter conveniently located for servicing. Fuel consumption of the generator set with all engine-driven accessories operating shall not exceed 0.75 pounds (0.35 kg) of fuel per kilowatt-hour at any load between 50 to 100% of rated load.

3. Lubrication: The engine shall have a gear-type lubricating oil pump for supplying oil under pressure to main bearings, crank pin bearings and valve rocker mechanisms. Full flow oil filters, conveniently located for servicing, shall be provided. Filters shall be equipped with a spring-loaded bypass valve to ensure oil circulation if filters are clogged. Sufficient lubricating oil as recommended by the engine manufacturer shall be supplied to charge the lubricating oil system.

4. Cylinder Liners: The engine shall be provided with removable, wet or dry-type cylinder liners of close-grained alloy iron.

5. Air Cleaners: The engine shall be provided with one or more dry-type air cleaners.

6. Cooling: The engine shall be furnished with a cooling system having sufficient capacity for cooling the engine when the set is delivering full rated load and when operating in an ambient temperature of up to 110°F (43°C). In addition, the engine shall be equipped with a radiator and fan of a type and capacity recommended by the engine manufacturer. The radiator shall have a flange to permit the attachment of sheetmetal exhaust duct as shown on the drawings. The coding system shall be filled with a mixture of antifreeze (ethylene glycol type) and water. This mixture shall protect the coding system to -5°F (-20°C).

7. Exhaust System: The engine shall be equipped with a residential-rated welded steel exhaust silencer, of sufficient size to ensure low loss of power output due to excessive back pressure. The silencer shall be provided with a protective coating which shall remain intact and unblemished at operating temperatures of 100°F (38°C). Provide a stainless-steel flexible exhaust connection, complete with rain cap. See drawings for details.

8. Safety Controls and Alarms: The engine shall be equipped with automatic safety controls which will shut down the engine in the event of low lubricating oil pressure, high jacket water temperature and engine overspeed. The alarms shall be transmitted and displayed on the control panel.

9. Starting: The engine shall be equipped with a 24-volt electric starting system of sufficient capacity to crank the engine at a speed which will allow for full diesel start of the engine. The battery shall be of the lead-acid type, fully charged at 1,225 specific gravity for stationary service. Mounting shall be provided on the unit subbase. The battery charger shall be of the static, silicon rectifier type, self-regulated, and provide a 12-ampere DC charging rate to the battery. The input shall be from a single-phase, 120-volt AC power. The charging system shall be complete with voltmeter, ammeter, charging rheostat, and automatic equilizing timer.

   Automatic starting shall be initiated by the closing of contacts for this purpose in the automatic transfer switch. The starting system shall provide four cranking and three rest periods. A starting switch with the positions of "Automatic," "Off," and "Manual" shall be provided in the control panel. A 24-volt alarm system, both audio and visual, shall be provided for failure to start, safety shutdown, and charger failure.

D. ALTERNATOR. The alternator shall be a 4-pole, revolving field design, equipped with a solid-stage voltage regulator. Maximum regulation shall be ± 2% no-load to full load. The enclosure shall be of drip-proof construction. Insulation shall be Class F or equivalent. The alternator shall have a minimum 0.8 power factor while operating at sea level in an ambient temperature range from 0°F to 100°F (-18°C to 38°C). The alternator shall be provided with a full capacity output circuit breaker or fused disconnect as indicated on the one-line diagram.

E. CONTROL PANEL. The unit control panel shall be of the dead-front type, mounted adjacent to the alternator and contain the following instruments and controls:

1. Indicating and alarm lights described previously.

2. AC voltmeter and switch.

3. AC ammeter, current transformers and test switch.

4. Frequency meter.

5. Engine starting selector switch.

6. Lube oil pressure gage and alarm.

7. Coolant temperature gage.

8. Running time meter.

9. Generator output protection circuit breaker.

10. Automatic exercise and cycle timer (this unit may be included in Load Transfer Control, Paragraph 2.04).

11. Emergency shutdown button.

12. Time-delay relay to permit operation at no load after retransfer of load to normal source.

13. Contacts for transmission of failure alarm to remote location.

F. LOAD TRANSFER CONTROL

1. Provide for each engine generator set, an automatic transfer switch capable of transferring the rated output of the generator from normal to standby power.

2. The transfer switch shall be 3-phase, 3-pole, rated for 380/220-volt operation. The switch shall be electrically and mechanically held, have high current breaking capacity with silver-surfaced contacts complete with arc barriers and magnetic blowout coils. The contacts shall be rated in accordance with UL 1008 for current carrying and switching capabilities. The switch shall be UL listed, approved, and so labeled.

3. Interlocking: The transfer switch shall be interlocked to prevent supplying the load from more than one source at a time.

4. Control: The transfer switch shall transfer from normal to standby when normal voltage falls to 70% of rated value and retransfer to normal voltage when normal voltage returns to 90% of rated value. Adjustable time delay shall be provided to prevent transfer and retransfer on voltage dips. The load transfer unit shall be equipped with a voltage sensing device to start the engine on power failure and prevent load transfer until the generator has reached rated voltage. An auxiliary contact shall activate an indicating light to display when the plant is operating on standby power.

G. PLANT MOUNTING. The engine and alternator shall be equipped with a suitable fabricated steel subbase for mounting the entire set as a unit on a concrete foundation. All instrument panels, safety alarms and measuring devices shall be mounted on or within the subbase and equipped with suitable shock and vibration isolators. In addition, the engine shall be equipped with suitable shock and vibration isolators.

H. FINISH AND PAINTING. The entire diesel electric set shall be factory painted with heat-resistant enamel of at least 2 coats of the manufacturer's standard color. Manufacturer shall ship with the unit one quart of identical paint for touchup purposes.

I. SPARE PARTS. The Contractor shall furnish the following spares for each generator:

1. One complete replacement set of combustion air filters; fuel oil filters; all V-belts; fuel oil transfer pump packing; any special tools required for maintenance.

2. Two complete replacement sets of lube oil filters.

J. FUEL STORAGE AND PIPING

1. Underground fuel tank shall be 400-liter minimum capacity.

2. Day tank shall be of 40-liter capacity, complete with threaded pipe connections for inlet, engine suction, engine return, overflow, vent and drain. Unit shall be installed in strict accordance with manufacturer's instructions.

3. Fuel lines shall be black steel pipe with plain ends and welded fittings or copper tubing with solder fittings. Supply and gage lines shall run to within 7.5 cm of the bottom of the tank and return to fill lines to within 45 cm of the tank bottom. Return, vent and supply lines shall be buried 60 cm minimum.

   Fill and vent lines shall be galvanized steel with screwed cast-iron fittings. Vent line shall be terminated with hooded vent or return bend and screened against insects.

Tank shall be equipped with a separate fill line with a cast-iron fill box set in concrete flush with grade. Fill box shall have watertight cover and fill cap with provision for locking. A water drain hole shall be provided.

6. Fuel indicator shall be a remote liquid meter, hydraulic type, self-powered and fully automatic, suitable for fuel oil service.

K. INSTALLATION

1. Generator set shall be installed in strict accordance with the manufacturer's specifications. All equipment permanently mounted on concrete shall be leveled, aligned, and have a minimum of 4 cm of dry pack grout Grout shall be neatly trimmed and finished and all splatter shall be completely cleaned from all surfaces.

2. Tank and related equipment shall be installed in strict accordance with manufacturer's recommendations. Tank shall be bedded and backfilled as specified for pipes. All pipes shall be embedded in concrete, and all pipes which may come in contact with other metal parts shall be covered with heat-shrink plastic sleeves. Insulating unions shall be installed on all fuel supply and return lines just above the ground or concrete surface. Nonconductive bushings shall be furnished with the tank and must be used for all connections of the piping system with the tank.

L. FACTORY TESTING. The manufacturer shall provide certified copies of a 4-hour full-load test with recordings of voltage, frequency, amperage, engine temperature, lube oil pressure and load transfer results.

M. FIELD TESTS. The units shall be field tested with all standby loads picked up and operated for a minimum period of two hours. Six copies of the test results shall be provided to the Engineer.

N. OPERATION AND MAINTENANCE INSTRUCTIONS. The Contractor shall furnish five copies of operating and maintenance instructions covering the engine generator and such auxiliary equipment as may require published operating instructions or periodic maintenance. Two copies shall be furnished to the Engineer and three copies to the Contracting Agency.

SECTION 16400 - SERVICE AND DISTRIBUTION

A. DESCRIPTION OF WORK. The work included in this section consists of providing the complete secondary service and distribution system as specified herein and shown on the drawings.

B. SECONDARY MAIN FEEDERS. Provide rigid conduit and cabling as described in Section 16100, Basic Materials and Methods, for secondary feeders from serving utility transformer to main service entrance breaker or service entrance circuit breaker panelboard.

C. METERING. The Contractor shall install meter base and provide service conduit in accordance with the serving utility standards.

D. SERVICE ENTRANCE SWITCHBOARDS.

1. General: The switchboards shall be rated 380/220 volts, 3-phase, 4-wire, full neutral, braced to withstand a short circuit of 50,000 amperes symmetrical. The switchboard shall be complete as shown on the drawings and described herein. It shall be provided with a UL label indicating that it is suitable for service entrance, or equivalent local certification by an appropriate authority.

2. Enclosure Construction: The switchboard framework shall be fabricated on a die-formed steel base or base assembiy consisting of formed steel and commercial channel welded or bolted together to rigidly support the entire shipping unit for moving on rollers and floor mounting. The framework is to be formed code-gage steel, rigidly welded and bolted together to support all cover plates, bussing, and component devices during shipment and installation.

   Each switchboard section shall have an open bottom and individual removable top plate for installation and termination of conduit. Top and bottom conduit area is to be clearly shown and dimensioned on the shop drawings. The wireway front covers are to be hinged to permit access to the branch switch load side terminals without removing the covers. All front plates used for mounting meters, selector switches or other front mounted devices shall be hinged with all wiring installed and laced with flexibility at the hinged side. All closure plates shall be screw removable and small enough for easy handling by one man. The paint finish shall be gray enamel over a rust-inhibiting phosphate primer.

3. Bussing:

   a. The switchboard bussing shall be plated and of sufficient area to continuously conduct rated full load current with a maximum average temperature rise of 50°C above an ambient temperature of 40°C. Current density shall not exceed 1000 amperes per square inch (1.5 amperes per mm^2) for copper and 705 amperes per square inch (1.1 amperes per mm^2) for aluminum.

   b. The bus bars shall be rigidly braced to comply with the integrated equipment rating of the switchboard.

   c. The main horizontal bus bars between sections shall be located on the back of the switchboard to permit a maximum of available conduit area. The horizontal main bus bar supports, connections, and joints are to be bolted with grade 5 carriage bolts and Belleville washers.

4. Main Circuit Breakers: The main circuit breakers shall be thermal-magnetic, molded case type with trip ratings as shown on the drawings and a minimum interrupting capacity of 22,000 amperes symmetrical at 400 volts. The breakers shall have quick-make and quick-break toggle mechanism, and shall be trip free on overload and short circuit. The breakers shall have common trip with single handle which shall indicate the open, closed, or tripped position.

5. Secondary Wiring: All wiring for relays, instruments, meters, controls, transformers and terminal blocks shall be provided. Such control wiring shall be stranded, 400 volts, NEC Type SIS or TA insulated switchboard wire. Hinge wires shall be extra flexible stranding. Each wire shall be identified at each end with a plastic sleeve identification.

6. Nameplates: Engraved, laminated plastic nameplates, white characters on black background, shall be provided for all breakers and instruments.

7. Factory Test: The switchboard shall be completely factory assembled, wired and tested prior to shipment. Testing shall include all standard factory tests including complete electrical operational test of each switch and verification of all protective relaying and metering circuits for proper wiring and functional operation.

E. PANELBOARDS

1. Panelboards shall be of the dead-front safety type equipped with bolt-on thermal-magnetic circuit breakers and shall be of the type shown on the drawings. The breakers shall have quick-make and quick-break toggle mechanisms, and shall be trip free on overload and short circuit. Multiple pole breakers shall have common trip with single handle. The breaker handle shall indicate the open, closed, or tripped position. Panelboards shall be equipped with the type, size and number of branch circuit breakers as shown on the drawings and shall be of the type and size indicated. Panelboards shall be enclosed in code-gage steel cabinet complete with door, door lock, circuit identification, directory holder, neutral bar when required and lugs for all cable connections. Trims and doors shall have a primer coat and a finish coat of the manufacturer's standard color. Code size wiring gutters shall be provided at the top, sides, and bottom. Where "SPACE" is indicated, space shall be bussed for future breakers. Panel fronts shall be provided with removable 1-pole fillers in spaces. Branch connectors, mounting brackets and other hardware shall be provided for future breakers as indicated on drawings. Circuit-breaker units shall be mounted on channel iron or formed-steel mounting backs, drilled and tapped so that units of same frame size and number of poles may be interchanged and removed from the front without disturbing the adjacent units. Panels shall be bussed according to the requirements shown on the drawings and shall have lugs equipped with approved connectors for the size of conductor feeding the panel. Double lugs shall be provided for handling the double feeder conductors. Each circuit shall be permanently numbered. Plastic or steel buttons secured by means of rivets or grommets are acceptable.

2. Each panel shall have a typewritten directory mounted under a transparent protective cover, set in a metal frame on the inside of the cabinet door. The directory shall contain the following information:

   a. Panel Designation:

      (1) Distribution breaker from which it is fed.

(2) For each circuit breaker, complete information concerning the outlet controlled, including the room number of area designated on the plans and a blank space to insert its own designation if need be.

(3) This directory shall be not less than 12.5 by 15 cm or equivalent area for a 42-circuit panel, with small panels in proportion.

b. Panels for 380/220 volt system shall be Square D, type NH1B, or General Electric, Westinghouse, or ITE equivalent, with circuit breakers having a minimum interrupting capacity of 14,000 amperes symmetrical.

F. SERVICE CONDUIT. Service conduit shall be routed as shown on the drawings or determined by the electric utility. Minimum cover shall be 18 inches. Avoid interference with building footings or buried piping.

G. METERING. Meter bases shall be installed by the Contractor where required by the electric utility.

H. FEEDERS. Raceways and cabling shall be provided between switch gear and motor control centers, automatic transfer switch and main panel, motor control center to distribution panels, and all motor feeders as required. Conduit and wire are to be as desc' 'bed in Section 16100, Basic Materials and Methods.

I. PANELBOARDS shall be set in place and securely affixed to the wall in locations indicated on the drawings. All circuits shall be properly identified and proper phase relationships verified.

J. TESTS. Test all switches and related devices in accordance with Section 16100.

SECTION 16500 - LIGHTING

A. DESCRIPTION OF WORK. The work included under this section consists of providing a complete lighting system as specified herein and shown on the drawings.

B. Submit fixture construction details, photometric data, ballast type, sound rating and dimmers.

C. QUALITY ASSURANCE. The Contractor shall test all lighting installations and demonstrate satisfactory operation of all switching and dimming controls upon completion of the installation. The Contractor shall replace all defective lamps and/or ballasts prior to occupancy. All fixtures shall be cleaned and visible labels removed.

D. FIXTURES. Refer to the fixture schedule on the drawings for type designations, description and required lamps. The Contractor shall be responsible for the complete equipment of all fixture types called for. Architectural drawings shall be consulted for necessary details of exact mounting methods and locations where required. Fixtures shall be grounded in accordance with Article 410E of the NEC.

E. BALLASTS shall totally isolate line voltage from lampload, to conform with NEC requirements.

1. All fluorescent fixtures shall be equipped with ballasts suitable for the line voltage and for type, size and number of lamps required by the fixtures, and the fixtures shall be so wired. All ballasts shall be high-power factor type, full or standard cross section. Ballasts shall be low noise level.

2. All mercury vapor fixtures shall be equipped with ballasts suitable for line voltage and for type, and wattage of lamps employed, and be so wired. All mercury vapor ballasts shall be constant wattage, auto regulating, high power factor, -20°F (-30°C) start with thermal barrier between capacitor and ballast. Ballasts shall have low noise level.

3. All standard ballasts for 24-inch (60 cm) long or longer lamps shall have built-in overload protection consisting of a thermal device (or devices) which will disconnect the ballast from the line when an abnormal temperature is reached. The thermal device shall be suitable for 43°C ambient temperatures, so as to not cause nuisance tripping.

F. LAMPS. The Contractor shall furnish and install all lamps required in all fixtures of the size shown on the drawings.

G. ACCESSORIES. Fixtures shall be furnished complete with all lenses, trims, hangers, nipples and extensions necessary for a complete installation. All light diffusing media shall be free of scratches or cracks. In general, diffusers shall be of acrylic material unless otherwise noted.

H. POLES AND LIGHTING STANDARDS. The Contractor shall provide poles and bases for fixtures as indicated on the drawings.

I. INSTALLATION

1. Supports:

a. Fluorescent fixtures 48 inches (120 cm) or longer shall not be supported from outlet box ears.

b. Continuous runs of fixtures shall be installed straight and true and shall be equipped with all necessary parts such as joining straps, couplings, nipples, etc., for complete and workable units. All recessed fixtures shall be installed using support brackets, grounds, plaster frames, etc. as recommended by the fixture manufacturer. All supports for fixtures shall be furnished. All stem lengths shall be adjusted to meet conditions. Mounting heights to bottom of fixtures shall be adjusted to conform to job conditions.

2. Grounding: Lighting systems shall be securely grounded. For rigid conduit, a threaded hub or double locknut and bushing connection shall be considered adequate. For systems employing flexible conduit feeds, a green insulated No. 12 AWG (4.0 mm^2) solid wire shall be run with the phase conductors, and bonded to the box and fixture at each end of the flexible conduit. The ground connection shall be accomplished by means of cadmium-plated round-head machine screws, lockwasher and nut.

3. Coordination: The Electrical Contractor shall coordinate with the ceiling installer to verify that adequate support is provided for the fixtures. The Electrical Contractor shall provide adequate fixture attachment in accordance with NEC. The Electrical Contractor shall inspect the mechanical plans and verify that no interferences occur with diffusers, grilles or duct work.