TECHNICAL SPECIFICATIONS

EAST CASEY COUNTY WATER DISTRICT

Allen Town Booster Pump Station

CASEY COUNTY, KENTUCKY

PREPARED BY:

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452 VERSAILLES ROAD
FRANKFORT, KENTUCKY 40601

PROJECT NO. 2010105

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SECTION 01001

GENERAL SPECIFICATIONS

1.0 DESCRIPTION OF THE WORK AND DESIGNATION OF OWNER

These Specifications and accompanying Drawings describe the work to be done and the materials to be furnished for the construction of the project entitled Allen Town Booster Pump Station. All references to the Owner in these Specifications, Contract Documents and plans shall mean the East Casey County Water District.

2.0 AVAILABLE FUNDS

The attention of all Bidders is directed to the fact that funds will be made available through State Revolving Fund for the award of the contract through an appropriation of the Kentucky General Assembly, administered by the Kentucky Infrastructure Authority.

3.0 TIME OF COMPLETION

The time allowed for the completion of is 90 calendar days. The time allowed for completion shall begin at midnight, local time, on the date which the Owner, or his authorized representative, the Engineer, shall instruct the Contractor in writing to start work, but no later than 10 days after Notice to Proceed.

Additional time will be allowed the Contractor to cover approved over-runs or additions to the contract in the same proportion that the said over-run or addition in net monetary value bears to the original amount; the total of said additional time to be computed to the nearest whole calendar day.

4.0 LIQUIDATED DAMAGES

It is understood that time is the essence of this contract and that the Owner will sustain damages, monetary and otherwise, in the event of delay in completion of the work hereby contracted.

Therefore, if the said Contractor shall neglect, fail or refuse to complete the work within the time herein specified, or any proper extension thereof granted by the Owner, then the Contractor does hereby agree, as a part of the consideration for the awarding of these contracts, to pay to the Owner the amount specified in the contract, not as a penalty but as liquidated damages for such breach of contract as hereinafter set forth, for each and every calendar day that the Contractor shall be in default after the time stipulated in the Contract for completing the work.

The said amount is fixed and agreed upon by and between the Contractor and the Owner because of the impracticability and extreme difficulty of fixing and ascertaining the actual damages the Owner would in such event sustain, and said amount is agreed to be the amount of damages which the Owner would sustain and said amount shall be retained from time to time by the Owner from current periodical estimates.

Liquidated damages are fixed at $500 per calendar day of over-run beyond the date set for completion or authorized extension thereof.

5.0 INSURANCE

Insurance is to be furnished by the Contractor for the benefit of the Owner, Contractor, and Subcontractors as their interests may appear. The minimum amounts of insurance coverage to be furnished under these contracts, in accordance with the applicable provisions of the General Conditions are indicated in Section 00800, SC-5.04.

All policies written for and applicable to the contract of which this Specification is a part shall provide for a minimum of fifteen (15) days written cancellation notice with notice to be given both to the Owner and the Engineer. The Owner and Engineer shall be included as additional insured parties.

6.0 PERFORMANCE AND PAYMENT BOND

The Contractor shall furnish separate performance and payment bonds issued by an approved bonding company in an amount at least equal to one hundred percent (100%) of the contract price, as security for the faithful performance of this contract and for the payment of persons performing labor and furnishing materials in connection with this contract. These bonds shall be executed by a company authorized to do business in the State of Kentucky and shall be signed or countersigned by a Kentucky resident agent. Bonds shall remain in effect for one year after date of final acceptance of the work.

7.0 SITE DIMENSIONS

All Contractors furnishing materials and equipment for this contract shall obtain exact dimensions at the site. Scale or figure dimensions on the drawings and details show the correct size under ideal conditions and shall not, under any circumstances, be so construed as to relieve the Contractor from responsibility for taking measurements at the site and furnishing materials or equipment of the correct size.

8.0 DAMAGE TO EQUIPMENT STORED AND/OR IN PLACE PRIOR TO INITIAL OPERATION

Any equipment damaged or which has been subjected to possible damage by reason of inundation, improper storage and/or protection during the construction period of project, shall be handled only as follows:

a) Be replaced with new equipment.

b) With approval of the Engineer, be returned to the manufacturer of the equipment, or his authorized repair agency, for inspection and repair provided, however, that such repair after inspection will place the equipment in new condition, and restore the manufacturer's guarantee the same as for new equipment.

9.0 SALVAGED MATERIALS AND EQUIPMENT

All materials and/or equipment to be removed from existing structures and not specifically specified to be re-used shall remain the property of the Owner. Such materials and/or equipment shall be stored on sites by the Contractor as directed by the Owner.

The use of second hand and/or salvaged materials will not be permitted, unless specifically provided for in the detailed specifications. Materials and equipment shall be new when turned over to the Owner.

10.0 TEMPORARY FACILITIES

a) Construction yard shall be located on job site. Provide security and safety protection.

b) The obtaining of all utilities for construction, including power and water, shall be the responsibility of the Contractor, and he shall bear the cost of all utilities used for construction. Cost of all connections and facilities for use of utilities shall be borne by the Contractor.

c) Each Contractor shall construct and maintain, in a sanitary condition, sanitary facilities for his employees and also employees of his subcontractors. At completion of the contract work these sanitary facilities shall be properly disposed of as directed by the Engineer.

d) Temporary construction for safety measures, hoists and scaffolds shall be erected in accordance with the General Conditions.

e) The obtaining of all utilities for construction, including power and water, shall be the responsibility of the Contractor, and he shall bear the cost of all utilities

used for construction. Cost of all connections and facilities for use of utilities shall be borne by the Contractor.

11.0 PROPERTY PROTECTION

Care is to be exercised by the Contractor in all phases of construction to prevent damage and injury to the Owner's or other property.

In connection with work performed on "private property" (property other than that belonging to the Owner), the Contractor shall confine his equipment, the storage of materials, and the operation of his workmen to the limits indicated on the plans, or to lands and right-of-way provided for the project by the Owner, and shall take every precaution to avoid damage to the private property Owner's buildings, grounds and facilities.

Fences, hedges, shrubs, etc. within the construction limits shall be carefully removed, preserved, and replaced when the construction is completed. Where ditches or excavations cross lawns, the sod shall be removed carefully and replaced when the backfilling has been completed. If sod is damaged or not handled properly, it shall be replaced with new sod equal to existing sod at the Contractor's expense. Grassed areas, other than lawns, shall be graded, fertilized and seeded when construction is completed. When construction is completed the private property Owner's facilities and grounds shall be restored to as good or better condition than found as quickly as possible at the Contractor's expense.

Reasonable care shall be taken during construction to avoid damage to vegetation. Ornamental shrubbery and tree branches shall be temporarily tied back where appropriate, to minimize damage. Trees which receive damage to branches shall be trimmed of those branches to improve the appearance of the tree. Tree trunks receiving damage from equipment shall be treated with a tree dressing.

12.0 CONFLICT WITH OR DAMAGE TO EXISTING UTILITIES AND FACILITIES

Insofar as location data is available to the Engineers, existing underground utilities (such as waterlines, sewer lines, gas lines, telephone conduits, etc.) are accurately located on the drawings. Due, however, to the approximate nature of much of this data, the location of any particular facility cannot be certified to be correct. In general, locations and elevations shown are approximate only.

Before proceeding with the work, the Contractor shall confer with all public or private companies, agencies, or departments that own and operate utilities in the vicinity of the construction work. The purpose of the conference is to verify the location of, and possible interference with, the existing utilities that are shown on

the Plans, arrange for necessary suspension of service, and make arrangements to locate and avoid interference with all utilities that are not shown on the Plans.

13.0 CONTROL OF EROSION

The Contractor shall be responsible for control of siltation and erosion from the project work. Control shall include all necessary ditching, check dams, mulching, etc. to prevent deposition of materials in roadside ditches. The Owner shall incur no extra costs from such work.

14.0 MEASUREMENT AND PAYMENT

14.1. MEASUREMENT OF QUANTITIES

All Work completed under the Agreement will be measured by the Engineer according to United States standard measure.

14.1.1. Unless otherwise specified, measurement of concrete quantities will include only that volume within the neat lines as shown on the Plans or as altered by the Engineer to fit field conditions. The prismoidal formula will be used in computing the volumes of structures, or portions of structures, having end sections of unequal areas.

14.1.2. All items which are measured by the linear foot, such as pipe, will be measured along the centerline distance of the installed item with no allowance for connections, fittings or laps at connections.

14.1.3. In computing volumes of excavation, borrow and embankments, the average end-area method will be used. For the purpose of ascertaining quantities, it is agreed that the planimeter shall be considered an instrument of precision adapted to the measurement of areas.

14.2 LUMP SUM

When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

14.3 PLAN QUANTITIES

When the plan quantities for a specific portion of the Work are designated as the pay quantities in the Contract Documents, they shall be the final quantities for which payment for such specific portion of the Work will be made, unless the dimensions of said portions of the Work shown on the plans are revised by the Engineer. When revised dimensions result in an increase or decrease in the

quantities of such Work, the final quantities for payment will be revised in the amount represented by the authorized changes in dimensions.

14.4 ACTUAL QUANTITIES

When actual quantities for a specific portion of the Work are designated as the pay quantities in the Contract Documents, they shall be the final quantities for which payment for such specific portion of the Work will be made. The actual quantities will be determined by the difference in field measurements and cross sections before and after construction.

14.5 SCOPE OF PAYMENT

The contract unit prices whether based on lump sum, plan quantities or actual quantities for the various bid items of the Contract Documents shall be considered full compensation for all labor, materials, supplies, equipment, tools, and all things of whatever nature required for the complete incorporation of the item into the Work the same as though the items were to read "in Plan" unless the Contract Documents provide otherwise.

14.6 PAYMENTS

Estimates for payment, partial payments and final payments shall be in accordance with and follow procedures set forth in the General Conditions and Supplementary Conditions.

15.0 ACCESS ROADS

The Contractor, Contractor's employees and all trucks delivering equipment, supplies or materials to the project shall use the access roads shown in the Plans for entering and leaving the project sites.

16.0 TESTING LABORATORY SERVICES

16.1 GENERAL

16.1.1 Work Included. From time to time during progress of the Work, the Owner may require that testing be performed to determine that materials provided for the Work meet the specified requirements; such testing includes, but is not necessarily limited to:

1) Material Compaction
2) Cast-In-Place Concrete

16.1.2 Related Work Described Elsewhere. Requirements for testing may be described in various Sections of these Specifications; where no testing

requirements are described, but the Owner decides that testing is required, the Owner may require testing to be performed under current pertinent standards for testing.

16.1.3 Selection of Testing Laboratory. The Owner will select a testing laboratory.

16.1.4 Codes and Standards. Testing, when required, will be in accordance with all pertinent codes and regulations and with selected standards of the American Society for Testing and Materials.

16.1.5 Product Handling. The Contractor shall promptly process and distribute all required copies of test reports for which he is responsible and related instructions to ensure all necessary retesting and/or replacement of materials with the least possible delay in progress of the Work.

16.2 PAYMENT FOR TESTING SERVICES

16.2.1 Initial Services. The Contractor will pay for all initial testing services required by the Owner.

16.2.2 Retesting. When initial tests indicate non-compliance with the Contract Documents, all subsequent retesting made necessary by the non-compliance shall be performed by a testing laboratory selected by the Contractor and approved by the Engineer and the costs thereof will be paid directly by the Contractor.

16.2.3 Contractor's Convenience Testing. Inspection or testing performed exclusively for the CONTRACTOR'S convenience shall be the sole responsibility of the Contractor.

16.3 EXECUTION

16.3.1 Cooperation with Testing Laboratory. Representatives of the testing laboratory shall have access to the Work at all times. The Contractor shall provide facilities for such access in order that the laboratory may properly perform its functions.

16.3.2 Schedules for Testing.

16.3.2.1 Establishing Schedule. By advance discussion with the testing laboratory selected by the Owner, the Contractor shall allow for the time required for the laboratory to perform its tests and to issue each of its findings. The Contractor shall allow for this time within the construction schedule.

16.3.2.2 Revising Schedule. When changes of construction schedule are necessary during construction, the Contractor shall coordinate all such changes of schedule with the testing laboratory as required.

16.3.2.3 Adherence to Schedule. When the testing laboratory is ready to test according to the determined schedule but is prevented from testing or taking specimens due to incompleteness of the Work, all extra costs for testing attributed to the delay may be back-charged to the Contractor and shall not be borne by the Owner.

16.3.3 Taking Specimens. All specimens and samples for testing, unless otherwise provided in these Contract Documents, will be taken by the testing laboratory; all sampling equipment and personnel will be provided by the testing laboratory; and all deliveries of specimens and samples to the testing laboratory will be performed by the testing laboratory.

17.0 SUBMITTALS AND SUBTITUTIONS

17.1 GENERAL

17.1.1 Work Included. Wherever possible throughout the Contract Documents, the minimum acceptable quality of workmanship and materials has been defined either by manufacturer's name and catalog number or by reference to recognized industry standards. To insure that the specified products are furnished and installed in accordance with design intent, procedures have been established for advance submittal of design data and for its review and approval or rejection by the Engineer.

17.1.2 Related Work Described Elsewhere.

17.1.2.1 Contractual requirements for submittals are described in the General Conditions and Supplementary Conditions.

17.1.2.2 Individual submittals required are described in the pertinent sections of these Specifications.

17.2 SUBSTITUTIONS

17.2.1 Engineer's Approval Required. The Agreement is based on the materials, equipment, and methods described in the Contract Documents. The Engineer will consider proposals for substitution of materials, equipment, and methods only when such proposals are accompanied by full and complete technical data and all other information required by the Engineer to evaluate the proposed substitution. Do not substitute materials, equipment, or methods unless such substitution has been specifically approved for this Work by the Engineer.

17.2.2 "Or Equal". Where the phrase "or equal" occurs in the Contract Documents, do not assume that material, equipment, or methods will be approved as equal by the Engineer unless the item has been specifically approved for this Work. The decision of the Engineer shall be final.

17.2.3 Availability of Specified Items. The Contractor shall verify prior to bidding that all specified items will be available in time for installation during orderly and timely progress of the Work. In the event the specified item or items will not be so available, the Contractor shall notify the Engineer prior to receipt of Bids.

17.3 IDNETIFICATION OF SUBMITTALS

The Contractor shall completely identify each submittal and resubmittal by showing at least the following information:

1) Name and address of submitter, plus name and telephone number of the individual who may be contacted for further information.

2) Name of project as it appears in these Specifications.

3) Drawing number and Specifications Section number to which the submittal applies.

4) Whether this is an original submittal or resubmittal.

17.4 COORDINATION OF SUBMITTALS

17.4.1 General. Prior to submittal for Engineer's review, the Contractor shall use all means necessary to fully coordinate all material, including the following procedures:

1) Determine and verify all field dimensions and conditions, materials, catalog numbers, and similar data.

2) Coordinate as required with all trades and with all public agencies involved.

3) Secure all necessary approvals from public agencies and others and signify by stamp, or other means, that they have been secured.

4) Clearly indicate all deviations from the Contract Documents.

17.4.2 Grouping of Submittals. Unless otherwise specifically permitted by the Engineer, the Contractor shall make all submittals in groups containing all associated items; the Engineer may reject partial submittals as not complying with the provisions of the Contract Documents.

17.5 TIMING OF SUBMITTALS

The Contractor shall make all submittals far enough in advance of schedule dates of installation to provide all required time for reviews, for securing necessary approvals, for possible revision and resubmittal, and for placing orders and securing delivery. In scheduling, allow at least five full working days for the Engineer's review following his receipt of the submittal.

18.0 INSTALLATION REQUIREMENTS

Manufactured articles, materials, and equipment shall be applied, installed, connected, erected, used, cleaned, and conditioned as directed by the respective manufacturers, unless otherwise specified.

19.0 ENDANGERED SPECIES ACT PROVISIONS

The federally endangered Indiana bat (*Myotis sodalis*) is known to occur in the vicinity of this project. This species normally uses trees with exfoliating (i.e., loose) bark that are greater than six inches in diameter at breast height as maternity and roost sites. As a result, if any tree with a diameter greater than six inches at breast height needs to be removed, it shall be removed between October 15 and March 31.

20.0 PROOF OF COMPLIANCE

Whenever the Contract Documents require that a product be in accordance with Federal specification, ASTM designation, ANSI specification, or other association standard, the Contractor shall present an affidavit from the manufacturer certifying that the product complies therewith. Where requested or specified, the Contractor shall submit supporting test data to substantiate compliance.

21.0 PROJECT RECORD DOCUMENTS

21.1 As the Work progress, the Contractor shall keep a complete and accurate record of changes or deviations from the Contract Documents and the Shop Drawings, indicating the Work as actually installed. Changes shall be neatly and correctly shown on the respective portion of the affected document, using blackline prints of the Drawings affected, or the Specifications, with appropriate supplementary notes. This record set of Drawings, Shop Drawings, and Specifications shall be kept at the job site for inspection by the Engineer.

21.2 The records above shall be arranged in order, in accordance with the various sections of the Specifications, and properly indexed. Prior to application for final payment, and as a condition to its approval by the Engineer, deliver the record Drawings and Specifications, arranged in proper order, indexed, and endorsed as hereinbefore specified.

21.3 No review or receipt of such records by the Engineer or Owner shall be a waiver of any deviation from the Contract Documents or the Shop Drawings or in any way relieve the Contractor from his responsibility to perform the Work in accordance with the Contract Documents and the Shop Drawings to the extent they are in accordance with the Contract Documents.

22.0 PROJECT MEETINGS

The Contractor's Superintendent for the Work shall attend project meetings as required by either the Owner or Engineer.

23.0 VIDEO TAPE

The line Contractor, before proceeding with any work, shall make or have made a video of all areas where work is to be performed and a copy of this video cassette shall be furnished to the Engineer to review for completeness. This video shall be utilized as backup and reference for claims and cleanup.

24.0 DAILY REPORTS

The project inspector, as designated by the Owner and/or Engineer, will keep a daily record of materials installed. This daily report will be used by the Owner and the Engineer to determine the payments due to the Contractor. The Contractor shall sign the inspector's daily report each day. Should the contractor disagree with the inspector's report, the differences shall be resolved before the end of the next day, with the Contractor signing the daily report.

25.0 FINAL ADJUSTMENT OF QUANTITIES

Upon completion of the project, a final adjusting change order will be written to reconcile the differences between the bid quantities and the actual quantities installed. This final adjusting change order will be determined based on the inspector's daily reports.

SECTION 02002

ACCESS ROAD

1.0 GENERAL

This specification covers the earthwork and surfacing necessary to construct the access road in accordance with the Drawings and the direction of the ENGINEER. The access road will serve as the construction access road and as the water utility's service access road once the project is completed.

2.0 LOCATION

The layout of the access road will generally be as shown on the Drawings. The exact location and cross-section of the road will be as directed by the ENGINEER at the time of construction and will be such as to insure its stability and to keep the grade of the road to a minimum.

3.0 FILL

All roadway fill will be compacted as directed by the ENGINEER with the hauling/placement equipment to insure its stability.

4.0 DRAINAGE

Pipe shall be 15" high density corrugated polyethylene pipe unless otherwise specified. ADS N-12 ST IB pipe or approved equal will be accepted.

5.0 SURFACING

The access roads to the tanks will be surfaced with four inches of #2 coarse aggregate overlain with 2" of #57 coarse aggregate. It will not be necessary to surface uniform, competent rock surfaces. The coarse aggregate shall be in compliance with Section 805 of the Kentucky Department of Highways, "Standard Specification for Road and Bridge Construction."

6.0 PAYMENT

Payment for all work on the access roads shown on the Drawings and herein specified shall be included in the payment for Bid Item "Access Road" as contained in the Bid Schedule and no measurement of the quantities will be made. The information given on the Drawings is believed to be reasonably correct but is not guaranteed. The CONTRACTOR shall satisfy himself by actual

examination of the site of work as to the existing conditions and the amount of work required under this section.

SECTION 03251

EXPANSION, CONSTRUCTION, AND CONTROL JOINTS

1.0 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society for Testing and Materials (ASTM):
   a. A36, Standard Specification for Structural Steel.
   b. A525, Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
   c. D226, Standard Specification for Asphalt- Saturated Organic Felt Used in Roofing and Waterproofing.
   d. D227, Standard Specification for Coal-Tar-Saturated Organic Felt Used in Roofing and Waterproofing.
   e. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type) (AASHTO M33).
   f. D1056, Standard Specification for Flexible Cellular Materials-Sponge or Expanded Rubber.
   g. D 175 1, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

2. Corps of Engineers (COE): CRD-C-572, Corps of Engineers Specifications for Polyvinylchloride Waterstop.

3. American National Standards Institute (ANSI): ANSI/NSF 61, Drinking Water System Components, Health Effects.

1.2 SUBMITTALS

A. Shop Drawings-

1. Plastic Type Water Stops: Details of splices to be used and method of securing water stop in the forms and supporting water stop so as to maintain proper orientation and location during concrete placement.
2. Construction Joints: Layout and location indicating type to be used.
3. Joint fillers for horizontal joints.
4. Preformed control joints.
5. Water stop.

B. Samples: Splice, joint, and fabricated cross of each size, shape, and fitting of water stop(s) proposed for use.

C. Quality Control Submittals:

1. Joint Filler for Potable Water Structures: Copy of applicable NSF listing.
2. Water stop manufacturer's written instructions for product shipment, storage, handling, installation field splices, and repair.
3. Joint Filler and Primer: Manufacturer's written instructions for product shipment, storage, handling, application, and repair.
4. Preformed Control Joint: Manufacturer's written instructions for product shipment, storage, handling, application, and repair.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements: Acceptance of pourable joint filler for potable water structures by federal EPA or by a state health agency.

1. Pourable Joint Filler: Certified as meeting NSF 61.

B. Special Inspection (Kentucky Building Code 2007, Section 1704) :

1. Special Inspections to be performed under this contract is listed under General Provisions of Structural Drawings. If special inspection is required, Owner will retain the services of a Special Inspector of Record to inspect all applicable work under this contract and this Contractor is responsible for providing safe access to all areas of work under this contract to be inspected at no additional cost to the Owner or His/Her Agents. No reinforcing steel erection or concreting shall take place without written approval of the Special Inspector of Record (SIR). Any progression of work without the approval of the SIR will be subject to demolition at this contractor's expense. At the completion of the Special Inspection secure a written approval from the SIR for placing concrete in the forms that were approved for concreting.
2. The extent of special inspection to be performed is listed in Table 1704.4 of the Kentucky Building Code 2007 (KBC 2007).

1.4 DELIVERY, STORAGE, AND HANDLING

A. Acceptance at Site: Verify that water stops delivered are in accordance with cross-section dimensions as shown and manufacturer's product data prior to unloading and storing onsite.

2.0 PRODUCTS

2.1 LABYRINTH WATER STOP

A. Extruded from polyvinyl chloride (PVC) in conformance with Corps of Engineers' Specification CRD-C-572.

B. Size and configuration as shown.

2.2 PLASTIC WATER STOP

A. Extruded from an elastomeric plastic compound of which the basic resin shall be polyvinyl chloride (PVC). Reclaimed PVC in the compound is not acceptable.

B. Specific Gravity: Approximately 1.37.

C. Shore Durometer Type A Hardness: Approximately 80.

D. Performance Requirements: Corps of Engineers' Specification CRD-C-5 72.

E. Type: Center bulb with a number of parallel ribs or protrusions on each side of strip center.

F. Corrugated or tapered type water stops are not acceptable.

G. Thickness: Constant from bulb edge to the outside stop edge.

H. Minimum Weight per Foot of Water Stop:

1. 1.62 pounds for 3/8-inch by 6-inch.
2. 2.30 pounds for 3/8-inch by 9-inch.

I. Manufacturers and Catalog Numbers:

1. Vulcan Metal Products, Inc., Construction Materials Division, Birmingham, AL; Catalog No. 3/81-15M: Type 8069 (6-inch by 3/8-inch).
2. Vinylex Corp., Knoxville, TN; Catalog No. 03250/VIN: No. RB6-38H (6-inch by 3/8-inch).
3. Greenstreak Plastic Products, St. Louis, MO; Catalog No. 03250/GRD: Style 732 (6-inch by 3/8-inch).
4. A. C. Horn, Inc., Beltsville, MD; Catalog No. CSP-162: Type 9 (6-inch by 3/8-inch).

2.4 WIRE LOOPED PLASTIC WATER STOP

A. Furnish as an alternative to plastic water stops.

B. Same material and geometry as plastic water stops.

C. Furnish with continuous galvanized wire looping at edge for convenience in positioning and securing stop in place in the forms.

D. Manufacturers and Catalog Numbers: Paul Murphy Plastics, Roseville, MI; "Wire Stop Water Stop",- geometry numbers ACR 6380, ACR 9380, as shown on Paul Murphy Plastics Co. Drawing No. CCP-120-12M.

2.5 BOND BREAKER

A. Tape for Expansion Joints: Adhesive-backed glazed butyl or polyethylene tape same width as the joint that will adhere to the premolded joint material or concrete surface.

B. Use either bond breaker tape or a bond prevention material as specified in Section 03300, CAST-IN-PLACE CONCRETE, except where a tape is specifically called for.

2.6 PREMOLDED JOINT FELLER

A. Bituminous Type: ASTM D994 or D1751

B. Sponge Rubber: Neoprene, closed-cell, expanded; ASTM D1056, Type 2C5, with a compression deflection, 25 percent deflection (limits), 119 to 168 kPa (17 to 24 psi) minimum.

1. Manufacturer and Product: Rubatex Corp.; R45 IN.

2.7 PREFORMED CONTROL JOINT

A. One-Piece, Flexible, Polyvinyl Chloride Joint Former:

1. Manufacturer and Product: Vinylex Corp., Knoxville, TN- Kold-Seal Zip-Per Strip KSF-150-50-50.

B. One-Piece Steel Strip with Preformed Groove:

1. Manufacturer and Product: Burke Concrete Accessories, Inc., San Mateo, CA; Keyed Kold Retained Kap.

C. Furnish in full-length, unspliced pieces.

2.8 POURABLE JOINT FILLERS

A. Filler for Potable Water Structures:

1. Meet requirements of ANSI/NSF 61
2. Multicomponent sealant, self-leveling or nonsag as required for level, sloping, or vertical joints.
3. Color: White.

4. Manufacturers and Products:
   a. Sika Chemical Co., Lyndhurst, NJ; Sikaflex-2C or Sikaflex-1A.
   b. Product Research Chemical Corp., Gloucester City, NJ; Permapol RC-270SL Reservoir Sealant or RC-270 Gun Grade Reservoir Sealant, with PRC Primer No. 57.

2.9 STEEL EXPANSION JOINT DOWELS

A. Dowels: ASTM A36 round smooth steel bars.

B. Bar Coating: Two-coat System No. 29A, FUSION BONDED, STEEL DOWEL COATING, as specified in Section 09900, PAINTING [A: AND PROTECTIVE COATINGS,] with a factory-applied lubricating coating.

2.10 ACCESSORIES

A. Joint Sealants: As specified in Section 07900, JOINT SEALANTS.

B. Nonshrink Grout:

1. As specified in Section 03600, GROUT.
2. Compatible with joint sealant.

C. Roofing Felt: ASTM D226, Type II, 30-pound asphalt-saturated or equal weight of ASTM D227 coal-tar saturated felt.

D. Reinforcing Steel: As specified in Section 03210, REINFORCING STEEL.

E. Nails: As required for securing bituminous type premolded joint filler.

F. Masking Tape: As required to temporarily adhere to concrete at each side of joint to receive filler.

3.0 EXECUTION

3.1 GENERAL

A. Construct straight joints; make vertical or horizontal, except where walls intersect sloping floors.

B. Commence concrete placement after the joint preparation is complete.

C. Time between Concrete Pours: As specified in Section 03300, CAST-IN-PLACE CONCRETE.

3.2 SURFACE PREPARATION

A. Construction Joints: Prior to placement of abutting concrete, clean contact surface:

1. Remove laitance and spillage from reinforcing steel and dowels.
2. Roughen surface to a minimum of 1/4-inch amplitude:
   a. Sandblast after the concrete has fully cured.
   b. Water blast after the concrete has partially cured
   c. Green cut fresh concrete with high pressure water and hand tools.
3. Perform cleaning so as not to damage water stop, if one is present.

B. Expansion Joint with Pourable Filler:

1. Use motorized wire brush or other motorized device to mechanically roughen and thoroughly clean concrete surfaces on each side of joint from plastic water stop to the top of the joint.
2. Use clean and dry high pressure air to remove dust and foreign material, and dry joint.
3. Prime surfaces before placing joint filler.
4. Avoid damage to water stop.

C. Expansion Joint without Pourable Filler:

1. Coat concrete surfaces above and below plastic water stop with bond breaker.
2. Do not damage water stop.

D. Control Joint:

1. Join water stops at intersections to provide continuous seal.
2. Center water stop on joint.
3. Secure water stop in correct position to avoid displacement during concrete placement.
4. Repair or replace damaged water stop.
5. Place concrete and vibrate to obtain impervious concrete in the vicinity of all joints.
6. Joints in Footings and Slabs:
   a. Ensure that space beneath plastic water stop is completely filled with concrete.
   b. During concrete placement, make a visual inspection of the entire water stop area.
   c. Limit concrete placement to elevation of water stop in first pass, vibrate the concrete under the water stop, lift the water stop to confirm full consolidation without voids, then place remaining concrete to full height of slab.
   d. Apply procedure to full length of plastic water stops.

3.3 INSTALLATION OF WATER STOPS

A. General:
   1. Join water stops at intersections to provide continuous seal.
   2. Center water stop on joint.
   3. Secure water stop in correct position to avoid displacement during concrete placement.
   4. Repair of replace damaged water stop.
   5. Place concrete and vibrate to obtain impervious concrete in the vicinity of all joints.
   6. Joints in Footings and Slabs:
      a. Ensure that space beneath plastic water stop is completely filled with concrete.
      b. During concrete placement, make a visual inspection of the entire water stop area.
      c. Limit concrete placement to elevation of water stop in first pass, vibrate the concrete under the water stop, lift the water stop to confirm full consolidation without voids, then placing remaining concrete to full height of slab.
      d. Apply procedure to full length of plastic water stops.

B. Labyrinth Water Stops: Install in accordance with the manufacturer's written instructions. Use heat butt weld splices only.

C. Plastic Water Stop:

   1. Install in accordance with manufacturer's written instructions.
   2. Splice in accordance with the water stop manufacturer's Written instructions using a thermostatically controlled heating iron. Butt splice unless specifically detailed otherwise.
      a. Allow at least 10 minutes before the new splice is pulled or strained in any way.
      b. Finished splices shall provide a cross-section that is dense and free of porosity with tensile strength of not less than 80 percent of the unspliced materials.
   3. Wire looped plastic water stop may be substituted for plastic water stop.

3.4 EXPANSION JOINT INSTALLATION

A. General:

   1. Place bond breaker above and below water stop when premolded joint filler and pourable joint filler is not used.
   2. Premolded Joint Filler:
      a. Sufficient in width to completely fill the joint space where shown.
      b. If a water stop is in the joint, cut premolded joint filler to but tightly against the water stop and the side forms.

3. Precut premolded joint filler to the required depth at locations where joint filler or sealant is to be applied.
4. Form cavities for joint filler with either precut, premolded joint filler, or smooth removable accurately shaped material. Entire joint above water stop, in slabs, shall be formed and removed so that entire space down to water stop can be filled with the pourable joint filler.
5. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface.

B. Bituminous Type Premolded Joint Filler:

1 Drive nails approximately I -foot 6 inches on center through the finer, prior to installing, to provide anchorage embedment into the concrete during concrete placement.
2. Secure premolded joint filler in forms before concrete is placed.
3. Install in walkways, at changes in direction, at intersections, at each side of driveway entrances, and at 45-foot intervals, maximum.

C. Pourable Joint Filler:

1. General: Install in accordance with the manufacturer's written instructions, except as specified below:
   a. Apply primer prior to pouring joint filler.
   b. Fill entire joint above the water stop with joint filler as shown.
   c. Use masking tape on top of slabs at sides of joints ; clean spillage. Remove masking tape afterwards.
2. Rubber Asphalt Type, Hot-Applied:
   a. Heat filler material in a double-walled boiler.
   b. Place filler in the joint by means of a nozzle from a portable pouring type container to prevent spillage outside of the joint.
   a. Begin pouring joint filler at the bottom of the horizontal joint and proceed upwards in a manner that will preclude the possibility of trapping air in the joint.
3. Rubber Asphalt Type, Cold-Applied: Place cold-applied, two-component fillers in accordance with manufacturer's written instructions.
4. Multicomponent Type for Potable Water Structures: Install in accordance with manufacturer's written instructions.

D. Steel Expansion Joint Dowels:

1. Install coated and lubricated bars parallel to wall or slab surface and in true horizontal position perpendicular to the joint in both plan and section view, so as to permit joint to expand or contract without bending the dowels.
2. Secure dowels tightly in forms with rigid ties.

3. Install reinforcing steel in the concrete as shown to protect the concrete on each side of the dowels and to resist any forces created by joint movement.

3.5 CONTROL JOINT INSTALLATION

A. Locate reinforcing and dowels as shown.

B. Install PVC water stop.

C. Concrete surfaces shall be dense and smooth.

D. Install bond breaker to concrete surfaces above and below water stop.

3.6 PREFORMED CONTROL JOINTS

A. Use only where specifically shown; do not use in water-holding basins.

B. Locate flush, or slightly below the top of slab.

C. Install in accordance with manufacturer's written instructions in straight, full length unspliced pieces.

D. Steel Strip Type with Preformed Groove: Brace to withstand pressure of concrete during and after placement.

END OF SECTION 03251

SECTION 03310

CONCRETE WORK

1.0 GENERAL

1.1 DESCRIPTION

A. Work Included: Extent of concrete work is shown on drawings.

B. Related Work:

1. Documents affecting work of this Section include, but are not limited to, General Conditions, Supplementary Conditions, and Division 1 of these Specifications.
2. Section 02220: Excavating, Backfilling, and Compacting.
3. Section 03251: Expansion, Construction and Control Joints
4. Section 03400: Precast Concrete
5. Section 03600: Grout

1.2 QUALITY ASSURANCE

A. Codes and Standards: Comply with provisions of following codes, specifications and standards, except where more stringent requirements are shown or specified:

1. ACI 301 "Specifications for Structural Concrete for Buildings"
2. ACI 318 "Building Code Requirements for Reinforced Concrete"
3. ACI 350 R – "Environmental Engineering Concrete Structures"
4. Concrete Reinforcing Steel Institute, "Manual of Standard Practice.

B. Concrete Testing Services

1. Engage a testing laboratory acceptable to ENGINEER to perform material evaluation tests and to design concrete mixes.
2. Contractor will engage testing laboratory to perform sampling and testing during placement of concrete.
3. Contractor will engage a testing laboratory to conduct tests of compression test specimens.
4. Materials and installed work may require testing and retesting as directed by ENGINEER, at any time during progress of work. Allow free access to material stockpiles and facilities. Re-testing of rejected materials and installed work shall be done at Subcontractor's expense.

1.3 SUBMITTALS

A. Product Data: Submit data for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, waterstops, joint systems, curing compounds, dry-shake finish materials, and others as requested by ENGINEER.

B. Shop Drawings - Reinforcement: Submit shop drawings for fabrication, bending, and placement of concrete reinforcement. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures" showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of concrete reinforcement. Include special reinforcement required at openings through concrete structures.

C. Laboratory Test Reports: Submit laboratory test reports for concrete materials and mix design test as specified.

D. Material Certificates: Provide materials certificates in lieu of materials laboratory test reports when permitted by ENGINEER. Material certificates shall be signed by manufacturer and Subcontractor, certifying that each material item complies with, or exceeds, specified requirements.

2.0 PRODUCTS

2.1 FORM MATERIALS:

A. Forms for Exposed Finish Concrete: Unless otherwise indicated, construct formwork for exposed concrete surfaces with plywood, metal-framed plywood faced or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings. Provide form material with sufficient thickness to withstand pressure of newly-placed concrete without bow or deflection. Use plywood complying with U. S. Product Standard PS-1 "B-B (Concrete Form) Plywood", Class I, Exterior Grade or better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.

B. Forms for Unexposed Finish Concrete: Form concrete surfaces which will be unexposed in finished structure with plywood, lumber, metal or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.

C. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain nor adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces.

D. Forms for Textured Finish Concrete: Form textured finish concrete surfaces with units of face design, size, arrangement and configuration as shown on drawings or as required to match ENGINEER's control sample. Provide solid backing and form supports to ensure stability of textured form liners.

E. Cylindrical Columns and Supports: Form round-section members with fiberglass reinforced plastic, or paper or fiber tubes. Construct paper or fiber tubes of laminated plies using water-resistant adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation.

2.2 REINFORCING MATERIALS:

A. Reinforcing Bars: ASTM A615, Grade 60, deformed.

B. Supports for Reinforcement: Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI specifications, unless otherwise acceptable.

1. For slabs-on-grade: Use supports with sand plates or horizontal runners where base material will not support chair legs.
2. For exposed-to-view concrete surfaces: Where legs of supports are in contact with forms, provide supports with legs which are plastic protected (CRSI, Class 1) or stainless steel protected (CRSI, Class 2).

2.3 CONCRETE MATERIALS:

A. Portland Cement: ASTM C150, Type II, unless otherwise acceptable to ENGINEER. Use one brand of cement throughout project, unless otherwise acceptable to ENGINEER.

B. Fly Ash: ASTM C618, Type C or Type F. Loss on ignition shall not exceed 3 1/2%. Limit use of fly ash to not exceed 25% of cement content by weight.

C. Normal Weight Aggregates: ASTM C33, and as herein specified. Provide aggregates from a single source for exposed concrete.

1. For exterior exposed surfaces, do not use fine or coarse aggregates containing spalling-causing deleterious substances.

2. For interior slabs-on-grade coarse aggregates shall be graded such that not more than 18 percent nor less than 8 percent of the total aggregate is retained on the 3/4", 1/2", 3/8" and number 4 sieves.

D. Water: Drinkable.

E. Admixtures: The amount of water soluble chloride ions added to the mix by the admixtures shall not exceed 0.3% by weight of cement. Provide admixture manufacturer's written certification of weight of added chloride ions per ounce for each admixture.

1. Air-Entraining Admixture: ASTM C260.
2. Water-Reducing Admixture: ASTM C494, Type A
3 High-Range Water-Reducing Admixture (SuperPlasticizer): ASTM C494, Type F or Type G
4. Water-Reducing, Non-Chloride Accelerator Admixture: ASTM C494 Type E
5. Water-Reducing, Retarding Admixture: ASTM C494, Type D

2.4 RELATED MATERIALS

A. Waterstops: Provide waterstops at construction joints as indicated. Size to suit joints.

1. Polyvinyl Chloride Waterstops

B. Joint Filler: ANSI/ASTM D994, bituminous impregnated fiberboard; closed cell neoprene; self-expanding cork; of the size detailed and in locations indicated on the Drawings. Bituminous impregnated fiberboard shall not be used to fill joints in liquid retaining structures.

C. Joint Covers: ANSI/ASTM B221; alloy extruded aluminum retainers with resilient neoprene fill strip; extruded aluminum cover plate; 25 shore hardness; to permit plus of minus 50 percent joint movement; of longest manufactured length; mounted as detailed or per manufacturer's recommendations.

D. Sealants: Specified in Section 03251.

E. Moisture Barrier: Provide moisture barrier cover over prepared base material where indicated. Use only materials which are resistant to decay when tested in accordance with ASTM E154, as follows:

1. Polyethylene sheet not less than 8 mils thick.

F. Non-Shrink Grout: CRD-C 621, factory pre-mixed grout.

G. Smooth Dowels: Provide smooth dowels frabricated from plain steel bars conforming to ASTM A-615 or approved equal.

H. Liquid Membrane-Forming Curing Compound: Liquid type membrane-forming curing compound complying with ASTM C309, Type I, Class A with % solids not less than 25%. Moisture loss not more than 0.03 gr./sq. cm. when applied at 300 square ft./gal.

I. Impervious sheet conforming to ASTM C-171, polyethylene film shall be white opaque.

J. Bonding Compound: Polyvinyl acetate or acrylic base, rewettable type.

2.5 PROPORTIONING AND DESIGN OF MIXES

A. Prepare design mixes for each type and strength of concrete as follows:

1. Prepare concrete mixes, other than slab on grade concrete in accordance with ACI 301 Section 4.2.3
2. Prepare slab on grade concrete mixes in accordance with ACI 302 Section 5.2.4 (Method B).

B. Submit written reports to ENGINEER of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until mixes have been reviewed by ENGINEER.

C. Design mixes to provide normal weight concrete with the following properties, as indicated on drawings and schedules:

1. 4500 psi 28-day compressive strength.

D. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Subcontractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to Owner, and as accepted by ENGINEER. Laboratory test data for revised mix design and strength results must be submitted to and accepted by ENGINEER before using in work.

E. Admixtures:

1. Use water-reducing admixture or high range water-reducing admixture (super plasticizer) in concrete as required for placement and workability. The use of a water-reducing admixture is required for slabs on grade.

2. Use non-chloride accelerating admixture in concrete slabs placed at ambient temperatures below 50 degrees F. (10 degrees C.).
3. Use air-entraining admixture in exterior exposed concrete. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content with a tolerance of plus-or-minus 1-1/2% within following limits:
   a. Concrete structures and slabs exposed to freezing and thawing or de-icer chemicals
      5.5% 1-1/2" maximum aggregate.
      6.0% 1" maximum aggregate.
      6.0% 3/4" maximum aggregate.
   b. Other Concrete: 2% to 4% air.
4. Use admixtures for water-reducing and set-control in strict compliance with manufacturer's directions.

F. Water-Cement Ratio: Provide concrete for following conditions with maximum water-cement (WC) ratios as follows:
Subjected to freezing and thawing: WC 0.42.

G. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:

1. Ramps, slabs, and sloping surfaces: 4 inches.
2. Concrete containing HRWR admixture (super-plasticizer): Not more than 8 inches after addition of HRWR to site verified 2 inch to 3 inch slump concrete.
3. Other Concrete: 4 inches.

H. Concrete Mixes:

1. Ready-Mix Concrete: Comply with requirements of ASTM C94 and as herein specified. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C94 may be required.

3.0 EXECUTION

3.1 FORMS

A. Design, erect, support, brace and maintain formwork to support vertical and lateral loads that might be applied until such loads can be supported by concrete structure. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation and position.

B. Design formwork to be readily removable without impact, shock or damage to cast-in-place concrete surfaces and adjacent materials.

C. Construct forms to sizes, shapes, lines and dimensions shown, and to obtain accurate alignment, location, grades, level and plumb work in finished structures. Provide for openings, offsets, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in work. Use selected materials to obtain required finishes. Solidly butt joints and provide back-up at joints to prevent leakage of cement paste.

D. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and for easy removal.

E. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings to forms to prevent loss of concrete mortar. Locate temporary openings on forms at inconspicuous locations.

F. Chamfer exposed corners and edges as indicated, using wood, metal, PVC or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.

G. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection, and to prevent spalling concrete surfaces upon removal. Unless otherwise indicated, provide ties so portion remaining within concrete after removal is 1" inside concrete and will not leave holes larger than 1" diameter in concrete surface.

H. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses and chases from trades providing such items. Accurately place and securely support items built into forms.

I. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is placed. Retighten forms and bracing after concrete placement as required to eliminate mortar leaks and maintain proper alignment.

3.2 PLACING REINFORCEMENT

A. Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars", for details and methods of reinforcement placement and supports, and as herein specified.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials which reduce or destroy bond with concrete.

C. Accurately position, support and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as required.

D. Place reinforcement to obtain at least minimum coverages for concrete protection. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

E. Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.

3.3 JOINTS

A. Construction Joints: Locate and install construction joints as indicated or, if not indicated, locate so as not to impair strength and appearance of the structure, as acceptable to ENGINEER.

B. Provide keyways at least 1 1/2" deep in construction joints in walls; keyways in construction joints in slabs to follow ACI recommendations for keyed construction joints.

C. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise noted.

D. Place dowels perpendicular to construction and expansion joints. Dowels shall be accurately aligned parallel to the finished surface, and shall be rigidly held in place and supported during concrete placement. One end of the dowels shall be oiled or coated with high density polyethylene having a minimum thickness of 14 mils.

E. Waterstops: Provide waterstops in construction joints as indicated. Install waterstops to form continuous diaphragm in each joint. Make provisions to support and protect exposed waterstops during progress of work.

Fabricate field joints in waterstops in accordance with manufacturer's printed instructions.

F. Isolation (Expansion) Joints in Slabs-on-Grade: Construct isolation joints in slabs-on-grade at points of contact between slabs on grade and vertical surfaces, such as column pedestals, foundation walls, grade beams and elsewhere as indicated.

G. Contraction (Control) Joints in Slabs-on-Grade: Construct contraction joints in slabs-on-grade to form panels of patterns as shown.

1. Contraction joints shall be formed by saw cuts as soon as possible after slab finishing as may be safely done without dislodging aggregate.

H. Install joint covers in accordance with manufacturer's instructions.

I. Joint Filler and sealant materials are specified in Section 03251 of these specifications.

3.4 INSTALLATION OF EMBEDDED ITEMS

A. General: Set and build into work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions and directions provided by suppliers of items to be attached thereto.

3.5 PREPARATION OF FORM SURFACES

A. Clean re-used forms of concrete matrix residue, repair and patch as required to return forms to acceptable surface condition.

B. Coat contact surfaces of forms with a form-coating compound before reinforcement is placed.

C. Thin form-coating compounds only with thinning agent of type and in amount and under conditions of form-coating compound manufacturer's directions. Do not allow excess form-coating material to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.

D. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

3.6 CONCRETE PLACEMENT

A. Preplacement Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast-in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work. Moisten wood forms immediately before placing concrete where form coatings are not used.

B. Coordinate the installation of joint materials, perimeter insulation and moisture barriers with placement of forms and reinforcing steel.

C. General: Comply with ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete" and as herein specified.

D. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete as nearly as practicable to its final location to avoid segregation.

E. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers not deeper than 24" and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.

F. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with recommended practices.

G. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine. Place vibrators to rapidly penetrate placed layer and at least 6" into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of mix.

H. Maintain reinforcing in proper position during concrete placement operations.

I. Cold Weather Placing: Protect concrete work from physical damage or reduced strength which could be caused by frost, freezing actions, or low temperatures, in compliance with ACI 306 and as herein specified.

1. When air temperature has fallen to or is expected to fall below 40 degrees F (4 degrees C.), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 degrees F (10 degrees C), and not more than 80 degrees F. (27 degrees C) at point of placement.
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt and other materials containing antifreeze agents or chemical accelerators, unless otherwise accepted in mix designs.

J. Hot Weather Placing: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 degrees F (32 degrees C). Mixing water may be chilled or chopped ice may be used to control temperature provided water equivalent of ice is calculated to total amount of mixing water. Use of liquid nitrogen to cool concrete is Subcontractor's option.
2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
3. Fog spray forms, reinforcing steel and subgrade just before concrete is placed.
4. Use water-reducing retarding admixture (Type D) when required by high temperatures, low humidity, or other adverse placing conditions.

3.7 FINISH OF FORMED SURFACES

A. Rough Form Finish: For formed concrete surfaces not exposed to view in the finish work or by other construction, unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding 1/4" in height rubbed down or chipped off.

B. Smooth Form Finish: For formed concrete surfaces exposed to view or that are to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, dampproofing, painting or other similar system. This is as-cast concrete surface obtained with selected form facing material, arranged orderly and

symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smoothed.

C. Smooth Rubbed Finish: Unless noted otherwise, all formed exposed surfaces exposed to view (Limited to one foot below grade and one foot below the minimum liquid level for open structures that are to contain liquids) shall have a finish conforming to ACI 301. Provide smooth rubbed finish to exposed concrete surfaces, which have received smooth form finish treatment, not later than one day after form removal.

1. Moisten concrete surfaces and rub with carborundum brick or other abrasive until a uniform color and texture is produced. Do not apply cement grout other than that created by the rubbing process.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces, strikeoff smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.8 MONOLITHIC SLAB FINISHES

A. Scratch Finish: Apply scratch finish to monolithic slab surfaces that are to receive concrete floor topping or mortar setting beds for tile, portland cement terrazzo, and other bonded applied cementitious finish flooring material, and as otherwise indicated.

1. After placing slabs, plane surface so that depressions between high spots do not exceed 1/2" under a 10' straightedge. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set, with stiff brushes, brooms or rakes.

B. Float Finish: Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as hereinafter specified.

1. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating when surface water has disappeared or when concrete has stiffened sufficiently to permit operation of power-driven floats, or by hand-floating if area is small or inaccessible to power units. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.

C. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed to view, and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint or other thin film finish coating system.

1. After floating, begin first trowel finish operation using a power-driven trowel.
2. Begin final troweling when surface produces a ringing sound as trowel is moved over surface.
3. Consolidate concrete surface by final troweling operation, free of trowel marks, uniform in texture and appearance, and with surface leveled to a tolerance of Ff 23, Fl 17.
4. Grind smooth surface defects which would telegraph through applied floor covering system.

D. Trowel and Fine Broom Finish: Where ceramic or quarry tile is to be installed with thin-set mortar, apply trowel finish as specified, then immediately follow with slightly scarifying surface by fine brooming.

E. Non-Slip Broom Finish: Apply non-slip broom finish to exterior concrete platforms, steps and ramps and elsewhere as indicated.

1. Immediately after trowel finishing, slightly roughen concrete surface by brooming with fiber bristle broom perpendicular to main traffic route. Coordinate required final finish with ENGINEER before application.

F. Chemical-Hardener Finish: Apply chemical-hardener finish to interior concrete floors where indicated. Apply liquid chemical-hardener after complete curing and drying of the concrete surface. Dilute liquid hardener with water (parts of hardener/water as follows), and apply in three coats: first coat, 1/3 strength; second coat, 1/2 strength; third coat, 2/3 strength. Evenly apply each coat and allow 24 hours for drying between coats.

1. Apply proprietary chemical hardeners in accordance with manufacturer's printed instructions.
2. After final coat of chemical-hardener solution is applied and dried, remove surplus hardener by scrubbing and mopping with water.

3.9 CONCRETE CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

1. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.
2. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.

3. Maintain ambient temperature at 70 degrees F for three days after placing concrete.

B. Curing Methods: Perform curing of concrete by moist curing, moisture-retaining cover curing, or curing and sealing compound as herein specified.

1. Moist curing: Provide moist curing by covering concrete surface with absorptive cover, thoroughly saturating cover with water and keeping continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent covers.
2. Moisture-retaining cover curing: Provide moisture-retaining cover curing by covering concrete surfaces and edges with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3" and sealed by waterproof tape or adhesive. Immediately repair any hales or tears during curing period using cover material and waterproof tape.
3. Curing and sealing compound: Provide curing and sealing compound to interior slabs and to exterior slabs, walks, and curbs, as follows: Apply specified curing and sealing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours). Apply uniformly in continuous operation by power-spray or roller in accordance with manufacturer's directions. Re-coat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
4. Do not use membrane curing compounds on surfaces which are to be covered with coating material applied directly to concrete, liquid floor hardener, waterproofing, dampproofing, membrane roofing, flooring (such as ceramic or quarry tile, glue-down carpet), painting and other coatings and finish materials, unless otherwise acceptable to ENGINEER.

C. Curing Formed Surfaces: Cure formed concrete surfaces, including undersides of beams, supported slabs and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing methods specified above, as applicable.

D. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of curing and sealing compound unless otherwise noted.

1. Final cure concrete surfaces to receive liquid floor hardener or finish flooring by use of moisture-retaining cover unless otherwise directed.

3.10 SHORES AND SUPPORTS

A. Comply with ACI 347 for shoring and re-shoring in multistory construction, and as herein specified.

B. Extend shoring from ground to roof for structures 4 stories or less, unless otherwise permitted.

C. Extend shoring at least 3 floors under floor or roof being placed for structures over 4 stories. Shore floor directly under floor or roof being placed, so that loads from construction above will transfer directly to these shores. Space shoring in stories below this level in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members where no reinforcing steel is provided. Extend shores beyond minimums to ensure proper distribution of loads throughout structure.

D. Remove shores and re-shore in a planned sequence to avoid damage to partially cured concrete. Locate and provide adequate re-shoring to safely support work without excessive stress or deflection.

1. Keep re-shores in place a minimum of 15 days after placing upper tier, and longer if required, until concrete has attained its required 28-day strength and heavy loads due to construction operations have been removed.

3.11 REMOVAL OF FORMS

A. Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50 degrees F. (10 degrees C) for 24 hours after placing concrete, provided concrete is sufficiently hard to not be damaged by form removal operations, and provided curing and protection operations are maintained.

B. Formwork supporting weight of concrete, such as beam soffits, joists, slabs and other structural elements, may not be removed in less than 14 days and until concrete has attained design minimum compressive strength at 28-days. Determine potential compressive strength of in place concrete by testing field-cured specimens representative of concrete location or members.

C. Form facing material may be removed 4 days after placement, only if shores and other vertical supports have been arranged to permit removal of form facing material without loosening or disturbing shores and supports.

3.12 REUSE OF FORMS

A. Clean and repair surfaces of forms to be reused in work. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable for exposed surfaces. Apply new form coating compound as specified for new formwork.

B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use "patched" forms for exposed concrete surfaces, except as acceptable to ENGINEER.

3.13 MISCELLANEOUS CONCRETE ITEMS

A. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place and cure concrete as herein specified, to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections and terminations slightly rounded.

C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

D. Grout base plates and foundations as indicated, using specified non-shrink grout. Use non-metallic grout for exposed conditions, unless otherwise indicated.

3.14 CONCRETE SURFACE REPAIRS

A. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to ENGINEER.

1. Cut out honeycomb, rock pockets, and voids over 1/4" in any dimension, down to solid concrete but, in no case to a depth of less than 1". Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water and brush-coat the area to be

patched with specified bonding agent. Place patching mortar after bonding compound has dried.

B. For exposed to view surfaces: Blend white portland cement and pigmented portland cement so that, when dry, patching mortar will match color surrounding. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.

C. Repair of Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of ENGINEER. Surface defects, as such, include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets; fins and other projections on surface; and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes, fill with dry pack mortar, or precast cement cone plugs secured in place with bonding agent.

D. Repair concealed formed surfaces, where possible, that contain defects that affect the durability of concrete. If defects cannot be repaired, remove and replace concrete.

E. Repair of Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface plane to tolerances specified for each surface and finish. Correct high areas as herein specified. Test unformed surfaces sloped to drain for trueness of slope, in addition to smoothness using a template having required slope.

F. Repair finished unformed surfaces that contain defects which affect durability of concrete. Surface defects, as such, include crazing, cracks in excess of 0.015" wide, spalling, pop-outs, honeycomb, rock pockets and other objectionable conditions.

G. Correct high areas in unformed surfaces by grinding, after concrete has cured at least 14 days.

H. Repair defective areas, except random cracks and single holes not exceeding 1" diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean square cuts and expose reinforcing steel with at least 3/4" clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding compound. Fill areas with concrete repair mortar. Place, compact and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

I. Repair isolated random cracks and single holes not over 1" in diameter with concrete repair mortar. Groove top of cracks and cut-out holes to sound concrete and clean of dust, dirt and loose particles. Dampen cleaned concrete surfaces and apply bonding compound. Mix repair mortar in accordance with manufacturers printed instructions. Place repair mortar after bonding compound has dried. Finish to match existing concrete. Keep patched area continuously moist for not less than 72 hours.

J. Perform structural repairs with prior approval of ENGINEER for method and procedure, using specified epoxy adhesive and mortar.

K. Repair methods not specified above may be used, subject to acceptance of ENGINEER.

3.15 QUALITY CONTROL TESTING DURING CONSTRUCTION

A. The contractor will engage a testing laboratory to perform and report compressive strength tests. All concrete sampling and testing shall be performed by an ACI certified level 1 technician.

B. The contractor will engage an ACI certified level 1 technician to inspect reinforcement placement and soil/rock bearing conditions prior to placing concrete. Notify testing agency at least 24 hours prior to concrete placement.

C. Sampling and testing for quality control during placement of concrete will include the following:

1. Sampling Fresh Concrete: ASTM C172, except modified for slump to comply with ASTM C94.
2. Slump: ASTM C143: one test at point of discharge for each day's pour of each type of concrete; additional tests when concrete consistency seems to have changed.
3. Air Content: ASTM C173, volumetric method for lightweight or normal weight concrete; ASTM C231 pressure method for normal weight concrete; one for each day's pour of each type of concrete.
4. Concrete Temperature: Test hourly when air temperature is 40 degrees F (4 degrees C) and below, and when 80 degrees F (27 degrees C) and above; and each time a set of compression test specimens made.
5. Compression Test Specimen: ASTM C31; one set of 3 standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field-cure test specimens are required.

6. Compressive Strength Tests: ASTM C39; one set for each day's pour exceeding 5 cubic yards plus additional sets for each 50 cubic yards over and above the first 50 cubic yards of each concrete class placed in any one day; one specimen tested at 7 days, two specimens tested at 28 days. When frequency of testing will provide less than 5 strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches or from each batch if fewer than 5 are used. Throughout the job, the Engineer or Engineer's Representative shall direct when cylinders shall be taken and in what number they shall be taken.

D. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength, and no individual strength test result falls below specified compressive by more than 500 psi.

E. Test results will be reported in writing to ENGINEER and Contractor within 24 hours that tests are made. Reports of compressive strength tests will contain the project identification name and number, date of concrete placement, slump and temperature at time of sampling, name of concrete testing service, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; compressive breaking strength and type of break for both 7-day tests and 28-day tests.

F. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but will not be used as the sole basis for acceptance or rejection.

G. Additional Tests: The testing service will make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by the ENGINEER. Testing service may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42, or by other methods as directed. Subcontractor shall pay for such tests conducted, and any other additional testing as may be required, when unacceptable concrete is verified.

END OF SECTION 03310

SECTION 03600

GROUT

1.0 GENERAL

1.1 REFERENCES

A. The following is a list of standards, which may be referenced in this section:

1. American Society for Testing and Materials (ASTM):
   a. C230, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   b. C 10 18, Standard Test Method for Flexural Toughness and First-Crack Strength of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading).
   c. C 1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
   d. C 1116, Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
   e. D4580, Measuring Delaminations in Concrete Bridge Decks by Sounding, Practice for.
2. Corps of Engineers (COE):
   a. CRD-C61 1, Flow of Grout for Preplaced Aggregate Concrete.
   b. CRD-C621, Specification for Nonshrink Grout

1.2 SUBMITTALS

A. Shop Drawings:

1. Product data of grouts.
2. Proposed method for keeping existing concrete surfaces wet prior to placing grout.
3. Forming method for fluid grout placements.
4. Curing method for grout.

B. Quality Control Submittals:

1. Manufacturer's Written Instructions:
   a. Adding fiber reinforcing to batching.
   b. Cement-water ratio of grout topping.
   c. Mixing of grout.
2. Manufacturer's proposed training schedule for grout work.
3. Manufacturer's Certificate of Compliance:
   a. Grout free from chlorides and other corrosion-causing chemicals.
   b. Nonshrink grout properties of Categories H and III, verifying expansion at 3 or 14 days will not exceed the 28 day expansion and nonshrink properties are not based on gas or gypsum expansion.

4. Manufacturer's Certificate of Proper Installation.
5. Statements of Qualification: Nonshrink grout manufacturer's representative.
6. Test Reports:
   a. Test report for 24-hour evaluation of nonshrink grout. Independent testing laboratory to certify that testing was conducted within the past 18 months.
   b. Test results and service report from the demonstration and training session, and from field tests.
   c. Field test reports and laboratory test results for field-drawn samples.

1.3 QUALIFICATIONS

A. Nonshrink Grout Manufacturer's Representative: Authorized and trained representative of grout manufacturer. Minimum of 1 year experience that has resulted in successful installation of grouts similar to those for this Project.

1.4 GUARANTEE

A. Manufacturer's guarantee shall not contain disclaimer on the product data sheet, grout bag, or container limiting responsibility to only the purchase price of products and materials furnished.

B. Manufacturer guarantees participation with CONTRACTOR in replacing or repairing grout found defective due to faulty materials, as determined by industry standard test methods.

2.0 PRODUCTS

2.1 NONSHRINK GROUT SCHEDULE

A. Furnish nonshrink grout for applications in grout category in the following schedule:

Application	Temperature Range	Maximum Placing Time	
	40 to 100 deg F	20 min	Greater Than 20 min
Filing Tie Holes	I	I	I
Blockouts for Gate Guides	I or II		II
Precast Joints	I or II		II
Through-bolt openings	II	II	II
Machine bases 25 hp or less	II	II	II
Patching concrete walls	II	II	II
Machine bases 26 hp and up	III	III	III

Baseplates and/or soleplates with vibration, thermal movement, etc.	III	III	III

2.2 NONSHRINK GROUT

A. Category I:

1. Nonmetallic and nongas-liberating flowable fluid.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Test in accordance with AS TM C 1107:
   a. Flowable consistency 140 percent, five drops in 30 seconds, in accordance with ASTM C230.
   b. Flowable for 15 minutes.
4. Grout shall not bleed at maximum allowed water.
5. Minimum strength of grout, 3,000 psi at 3 days, 5,000 psi at 7 days, and 7,000 psi at 28 days.
6. Manufacturers and Products:
   a. Master Builders Co., Cleveland, OH; SET GROUT.
   b. Euclid Chemical Co., Cleveland, OH; NS Grout.
   c. Dayton Superior Corp., Miamisburg, OH; Sure-Grip High Performance Grout.

B. Category II

1. Nonmetallic, nongas-liberating flowable fluid.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with COE CRD-C621 and ASTM C 1107, Grade B:
   a. Fluid consistency 20 to 30 seconds in accordance with COE CRD-C61 1.
   b. Temperatures of 40, 80, and 100 degrees F.
5. One (1) hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of grout, 2,500 psi at 1 day, 4,500 psi at 3 days, and 7,000 psi at 28 days.
7. Maintain fluid consistency when mixed in 1 to 9 yard loads in ready-mix truck.
8. Manufacturers and Products:
   a. Master Builders Co., Cleveland, OH; Master Flow 928.
   b. Five Star Products Inc., Fairfield, CT; Five Star 100.
   c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.

C. Category III:

1. Metallic and nongas-liberating flowable fluid.
2. Prepackaged aggregate grout requiring only the addition of water.

3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with COE CRD-C621 and ASTM C 1107, Grade B:
   a. Fluid consistency 20 to 30 seconds in accordance with COE CRD-C61 1.
   b. Temperatures of 40 and 100 degrees F.
5. One (1) hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of grout, 4,000 psi at 1 day, 5,000 psi at 3 days, and 9,000 psi at 28 days.
7. Maintain fluid consistency when mixed in I to 9 yard loads in ready-mix truck.

8. Manufacturers and Products: Master Builders Co., Cleveland, OH; EMBECO 885.

3.0 EXECUTION

3.1 NONSHRINK GROUT

A. General: Mix, place, and cure nonshrink grout in accordance with grout manufacturer's representative training instructions.

B. Form Tie or Through-Bolt Holes: Provide nonshrink grout, Category I and II, Fill space with dry pack dense grout hammered in with steel tool and hammer. Through-bolt holes, coordinate dry pack dense grout application with vinyl plug in Section 03 100, CONCRETE FORMWORK and bonding agent in Section 03300, CAST-IN-PLACE CONCRETE.

C. Grouting Machinery Foundations:

1. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material.
2. Set machinery in position and wedge to elevation with steel wedges, or use cast-in leveling bolts.
3. Form with watertight forms at least 2 inches higher than bottom of plate.
4. Fill space between bottom of machinery base and original concrete in accordance with manufacturer's representative training instructions.

3.2 FIELD QUALITY CONTROL

A. Evaluation and Acceptance of Nonshrink Grout:

1. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.

2. Perform flow cone and bleed tests, and make three 2-inch by 2-inch cubes for each 25 cubic feet of each type of nonshrink grout used. Restraining caps for cube molds in accordance with COE CRD-C621.
3. For large grout applications make three more cubes, one more flow cone test, including bleed test for each additional 25 cubic feet of nonshrink grout placed.
4. Consistency: As specified in Article NONSBRINK GROUTS. Reject grout with consistencies outside range requirements.
5. Segregation: As specified in Article NONSHRINK GROUTS. Reject grout when aggregate separates.
6. Nonshrink grout cubes shall test equal to or greater than minimum strength.
7. Strength Test Failures: Reject nonshrink grout work failing strength tests, remove and replace grout.
8. Perform bleeding test to demonstrate grout will not bleed.
9. Store cubes at 70 degrees F.
10. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with COE CRD-C62 1.

3.3 MANUFACTURER'S SERVICES

A. General:

1. Coordinate demonstrations, training sessions, and applicable site visits with grout manufacturer's representative.
2. Provide and conduct onsite, demonstration and training sessions for leech tests, mixing, flow cone measurement, cube testing, application, and curing for each category and type of nonshrink grout.
3. Coordinate necessary equipment and materials are available for demonstration.

B. Training:

1. Grout manufacturer's representative shall train CONTRACTOR to perform grout work.
2. Establish location at site and schedule time for grout manufacturer's demonstration and training session of proposed nonshrink grouts. Mix nonshrink grouts to required consistency, test, place, and cure on actual Project, e.g., baseplates and tie holes to provide actual on-the-job training.
3. Use minimum of five bags for each grout Category H and Category III. Mix grout to fluid consistency and conduct flow cone and two bleed tests, make a minimum of six cubes for testing of two cubes at 1, 3, and 28 days. Use remaining grout for final Work. Training includes methods for curing grout.
4. Mix sufficient grout Category I for minimum of 15 tie holes.
5. Patching through-bolt holes and blockouts for gate guides, and similar items.
6. Transport test cubes to an independent test laboratory and obtain test reports.

3.4 SUPPLEMENTS

A. The supplement listed below, following "END OF SECTION 03600" is part of this Specification.

1. 24-hour Evaluation of Nonshrink Grout Test Form and Grout Testing Procedures.

END OF SECTION 03600

SUPPLEMENT I

_____

(Test Lab Name)

_____

(Address)

_____

(Phone No.)

24-HOUR EVALUATION OF NONSHRINK GROUT TEST FORM

OBJECTIVE: Define standard set of test procedures for an independent testing laboratory to perform and complete within a 24-hour period.

SCOPE: Utilize test procedures providing 24-hour results to duplicate field grouting demands. Intent of evaluation is establish grout manufacturer's qualifications.

PRIOR TO TEST: Obtain five bags of each type of grout.

1. From intended grout supplier for Project.
2. Five bags of grout shall be of same lot number.

ANSWER THE FOLLOWING QUESTIONS FOR GROUT BEING TESTED FROM LITERATURE, DATA, AND PRINTING ON BAG:

A. Product data and warranty information contained in company literature and data? Yes_____ No____

B. Literature and bag information meet specified requirements? Yes_____ No____

C. Manufacturer guarantees grout as specified in Article GUARANTEE? Yes_____ No____

D. Guarantee extends beyond grout replacement value and allows participation with CONTRACTOR in replacing and repairing defective areas? Yes_____ No____

E. Water demands and limits printed on bag? Yes_____ No____

F. Mixing information printed on the bag? Yes_____ No____

G. Temperature restrictions printed on bag? Yes_____ No____

*Rejection of a grout will occur if one or more answers are noted NO.

GROUT TESTING PROCEDURES

A. Bagged Material:

1. List lot numbers.

2. List expiration date.

3. Weigh bags and record weight.

ENGINEER will disqualify grout if bag weights have misstated measure plus or minus 2 pounds by more than one out of five bags. (Accuracy of weights is required to regulate amount of water used in mixing since this will affect properties.)

B. Mixing and Consistency Determination:

1. Mix full bag of grout in 10 gallon pail.

2. Use electric drill with a paddle device to mix grout (jiffy or jiffler type paddle).

3. Use maximum water allowed per water requirements listed in bag instructions.

4. Mix grout to maximum time listed on bag instructions.

5. In accordance with COE CRD-C611 (flow cone) determine time of mixed grout through the flow cone. _____ seconds

6. Add water to attain 20 to 30 second flow in accordance with COE CRD-C61 1.

7. Record time of grout through cone at new water demand. _____ seconds

8. Record total water needed to attain 20 to 30 second flow. _____ pounds

9. Record percent of water. _____ percent

C. When fluid grout is specified and additional water is required beyond grout manufacturer's fisted maximum water, COE CRD-C621 will be run at new water per grout ratio to determine whether grout passes using actual water requirements to be fluid. Use new water per grout ratio on remaining tests.

D. Bleed Test:

1. Fill two gallon cans half full of freshly mixed grout at ambient temperatures for each category and at required consistency for each.

2. Place one can of grout in tub of ice water and leave one can at ambient temperature.

3. Cover top of both cans with glass or plastic plate preventing evaporation.

4. Maintain 3 8 to 42 degrees F temperature with grout placed in ice and maintain ambient temperature for second container for I hour.

5. Visually check for bleeding of water at 15-minute intervals for 2 hours.

6. Perform final observation at 24 hours.

If grout bleeds a small amount at temperatures specified, grout will be rejected.

E. Extended Flow Time and Segregation Test (for Category H and 111):

1. Divide the remaining grout into two 3 gallon cans. Place the cans into the 40-degree F and 100-degree F containers and leave for 20, 40, and 60 minutes. Every 20 minutes remove and check for segregation or settlement of aggregate. Use a gloved hand to reach to the bottom of the can, if more than 1/4-inch of aggregate has settled to the bottom or aggregate has segregated into clumps reject the grout.

2. Right after the settlement test mix the grout with the drill mixer for 10 seconds. Take a COE CRD-C611 flow cone test of grout and record flow time. Maintain this process for I hour at ambient temperatures of 40 and 100 degrees F.

   a. 20 min _____ sec. @ 40 degrees F.
   b. 40 min _____ sec. @ 40 degrees F.
   c. 60 min _____ sec. @ 40 degrees F.
   d. 20 min _____ sec. @ 100 degrees F.
   e. 40 min _____ sec. @ 100 degrees F.
   f. 60 min _____ sec. @ 100 degrees F.

   All Category 11 and III grout that will not go through the flow cone with continuous flow after 60 minutes will be disqualified.

   _____ Qualified

   _____ Disqualified

F. 24-hour Strength Test:

1. Using grout left in mixing cans in accordance with COE CRD-C621 for mixing and consistency determination test and for extended time flow test, make minimum of nine cube samples.

2. Store cubes at 70 degrees F for 24 hours.

3. Record average compressive strength of nine cubes at 24 hours.

Grout will be disqualified if 24-hour compressive strengths are under 2,500 psi for grouts claiming fluid placement capabilities.

Grouts that have not been disqualified after these tests are qualified for use on the Project for the application indicated in Nonshrink Grout Schedule.

_____	_____
Signature of Independent Testing Laboratory	Date Test Conducted

SECTION 04051

WATER REPELLENT
CONCRETE MASONRY UNIT WALLS

1.0 GENERAL

The split-face concrete masonry unit (CMU) wall shall be constructed with the DRY-BLOCK System as manufactured by Grace Construction Products, Cambridge, MA or approved equal. The DRY-BLOCK system consists of 3 separate products:

- DRY-BLOCK Block Admixture, a liquid polymeric admixture, is mixed into the concrete during manufacture of the CMU.
- DRY-BLOCK Mortar Admixture is added to the mortar mix.
- INFINISEAL DB Sealer is then either sprayed, rolled or brush applied to the outside surface of the walls.

2.0 MATERIALS

2.1 CONCRETE MASONRY UNITS

The CMU's shall be produced only by qualified producers who are subjected to annual qualifications of their mix designs and admixture dosage rates to ensure the ability to manufacture water repellent units. The units shall be heavy weight.

2.2 MORTAR

Mortar Admixture is added at the recommended dosage rate, which is dependent on the type of mortar being used.

Agitate Mortar Admixture before using. Mortar admixture should be added to the mix water prior to charging the cement and sand. Reduce the initial water used in the mortar. The mortar joints shall have a well tooled concave joint profile.

Excess mortar shall be removed promptly from the face of the masonry units. Strong acids, sand blasting, and high pressure cleaning to remove hardened mortar will not be allowed.

2.3 SEALER

The water repellent sealer shall be applied to the finished water repellent CMU wall. The sealer shall be equal to INFINISEAL DB as manufactured by Grace Construction Products, Cambridge, MA. The preparatory work, surface preparation, protection of surrounding areas, application methods, drying and

curing times, post-application cleaning shall be in strict accordance with manufacture's recommendations and data sheets.

3.0 INSTALLATION

The entire CMU water repellent system shall be installed in strict accordance with the manufacturer's recommendations. The contractor shall submit the specifications and data sheets to the engineer for approval prior to construction of the CMU walls.

4.0 PAYMENT

Cost shall be included in the work to which it is subsidiary. No separate measurement and payment will be made.

SECTION 05003

MISCELLANEOUS METALS

1.0 GENERAL

The Contractor shall furnish all labor, materials, equipment and services necessary for fabrication and erection of all miscellaneous steel angles, beams, plates and channels as shown on the Drawings and specified herein and not specifically included under other sections of these Specifications.

1.1 QUALITY ASSURANCE STANDARDS

A. Codes and Standards: All work shall comply with provisions of following, except as otherwise indicated:

1. AISC "Code of Standard Practice for Steel Buildings and Bridges".
2. Paragraph 4.2.1 of the above code is hereby modified by deletion of the following sentence: "This approval constitutes the owner's acceptance of all responsibility for the design adequacy of any connections designed by the fabricator as a part of his preparation of these shop drawings."
3. AISC "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings", including "Commentary" and Supplements thereto as issued.
4. AISC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts" approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation.
5. AWS D1.1 "Structural Welding Code".
6. ASTM A 6 "General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use".

B. Qualifications for Welding Work: Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedure".

1. Provide certification that welders to be employed in work have satisfactorily passed AWS qualification tests.

a) If recertification of welders is required, retesting will be Contractor's responsibility.

1.2 SUBMITTALS

Shop drawings, giving complete information necessary for fabrication, layout and installation of all metal work, shall be submitted to the Engineer for approval prior to fabrication.

The preparation of shop drawings for fabricated metal items shall be coordinated by the Contractor with the manufacturers of various equipment in order to comply with details, locations, openings, etc. required by the manufacturers.

Field measurements shall be made to verify all dimensions in the field, which may affect installation of work before shop drawings are made and/or fabrication is performed.

2.0 MATERIALS

2.1 STRUCTURAL METALS

2.1.1 Steel wide flange shapes shall conform to the requirements of ASTM A 992, grade 50. All other shapes, plates and bars shall be ASTM A36, or ASTM A 572, grade 50. (Non-exposed and interior)

2.1.2 Aluminum shall conform to the requirements of ASTM B209, alloy 6061-T6.

2.2 ANCHORAGE ITEMS

The Contractor shall furnish all bolts, nuts, shims, pins, screws, straps, nails and other anchors, which may be required by the Drawings or job conditions, to secure all items permanently in place, whether or not specifically called for or shown on the Drawings.

3.0 EXECUTION

3.1 FABRICATION AND INSTALLATION OF METAL WORK.

All metal items shall be accurately fabricated and erected with exposed joints close fitting. All joints shall be of such character and so assembled that they will be as strong and rigid as adjoining sections. Joints shall be located where least conspicuous. Items shall have smooth finished surfaces except where otherwise shown or specified.

Where welding is required or permitted, it shall conform to the requirements for shielding metal arc welding of the Standard Code for Arc and Gas Welding in Building Construction of the American Welding Society. Shop drawings shall show welding and shall indicate the size, length, spacing and type of welds.

Joints required to be welded shall be continuously welded or spot-welded as specified and face of welds dressed flush and smooth where exposed to view.

Members or parts to be built in with masonry or concrete shall be in a form affording a suitable anchorage or shall be provided with approved anchors, expansion shields or other approved means of securing members.

Ferrous and non-ferrous metals shall be insulated at all contacts with felt washers, strips or sheets, bitumastic paints, or other approved means.

3.1.1 All required anchors, couplings, bolts, and nuts required to support miscellaneous metal work shall be furnished and installed as required.

3.1.2 Weights of connections and accessories shall be adequate to safely sustain and withstand stresses and strains to which they will be normally subjected.

3.1.3 Connections shall be bolted except where welding is called for in the Drawings. Bolts shall have a minimum of 1/2-inch diameter unless noted or required otherwise.

3.1.4 Accurately place all miscellaneous metal items in the locations and to the required elevations.

3.1.5 Adequately brace any items which are cast in concrete masonry work.

3.1.6 Use concealed anchors wherever possible.

3.2 CLEANING

Remove and properly dispose of all debris and litter; leave the work area in a clean condition.

END OF SECTION 05003

SECTION 05120

STRUCTURAL STEEL

1.0 GENERAL

1.1 REFERENCES

A. The following is a list of standards, which may be referenced in this Section:

1. American Institute of Steel Construction (AISC):
   a. Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design.
   b. Allowable Stress Design Specification for Structural Joints using ASTM A325 or A490 Bolts.
   c. Code of Standard Practice for Steel Buildings and Bridges.
   d. AISC Quality Certification Program.

2. American Society for Testing and Materials (ASTM):
   a. A36 or A992, Standard Specification for Structural Steel.
   b. A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   c. A242, High-strength Low-alloy Structural Steel.
   d. A325, Standard Specification for High-Strength Bolts for Structural Steel Joints.
   e. A490, Standard Specification for Heat-Treated Steel Structural bolts, 150 ksi Minimum Tensile Strength.
   f. A500, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   g. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
   h. A563, Standard Specification for Carbon and Alloy Steel Nuts.
   i. F436, Standard Specification for Hardened Steel Washers.
   j. F959, Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.

3. American Society of Nondestructive Testing (ASNT): SNT-TC- I A, Recommended Practice.

4. American Welding Society (AWS):
   a. B2.1, Standard for Welding Procedure and Performance Qualification.
   b. D1.1, Structural Welding Code-Steel.
   c. QC I, Standard and Guide for Qualification and Certification of Welding Inspectors.

1.2 SUBMITTALS

A. Shop Drawings:

1. Provide details showing:
   a. Erection plans.
   b. Members and their connections.
   c. Anchor bolt layouts.
   d. Hardened washer details.
   e. Joint details for complete penetration welds.
   f. Schedules for fabrication procedures.

2. Name and address of manufacturer(s).
3. Product specifications.
4. Manufacturers' testing procedures and standards.
5. Preparation and installation or application instructions, as appropriate.

B. Quality Control Submittals:

1. Mill Certificates.
2. High-Strength Bolts (Zinc-Coated):
   a. Certificates of Compliance that products meet chemical and mechanical requirements of standards specified.
   b. Manufacturer's inspection test report results for production lot(s) furnished, to include:
      1. Tensile strength.
      2. Yield strength.
      3. Reduction of area.
      4. Elongation and hardness.

   c. Certified Mill Test Reports for Bolts and Nuts:
      1. Name and address of manufacturer.
      2. Bolts correctly marked.
      3. Marked bolts and nuts used in required mill tests and manufacturer's inspection tests.

3. Direct Tension Indicators: Furnish manufacturer's test report meeting requirements of ASTM F959.
4. Methods proposed to resolve misalignment between anchor bolts and bolt holes in steel members.

C. Fabricator Certification :

1. The structural steel fabrication shop shall be certified by the American Institute of Steel Construction in the categories of Conventional Steel Structures and Complex Steel Structures as minimum and endorsed for Sophisticated Paint Category. Submit a copy of the current certification for ENGINEER's review and approval. At the completion of fabrication, the

fabricator shall submit to the ENGINEER a certificate of compliance addressed to the building official stating that the work was performed in accordance with the approved construction documents and Change/Field Orders.

D. Erector Certification:

1. The structural steel erector shall be certified by the American Institute of Steel Construction in the categories of Certified Steel Erector as minimum. Submit a copy of the current certification for ENGINEER's review and approval. At the completion of erection of structural steel, the erector shall submit to the ENGINEER, a certificate of compliance addressed to the building official stating that the work was performed in accordance with the approved construction documents and Change/Field Orders.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Welder/Welding Operator: In accordance with AWS D1.1.1

B. Special Inspection (Kentucky Building Code 2007, Section 1704) :

1. Special Inspections to be performed under this contract is listed under General Provisions of Structural Drawings. If special inspection is required, Owner will retain the services of a Special Inspector and this Contractor is responsible for providing safe access to all areas of His/Her work for inspection at no additional cost to the Owner or His/Her Agents.

2. The extent of special inspection to be performed is listed in Table 1704.3 of the Kentucky Building Code 2007 (KBC 2007).

C. Fabricator Certification :

1. The structural steel fabrication shop shall be certified by the American Institute of Steel Construction (AISC) in the categories of Conventional Steel Structures and Complex Steel Structures as minimum and endorsed for Sophisticated Paint Category. At the completion of fabrication, the fabricator shall submit a certificate of compliance addressed to the building official stating that the work was performed in accordance with the approved construction documents and Change/Field Orders.

2. If the Fabricator is not certified by the AISC, Special Inspection of the fabrication of the structural steel shall be performed, by the ENGINEER approved Special Inspector according to Article 1704.2 of the KBC 2007 and the cost of Special Inspection shall be back-charged to the Steel Fabricator.

D. Erector Certification :

1. The structural steel erector shall be certified by the American Institute of Steel Construction in the categories of Certified Steel Erector as minimum. At the completion of erection of the structural steel, the erector shall submit a certificate of compliance addressed to the building official stating that the work was performed in accordance with the approved construction documents and Change/Field Orders.

2. If the Erector is not certified by the AISC, Special Inspection of the erection of the structural steel shall be performed, by the ENGINEER approved Special Inspector according to Article 1704.3 of the KBC 2007 and the cost of Special Inspection shall be back-charged to the Steel Erector.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Load structural members in such a manner that they will be transported and unloaded without damage to coatings and without being excessively stressed, deformed, or otherwise damaged.

B. Storage:

1. Protect structural steel members and packaged materials from corrosion and deterioration.
2. Store in dry area and not in direct contact with ground.
3. Protect fasteners from dirt and moisture. Do not remove lubricant from bolts and nuts.

C. Handle materials to avoid distortion or damage to members or supporting structures.

2.0 PRODUCTS

2.1 MATERIALS

A. Steel wide flange shapes: ASTM A992, Grade 50, unless otherwise shown.

B. Rolled Plates, Shapes, and Bars: ASTM A36, Grade 36, unless otherwise shown.

C. Structural Steel Pipe: ASTM A501 or ASTM A53, Type E or S, Grade B.

D. Structural Tubing: ASTM A500, Grade B (fy equals 46 ksi); provide full-length members without splices unless otherwise noted or approved.

E. Welding Materials: AWS D1.1.1, E7OXX

2.2 FASTENERS

A. Anchor Bolts: ASTM A-36 or ASTM A-307

B. High-Strength Bolts: ASTM A325 or ASTM A490, bolt type 1, zinc coated. Bolt length and thread length shall be as required for the connection type shown, with hardened washers as required.

C. Direction Tension Indicators (DTIs or Load Indicator Washers):

1. ASTM F959, coating type to match bolt finish.
2. Manufacturer: J&M Turner, Southhampton, PA.

D. Tension-Control Bolts:

1. High-strength, ASTM A325 or ASTM 490.
2. Manufacturers:
   a. LeJeune Bolt Company, Lakeville, MN.
   b. Nucor Fasteners, Saint Joe, IN.
   c. Bristol Machine Co., Walnut, CA.

E. Nuts: ASTM A563, type to match bolt type and finish.

F. Hardened Washers: ASTM F436, type to match bolt finish.

G. Welded Anchor Studs:

1. Headed concrete anchor studs (HAS), deformed bar anchors (DBA), or threaded anchor studs (TAS), as shown.
2. Manufacturer: Nelson Stud Welding Co., Loraine, OH.

2.3 ANCILLARY MATERIALS

A. Surface Preparation and Primer: As specified in Section 9900, PAINTING

B. Grout: Non-shrink grout as specified in Section 03310.

2.4 FABRICATION

A. General:

1. Fabricate as shown and in accordance with AISC Specifications.
2. Mark and match mark materials for field assembly.
3. Complete assembly, including bolting and welding of units, before start of finishing operations.
4. Fabricate to agree with field measurements.

B. Connections:

1. Shop Connections: Weld or bolt, as shown.
2. Develop full strength of members joined and meet requirements of AISC Manual of Steel Construction tables for bolted double-angle shear connections, unless otherwise shown.

C. Welded Construction:

1. Comply with AWS D1.1 for procedures, appearance, and quality of welds, and methods used in correcting welding.
2. Groove and Butt Welds: Complete penetration unless otherwise specified.

D. Interface with Other Work:

1. Holes:
   a. As necessary or as indicated for securing other Work to structural steel framing, and for passage of other Work through steel framing members.
   b. No flame-cut holes will be permitted without prior approval of the ENGINEER.

2. Weld threaded nuts to framing, and other specialty items as shown to receive other Work.

E. Shop Paint Primer:

1. Surface Preparation: Clean and remove slag from welds before painting.
2. Coat members with primer except at future field welds, bolt-ups, and concrete embedment.
3. Apply primer in accordance with Section 9, PAINTING within 8 hours after surface preparation.

F. Slip-Critical Bolted Connections:

1. Mask faying surfaces of slip-critical bolted connections to be shop painted, or blast clean and coat with a Class A paint as specified in Section 9, PAINTING.
2. Roughen galvanized faying surfaces with hand wire brushing.

3.0 EXECUTION

3.1 ERECTION

A. Meet requirements of AISC Code of Standard Practice for Steel Buildings and Bridges.

B. Install CONTRACTOR-designed temporary construction bracing to provide necessary support until all components are in place and construction is complete.

C. High-Strength Bolted Connections:

1. Tighten in accordance with AISC Specification for Structural Joints Using ASTM A325 or A490 Bolts.
2. Hardened Washers:
   a. Provide at locations required by Washer Requirements section of AISC Specification for Structural Joints Using ASTM A325 or A490 Bolts, to include all slip-critical connections using slotted or oversized holes or A490 bolts.
   b. Use beveled style and extra thickness where required by AISC Specification.
   c. Do not substitute Direct Tension Indicators (DTI) for hardened flat washers required at slotted and oversize holes.
3. For bearing-type connections not fully tensioned, tighten to snug-tight condition. Use a hardened washer over slotted or oversize holes in outer plies.
4. Tension-control bolts may be used in snug-tight bearing connections only.

D. Fully Tensioned Bolted Connections:

1. Use DTIs at all slip-critical and fully tensioned bearing-type connections.
2. Position within bolted assembly in accordance with ASTM F959.
3. Install bolts, with DTIs plus hardened washers as required, in all holes of an assembly and tighten until all plies are in firm contact and fasteners are uniformly snug tight.
4. Final tighten all bolts, beginning at the most rigid part of the bolted connection and progressing toward the free edges, until the DTI's have been compressed to an average gap equal to or less than shown in Table 2, ASTM F959.

3.2 ANCHOR BOLTS

A. Coordinate installation of anchor bolts and other connectors required for securing structural steel to in-place work.

B. Provide templates and other devices for presetting bolts and other anchors to accurate locations.

3.3 SETTING BASES AND BEARING PLATES

A. Clean concrete and masonry bearing surfaces of bond reducing materials and roughen to improve bond to surfaces.

B. Clean bottom surface of base and bearing plates.

C. Set loose and attached baseplates and bearing plates for structural members on wedges, leveling nuts, or other adjustable devices.

D. Tighten anchor bolts after supported members have been positioned and plumbed.

E. Grout Under Baseplates: As specified in Section 03310, prior to placing loads on structure.

3.4 FIELD ASSEMBLY

A. Set structural frames accurately to lines and elevations shown.

B. Align and adjust various members forming a part of a complete frame or structure before permanently fastening.

C. Clean bearing surfaces and other surfaces that will be in permanent contact before assembly.

D. Perform necessary adjustments to compensate for minor discrepancies in elevations and alignment.

E. Level and plumb individual members of structure within tolerances shown in AISC Code of Standard Practice for Steel Buildings and Bridges.

F. Establish required leveling and plumbing measurements on mean operating temperature of structure.

G. Provide additional field connection material as required by AISC Code of Standard Practice for Steel and Bridges.

3.5 MISFITS AT BOLTED CONNECTIONS

A. Where misfits in erection bolting are encountered, immediately notify ENGINEER for approval of one of the following methods of correction:

1. Ream holes that must be enlarged to admit bolts and use oversized bolts.
2. Plug weld misaligned holes and re-drill holes to admit standard size bolts.
3. Drill additional holes in the connection, conforming with AISC Standards for bolt spacing and end and edge distances, and add additional bolts.
4. Reject members containing misfit, incorrect sized or misaligned holes and fabricate a new member to ensure proper fit.
5. Do not enlarge incorrectly sized or misaligned holes in members by burning or by use of drift pins.

3.6 MISFITS AT ANCHOR BOLTS

A. Resolve misalignments between anchor bolts and bolt holes in steel members in accordance with approved submittal.

B. Do not flame cut to enlarge holes.

3.7 GAS CUTTING

A. Do not use gas cutting torches in field for correcting fabrication errors in structural framing.

B. Secondary members not under stress and concealed in finished structure may be corrected by gas cutting torches, if approved by ENGINEER.

C. Finish flame-cut sections equivalent to sheared and punched appearance.

3.8 PAINTING TOUCHUP

A. Immediately after erection, clean field welds, bolted connections, and abraded areas of slag and shop paint primer.

B. Apply touchup paint primer by brush or spray of same thickness and material as that used in shop application and as specified in Section 9, PAINTING.

3.9 FIELD QUALITY CONTROL-BOLTED CONNECTIONS

A. High-Strength Bolted Connections: All high-strength bolted connections will be inspected by an independent testing agency, retained by the Owner in accordance with the AISC Specification for Structural Joints Using ASTM A325 or A490 Bolts and per KBC 2007 and 2003 Supplements as follows:

1. Marking identification and conformance to ASTM standards.
2. Alignment of bolt holes.
3. Placement, type, and thickness of hardened washers.
4. Tightening of bolts.

B. Bearing-Type Connections Not Fully Tensioned: Snug-tight condition with all plies of the joint in firm contact.

C. Fully Tensioned Bearing and Slip-Critical Connections:

1. Conduct Pre-Installation Test.
2. Monitor installation and tightening of DTI's.
3. Monitor condition of faying surfaces for slip-critical connections.

D. Pre-Installation Test:

1. Conduct jobsite test prior to start of work using a bolt tension measuring device.
2. Select representative sample of not less than three bolts of each diameter, length, and grade.
3. Include DTI's and flat hardened washers as required to match actual connection assembly.
4. Conduct test in accordance with the Specification for Structural Joints Using ASTM A325 or A490 Bolts.

E. Nondestructive Testing (NDT) Report: Prepare and submit a written NDT report identifying location of inspected bolted connections and summary of corrections as required to meet code acceptance criteria.

F. Defective Connections: All defective and improperly tightened high-strength bolted connections shall be corrected.

3.10 FIELD QUALITY CONTROL -- WELDED CONNECTIONS

A. All welded connections for structural steel shall be inspected and tested by an independent testing agency, retained by the Owner in accordance with the AWS D1.1 Structural Welding Code.

B. Selection of Welds to be Tested: As per Special Inspection requirements of the KBC 2007.

C. Unless otherwise specified, the Special Inspector retained by the Owner will perform nondestructive testing (NDT) of welds in accordance with Chapter 6 of AWS D1.1 and per the Section 1704 of the Kentucky Building Code 2007.

1. Butt Joint Welds: 10 percent randomly radiographically tested and repaired.
2. Groove Welds: 10 percent randomly ultrasonically tested and repaired.
3. Fillet Welds: 10 percent randomly examined and repaired, using either dye penetrant or magnetic particle inspection methods.
4. All Welds: 100 percent visually inspected.

D. The certified welding Special Inspector shall be present whenever field welding is performed and shall:

1. Verify conformance of specified job material and proper storage.
2. Monitor conformance with approved welding procedure specifications.
3. Monitor conformance of welder/welding operator qualification.
4. Provide 100 percent visual inspection of all welds.
5. Supervise nondestructive testing personnel and evaluate test results.
6. Maintain records and prepare report confirming results of inspection and testing.

E. Defective Connections: All defective welds shall be repaired and retested until certified acceptable in accordance with AWS D1.1.1

END OF SECTION 05120

SECTION 07214

FOAMED-IN-PLACE MASONRY WALL INSULATION

1.0 GENERAL

1.1 SUMMARY

A. Extent of insulation work is shown on drawings and indicated by provisions of this section.

B. Applications of insulation specified in this section include the following:

1. Foamed-in-Place masonry insulation for thermal, sound and fire resistance values.

1.2 SUBMITTALS

A. Product and technical presentation as provided by the manufacturer.

B. Certified Test Reports: With product data, submit copies of certified test reports showing compliance with specified performance values, including R-values, fire performance and sound abatement characteristics.

C. Material Safety Data Sheet: Submit Material Safety Data Sheet complying with OSHA Hazard Communication Standard, 29 CRF 1910 1200.

1.3 QUALITY ASSURANCE

A. Manufacturing Standards: Provide insulation produced by a single and approved manufacturer. The product must come from the manufacturer pre-mixed to ensure consistency.

B. Installer Qualifications for Foamed-in-Place Masonry Insulation: Engage an experienced dealer/applicator who has been trained and licensed by the product manufacturer and which has not less than ten (10) years direct experience in the installation of the product used.

C. Warranty: Upon request, a one year product and installation warranty will be issued by both the manufacturer and installer.

D. Fire Performance Characteristics: Provide insulation materials which are identical to those whose fire performance characteristics, as listed for each material or assembly of which insulation is a part, have been determined by testing, per methods indicated below, by a testing agency acceptable to authorities having jurisdiction.

E. Insurance: Insulation Subcontractor shall carry Products and Completed Operations Insurance with minimum liability limits of $5,000,000.

Product must be classified by Underwriters Laboratory [R] ("UL") as to Surface Burning Characteristics

Fire Resistance Ratings:	ASTM E-119
Surface Burning Characteristics:	ASTM E-84
Combustion Characteristics:	ASTM E-136

2.0 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturers of Foamed-in-Place Masonry Insulation: Subject to compliance with requirements, provide products from the following:

1. **"Core-Fill 500[TM]"** – Tailored Chemical Products, P.O. Drawer 4186, Hickory, NC 28663, 800-627-1687.

2. Air Krete, Inc.
   P.O. Box 380
   Weedsport, NY 13166

3. CP Chemical Co. (Tripolymer)
   White Plains, NY

2.2 INSULATING MATERIALS

A. General: Provide insulating materials which comply with requirements indicated for materials, compliance with referenced standards, and other characteristics.

B. Foamed-in-Place Masonry Insulation: Two (2) component thermal insulation produced by combining a plastic resin and catalyst foaming agent surfactant which, when properly ratioed and mixed, together with compressed air produce a cold-setting foam insulation in the hollow cores of hollow unit masonry walls.

1. Fire-Resistance Ratings: Minimum four (4) hour fire resistance wall rating (ASTM E-1 19) for 8-inch (8") and 12-inch (12") concrete masonry units when used in standard two (2) hour rated CMUs.

2. Surface Burning Characteristics: Maximum flame spread, smoke developed and fuel contributed of 0, 5 and 0 respectively.

3. Combustion Characteristics: Must be noncombustible, Class A building material.

4. Thermal Values: "R" Value of 4.91/inch @ 32 degrees F mean; ASTM C-177.

5. Sound Abatement: Minimum Sound Transmission Class ("STC") rating of 53 and a minimum Outdoor Indoor Transmission Class ("OITC") rating of 44 for 8-inch (8") wall assembly (ASTM E 90-90).

3.0 EXECUTION

3.1 INSPECTION AND PREPARATION

A. Application Assemblies:

1. Block Walls: 6", 8", 10" or 12" concrete masonry units

2. Cavity Walls: 2" cavity of greater

3.2 INSTALLATION OF FOAMED-IN-PLACE INSULATION

A. General: Install foamed-in-place insulation from interior, or as specified, prior to installation of interior finish work and after all masonry and structural concrete work is in place; comply with manufacturer's instructions.

B. Installation: Fill all open cells and voids in hollow concrete masonry walls where shown on drawings. The foam insulation shall be pressure injected through a series of 5/8" to 7/8" holes drilled into every vertical column of block cells (every 8" on center) beginning at an approximate height of four (4) feet from finished floor level. Repeat this procedure at an approximate height of ten (10) feet above the first horizontal row of holes (or as needed) until the void is completely filled. Patch holes with mortar and score to resemble existing surface.

4. MEASUREMENT AND PAYMENT

Payment shall be included in the work to which it is subsidiary unless otherwise shown in the Bid Schedule.

- End of Section -

SECTION 11210

PUMP STATION

1.0 SCOPE OF WORK

The Contractor shall furnish all labor, tools, equipment, materials, and perform all work and services necessary for or incidental to the furnishing and complete installation of the water booster pump station as shown on the drawings and as specified in accordance with provisions of the contract documents.

The approved manufacturer shall submit complete manufacturers information on all individual items that make up the water booster pump station and will provide 24" x 36" drawings with at least three (3) different views. Six (6) individually bound booklets shall be submitted for approval.

The Contractor shall furnish and install the water booster pump station, with all the necessary piping, controls, and appurtenances as shown on the plans and as specified herein. The water booster pump station shall be complete with all necessary equipment installed in a concrete block building.

The manufacturer of this equipment shall be one recognized and established in the design production of water booster pump stations. The water booster pump station manufacturer shall maintain regular production facilities at their place of business. Those facilities shall be open for inspection by a representative of the owner at the time during construction and testing of this equipment. Equipment manufactured by a fabricator independent of the firm of record on the equipment submittal will not be allowed. Manufacturer shall have not less than five similar installations in the U.S. and shall have been in business principally manufacturing water booster pump station under the same name for not less than 5 years.

2.0 PUMP STATION BUILDING

The building shall be of fiberglass enclosure and shall have the dimensions as shown on the plans.

All concrete shall be Class "A" in accordance with KTC Specification 601. All reinforcing steel shall conform to KTC Specification 811.

Construct 1-3/4" thickness doors of 6063-T5 aluminum alloy rails and stiles minimum 5/15" depth. Provide joinery of 3/8" diameter full width tie rods through extruded splines top and bottom integral to standard tubular shaped rails and stiles reinforced to accept hardware as specified. Provide hex type aircraft nuts for joinery without welds, glues or other methods for securing internal door extrusions. Finish integral reglets to accept the face sheet to permit a flush appearance. Rail caps or other face sheet capture methods are not acceptable.

All interior ductile iron piping, valves, pumps and metal surfaces to receive two coats of Tnemec 66 HB Epoxoline or approved equal. Also, one coat of primer if needed. No interior ductile iron piping with asphalt or bituminous coatings will be permitted. Finish coat shall be gray in color.

3.0 OPERATING CONDITIONS

The pump stations shall be capable of delivering the fluid medium at the following capacities and heads.

Allen Town Booster Pump Station

Minimum	0 gpm @ 360' TDH
Design	160 gpm @ 265' TDH
Maximum	200 gpm @ 200' TDH
Efficiency at Design	76%
Horsepower	20.0
Electric	3 phase 230 volt
Speed	3500 rpm

NPSH requirements shall not exceed 20 feet at Design GPM.

The pump driver shall be a standard, A.C. induction motor, Totally Enclosed Fan Cooled for the Pumps, of the vertical, normal thrust type.

4.0 BOOSTER PUMPS

4.1 GENERAL

The booster pumps employed within the packaged water booster pumping station shall meet the hydraulic and driver data as set forth in the specification section titled, "OPERATING CONDITIONS". The booster pumps shall be installed in the field under the direction and at the cost of the station manufacturer. The installation of the booster pumps shall be as shown on the plans covering this project.

Prior to acceptance of an equipment proposal covering the packaged water booster pumping station, detailed data shall be furnished the Engineer or the Owner and shall include the following booster pump information:

1. A data sheet covering each pump completely filled in.

2. Performance Curve showing expected performance at points other than the design conditions. Curve shall show head, capacity, efficiency, and horsepower based on performance and shall cover the complete operating range of the pump from zero capacity to the maximum capacity. The curve is to also include a net positive suction head required curve.

3. Drawings of the proposed equipment giving general dimensions sufficient to determine how the equipment is to be supported and if it will fit within the space available.

4.2 BOOSTER PUMP STATION

The pump end shall be of the vertical multi-stage design with the motor mounted directly to the top of the pump. The pump models shall be furnished as shown on the plans and installed in accordance with the recommendations of the manufacturer. Pump shall be capable of operating continuously at temperatures from 5° F to 250° F (-15° C to 121° C) and working pressures of 200 psi.

The pump suction/discharge chamber, motor stool and pump shaft coupling shall be constructed of cast iron. The impellers, pump shaft, diffuser chambers, outer discharge sleeve and impeller seal rings or seal ring retainers shall be constructed of stainless steel. The impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement. Intermediate and lower shaft bearings shall be Tungsten Carbide and Ceramic. Pumps shall be equipped with a high temperature mechanical seal assembly with Tungsten Carbide/Carbon or Tungsten Carbide/Tungsten Carbide seal faces mounted in stainless steel seal components.

The pump motor shall be sized to ensure the pump is non-overloading when operating on the specified pump curve. The motor shall be of the horsepower, voltage, phase and cycle as shown on the drawings. Motor design shall be of the open drip with a NEMA C face design operating at a nominal 3,500 rpm with a minimum service factor of 1.15. Lower motor bearings shall be adequately sized to ensure long motor life.

Pumps shall be Grundfos Model CR32-4 or approved equal.

5.0 GATE VALVES

Gate valves for fabricated pipe systems shall be resilient seat type, iron body, flanged, fully bronze mounted with O-ring seals, and suitable for working water pressures of not less than 250 PSIG. Housed valves shall be left uncoated to allow painting without the use of tar stop. Valves shall be of standard manufacture and of the highest quality both of materials and workmanship and shall conform to the latest revision of AWWA Specification C-500. Unless otherwise shown on the plans, all housed gate valves shall be non-rising stem. Valves shall be rated for a working pressure of not less than 250 psi and shall have flanges drilled 125 lbs. pattern. Unless otherwise shown on the Drawings, housed valves and valves in basins shall be handwheel operated.

Handwheels shall be ANSI B16.1 Class 125. Handwheels shall have not less than the following diameters:

Size Valves	Diameter
1"	3 1/8"
1 1/2"	4 1/4"
2"	6"
3"	8"

*Buried service gate valves specified in Section 13104.

Size Valves	Diameter
4"	10"
6"	12"
8"	14"
10"	16"
12"	18"

Size Valves	Diameter
14"	20"
16"	22"
18"	24"

Valve stand handwheels and handwheels on extended stems, shall have the same minimum diameters as those shown for handwheels directly on valves. Extension stems for O.S&Y valves shall be non-rising, with clamp to valve handwheel and hollow shaft for rising stem of valve, with adjustable cast iron guides per each eight (8) feet of extension stem length maximum. All extension stems shall be connected with suitable coupling castings for connection to and removal from valves and stands. Nuts and bolts on all extension stem connections shall be stainless steel.

6.0 Restrained Flange Adapter

Each pump suction and discharge pump run shall include restrained flange adapters. Flanged adapters shall be made of ductile iron conforming to ASTM A536 and have flange bolt circles that are compatible with ANSI/AWWA C110/A21.10 (125# Class 150 Bolt Pattern).

Restrained for flange adapter shall consist of a plurality actuated gripping wedges to maximize restraint capability. Torque limiting actuating screws shall be used to insure proper initial set of gripping wedges.

The restrained flange adapter shall be series 2100 Megaflange or approved equal.

7.0 PRESSURE GAUGES

All pressure gauges within the booster pumping station shall have 4-1/2" minimum diameter faces. The case shall be black, cast aluminum, flanged back type with close type ring and clear glass face. The gauge connections shall be at the bottom of the gauge and will be 1/4" N.P.T. The gauge internal construction shall include phospor bronze bourdon tube with a brass movement, bronze bushed independently mounted. Pressure gauge range and scale graduations shall be in feet of water and psi as follows:

INLET PRESSURE - 0 to 100 psi, 20 psi figure intervals,
with graduating marks every 2 psi.

OUTLET PRESSURE - 0 to 300 psi, 50 psi figure intervals,
with graduating marks every 5 psi.

8.0 SILENT GLOBE CHECK VALVES

Each pump discharge pipe run shall include a silent globe check valve. The check valve shall consist of a heavy cast iron body, bronze seat, bronze disc, and stainless steel spring. The valve disc shall be center guided at both ends with integral shaft and shall be springs loaded for silent operation. The spring shall be helical or conical and stone tumbled to achieve a micro-finish to resist mineral deposits.

All materials shall conform to ASTM specifications as follows:

Valve Body: Cast Iron ASTM A126 Class B
Disc and Seat: Bronze ASTM B584
Spring: Stainless Steel ASTM A313.5/ Stone Tumbled and Stress Relieved

9.0 STRAINERS

Two (2) basket strainers, aka suction diffusers, shall be a part of the station assembly. Strainers shall be Mueller Model 125F, or equal as shown on the drawings.

10.0 FACTORY START-UP SERVICE

After the pump station has been completely constructed, including the electrical service, and has been put under pressure by the installer, then a factory service representative will be scheduled to visit the jobsite and put the booster station into trouble free, automatic operation.

The service representative will spend one (1) full day at the jobsite. In addition to his start-up duties, he shall explain and demonstrate the operation of the booster pump station to a representative of the owner. The service representative at this time shall pass over to the owner's representative two (2) bound copies of the booster pump station maintenance and operation manual.

A complete service report shall be made out and signed by the factory service representative and a representative of either the owner or project engineer. Copies of the start-up report will be distributed as follows: one (1) copy each to the manufacturer's project file, consulting engineer's project file, contractor's project file and the owner's equipment file.

11.0 POWER

Owner shall provide power to the site.

12.0 MEASUREMENT AND PAYMENT

The unit bid price for the Pump Station shall constitute full payment for furnishing, installing, and making fully operable, according to the plans and specifications.

Section 11215

Booster Pump Station Control System

A. Control System

The pump control system shall consist of the following components: one (1) duplex pump interface panel (pilot), two (2) variable frequency drives and all necessary equipment for automatic and time clock operation.

The duplex interface panel shall be housed in a Nema 12 enclosure and shall include components responsible for bringing each drive/pump system on-line. Panel shall interface with (2) separate low suction pressure controllers (1 each pump) for monitoring the suction side of the system. The pressure controller will disengage the system for low suction pressure at 20 psi and will re-set at 30 psi. Pilot panel will also interface with (1) common high pressure controller which will shut down either pump if a pre-selected high pressure condition occurs. Condition will reset at 220 psi. Pilot panel shall include separate indication for a low or high pressure condition with a light mounted on the panel door. Panel shall use a 4 position switch (auto, manual, timed, off).

In the automatic position, pump 1 will start and shall use the VFD PID closed loop integral to maintain 205 psi on the discharge side of the system. If the VFD output were to drop below 20 Hz, the drive will enter the sleep mode until the discharge pressure drops to 190 psi (generally 15 psi less than the hold pressure). At this point, the drive will emerge from the sleep mode and increase speed to maintain the pre-set discharge pressure.

In the manual position each individual pump/VFD system can be controlled manually at the VFD touch pad.

If time clock position is selected then station will operate at user pre-selected time intervals and shall utilize the same features as in auto, but only cycle ON/OFF by timer or shutdown on either a low suction or high discharge condition. System shall automatically reset after a low suction or high discharge condition clears.

In order for the system to function properly each side of the system (pump 1 & pump 2) must have its own low suction electronic controller similar to the Merciod EDA series. System must also include a common electronic high pressure controller which will provide the 4-20 ma signal to the VFDs. The VFD using the PID circuitry will monitor the discharge pressure and ramp up/down to maintain a pre-set pressure.

System shall include a pump fail circuit which will bypass failed pump and switch to next pump until manually reset and condition has cleared.

B. Variable Frequency Drives

2.1 Acceptable Manufacturers

A. Danfoss VLT® FC202 AQUA Series VFD (Variable Frequency Drive) or approved equal.

2.2 General

A. Furnish complete VFD as specified herein or in the equipment schedule for loads designated to be variable speed. VFD's shall be both constant and variable torque rated.

B. The manufacturer of the VFD shall demonstrate a continuous period of manufacturing and development of VFD's for a minimum of 25 years. VFD's that are brand-labeled are not acceptable.

C. The VFD shall produce an output waveform capable of handling maximum motor cable distances of up to 1,000 ft. (unshielded) without tripping.

D. The VFD shall utilize VVC^{PLUS}, an output voltage-vector switching algorithm, or equivalent, in both variable and constant torque modes. VVC^{PLUS} provides rated RMS fundamental voltage from the VFD. This allows the motor to operate at a lower temperature rise, extending its thermal life. VFD's that cannot produce rated RMS fundamental output voltage or require the input voltage to be increased above motor nameplate value to achieve rated RMS fundamental output voltage are not acceptable.

E. The VFD selected must be able to source the motor's full load nameplate amperage (fundamental RMS) on a continuous basis, and be capable of running the motor at it's nameplate RPM, voltage, current, and slip without having to utilize the service factor of the motor.

F. The VFD will be capable of running either variable or constant torque loads. In variable torque applications, the VFD shall provide a CT-start feature and be able to provide full torque at any speed up to the base speed of the motor. In either CT or VT mode, the VFD shall be able to provide it's full rated output current continuously and 110% of rated current for 60 seconds.

G. An Automatic Energy Optimization (AEO) selection feature shall be provided in the VFD to minimize energy consumption in variable torque applications. This feature shall dynamically adjust output voltage in response to load, independent of speed. This feature shall incorporate power factor compensation. Output voltage adjustment based upon frequency alone is not acceptable for single motor VT configurations.

H. For multi-motor variable torque configurations, user-selectable load profile curves including VT-High, VT-Medium, and VT-Low shall be provided to ensure easy commissioning and improved energy efficiency. VFD's requiring the operator to assign load torque data-points to create a V/Hz profile are not acceptable.

I. Switching of the input power to the VFD shall be possible without interlocks of damage to the VFD at a minimum interval of 2 minutes.

J. Switching of power on the output side between the VFD and the motor shall be possible with no limitation or damage to the VFD and shall require no additional interlocks.

K. An Automatic Motor Adaptation function shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to spin the motor shaft or decouple the motor from the load to accomplish this optimization. Additionally, the parameters for motor resistance and motor reactance shall be user-programmable.

L. The VFD shall have temperature controlled cooling fans for quiet operation, minimized internal losses, and greatly increased fan life.

M. VFD shall provide full torque to the motor given input voltage fluctuations of up to ±10% of the rated input voltage. Additionally, sustained line voltage reductions up to 15% shall not cause the VFD to trip.

N. The VFD shall provide dual built-in DC link reactors to minimize power line harmonics and to provide near unity power factor. VFD's without a DC link reactor shall provide a 5% impedance line side reactor, at a minimum.

2.3 Protective Features

A. VFD shall have input surge protection utilizing MOV's, spark gaps, and Zener diodes to withstand surges of 2.3 times line voltage for 1.3msec.
B. VFD shall include circuitry to detect phase imbalance and phase loss on the input side of the VFD.
C. VFD shall auto-derate the output voltage and frequency to the motor if an input phase is lost if it is desirable to maintain operation without decreasing the life expectancy of the VFD. The use of this feature shall be user selectable and export a warning during the event.
D. VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.
E. VFD shall auto-derate the output voltage and frequency to the motor in the presence of sustained ambient temperatures higher than the normal operating range, so as not to trip on an inverter temperature fault. The use of this feature shall be user-selectable and a warning will be exported during the event.
F. The VFD shall have the option of an integral RFI filter. Enclosures shall be made of metal to minimize RFI and provide immunity.

2.4 Interface Features

A. VFD shall provide an alphanumeric backlit display keypad which may be remotely mounted using standard 9-pin cable. VFD may be operated with keypad disconnected or removed entirely. Keypad may be disconnected during normal operation without the need to stop the motor or disconnect power to the VFD.
B. VFD shall display all faults in plain text; VFD's which can display only fault codes are not acceptable.
C. The keypad shall feature a 4-line display, and be capable of digitally displaying up to four separate operational parameters or status values simultaneously (including process values with the appropriate engineering unit) in addition to Hand/Off/Auto, Local/Remote, and operating status.
D. Two lines of the display shall allow "free text programming" so that a description, or the actual name, of the equipment being controlled by the VFD can be entered into the display.
E. Keypad shall provide an integral H-O-A (Hand-Off-Auto) and Local-Remote selection capability, and manual control of speed locally without the need for adding selector switches, potentiometers, or other devices.
F. All VFD's shall be of the same series, and shall utilize a common control card and LCP (keypad/display unit) throughout the rating range. The control cards and keypads shall be interchangeable.
G. VFD keypad shall be capable of storing drive parameter values in non-volatile RAM uploaded to it from the VFD, and shall be capable of downloading stored values to the VFD to facilitate programming of multiple drives in similar applications, or as a means of backing up the programmed parameters.
H. VFD display shall indicate which digital inputs are active, and the status of each relay.
I. VFD display shall indicate the value of any voltage or current signal connected to the analog input terminals.
J. VFD display shall indicate the value of the current on the analog output terminals.
K. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
L. Dual protection shall be provided to prevent unauthorized changes to the programming of the VFD. The parameters can be locked via a digital input and/or the unit can be programmed not to allow an unauthorized user to change the parameter settings.

M. A quick setup menu with factory preset typical parameters shall be provided on the VFD to facilitate commissioning. Use of macros shall not be required.
N. A digital elapsed time meter and kilowatt hour meter shall be provided in the display.
O. VFD shall provide full galvanic isolation with suitable potential separation from the power sources (control, signal, and power circuitry within the drive) to ensure compliance with PELV requirements and to protect PLC's and other connected equipment from power surges and spikes.
P. All inputs and outputs shall be optically isolated. Isolation boards between the VFD and external control devices shall not be required.
Q. There shall be eight fully programmable digital inputs for interfacing with the systems external control and safety interlock circuitry.
R. The VFD shall have two voltage analog signal inputs and one current signal input, and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include 0-10 V dc, 0-20 mA and 4-20 mA.
S. Two programmable analog outputs shall be provided for indication of drive status. These outputs shall be programmable for output speed, voltage, frequency, motor current and output power. The analog output signal shall be 0-20 mA or 4-20 mA
T. The VFD shall provide two user programmable relays with 31 selectable functions. One form 'A' 50VAC and one form 'C' 230VAC/2A rated dry contact relay outputs shall be provided.
U. Floating point control interface shall be provided to increase/decrease frequency in response to external switch closures.
V. The VFD shall accept a NC motor temperature overtemperature switch input, as well as possess the capability to accept a motor thermistor input.
W. The VFD shall store in memory the last 20 faults and record all operational data.
X. Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until isolation valves, seal water pumps or other types of auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.
Y. The VFD shall be equipped with a standard RS-485 serial communications port utilizing either the Danfoss FC or Profibus DPV1 protocol, and also be capable of supporting the following communications protocols by the use of an integrally mounted, field-installable option board: Profibus DP, DeviceNet, or Modbus RTU.
Z. The VFD shall be supplied with a standard RS-485 serial communications data port. A Windows® compatible software to display all monitoring, fault, alarm, and status signals shall be available. This software shall allow parameter changes, storage of all VFD operating and setup parameters, and remote operation of the VFD.

2.5 Adjustments

A. The VFD shall have an adjustable output switching frequency.
B. Four complete programming parameter setups shall be provided, which can be locally selected through the keypad or remotely selected via digital input(s), allowing the VFD to be programmed for up to four alternate control scenarios without requiring parameter changes.
C. In each programming set up, independent acceleration and deceleration ramps shall be provided. Acceleration and deceleration time shall be adjustable over the range from 0 to 3,600 seconds to base speed.
D. The VFD shall have four programmable "skip frequencies" with adjustable bandwidths to prevent the driven equipment from running at a mechanically resonant frequency.
E. VFD shall include an automatic acceleration and deceleration ramp-time function to prevent nuisance tripping and simplify start-up.
F. In each programming setup, independent current limit settings, programmable between 50% and 110% of the drives output current rating, shall be provided.

G. A built-in PID controller shall be able to accept two feedback signals and two set-points. Response to the set-point/feedback differences must be programmable to allow choices between different calculation methods for the feedback signals.
H. PID parameter settings shall be adjustable while the VFD is operating, to aid in tuning the loop at start up. The VFD will also be capable of simultaneously displaying setpoint reference and feedback values with appropriate engineering units, as well as output frequency, output current, and run status while programming the PID function.
I. The VFD will include a "loss of follower" function to detect the loss of process feedback or reference signals with a live-zero value, with a user-selectable choice of responses (go to set speed, min speed, max speed, stop, stop and trip).
J. A Sleep Mode function shall be provided to reduce wear and heating of the pump and other equipment in periods where system demands are minimal. This function will operate in both open and closed loop modes:
    1. In closed loop process control, when the output speed drops to a user-programmed minimum value ("sleep frequency") for a specified time ("sleep mode timer"), the drive will enter sleep mode and either go into standby or boost mode before entering standby. The drive shall automatically restart the motor once the output of the PID processor exceeds a programmable value "wake up frequency".
        a. Boost mode shall prevent short-cycling of the motor by temporarily adjusting the setpoint by a user programmable percentage. Upon reaching this valve, the unit will go into standby.
    2. In open loop, the drive shall be capable of entering sleep mode if the input reference drops below a user programmable value. When the input reference increases above a programmable reference, the drive will automatically start.
K. The VFD will include a user selectable Reset function, which enables the selection of between zero and twenty restart attempts after any self-clearing fault condition (under-voltage, over-voltage, current limit, inverter overload and motor overload), or the selection of an infinite number of attempts. The time between attempts shall be adjustable from 0 through 600 seconds.
L. An automatic "on delay" function may be selected from 0 to 120 seconds.
M. The VFD will include a user-selectable Auto-Restart function which enables the VFD to power up in a running condition after a power loss, to prevent the need to manually reset and restart the VFD.

2.6 Service Conditions

A. Ambient Temperature of the VFD, -10 to 40°C (14 to 104°F)
B. 0 to 95% relative humidity, non-condensing.
C. Elevation to 1000 meters (3,300 feet) without derating.
D. VFD's shall be rated for line voltage of 550 to 600VAC, 380 to 480VAC, or 200 to 240VAC; with ±10% variation. Line frequency variation of ± 2% shall be acceptable.
E. No side clearance shall be required for cooling of the units.

C. EXECUTION

3.1 Submittals

A. Submit manufacturer's performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD's FLA rating, certification agency file numbers, catalog information and catalog cut-sheets for all major components.
B. All drawings shall be in an 8.5 X 11" reproducible format, and incorporate the manufacturer's title block on the drawing.

C. This specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.
D. Three copies of all submittals shall be provided.
E. Submit a computer generated Harmonic Distortion Analysis for the jobsite location.

3.2 Quality Assurance

A. The manufacturer shall be both ISO-9001 and ISO-14001 certified.
B. All products shall be CE marked, UL labeled, and meet the requirements of UL-508C.
C. To ensure quality and minimize infantile failures on the jobsite, all VFD's shall be tested by the manufacturer. The VFD shall operate a dynamometer at full load and speed under elevated temperature conditions.
D. All optional features shall be functionally tested at the factory for proper operation.
E. Factory test documentation shall be available upon request.

3.3 Examination

A. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer's recommendations shall be verified.
B. The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

3.4 Start Up

A. The VFD manufacturer shall be able to provide start-up of the VFD and any other supplied components by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified technicians for VFD field repair shall not be acceptable as start-up agents. Start-up and training service shall be provided at the manufacturer's published straight-time rates plus travel and living expenses.
B. The manufacturer shall provide free 24-hr. customer technical support assistance and access to online technical publications.

3.5 Warranty

A. The manufacturer shall offer a standard warranty for a period of 18 months from date of shipment, or 12 months from the date of installation, whichever is shortest.
B. The VFD manufacturer shall offer a program of extended and on-site warranties for up to a 5 years. On-site warranties shall cover the costs for all necessary travel, labor, living expenses and parts to provide factory authorized service at the VFD installation site.

END OF SECTION

SECTION 15100

WATER LINES

1.0 GENERAL

The Contractor shall furnish all labor, materials, and equipment to install the water lines as shown on the plans and as specified herein.

The water lines may be either pressure-rated plastic pipe (PVC) using the ASTM or AWWA C-900 standard, or ductile iron (DI), all as specified hereinafter and as noted on the plans. The bid documents shall show the amounts of each type and class of pipe to be provided by the Contractor.

The Owner will obtain all rights-of-way for operations through private property. It will also secure building permits and the permits for all pipe laid in highway rights-of-way. Any charges for inspections or other fees required will be the responsibility of the Contractor since the amounts of these are dependent upon the operation of the Contractor.

1.1 KENTUCKY TRASPORATION CABINET BONDING

The Kentucky Transportation Cabinet will require that the Owner post a bond for all work accomplished on their right-of-way. Each contract on which work is to be performed will be a separate application and will require a separate bond. Each permit will have conditions attached and these conditions will vary depending on the area where work is to be performed. In areas where traffic control may pose a problem, working hours may be limited. A copy of the encroachment permit will be provided to the Contractor. The Contractor will be responsible for knowledge of the permit's content and conditions in order that the construction may be accomplished in accordance with the specified requirements.

Should any additional bonds or requirements be imposed by the Kentucky Transportation Cabinet, the Owner shall also be responsible for the bonding of the additional requirements.

2.0 MATERIALS

2.1 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

This specification covers rigid, pressure-rated, polyvinyl chloride pipe and fittings, hereinafter called PVC pipe and PVC fittings, for sizes 1/2 inch through 12-inch. Pipe shall be as manufactured by North American Diamond, J-M, or approved equal.

2.1.1 General.

2.1.1.1 Pipe Markings. Depending on the type of PVC pipe being used, the following shall be marked along the length of each joint of pipe: manufacturer's name, nominal pipe size and size base, material code (PVC 1120), dimension ratio or standard dimension ratio, pressure class or rating, production record code, certification seal (NSF logo), and, for C-900 PVC pipe, specification designation (i.e., AWWA C-900).

2.1.1.2 Underground Marking for PVC Pipe. Underground marking for either ASTM or C-900 PVC pipe shall be both of the following types.

2.1.1.2.1 *Underground Marking Wire.* At all locations where PVC pipe is utilized, a detectable underground marking wire shall be placed in the trench approximately 12-inches above the pipe. The wire used shall be No. 12 insulated copper wire. Extreme care shall be exercised in connecting and taping splices and joints to assure continuity. At each valve box the wire shall be looped to the surface extending 12-inches above the concrete valve box pad (see Std. Dwg. for valve). When the entire project or pipeline segment is complete, including meter installation and leak repairs, the locating wire system shall be checked for continuity.

2.1.1.2.2 *Underground Marking Tape.* At all locations where PVC pipe is utilized, a detectable underground marking tape shall be placed in the trench approximately twelve inches below the finished grade. The tape used shall be mylar encased aluminum foil with the printing "CAUTION - Buried Water Line Below". Printing shall be readable through the clear mylar and surface printing is not acceptable. Tape size shall be 2 inch width as provided by Lifeguard, Inc. or approved equal. Color of the tape shall be blue.

2.1.2 Polyvinyl Chloride (PVC) Pipe—ASTM Standard.

2.1.2.1 PVC Pipe. PVC pipe shall be extruded from Type 1, Grade 1, polyvinyl chloride material with a hydrostatic design stress of 2,000 psi for water at 73.4°F, designated as PVC 1120, meeting ASTM Specifications D-1784 for material and D-2241 for pipe, latest revisions. Pipe shall also meet all applicable provisions of the Product Standards and shall bear the National Sanitation Foundation (NSF) seal of approval in compliance with NSF Standard No. 14. PVC pipe having a maximum hydrostatic working pressure of 160 psi (SDR-26), 200 psi (SDR-21), 250 psi (SDR-17), or 315 psi (SDR-13.5) shall be used as shown in the Bid Documents and Plans.

Samples of pipe and physical and chemical data sheets shall be submitted to the Engineer for review and determination of compliance with these specifications before pipe is delivered to job. The pipe shall be homogeneous throughout and free from cracks, holes, foreign inclusions or other defects.

The workmanship, pipe dimensions and tolerances, outside diameters, wall thickness, eccentricity, sustained pressures (ASTM D-1598), burst pressures (ASTM D-1599), flattening, extrusion quality (ASTM D-2152), marking and all other requirements of the Product Standard PS 22-70 shall be conformed with in all respects. No pipe, 2 inches in diameter or larger, with a wall thickness less than 0.090 inches may be used.

Pipe shall be furnished in 20 feet or 40 feet lengths. The pipe may be double plain end or with bell on one end. Male ends of pipe must be beveled on the outside. Pipe shall have a ring painted around the male end or ends in such a manner as to allow field checking of setting depth of pipe in the socket. This requirement is made to assist construction superintendents and inspectors in visual inspection of pipe installation.

Pipe must be delivered to job site by means which will adequately support it, and not subject it to undue stresses. In particular, the load shall be so supported that the bottom rows of pipe are not damaged by crushing. Pipe shall be unloaded carefully and strung or stored as close to the final point of placement as is practical. Pipe must not be exposed to the direct rays of the sun for an extended period of time. If pipe is not to be installed shortly after delivery to the job site, it must be stored in a shaded location and strung as needed.

2.1.2.2 PVC Pipe Jointing. Pipe shall be joined with slip-type joints with rubber gaskets. Pipes with bells shall have all parts of the bell, including the gasket groove, made from the same extruded piece, integral with the pipe, and shall be thickened to meet standard dimension ratios of wall thickness to outside diameter. This manufacturing procedure shall be the normal practice of the pipe manufacturer and proven by past performance of pipe in service. The gasket groove shall be constructed such that gasket rollout will not occur. Rubber gasketing shall conform to ASTM D-3139.

Joint lubricant shall be of a type recommended by the manufacturer for their pipe subject to the Engineer approval. Lubricant shall be water soluble, non-toxic and have no objectionable properties.

Due to special requirements for special gaskets for use within 200 feet of underground fuel tanks, gas lines, and/or oil transport lines, PVC pipe shall not be used under these circumstances.

2.1.2.3 PVC Couplings. Where PVC couplings are used, they shall be of the same material as the pipe and may be of the moulded, or extruded type. PVC couplings shall have a minimum rating of 200 psi for continuous operation at 73.4 degrees F.

2.1.2.4 Fittings Ductile iron mechanical joint fittings with appropriate adapter as manufactured by Tyler, U.S. Pipe, Clow, Union Foundry or approved equal,

shall be used with PVC pipe. All such fittings shall be approved by the pipe manufacturer, and complete data sent to the Engineer, including the manufacturer's approval, for review. Fittings shall comply with AWWA C-110 or C-153 and shall be manufactured for the size and pressure class of the line on which they are used. Use of transition gaskets will not be allowed unless specifically approved by the pipe manufacturer. Coatings and lining shall be in accordance with section 2.2.7 of the Specifications.

2.1.2.5 Service Connections. All service connections on PVC lines shall be made by means of tees, factory tapped couplings, or bronze service clamps, manufactured specifically for use with PVC pipe as manufactured by Ford or approved equal, and appropriate corporation stop. Whenever possible, corporation steps shall be installed in plastic lines before conducting hydrostatic tests.

2.1.3 Polyvinyl Chloride (PVC) Pipe—AWWA C-900 Standard.

This specification covers the requirements for AWWA approved Polyvinyl Chloride Pressure Pipe for water supply and distribution systems.

2.1.3.1 PVC Pipe—AWWA C-900 Standard. PVC pipe shall meet the requirements of AWWA C-900 or C-905, latest revision and shall be furnished in cast-iron pipe equivalent outside diameters with rubber gasketed joints.

C-900 PVC pipe shall be made from Class 12454-A or Class 12454-B virgin compounds as defined in ASTM D-1784. The standard code designation shall be PVC 1120. The PVC compounds shall be tested and certified as suitable for potable water products by the NSF Testing Laboratory and shall carry the NSF approval marking.

Solvent-cement couplings or joints shall not be used. PVC joints using elastomeric gaskets shall be tested as assembled joints and shall meet the laboratory performance requirements specified in ASTM D-3139.

Pipe shall be DR (Dimension Ratio) 18, or DR 14 as shown on the plans or the bid form.

Pipe and couplings shall meet or exceed the following test requirements:

Hydrostatic Integrity - Each standard and random length of pipe shall be proof-tested at four times its rated class pressure for a minimum of 5 seconds. Bells or couplings shall be tested with pipe. The pipe and couplings shall further meet or exceed the pressure test requirements of ASTM D-1598 and D-1599.

Flattening - The pipe shall not split, crack, or break when tested by the parallel-plato method as specified by ASTM D- 2241.

Extrusion quality - The pipe shall not flake or disintegrate when tested by the acetone-immersion method as specified in ASTM D-2241.

Standard length - Pipe shall be furnished in standard laying lengths of 20 ft. ± 1 in. A maximum of 15 percent of each pipe size may be furnished in random lengths of not less than 10 ft. each.

2.1.3.2 C-900 PVC Pipe Jointing. Pipe shall be joined with slip-type joints with rubber gaskets. Manufacturing and installation procedures shall be as recommended by the manufacturer and as described for PVC pipe in section 2.1.2 of this specification.

2.1.3.3 Fittings. Fittings for municipal PVC shall be ductile iron only. Fittings shall be mechanical joint. Fittings shall be manufactured for the size and pressure class of the line on which they are used and shall comply with AWWA C-110 or C-153. Coatings and lining shall be in accordance with section 2.2.7 of the Specifications. Fittings shall be as manufactured by Tyler, Clow, U.S. Pipe, Union Foundry or approved equal.

2.1.3.4 Service Connections. Service connections shall be made by means of bronze service clamps manufactured specifically for use with C-900 PVC pipe and appropriate corporation stops. Clamps shall be Mueller Catalog No. H-161 or approved equal.

2.2 DUCTILE IRON PIPE

These specifications cover ductile iron pipe (3-inch diameter and greater) to be used in water transmission systems with mechanical joints, rubber ring slip type joints or flanged joints.

2.2.1 General. Ductile iron pipe shall be designed in accordance with AWWA and for pressures and conditions as stated in these specifications or called for on the plans. Ductile iron pipe shall conform to AWWA C-151.

2.2.2 Minimum Nominal Thickness. The specified thickness will be determined for the given internal and external loading requirements in accordance with AWWA C-150. The class of pipe, wall thickness, and coatings required will be shown on the plans or the bid form and/or as specified herein for all ductile iron pipe installation.

2.2.3 River Crossing Pipe. River crossing pipe shall be ductile iron, Flex-Lok as manufactured by the American Cast Iron Pipe company or equal conforming to the appropriate requirements of AWWA C150/ANSI A21.50 and AWWA C151/ANSI A21.5 with a minimum thickness class of 54.

2.2.4 Lengths. Pipe may be furnished in 12, 16, 16 1/2, 18 or 20 feet nominal laying lengths.

2.2.5 Marking. The net weight, class or nominal thickness and sampling period shall be marked on each pipe.

2.2.6 Pipe Joints for Ductile Iron Pipe. Joints for buried pipe shall be either mechanical joint or push-on joint conforming to the requirements of AWWA C-111. Mechanical joint bolts and nuts shall be the low-alloy steel type conforming to AWWA C-111.

Interior piping of vaults, plants, etc. shall be supplied with flanged joints meeting the requirements of AWWA C-115. Special joints, such as the "locked" or "restrained" type, shall be as shown on the plans and/or called for in the bid schedule.

Gaskets resistant to hydrocarbon penetration shall be used within 200 feet of underground fuel tanks, gas lines, and/or oil transport lines. The gaskets shall be approved by the Engineer.

2.2.7 Coatings and Lining. All buried ductile iron pipe shall have manufacturer's outside coal tar or asphaltic base coating and a cement lining and bituminous seal coat on the inside. Cement mortar lining and a bituminous seal coat inside shall conform to AWWA C-104 latest revision.

Where specifically called for on the plans, pipe and fittings housed and in vaults shall be lined and coated on the inside as specified herein for buried ductile iron pipe and fittings, but shall be left uncoated on the outside so that it may be painted without the use of tar stop.

2.2.8 Fittings for Ductile Iron Pipe. Ductile iron mechanical, push-on and flanged joints shall conform to AWWA C-110 for centrifugally cast iron water pipe. Mechanical joints shall also conform in all respects to AWWA C-111. All fittings shall be manufactured for the size and pressure class of the pipeline in which they are to be used. All fittings shall be furnished complete with all joint accessories. All ductile iron pipe fittings for water, sewer, air, gas and force main service shall be coated outside and lined on the inside the same as the line on which they are installed.

3.0 EXECUTION

3.1 HAULING AND STORAGE

The Contractor shall notify the Engineer when pipe will be received on the job so that proper arrangements may be made for inspecting the unloading and stringing, as well as inspecting and examining the pipe materials.

All pipe shall be covered with tarpaulin during hauling from the manufacturer to the job site. It is acceptable for the front end only to be covered. The intent is to prevent diesel exhaust residue from coating the pipe and/or contaminating the gaskets.

Care must be exercised in the handling of all materials and equipment. The Contractor will be held responsible for all breakage or damage to items caused by his workmen, agents, or appliances for handling or moving. Pipes and other castings shall in no case be thrown or dropped from cars, trucks, or wagons to the ground, but shall be lowered gently and not allowed to roll against or strike other castings and unyielding objects violently.

Valves, castings, fabricated metal, reinforcing steel, etc. shall be yarded or housed in some convenient location by the Contractor and delivered at the construction site as required. All equipment and materials subject to damage from the weather, dampness, changes in temperature, or exposure shall be protected by a dry, weatherproof enclosure until ready for installation or use. The cost of all hauling, handling, and storage shall be included in the prices bid for equipment and materials in place. The Owner takes no risk or responsibility for fire, flood, theft, or damage until after the final acceptance of the work.

3.2 LINES AND GRADES

The Contractor will be required to accomplish any detailed layout, including that required for establishing the grade of the pipe line.

3.3 TRENCH EXCAVATION

3.3.1 General. This section describes the acceptable methods of trenching for the installation of pressure pipe and casing pipe in an open trench.

Trenching may be accomplished by means of a backhoe, trenching machine or by hand depending on the construction area.

At the Contractor's option, trenching, by a trenching machine or by backhoe is acceptable except as noted below:

Where the pipe line is being constructed close to other utilities, structures, building, or large trees, and it is reasonable to anticipate possible damage from the use of a backhoe, then trenching shall be made by hand methods.

The Contractor shall include in his unit price bid, all trenching necessary for installation of all pipelines as planned and specified. Trenching shall include all clearing and grubbing, including all weeds, briars, trees, stumps, etc. encountered in the trenching. The Contractor shall dispose of any such material by burning, burial, or hauling away (or as noted on the drawings), at no extra cost

to the Owner. It shall be the Contractor's responsibility to notify the appropriate State and local Air Pollution Control agencies when he conducts open burning of refuse. Ornamental shrubs shall be removed, protected, and replanted. Trenching also includes such items as minor street, road, sidewalk, pipe and small creek crossings, and cutting, moving or repairing damage to fences, poles, gates and/or other surface structures regardless of whether shown on the plans.

The Contractor shall protect existing facilities against danger or damage while pipeline is being constructed and backfilled, or from damage due to settlement of this backfill. In case of damage to any existing structures, repair and restoration shall be made at once and backfill shall not be replaced until this is done. In all cases, restoration and repair shall be such that the damaged structures will be in as good condition and serve its purpose as completely as before and such restoration and repair shall be done without extra cost to the Owner. The use of trench-digging machinery will be permitted except where its operations will cause damage to trees, buildings or existing structures above or below the ground. At such locations hand methods shall be employed to avoid such damage. All excavated material shall be piled in a manner that will not endanger the work and will avoid obstructing sidewalks and driveways. Gutters shall be kept clear or other satisfactory provisions made for street drainage.

All excavation shall be open trenches, except where the drawings call for tunnelling, boring, or jacking under structures, railroads, sidewalks and roads. The construction procedure for these types of excavation is described elsewhere in these specifications.

All trench excavation shall be termed unclassified and costs shall be included in the unit price bid for the pipe.

3.3.2 Clearing. The Contractor shall accomplish all clearing and/or grubbing as required for the construction under this contract. Clearing and grubbing shall include the cutting and removal of trees, stumps, brush, roots, logs, fences and other loose or projecting material and natural obstructions which, in the opinion of the Engineer, must be removed to properly construct and operate the facilities. Ornamental shrubs, plantings, fences, walls, etc. shall be removed and replanted or replaced or protected from the construction activity. Clearing and/or grubbing shall be incidental to the various bid items and no additional compensation will be paid for same.

3.3.3 Trench Depth. Trenches shall be excavated to the line and grade required for the installation of pipe at the elevations indicated on the plans. The minimum depth of cover shall be 30 inches above the top of the pipe, unless shown otherwise on the plans or on the Standard Details. When the pipe is laying in or on solid rock, the minimum depth of cover shall also be 30 inches above the top of the pipe. No additional compensation will be made for extra depth where required by the plans or due to Contractor error. Excavation, except as required

for exploration, shall not begin until the proposed work has been staked out. Materials which are not required for backfill and site grading shall be removed and disposed of as directed by the Engineer. Hauling, bedding, and backfilling shall be considered incidental to the various bid items and will not be paid for directly. Excavation shall be of sufficient depth to allow the piping to be laid on the standard pipe bedding in accordance with the section 3.4. The trenches shall be excavated to a minimum of six inches below the bottom of the pipe barrel in rock. In all cases where lines are under traffic a minimum cover of forty-two inches (42") shall be provided. Should it be necessary to avoid existing utilities, culverts, outlets, or other structures, the water line shall be carried deeper at no additional expense to the Owner.

Where the plans call for extra trench depth, this extra depth shall be provided at no extra cost.

3.3.4 Trench Width. Trench widths shall exceed the minimum width that will provide free working space on each side of the pipe and to permit proper backfilling around the pipe as shown in the accompanying table and unless specifically authorized by the Engineer, shall not be excavated to wider than two feet (2') plus the nominal diameter of the pipe at the top of the trench. Before laying the pipe, the trench shall be opened far enough ahead to reveal any obstruction that may necessitate changing the line and grade of the pipe. Should the Contractor fail to accomplish this, and changes are required, they shall be at his sole expense. In rock, all ledge rocks, boulders and large stones shall be removed to provide six inches (6") of clearance on each side and below all pipe and fittings.

Minimum Trench Width

Size	Width
Up to 4" Pipe	1'-6"
6" Pipe	2'-0"
8" Pipe	2'-0"
10" Pipe	2'-4"
12" Pipe	2'-6"
14" Pipe	2'-6"

Size	Width
15" Pipe	2'-8"
16" Pipe	2'-8"
18" Pipe	3'-0"
20" Pipe	3'-2"
21" Pipe	3'-4"
24" Pipe	3'-8"

3.3.5 Shoring, Sheeting, and Bracing of Excavation. Where unstable material is encountered, or where the depth of the excavation in earth exceeds five feet (5'), the sides of the trench or excavation shall be supported by substantial sheeting, bracing, or shoring. The design and installation of all sheeting, sheet piling, bracing or shoring shall be based on computations of pressure exerted by the materials to be retained under retaining conditions. Adequate and proper shoring of all excavations will be the entire responsibility of the Contractor. The

Standards of the Federal Occupational Safety and Health Act and the Kentucky Department of Labor shall be followed.

The Engineer will not be responsible for determining requirements for bracing or sheeting.

3.3.6 Removal of Water. The Contractor shall provide for adequate removal of all water and the prevention of surface water from entering the excavation. The Contractor shall maintain dry conditions within the excavations until the backfill is placed. No additional compensation will be paid for replacement and/or stabilization of prepared excavations due to flooding and/or deterioration from extended exposure. All water pumped or drained from the excavation shall be disposed of in a suitable manner without damage to adjacent property or to other work under construction.

3.3.7 Pavement Removal. Pavement removal shall be as indicated on the plans or directed by the Engineer. When so required, or when directed by the Engineer, only one-half (1/2) of the street crossings or road crossings shall be excavated before placing temporary bridges over the side excavated, for the convenience of the traveling public. All backfilled ditches shall be maintained in such a manner that they will offer no hazard to the passage of traffic. The convenience of the traveling public and the property Owners abutting the improvements shall be taken into consideration. All public or private drives shall be promptly backfilled or bridged at the direction of the Engineer. Pavement replacement shall be in accordance with Section 02405 of these specifications. Excavated materials shall be disposed of so as to cause the least interference and in every case the disposition of excavated materials shall be satisfactory to the Engineer.

3.3.8 Traffic Maintenance. The Contractor shall be held responsible for any damage that may occur to persons or property by reason of the failure of the Contractor to properly guard and flag all open trenches or obstructions along the routes of the water lines. The Contractor at his own expense shall maintain warning signs, barricades and watchmen or flag men to control traffic at such times as his work would interfere with the flow of traffic. No excavation shall begin that may present a safety hazard unless the signs, barricades, lights, etc. are available to protect the open excavation at the conclusion of the day. The Contractor will comply with all Federal and State Occupational Safety and Health requirements for this type of construction. The Contractor shall also comply with all local and Kentucky Department of Highways requirements for signing and traffic control.

3.3.9 Line Location. The location of pipelines and their appurtenances as shown are those intended for the final construction. However, conditions may present themselves before construction on any line is started that would indicate desirable changes in location. In such cases, the Owner reserves the right to

make reasonable changes in line and structure locations without extra cost, except as may be determined by extra units of materials and construction actually involved. The Owner is under no obligation to locate pipelines so they can be excavated by machine.

3.4 BEDDING OF PIPELINE

In all cases the foundation for pipe shall be prepared so that the entire load of the backfill on top of the pipe will be carried uniformly on the barrel of the pipe. The bells of the pipe shall not carry any of the load of the backfill. The Contractor should refer to the Standard Details for pipe bedding shown in the plans. The bedding specifications shall govern the backfill from the bottom of the trench up to the centerline or spring line of the pipe.

All ductile iron pipe shall be installed in accordance with Standard ANSI/AWWA C150-A21.50 Laying Condition Type 3 unless otherwise noted.

3.4.1 Stable Earth Foundation. On all PVC pipelines, the trench bottoms shall be smooth and free of frozen material, clodded dirt and stones over 1/2" diameter. Bottom dirt left by trenching equipment will usually provide adequate material to level the trench bottom and provide bedding support for the pipe barrel. If the trench bottom is free of dirt, soft material may be shoveled off the side walls or shoveled under the pipe to insure proper pipe barrel bedding. In areas where the trench bottom is hard, a layer of soft backfill must be provided to insure the pipe barrel is properly cushioned. See the plans for proper bedding material depth.

If the foundation is good firm earth the pipe may be laid directly on the undisturbed earth provided the pipe barrel is supported for its full length.

Bedding of No. 9 stone, fine gravel, sand or compacted finely graded select earth shall be used to correct irregularities in the subgrade.

As an alternative to the above method, excavation may be undercut to a depth below the required invert elevation that will permit laying the pipe on a bed of granular material or finely graded select earth to provide continuous support for the pipe barrel. Bedding depth shall be as shown on the plans.

The bedding is not a separate pay item and shall be included as incidental expense in the unit price for the pipe bid per foot of pipe.

3.4.2 Trenches In Rock. All installation in rock will utilize the undercutting method. Bedding will be with 6 inches crushed stone or suitable earth material.

3.4.3 Unstable Trenches. If unstable material is encountered which may not provide a suitable foundation for the pipe, the unstable material will be removed

and an adequate layer of encasement concrete or other special bedding shall be placed for the pipe foundation in accordance with the Standard Details in the plans. Such "special pipe foundation" shall only be installed if directed by the Engineer in writing or on the plans.

3.5 PIPE LAYING

3.5.1 General. Proper instruments, tools and facilities satisfactory to the Engineer shall be provided and used by the Contractor for the safe and convenient prosecution of the work. Each pipe manufacturer shall have an experienced representative on the job for at least one day at the commencement of jointing and laying operations.

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 materials, a swab of necessary length is to be available at all times.

All pipe shall be lowered carefully into the trench, properly aligned and properly 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. Excessive scratching of the exterior surface of the pipe will be cause for rejection of the pipe.

Under no circumstances shall pipeline 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 be commenced immediately after excavation is started. Pipe shall be laid with bell ends facing in the direction of laying.

When pipe laying is not in progress, the open ends of pipe shall be closed by approved means to prevent entrance of trench water into the line. Whenever water is excluded from the interior of the pipe, adequate backfill shall be deposited on the pipe to prevent floating. Any pipe which has floated shall be removed from the trench and relaid as directed by the Engineer. No pipe shall be laid in water or on frozen trench bottom, or whenever the trench conditions or the weather are unsuitable for such work.

If any defective pipe and fittings shall be discovered after the pipeline is laid, they shall be removed and replaced with a satisfactory pipe or fitting without additional charge to the Owner. Open ends of unfinished pipe lines shall be securely plugged or closed at the end of each day's work or when the line is left temporarily at any other time.

3.5.2 Laying Ductile Iron Pipe. Ductile iron pipe shall first be thoroughly cleaned at joints, then joined according to instructions and with tools

recommended by the manufacturer. Three (3) copies of instructions shall be furnished to the Engineer and one (1) copy shall be available at all times at the site of the work. The lining inside ductile iron pipe must not be damaged by handling.

All pipes must be forced and held together, or "homed" at the joints, before sealing or bolting. Pipe must be aligned as each joint is placed, so as to present as nearly true, straight lines and grades as is practical, and all curves and changes in grades must be laid in such a manner that the manufacturer's recommended maximum deflection is not exceeded at any joint.

Cutting of pipe may be done by wheeled pipe cutters or saws as the Contractor may elect, but the Contractor will be held responsible for breakage or damage caused by careless cutting or handling.

All ductile iron pipe shall be installed per AWWA C150 Laying Condition Type 3 unless otherwise noted, six inches (6") crushed stone bedding or suitable earth shall be used in rock. No pipe shall be laid resting on rock, blocking, or other unyielding objects. Jointing before placing in trench, and subsequent lowering of more than one section jointed together may be allowed, subject to the Engineer approval and direction.

When using pipe with push-on joints care must be exercised to make certain that the correct gasket is being used for the type of joint installed and that the gasket faces the proper direction. Before inserting the gasket, the groove and bell socket should be carefully cleaned of all dirt. If sand or dirt is permitted to remain in the groove, leaks may occur. Lubricant must be applied to bell socket, gasket and plain-end of pipe as required by manufacturer. Plain-end must be beveled before joint is made. Deflection required at the joint shall be obtained after the joint is made.

3.5.3 Laying Plastic Pipe. The trench bottom must be smooth and uniform and the alignment must conform with the plans. Bedding and cover as specified herein and shown in the Standard Details is required.

To make a clean and unobstructed joint, it is necessary to wipe the ring, groove and pipe spigot free from all foreign materials at the time of assembly. The ring must be positioned properly in the fitting to receive the pipe by a worker who is not in contact with the lubricant. In general, the lubricant is applied to the spigot (not the ring or groove). However, the manufacturer's instructions are to be followed in all cases. Only an approved lubricant may be used in accordance with the manufacturer's recommendations. All plastic pipe shall be joined by hand.

Where good bedding conditions are obtained PVC pipe smaller than 4 inches may be assembled outside the trench in longer sections (as conditions allow) and

then lowered into the trench. At any time when improper bedding is discovered or the pipe is severely deflected the pipe will be removed from the trench and the condition corrected. Pipe in sizes 4 inch and above may be assembled outside the trench but must be lowered into the trench as each joint is assembled. Regardless of installation methods all joints must be inspected after laying in trench for proper insertion and alignment. Field cuts and bevels will be allowed in accordance with the manufacturer's recommendations for these operations. A new reference mark shall be installed before joining any field cut pipe. The same requirements for clearance from rock or other objects, thrust blocking and deflections shall apply to PVC pipe as for other pipe materials.

C-900 PVC pipe of all sizes must be assembled in the trench in strict accordance with the manufacturer's requirements.

3.5.4 Installation of River Crossing Pipe. The ball joint pipe shall be assembled and installed in accordance with manufacturer's recommendations. Installation shall be made at time of low flow, using cofferdams as necessary to divert stream flow. The ball joint pipe shall be laid and allowed to settle before joining to the pipe on each side of the stream. The ball and joint pipes shall be tested separately once in place to detect any leaks or bad joints. After connecting to the land pipe, it shall be tested the same as specified for the other water mains. See the Drawings for additional installation requirements.

3.6 BACKFILLING

Backfilling must be started as soon as practicable after pipe has been laid. The ENGINEER shall be given a minimum of 8 hours for inspection before backfilling. The backfill shall be crushed rock, sand, or finely divided earth free from debris, organic material and stones, places simultaneously on both sides of pipe to the same level by hand.

In backfilling of the lower part of the trench beginning at the top of the bedding, the backfill material shall be carefully selected and walked-in around the pipe in 6" layers to a point 8 inches higher than the top of the pipe. The filling of the trench and the tamping of the backfill shall be carried on simultaneously on both sides of the pipe in such a manner that the completed pipe line will not be disturbed and injurious side pressures do not occur.

After the above specified backfill is hand placed, rock may be used in the backfill in pieces no larger than 18 inches in any dimension and to an extent not greater than one-half (1/2) the backfill materials used. If additional earth is required, it must be obtained and placed by the Contractor. Filling with rock and earth shall proceed simultaneously, in order that all voids between rocks may be filled with earth. Above the hand placed backfill, machine backfilling may be employed without tamping, (if not contrary to specified conditions for the location) provided caution is used in quantity per dump and uniformity of level of backfilling. Backfill

material must be uniformly ridged over trench and excess hauled away, with no excavated rock over 1-1/2 inch in diameter or pockets of crushed rock or gravel in top 6 inches of backfill. Ridged backfill shall be confined to the width of the trench and not allowed to overlap onto firm original earth and its height shall not be in excess of needs for replacement of settlement of backfill. All rock, including crushed rock or gravel from construction, must be removed from yards and fields. Streets, roadways and walks shall be swept to remove all earth and loose rock immediately following backfilling.

In the case of street, highway, railroad, sidewalk and driveway crossings or within any roadway paving or about manholes, valve and meter boxes, the backfill must be machine tamped in not over 4-inch layers, measured loose in accordance with the standard details. Where backfill is under paved driveways, streets, highways, railroads, sidewalks, paved parking areas and other areas where settlement is not allowed, crushed stone or coarse sand backfill only shall be used up to the paving surface. Crushed stone shall be Kentucky Department of Highways Standard Specification No. 57. Coarse sand backfill shall be spread in layers not over 4 inches thick and thoroughly compacted. Sand may be moistened to aide compaction. Tunnels shall be backfilled in not over 3-inch layers, measured loose, with selected material suitable for mechanically tamping. If material suitable for tamping cannot be obtained, sand, gravel or crushed rock shall be blown, packed or sluiced to complete fill all void spaces.

Where local conditions permit, pavement shall not be placed until 30 days have passed since placing backfill. Crushed stone is specified for roads and parking areas and sidewalks or their bases, shall be placed and compacted to the top of trench. Backfills shall be maintained easily passable to traffic at original ground level, until acceptance of project or replacement of paving or sidewalks.

Where the final surfacing is to be crushed stone, compacted earth backfill may be used in the trench to within 6 inches of the top as shown in the Standard Details.

The Kentucky Transportation Cabinet requires that water and sewer lines—when placed within the limits of the roadway embankment and/or beneath the roadway itself—be backfilled with sand, limestone sand (11's or smaller), or "flowable fill" as defined by Section 601.03.03.B(5) of their "Standard Specifications for Road and Bridge Construction". The Cabinet typically requires that sand, limestone sand, or flowable fill be used to backfill the trench and/or bore pit up to the subgrade elevation and extending to the outside edge of the shoulder.

Railroad Company and Highway Department requirements in regard to backfilling will take precedence over the above general specification where they are involved.

The Contractor shall protect all sewer, gas, electric, telephone, water and drain pipes or conduits, power and telephone poles and guy wires from danger of damage while pipelines are being constructed and backfilled, or from danger due to settlement of his backfill.

In case of damage to any such existing structures, repair and restoration shall be made at once and backfill shall not be replaced until this is done. In all cases, restoration and repair shall be such that the damaged structure will be in as good condition and serve its purpose as completely as before uncovering and such restoration and repair shall be done without extra charge.

No extra charge shall be made for backfilling of any kind, except as provided in the Bid. Backfilling shall be included as a part of the unit price bid for which it is subsidiary. No extra charge shall be made for supplying outside materials for backfill.

Before completion of contract, all backfills shall be reshaped, holes filled and surplus material hauled away, and all permanent walks, street, driveway and highway paving, and sod, replaced and reseeding performed.

The line Contractor shall be responsible for clean-up, grading, seeding, sodding or otherwise restoring all areas that he disturbs.

Any deficiency in the quantity of material for backfilling the trenches or for filling depressions caused by settlement, shall be supplied by the Contractor.

3.7 TIE-INS TO EXISTING PIPELINES

This work shall consist of connecting new water pipes to the existing system where shown on the plans and shall include the necessary fittings, tapping sleeves, valves and necessary equipment and material required to complete the connection.

Knowledge of pipe sizes in the existing system may not be accurate, therefore, it is recommended that the Contractor check outside diameters of existing pipe and types of pipe prior to ordering the required accessories. No additional payment will be allowed for matching pipe and/or accessories when the proper size is not ordered.

Neither the Owner nor the Engineer can guarantee the location of the existing lines. The Contractor shall verify the location of all existing water mains and valves pertaining to the proposed improvements before excavation is started.

The necessary regulation or operation of the valves on existing mains, to allow for the connections being made, shall be supervised by the Engineer. Before shutting down an existing water main or branch main for a proposed connection,

prior approval for a specific time and time interval shall be obtained from a representative of the Owner. At no time shall an existing main be shut down without the Owner's knowledge and permission.

Excavation to existing water mains shall be carefully made, care being exercised not to damage the pipe. The excavation shall not be of excessive size or depth beneath the pipe. The sides of the excavation shall be as nearly vertical as possible.

The Contractor shall be responsible for any damage to the existing system and any such damage shall be repaired to the satisfaction of the Engineer at the Contractor's expense.

The Contractor shall verify, by field inspection, the necessary sizes, lengths and the types of fittings needed for each inter-connection. Typical connections are shown on the plans and any modifications or changes shall be subject to the approval of the Engineer. The exact length of the proposed water main needed for this work shall also be determined by field measurement as required.

The probing required to locate existing mains is not a separate pay item.

3.8 PIPE ENTERING STRUCTURES

Ductile iron, steel or PVC pressure pipe, 4-inch diameter or larger, entering structure below original earth level, unsupported by original earth for a distance of more than six feet (6'), shall be supported by #57 crushed stone. Costs for the support shall be included in the unit price for the pipe.

3.9 OWNERSHIP OF OLD MATERIALS

Pipe – Unless otherwise indicated, all existing pipe that is to be abandoned that interferes with construction or is easily removed shall become the property of the Contractor. All pipe that is not easily removed or not required to be removed as a result of the new construction, shall be abandoned in place by this Contractor.

Pipe Line Fittings and Appurtenances – All pipe line fittings, valves, hydrants and other like appurtenances that are removed as a result of new construction shall be removed by this Contractor but shall become the property of the Owner. All such fittings and appurtenances shall be delivered to a point by the Contractor. Said point shall be on the Owner's property and shall be designated by the Engineer.

Other Materials – All other materials or items that are to be removed, demolished, or abandoned as a part of this contract shall become the property of the Contractor and shall be disposed of by him.

3.10 THRUST BLOCKS AND ANCHORAGE

Thrust blocks shall be installed whenever the pipe line changes direction, as at tees, bends, crosses, stops, as at a dead end; or at valves. The locations of thrust blocks depend on the direction of thrust and type of fitting. Their size and type depends on pressure, pipe size, kind of soil, and the type of fitting. Where thrusts act upward (as at vertical curves) the weight of the pipe, the water in the pipe and the weight of the soil over the pipe should be determined to make certain that the total weight is sufficient to resist upward movement. If there is not enough soil or if it will not compact over the pipe or it is too soft to resist movement, then ballast or concrete may be placed around the pipe in sufficient weight and volume to counteract the thrust. Where a fitting is used to make a vertical bend, the fitting may be anchored to a concrete thrust block designed to key in to undisturbed soil and to have enough weight to resist upward and outward thrust, since the newplaced backfill may not have sufficient holding power.

Thrust blocks shall be constructed of not less than Class B concrete conforming to KTC Specification 601 and placed between the fitting and the trench wall. It is important to place the concrete so it extends to undisturbed (freshly cut) trench wall.

3.11 MAINTENANCE OF FLOW OF DRAINS AND SEWERS

Adequate provision shall be made for the flow of sewers, drains and water courses encountered during construction. Any structures which are disturbed shall be satisfactorily restored by the Contractor.

3.12 INTERRUPTION OF UTILITY SERVICES

No valve, switch or other control on any existing utility system shall be operated for any purpose by the Contractor without approval of the Engineer and the Utility. All consumers affected by such operations shall be notified by the Contractor as directed by the Engineer and utility before the operation and advised of the probable time when service will be restored.

3.13 FENCING

Where water supply line is being constructed in fields where stock is being grazed, Contractor shall provide temporary fence as approved by the Engineer around open trenches to prevent stock from falling in trenches. Where trenching operations should isolate grazing stock from their source of water, Contractor will either provide temporary bridging over trench or else provide water for such stock.

Where trench crosses near sound existing corner posts and existing fence is in good condition, fence may be taken loose, rolled back and stored until pipe line is completed at this point, then replaced by stretching tightly and thoroughly stapling. Additional posts will be provided and additional new fence shall be provided when it is necessary to place the fence crossed by the water line in a condition equal to existing fence before water line was constructed.

Where it is necessary to cut existing fence, new end posts shall be installed on each side of the water line and the old fence thoroughly stapled to these new posts before cutting. After pipe line is completed at this point, a new fence of galvanized wire (No. 9 gauge with No. 11 filler wires) shall be stretched between these new end posts and thoroughly stapled to existing posts and any new intermediate posts necessary to provide a good fence. Replacement of fences shall be on a replacement in-kind basis, and shall be considered incidental to laying of the lines and any additional cost shall be included in the unit price bid per lineal foot of pipe.

3.14 PROTECTION OF ADJACENT LANDSCAPE

Reasonable care shall be taken during construction of the water lines to avoid damage to vegetation. Ornamental shrubbery and tree branches shall be temporarily tied back, where appropriate, to minimize damage. Trees which receive damage to branches shall be trimmed of those branches to improve the appearance of the tree. Tree trunks receiving damage from equipment shall be treated with a tree dressing.

In the course of construction, the Contractor may deflect horizontal alignment of the water line to avoid trees and to keep from damaging their roots. The Contractor shall be fully responsible for settling all claims by private property owners concerning damage to trees and shrubs.

3.15 COORDINATION WITH UTILITIES

The Plans show the general location of existing utilities such information having been determined from the utilities. However, such information shall be considered general and is not guaranteed by Owner, Engineer or the Utility.

Prior to construction, the Contractor shall arrange to meet with representatives of all utilities, and provide them with his anticipated work schedule. The Contractor shall have the utilities make their best determination of utility locations in the areas in which he is working. Throughout the progress of the work, such field markings of utilities shall be kept current.

Repairs to any utilities damaged by the Contractor shall normally be performed by the utility at the Contractor's expense, unless the Contractor and the utility negotiate other understandings and/or procedures.

3.16 BLASTING AND ROCK EXCAVATION

The Contractor shall make his own investigation as he deems necessary to ascertain the sub-surface conditions to be encountered in the work.

All blasting operations shall be conducted in accordance with municipal ordinances, state and federal laws and Section 9, Explosives, of the "Manual of Accident Prevention in Construction", published by the Associated General Contractors of America, Inc. Soil particle velocity shall not exceed limit set by Kentucky law. All explosives shall be stored in conformity with said ordinances, laws and safety regulations. No blasting shall be done within five feet of any water mains, sewer lines, natural or manufactured gas lines, liquid petroleum product lines or other utilities. Any damage done by blasting is the responsibility of the Contractor and shall be promptly and satisfactorily repaired by him.

The Contractor shall use delay caps or other approved methods to reduce earth vibrations and noise. Mud capping, as defined in the above manual, will not be permitted as a method of breaking boulders. No blasting shall be permitted on Sundays or after dark.

Prior to commencing with the work, the Contractor shall, during a preconstruction conference with the Owner and the Engineer, state clearly his approach to performing the excavations on the project. He shall be familiar with the laws and ordinances covering blasting and shall also give consideration to the use of hydraulically operated rock breaking devices in lieu of blasting where considered necessary. If blasting is not handled in an expert manner at all times, the Engineer reserves the right to suspend blasting and require the work to proceed without it.

Prior to blasting, the Contractor shall make his own detailed preblast survey of adjacent walks, curbs, retaining walls, house foundations, etc. to determine conditions prior to the work. Such a file of information, including photographs, may be certified in such a manner as the Contractor believes necessary since this information that may stand in his defense.

4.0 PAYMENT

Payment for supplying, transporting and storing pipe, trenching, standard bedding, pipe installation, fittings, thrust-blocking, pipe locating wire and tape, testing, backfilling (including flowable fill, if required), disinfection, seeding, crop damage, regular stream crossings, clean-up, tie-ins to other structures and other incidental items in this section shall be made on the basis of the unit price per lineal foot for the type and size of pipe installed. Payment will include all those items not specifically covered by another proposal. Pipe will be measured along the centerline of the pipe as installed with no deduction for valves and fittings.

SECTION 15101

TESTING AND STERILIZATION

1.0 TESTING

1.1 After the pipe has been laid, all newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure test of at least 1.5 times the working pressure at the point of testing, but in no case less than that required by other sections herein. In addition, a leakage test shall be conducted concurrently with the pressure test.

1.2 PRESSURE TEST

1.2.1 Test pressure shall:

1.2.1.1 Not be less than 1.25 times the working pressure at the highest point along the test section.

1.2.1.2 Not exceed pipe or thrust restraint design pressures at the lowest point along the test section.

1.2.1.3 Be of at least six (6) hour duration unless otherwise stipulated by owner.

1.2.1.4 Not vary by more than plus or minus 5 psi.

1.2.1.5 Not exceed twice the rated pressure of the valves or hydrants when the pressure of the test section includes closed gate valves or hydrants.

1.2.1.6 Not exceed the rated pressure of resilient seat butterfly valves when used.

1.2.2 Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the ENGINEER.

1.2.3 Before applying the specified test pressure, air shall be expelled completely from the pipe, valves, and hydrants. If permanent air vents are not located at all high points, the contractor shall install corporation cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test, the corporation cocks

shall be removed and plugged, or left in place at the discretion of the ENGINEER.

1.2.4 All exposed pipe, fittings, valves, hydrants, and joints shall be examined carefully during the test. Any damage or defective pipe, fittings, valves or hydrants that are discovered following the pressure test shall be repaired or replaced with sound material and the test shall be repeated until it is satisfactory to the ENGINEER.

1.3 LEAKAGE TESTING

1.3.1 Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain pressure within 5 psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water.

1.3.2 No pipe installation will be accepted if the leakage is greater than that determined by the following formula:

$$L = ND(P \text{ exp } 1/2)/133{,}200$$

in which L is the allowable leakage, in gallons per hour; N is the length of pipeline tested in feet; D is the nominal diameter of the pipe, in inches; and P is the average test pressure during the leakage test, in pounds per square inch gauge.

1.3.2.1 Allowable leakage at various pressures is shown in TABLE K-1.

1.3.2.2 When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gal/hr/in of nominal valve size shall be allowed.

1.3.2.3 When hydrants are in the test section, the test shall be made against the closed hydrant.

1.3.3 Acceptance shall be determined on the basis of allowable leakage. If any test of pipe laid discloses leakage greater than that specified in Section 1.3.2 the contractor shall, at his own expense, locate and repair the defective material until the leakage is within the specified allowance.

1.3.3.1 All visible leaks are to be repaired regardless of the amount of leakage.

Table K-1
Allowable Leakage Per 1,000 Ft. Of Pipeline (GPH)

Avg. Test Pressure psi	Nominal Pipe Diameter (Inches)								
	2	3	4	6	8	10	12	14	16
450	0.32	0.48	0.64	0.95	1.27	1.59	1.91	2.23	2.55
400	0.30	0.45	0.60	0.90	1.20	1.50	1.80	2.10	2.40
350	0.28	0.42	0.56	0.84	1.12	1.40	1.69	1.97	2.25
300	0.26	0.39	0.52	0.78	1.04	1.30	1.56	1.82	2.08
275	0.25	0.37	0.50	0.75	1.00	1.24	1.49	1.74	1.99
250	0.24	0.36	0.47	0.71	0.95	1.19	1.42	1.66	1.90
225	0.23	0.34	0.45	0.68	0.90	1.13	1.35	1.58	1.80
200	0.21	0.32	0.43	0.64	0.85	1.06	1.28	1.48	1.70
175	0.20	0.30	0.40	0.59	0.80	0.99	1.19	1.39	1.59
150	0.19	0.28	0.37	0.55	0.74	0.92	1.10	1.29	1.47
125	0.17	0.25	0.34	0.50	0.67	0.84	0.01	1.18	1.34
100	0.15	0.23	0.30	0.45	0.60	0.75	0.90	1.05	1.20

Avg. Test Pressure psi	Nominal Pipe Diameter (Inches)							
	18	20	24	30	36	42	48	54
450	2.87	3.18	3.82	4.78	5.73	6.69	7.65	8.60
400	2.70	3.00	3.60	4.50	5.41	6.31	7.21	8.11
350	2.53	2.81	3.37	4.21	5.06	5.90	6.74	7.58
300	2.34	2.60	3.12	3.90	4.68	5.46	6.24	7.02
275	2.24	2.49	2.99	3.73	4.48	5.23	5.98	6.72
250	2.14	2.37	2.85	3.56	4.27	4.99	5.70	6.41
225	2.03	2.35	2.70	3.38	4.05	4.73	5.41	6.03
200	1.91	2.12	2.55	3.19	3.82	4.46	5.09	5.73
175	1.79	1.98	2.38	2.98	3.58	4.17	4.77	5.36
150	1.66	1.84	2.21	2.76	3.31	3.86	4.41	4.97
125	1.51	1.68	2.01	2.52	3.02	3.53	4.03	4.53
100	1.35	1.50	1.80	2.25	2.70	3.15	3.60	4.05

2.0 STERILIZATION

2.1 GENERAL

It is the intent of this section to present essential procedures for disinfecting new and repaired water mains. The section is patterned after AWWA C651. The basic procedure comprises:

2.1.1 Preventing contaminating materials from entering the water mains during construction or repair and removing by flushing materials that may have entered the water main.

2.1.2 Disinfecting any residual contamination that may remain.

2.1.3 Determining the bacteriologic quality by laboratory test after disinfection.

2.2 PREVENTIVE MEASURES DURING CONSTRUCTION

2.2.1 Precautions shall be taken to protect pipe interiors, fittings, and valves against contamination. Pipe delivered for construction shall be strung so as to minimize entrance of foreign material. When pipe laying is not in progress, as, for example, at the close of the day's work, all openings in the pipe line shall be closed by water tight plugs. Joints of all pipe in the trench shall be completed before work is stopped. If water accumulates in the trench, the plugs shall remain in place until the trench is dry.

If dirt, that, in the opinion of the ENGINEER, will not be removed by the flushing operation (section 2.3) enters the pipe, the interior of the pipe shall be cleaned and swabbed as necessary, with a five (5%) percent hypochlorite disinfecting solution.

2.2.2 Packing Materials and Joints—No contaminated material or any material capable of supporting prolific growth of micro-organisms shall be used for sealing joints. Packing material shall be handled in such a manner as to avoid contamination. Where applicable, packing materials must conform to AWWA standards. Packing material for cast iron pipe must conform to AWWA C600. Yarning or packing material shall consist of molded or tubular rubber rings, rope of asbestos or treated paper. Materials such as jute or hemp shall not be used. The lubricant used in the installation of sealing gaskets shall be suitable for use in potable water. It shall be delivered to the job in enclosed containers and shall be kept clean.

2.3 PRELIMINARY FLUSHING

The main shall be flushed prior to disinfection unless disinfected by the method in section 2.4.2.1. It is recommended that the flushing velocity be not less than

2.5 ft/sec. The rate of flow required to produce this velocity in various diameters is shown in Table K-2. No site for flushing should be chosen unless it has been determined that drainage is adequate at the site.

Table K-2
Required Openings To Flush Pipelines
(40-PSI Residual Pressure)

Pipe Size (in)	Flow Required to Produce 2.5 fps Velocity (gpm)	Orifice Size (in)	Hydrants Required	
			Number of Hydrants	Nozzle Size (In)
4	100	15/16	1	2 1/2
6	220	1 3/8	1	2 1/2
8	390	1 7/8	1	2 1/2
10	610	2 5/16	1	2 1/2
12	880	2 13/16	1	2 1/2
14	1,200	3 1/4	2	2 1/2
16	1,565	3 5/8	2	2 1/2
18	1,980	4 3/16	2	2 1/2

2.4 FORM OF CHLORINE FOR DISINFECTION

The most common forms of chlorine used in the disinfecting solutions are liquid chlorine (gas at atmospheric pressure), calcium hypochlorite granules, sodium hypochlorite solutions.

2.4.1 Liquid Chlorine

2.4.1.1 *Use*: Liquid chlorine shall be used only when suitable equipment is available and only under the direct supervision of a person familiar with the physiological, chemical, and physical properties of this element and who is properly trained and equipped to handle any emergency that may arise. Introduction of chlorine-gas directly from the supply cylinder is unsafe and shall not be permitted.

NOTE: The preferred equipment consists of a solution fed chlorinator in combination with a booster pump for injecting the chlorine-gas water mixture into the main to be disinfected. Direct feed chlorinators are not recommended because their use is limited to situations where the water pressure is lower than the chlorine cylinder pressure.

2.4.2 Hypochlorites

2.4.2.1 *Calcium Hypochlorite*: Calcium hypochlorite contains seventy (70%) percent available chlorine by weight. It is either granular or tabular in form. The tablets, 6-8 to the ounce, are designed to dissolve slowly in water. Calcium hypochlorite is packaged in containers of various types and sizes ranging from small plastic bottles to one hundred (100) pound drums.

A chlorine-water solution is prepared by dissolving the granules in water in the proportion requisite for the desired concentration.

2.4.2.2 Sodium Hypochlorite: Sodium hypochlorite is supplied in strengths from five and one-quarter (5.25%) to sixteen (16%) percent available chlorine. It is packaged in liquid form in glass, rubber, or plastic containers ranging in size from one (1) quart bottles to five (5) gallon carboys. It may also be purchased in bulk for delivery by tank truck.

The chlorine-water solution is prepared by adding hypochlorite to water. Product deterioration must be reckoned with in computing the quantity of sodium hypochlorite required for the desired concentration.

2.4.2.3 *Application*: The hypochlorite solutions shall be applied to the water main with a gasoline or electrically powered chemical feed pump designed for feeding chlorine solutions. For small applications, the solutions may be fed with a hand pump, for example, a hydraulic test pump. Feed lines shall be of such material and strength as to withstand safely the maximum pressures that may be created by the pumps. All connections shall be checked for tightness before the hypochlorite solution is applied to the main.

2.5 METHODS OF CHLORINE APPLICATION

2.5.1 Continuous Feed Method: This method is suitable for general application.

2.5.1.1 Water from the existing distribution system or other approved sources of supply shall be made to flow at a constant, measured rate into the newly-laid pipe line. The water shall receive a dose of chlorine, also fed at a constant, measured rate. The two rates shall be proportioned so that the chlorine concentration in the water in the pipe is maintained at a minimum of 50 mg/L available chlorine. To assure that this concentration is maintained, the chlorine residual should be measured at regular intervals in accordance with the procedures described in the current edition of Standard Methods and AWWA M12—Simplified Procedures for Water Examination.

NOTE: In the absence of a meter, the rate may be determined either by placing a pitot gauge at the discharge or by measuring the time to fill a container of known volume.

TABLE K-3 gives the amount of chlorine residual required for each one hundred (100) feet of pipe of various diameters. Solutions of one (1%) percent chlorine may be prepared with sodium hypochlorite or calcium hypochlorite. The latter solution requires approximately one pound (1 lb.) of calcium hypochlorite in eight and five tenths (8.5) gallons of water.

Table K-3
Chlorine Required To Produce 50 mg/L Concentration
In 100 Ft. Of Pipe (By Diameter)

Pipe Size (in)	100 Percent Chlorine (lb)	1 Percent Chlorine Solutions (gal)
4	0.027	0.33
6	0.061	0.73
8	0.108	1.30
10	0.170	2.04
12	0.240	2.88

2.5.1.2 During the application of the chlorine, valves shall be manipulated to prevent the treatment dosage from flowing back into the line supplying the water. Chlorine application shall not cease until the entire main is filled with the chlorine solution. The chlorinated water shall be retained in the main for at least twenty-four (24) hours during which time all valves and hydrants in the section treated shall be operated in order to disinfect the appurtenances. At the end of this twenty-four (24) hour period, the treated water shall contain no less than 25 mg/L chlorine throughout the length of the main.

2.5.2 Slug Method: This method is suitable for use with mains of large diameter for which, because of the volumes of water involved, the continuous feed method is not practical.

2.5.2.1 Water from the existing distribution system or other approved source of supply shall be made to flow at a constant, measured rate (see section 2.5.1.1) into the newly laid pipe line. The water shall receive a dose of chlorine also fed at a constant, measured rate. The two rates shall be proportioned so that the concentration in the water entering the pipe line is maintained at no less than 300 mg/L. The chlorine shall be applied continuously and for a sufficient period to develop a solid column or "slug" of chlorinated water that will, as it passes along the line, expose all interior surfaces to a concentration of at least 300 mg/L for at least three (3) hours. The application shall be checked at a tap near the upstream end of the line by chlorine residual measurements.

2.5.2.2 As the chlorinated water flows past tees and crosses, related valves and hydrants shall be operated as to disinfect appurtenances.

2.6 FINAL FLUSHING

After the applicable retention period, the heavily chlorinated water shall be flushed from the main until the chlorine concentration in the water leaving the main is no higher than that generally prevailing in the system, or less than 1 mg/L. Chlorine residual determination shall be made to ascertain that the heavily chlorinated water has been removed from the pipe line.

2.7 BACTERIOLOGIC TESTS

2.7.1 After final flushing, and before the water main is placed in service, a sample or samples shall be collected from the end of the line and tested for bacteriologic quality and shall show the absence of coliform organisms. If the number and frequency of samples is not prescribed by the public health authority having jurisdiction, at least one sample shall be collected from chlorinated supplies where a chlorine residual is maintained throughout the new main. From unchlorinated supplies at least two samples shall be collected at least twenty-four (24) hours apart.

2.7.2 Samples for bacteriologic analysis shall be collected in sterile bottles treated with sodium thiosulphate. No hose or fire hydrant shall be used in collection of samples. A suggested sampling tap consists of a standard corporation cock installed in the main with a copper tube gooseneck assembly. After samples have been collected, the gooseneck assembly may be removed, and retained for future use.

2.8 REPETITION OF PROCEDURE

If the initial disinfection fails to produce satisfactory samples, disinfection shall be repeated until satisfactory samples have been obtained. The tablet method cannot be used in these subsequent disinfections. When the sample tests indicate that disinfection has been effective, the main may be placed in service.

2.9 PROCEDURE AFTER CUTTING INTO OR REPAIRING EXISTING MAINS

The procedures outlined in this Section apply primarily when mains are wholly or partially dewatered. Leaks or breaks that are repaired with clamping devices while the mains remain full of water under pressure present little danger of contamination and require no disinfection.

2.9.1 Trench "Treatment": When an old line is opened, either by accident or by design, the excavation will likely be wet and may be badly contaminated from nearby sewers. Liberal quantities of hypochlorite applied to open trench areas will lessen the danger from such pollution. Tablets have the advantage in such a situation because they dissolve slowly and continue to release hypochlorite as water is pumped from the excavation.

2.9.2 Main Disinfection: The following procedure is considered as a minimum that may be used.

2.9.2.1 *Swabbing With Hypochlorite Solution*: The interior of all pipe and fittings used in making the repair (particularly couplings and tapping sleeves) shall be swabbed with a five (5%) percent hypochlorite solution before they are installed.

2.9.2.2 *Flushing*: Thorough flushing is the most practical means of removing contamination introduced during repairs. If valving and hydrant locations permit, flushing from both directions is recommended. Flushing shall be started as soon as the repairs are completed and continued until discolored water is eliminated.

2.9.2.3 *Slug Method*: Where practicable, in addition to the procedures of section 2.9.2.1, a section of main in which the break is located shall be isolated, all service connections shut off, and the section flushed and chlorinated as described in section 2.5.2, except that the dose may be increased to as much as 500 mg/L, and the contact time reduced to as little as one-half (1/2) hour. After chlorination, flushing shall be resumed and continued until discolored water is eliminated.

2.9.3 Sampling: Bacteriologic samples shall be taken after repairs to provide a record by which the effectiveness of the procedures used can be determined. If the direction of flow is unknown, samples shall be taken on each side of the main break.

3.0 PAYMENT

No separate payment shall be made for testing and sterilization of water lines. Items described in this section shall be incidental to the cost of installing the water line.

SECTION 15110

INSTALLATION OF WATER LINE ACCESSORIES

1.0 GENERAL

The CONTRACTOR is to supply and install all valves, hydrants, blowoffs and other equipment at the locations shown on the plans in complete accordance with these specifications.

2.0 MATERIALS

2.1 Fire Hydrant. All fire hydrants shall have a six inch bell connection, shall have two hose outlets and one pumper connection, shall be designed for 250 pounds working pressure or 300 pounds hydrostatic pressure and shall conform to the latest specifications of the AWWA C502. All working parts shall be bronze. Both hose outlets shall be 2 1/2 inch with NST threads and the pumper outlet shall be 4 1/2 inch with NST thread. Hydrants shall be designed so that no water will be lost when they are broken off and so they can be repaired with a repair kit. Design, materials, and workmanship shall be similar and equal to the latest stock pattern ordinarily produced by the manufacturer. Length of barrel shall be such to provide a 3 1/2 foot bury depth. Working drawings and full description of hydrants shall be submitted to the ENGINEER before ordering. All hydrants shall have a 5 1/4 inch valve opening against pressure. The hydrants shall be equal to Mueller Model A423 or equal. All hydrant extensions will be the responsibility of the CONTRACTOR.

2.1.1 Paint. Hydrants shall be painted one coat of red paint and two finish coats of approved paint of color directed by the ENGINEER. All hydrants are to receive the final coat of paint after field installation.

2.2 GATE VALVE

All gate valves shall be the resilient seat-type, iron body, non-rising steam, fully bronze mounted, and suitable for working water pressures of not less than 200 psi for installations on PVC pipe and not less than 250 psi for installations on DI pipe. Valves shall be of standard manufacture and of the highest quality both of materials and workmanship and shall conform to the latest revision of AWWA Specification C-509. Valves shall be furnished with flanged connections for exposed piping and push-on or mechanical joint connections for buried service. Gate valves shall have a clear water way equal to the nominal diameter, and shall be opened by turning counter-clockwise. The operating nut or wheel shall have an arrow cast in the middle, indicating the direction of opening. Each valve shall have the maker's initials, pressure rating and the year in which manufactured, cast on the body. Prior to shipment from the factory each valve shall be tested by hydraulic pressure of at least 300 pounds per square inch.

2.3 BUTTERFLY VALVE

All butterfly valves shall be of tight closing, resilient seat type with seats securely fastened to valve body. No metal-to-metal seating surfaces will be permitted. Valves shall be bubble tight at the rated pressure in either direction and shall be satisfactory for applications involving throttling service and/or frequent operation and for applications involving valve operation after long periods of inactivity.

Valves shall be suitable for working water pressure of 200 psi unless otherwise specified or noted on the plans.

Cast Markings: valve size, manufacturer's name, class, direction of opening, and year of casting.

The valve discs shall rotate 90^{o} from the full open position to the tight shut position.

The valve discs shall be cast/ductile iron with a welded nickel edge free of ribbing or protrusions which may collect solids. The disc-to-shaft connections shall be via polished 316 SS pins. Sprayed or plated discs are not acceptable. All disc seating edges shall be smooth and polished.

The shafts shall be turned, ground and polished, and be of one-piece construction. The shafts shall also be constructed from stainless steel with diameters per AWWA C504, Class 75B.

The shaft seals shall be of Hycar or Hypalon and shall be provided to prevent leakage into the bearing chest areas.

The valve bearings shall be Teflon coated, self-lubricating, stainless steel design and construction.

The valve seats shall be Neoprene or Hypalon and shall be simultaneously molded, vulcanized and bonded to the valve body or a rigid reinforcing ring.

2.3.1 Operators. The valve operating mechanisms shall be for counterclockwise opening. There shall be no external moving parts on valve or operator except the operator input shaft. Input shaft is to be operated by a 2-inch square operating nut. Maximum required input force on the operator shaft to open and close the valve shall be 40 pounds. The total number of turns applied to the operating nut required to completely open the valve from a completely closed position shall be not less than twice the nominal valve diameter. An extension stem shall be furnished if required to bring the operating nut within 3 1/2 feet of finished grade. Extension stems shall be securely fastened to the valve stem. A stainless steel collar, 6-inches high, shall be welded to the operating gear box housing centered on the operating nut to hold

the valve box in place and seal it against dirt. The diameter of the collar shall be such that it will accept the valve box.

The valves shall be manufactured by M & H, Dresser, Dezurik or approved equal.

2.4 AIR RELEASE VALVES

A valve designed to allow exhaust of small pockets of air from the water main while in use shall be installed where shown on the plans or where directed by the ENGINEER. The air release valve shall have a 3/4" iron pipe thread inlet, cast iron body construction, bronze trim, with all internal parts of stainless steel. The valve shall have a minimum orifice size of 3/32". Valves shall be suitable for a working water pressure of 150 PSIG. The air release valve shall be mounted on 3/4" bronze riser pipe. The riser pipe shall be connected to the water main by use of a service clamp and a corporation stop. The riser shall also have a 3/4" bronze ball valve with stainless steel handle and be suitable for a 150 PSIG working water pressure. Air release valves shall be as manufactured by APCO Models 65 or 50, or approved equal.

Air release valves will be installed in the same type of box used for meter installation. The box must allow for adequate cover over the pipe at the installation.

In locations where the air release valve can not be placed directly above the water main, such as roadway drainage ditches, then a section of service tubing shall be used to locate the valve as directed by the ENGINEER. The service tubing shall be installed with a continuous upward slope to eliminate air pockets. Additional payment for the tubing shall be made based on the linear foot bid for service tubing. Tubing shall also be rodded through the box to support the valve. No additional payment will be made for the tubing supports.

2.5 VALVE BOXES

All valves (gate, air release, check, etc.) installed underground shall be installed in an approved valve box. Each gate valve shall be installed in a vertical position with a valve box. Valve boxes shall be of a cast iron, two or three-piece, slip-type consisting of a base, a center section and a top section with a cover marked "water". Where valve box is constructed in a paved area the box shall be a screw type box. The entire assembly shall be adjustable for elevation and shall be set vertically and be properly adjusted so that the cover will be in the same plane as the finished street surface (no more than 1/2" above ground in yards or pastures or 2" in unsodded areas). The assembly must provide for the required cover over the pipe at the installation site and shall rest on concrete pads as shown in the Standard Details. The CONTRACTOR shall furnish two (2) valve wrenches for the project.

2.6 BLOW-OFF VALVES

Blow-off valves shall be installed in accordance with the details and the specifications at locations shown on the plans and in other locations as directed by the ENGINEER. The CONTRACTOR should refer to the Standard Details for blow-off installation.

The blowoff pipe from the main to the flush valve shall be connected to the main by means of a tee. Do not use a corporation stop for this connection. The gate valve for the blow-off connection shall be a resilient seat gate valves in conformance with AWWA C509.

2.7 TAPPING SLEEVE AND VALVE

Tapping sleeves shall be as manufactured by Ford Meter Box Company, Inc., Model FTSC, or approved equal, and shall be rated for a minimum working water pressure of 150 psi. CONTRACTOR shall ascertain the type and size of pipe to which the connection is to be made prior to selection. The valve shall be as specified under Section 2.2 of this specification.

3.0 EXECUTION

3.1 FIRE HYDRANTS

Under this Item, the CONTRACTOR shall provide all labor, tools, equipment and materials to furnish and install hydrants with gate valves as shown on the drawing and as directed by the ENGINEER.

Hydrants shall be set at such elevations that the connecting pipe will have the same depth of cover as the distribution main. The back of the hydrant opposite the pipe connection shall be firmly wedged against one and one-half square feet or enough of the vertical face of the trench with concrete to prevent the hydrants from blowing off the line. In addition, all fittings, valves and hydrants shall be joined by the use of all-thread rods, nuts and "DUC-LUG" offsets as shown on the attached drawing to prevent movement of the hydrant. If the character of the soil is such, in the opinion of the ENGINEER, that the hydrant cannot be securely wedged, bridle rod collars shall be used which shall be not less than three-fourths inch stock and shall be protected by a coat of acid resistant paint.

Not less than seven cubic feet of No. 9 stone shall be placed around the base of the hydrant to insure drainage. Before the No. 9 stone is placed and before it is backfilled the drain hole shall be inspected and thoroughly cleaned if necessary. The backfill around the hydrant shall be thoroughly compacted to the grade line in a manner satisfactory to the ENGINEER. Hydrants shall have the interior cleaned of all foreign matter before installation.

All hydrants will be installed with the pumper connection facing the main access road or as directed by the ENGINEER.

Stuffing boxes shall be tightened and the hydrants shall be inspected in open and closed position to see that all parts are in working condition.

3.2 VALVES

Underground valves shall be nut operated, unless otherwise shown on the plans. Valve supplier shall furnish two standard stem iron wrenches for turning nut operated valves. All underground valves which have nuts deeper than 30 inches below the top of valve box shall have extended stems with nuts located within 2 feet of valve box cap. Buried service valves shall have either epoxy-coated or tar-coated exteriors.

Exposed service valves shall be equipped with an AWWA approved handwheel operator. The exterior of exposed valves shall be epoxy-coated, tar-coated, or as specified on the DRAWINGS.

3.3 TIE-IN CONNECTIONS

All tie-in connections shall include a valve if shown on the plans. The valve shall be as specified under Section 2.2 of this specification. The tie-in shall include all fittings and materials suitable to make the required connection. The fittings shall be mechanical joint, ductile iron type as specified in other sections of the Technical Specifications.

4.0 PAYMENT

Payment of the unit price bid for fire hydrants shall constitute full compensation for furnishing and installing the fire hydrants with associated tees, gate valve and incidental items as specified.

Payment for gate valves, air release valves, check valves and other special valves installed underground shall include all work necessary for a complete installation and shall include all valve stem boxes or other valve boxes and box covers. Payment will be made at the unit price bid for the type and size of valve installation.

Blowoff Assemblies will be paid for under their respective bid prices and such payment is to include the gate valve setting, boxes and six feet (6') of pipe. Any additional pipe required will be paid under bid price for pipe installed.

Payment for tapping sleeve and valves and for tie-ins shall constitute full compensation for furnishing and installing the connection and shall include all work necessary for complete installation and any incidental items as specified.

SECTION 15120

SPECIAL ITEMS OF CONSTRUCTION IN WATER LINE INSTALLATION

1.0 GENERAL

These specifications govern special crossings, installations and construction procedures required to deal with unusual construction items or special requirements of governing agencies.

2.0 MATERIALS

2.1 CASING PIPE

In general, the diameter, thickness, style, joints and materials selected for casing pipe shall be as shown on the plans or as specified herein and shall be considered as "minimum" requirements, all subject to prior approval of the Engineer. In all cases, the approval for construction by agreement with the private company and/or construction permit issued by the State, County, or Municipal agency will be required before construction starts.

Steel casing pipe for road and railroad crossings using the boring and jacking method shall be steel, plain end, uncoated and unwrapped, and shall be furnished in at least 18-foot lengths. Steel pipe shall meet the requirements of ASTM Specification A-120 and AWWA C200. Pipes up to and including 4 inches in diameter shall be Schedule 40. Pipe larger than 4 inches and less than 18 inches shall have a wall thickness equal to or greater than 0.312 inches under railroads and 0.250 for all other uses. Pipe larger than 18 inches under roads shall have a wall thickness as indicated in the table below.

Minimum Thickness (Inches)	Nominal Diameter (Inches)
Use Schedule 40	less than 4
0.250	4 thru 18
0.281	20
0.312	22
0.344	24
0.375	26
0.406	28 thru 30
0.438	32
0.469	34 thru 36
0.500	38 thru 42

The inside diameter of all casing pipes shall be a minimum of four inches (4") greater than the largest outside diameter of the carrier pipe, joint or coupling.

The pipe shall be steel, new material, with a minimum yield of 35,000 psi. The steel casing pipe shall be bored and/or jacked in place at the locations as shown on the plans or as directed by the Engineer. All joints between lengths shall be solidly welded with a smooth non-obstructing joint inside. Any field welding shall be performed by a certified welder and shall be in accordance with AWWA C206. The casing pipe may be extended beyond the boring limits by open trenching as shown in the Standard Details. This would apply when the casing is required from right-of-way to right-of-way or ditch line to ditch line. Open trenching at jacked or bored locations will be allowed no closer than 3 feet from the edge of pavement or toe of the slope embankment.

Positioning guides (insulators) shall be utilized on all carrier pipe which is within the casing pipe. Positioning shall be accomplished by the use of prebuilt spacers such as those manufactured by CALPICO or an approved equal. The Contractor shall submit the type of position guide proposed for use for the approval of the Engineer. Spacing of the positioning guides shall be in accordance with the Standard Drawings. The carrier pipe shall not be permitted to rest on bells or couplings. The spacers shall be sized to fit the carrier pipe and the walls of the encasement pipe.

The ends of the casing pipe shall be plugged and made watertight in a manner acceptable to the Engineer prior to backfilling. Casing seals as manufactured by Pipeline Seal & Insulator, Inc. (PSI), Advance Products & Systems, Inc. (APS) or equal shall be used.

Where road crossings are made using plastic pipe or copper, the location of joints under the roadway should be avoided by using lengths of adequate dimension for the crossing. This principle also applies to other types of pipe where sufficiently long lengths are available.

2.2 PAVEMENTS

2.2.1 Concrete Pavement Replacement. This pavement replacement shall be Portland cement concrete construction in accordance with the requirements shown in the Standard Details. It shall include all pavement replacement on concrete surfaced roads, concrete driveways, concrete sidewalks and concrete parking areas, both public and private.

2.2.2 Heavy-Duty Bituminous Pavement Replacement. This type of asphalt pavement replacement shall be bituminous concrete surface over concrete base in accordance with the details. This type of pavement replacement shall be used on all heavily trafficked roads having an existing pavement greater than 2", whether public or private, or in other locations as directed by the Engineer.

2.2.3 Light-Duty Bituminous Pavement Replacement. This type of pavement replacement shall be bituminous concrete constructed in accordance with the details. This item shall include all light-duty bituminous concrete roadways, bituminous driveways and bituminous parking lots, both public and private.

2.2.4 Crushed Stone Surface Replacement. This type of surface replacement shall include all graveled roadways, driveways, parking areas, or other gravel surfaced areas, both private and public. This type of surfacing may also be required as a base course for other pavement replacement.

2.3 CRUSHED STONE

The crushed stone backfill as noted on the drawings shall be dense #57 aggregate per Kentucky Department of Highways Specifications. The Contractor shall continuously be responsible for the maintenance of the aggregate and the surface of the trenches until the pavement replacement is completed.

2.4 PORTLAND CEMENT CONCRETE

Portland cement concrete for pavement replacement shall contain a minimum of 6 sacks of cement per cubic yard, the maximum free water content shall be 6 gallons per sack of cement, the slump shall be between 2 and 4 inches, and the concrete shall have minimum 28-day compression strength of at least 3,500 PSI. Cement, aggregate and water shall be described in these specifications for Class "A" concrete. A set of cylinders shall be made and tested for each 25 cubic yards of concrete placed, or fraction thereof, to supply representative sampling and testing of the concrete, upon the direction of the Engineer. The Contractor shall produce a broomed, or burlaped uniformly smooth and nonskid surface, consistent with the existing pavement.

Bituminous materials and mixes shall be consistent with the recommended practice of the asphalt institute and it shall conform to the requirements of the Kentucky Department of Highways for prime coat and Class 1 bituminous concrete. The bituminous concrete shall consist of a binder or base course and a surface course.

3.0 EXECUTION

3.1 ROAD CROSSINGS

In all cases, these crossings will be made in compliance with the requirements of the State Highway Department or the appropriate county or city office. State requirements will normally be described by the appropriate District Highway Office. In general, unless otherwise shown on the plans or directed otherwise by the Engineer, the crossing of all State Highways shall be accomplished by boring under the roadway. In addition, the crossing of service lines 1-1/2 inches and

greater under rigid and flexible surfaced paved roads shall be accomplished by boring and jacking a casing pipe under said roadway. In certain cases, as shown on the plans, service lines of all sizes will require casing pipe installed with the crossing.

Under state roads, requirements of the Kentucky Transportation Cabinet shall apply. Unless stated otherwise by the Engineer, all pipe crossing a state road shall be cased with casing pipe bored under the road. Pipe crossing under county roads or city streets shall be cased with casing pipe, and crossed in the manner as directed on the plans.

3.1.1 OPEN TRENCH CROSSINGS

The trench shall be excavated to a minimum width that will allow the pipe installation. The trench walls shall be kept as nearly vertical as possible. The minimum specified cover above the pipe shall be maintained. The Standard Details section shows the requirements for open trench crossings.

The backfill in the trench under any roads, driveways, or parking areas where the open trench method is used shall be of the type shown in the Standard Details and shall be deposited and compacted in uniform layers not to exceed the depth shown in the Standard Details.

The surface of the road, driveway, or parking area shall be replaced with the same type of material as specified under pavement replacement.

3.1.2 BORING AND JACKING

The work is herein defined as the operations in which both the boring by auger and the jacking of the casing pipe are done mechanically and in which the diameter of the casing pipe is too small to permit hand working at the heading of the casing pipe. Two basic methods are: (1) pushing the casing pipe into the fill or earth simultaneously as the boring auger drills out the ground and (2) drilling the hole through the fill or earth and pushing the casing or carrying pipe into the hole after the drill auger has completed the bore.

A suitable approach trench shall be opened adjacent to the slope of the embankment, or adjacent to point of bored and jacked section as shown on the plans. The approach trench shall be long enough to accommodate the selected working room. Guide timbers or rails for keeping the casing pipe on line and grade shall be accurately set and maintained in the bottom of the approach trench and with heavy timber back-stop supports installed at the rear of the approach trench to adequately take thrust of the jacks without any movement or distortion. It is paramount to the securing of acceptable tolerance limits of workmanship in the boring and jacking operation that extreme care be taken in the setting of all guides, rails and jacks to the end that the casing pipe in final

position be within the limits of acceptability for the placing and laying of the carrier pipe. The minimum cover of forty-two inches (42") under the roadway must be maintained. Additional depth may be required as shown on the plans.

3.2 RAILROAD CROSSINGS

At all railroad crossings, cover pipe (casing) for water lines (carrier pipe) shall be jacked or pushed beneath tracks and the carrier pipe jointed and pushed through the cover pipe. Detailed drawings of railroad crossings including the length of casing and depth below track are shown in the plans. Contractor shall obtain and pay for services of a representative of the railroad to direct the Contractor's operations while on the railroad property when required by the railroad.

3.3 FREE BORE

At locations indicated in the plans, the Contractor shall provide a jacking pit and bore through the earth at the proper line and grade. The augured hole shall be as small as practical to allow the carrier pipe to pass through.

This bid item does not apply to service tubing.

3.4 CREEK CROSSINGS

3.4.1 No Flow Conditions. Where required on the plans or instructed by the Engineer, the Contractor shall construct a special creek crossing as shown in the Miscellaneous Drawings. Crossings shall be scheduled for construction in times of no flow or very low flow, if practicable, otherwise the stream shall be directional bored. Concrete shall not be placed under water and Contractor shall provide suitable pumps to keep water out of trench excavation during stream crossing construction. Special creek crossings shall be designated as Type A or Type B as contained in the Standard Drawings.

3.4.2 Normal Earthern Stream Crossing. Where the stream crossing is made in earth or other beds which are stable (no casing or anchorage required), then the pipe will be laid in a narrow trench at the depth specified in the Standard Details to maintain the required cover between pipe and stream bed. Initial backfill will be mechanically compacted. Trench backfill in any stream crossing area from one (1) foot above the top of the pipe shall consist of trench excavated rock, if available. No extra payment will be made above normal construction for this type of creek crossing.

3.4.3 Blue Line Stream Crossing. All crossing of streams that appear as a blue line on a USGS 7.5 minute topographical map shall be accomplished in accordance with:

GENERAL CERTIFICATION
NATIONWIDE PERMIT #12
UTILITY LINE BACKFILL AND BEDDING

This document is bound in the back of the specifications. The Contractor shall read, understand and comply with the requirements and procedures.

Stream size, for purposes of this specification, is differentiated as large or small. A stream is classified as small when the distance across the stream channel at top of banks is 15 L.F. or less. A stream is classified as large when this measurement is greater than 15 L.F.

It is the intent of the plans to identify a stream crossing at each blue line stream. Small stream crossings may frequently be accomplished by trenching when the stream is in a no flow condition. **If the stream is in a flow condition, regardless of the size classification, the crossing shall be accomplished by directional boring or other method that complies with the General Certification and is approved by the Engineer.** Specific details for stream crossings are contained in the Miscellaneous Drawings.

3.4.4 Bypass Test Meter. At locations as indicated on the plans, where a new creek crossing is installed, a bypass test meter shall be installed. The meter shall be installed as a normal water meter with taps on each side of a valve, as shown on the Standard Drawing.

3.5 RIVER OR LAKE CROSSINGS

Crossings in rivers or lakes where the pipe cannot be laid in a trench shall normally be made with ductile iron pipe having ball and socket joints or polyethylene pipe as indicated on the Drawings. Details for any required installations of this type including pipe required, anchors (number, size and location), and installation technique are shown in the plans.

3.6 BRIDGE CROSSINGS

Wherever possible bridges will not be utilized for stream crossings. However, where it is necessary for the water line to be attached to bridges, the pipe shall be securely fastened to bridge stringers or beams using supports as dimensioned and located in the plans. The carrier pipe shall be insulated with Vermiculite or other approved material to prevent freezing. Expansion joints to allow for movement of the bridge will be required as shown on the plans.

3.7 WATER LINES AND SEWER LINES SEPARATION

3.7.1 General. Wherever sewer lines cross, or are adjacent to, each other, special precautions shall be taken.

3.7.2 Parallel Water and Sewer Lines. Water lines must, if possible, be located a minimum lateral distance of 10 feet from any existing or future sewer lines measured from outside diameters. Where water lines and sewer lines must be placed in the same trench, the water line must be located on a shelf, two feet (2') above and two feet (2') to the side of the sewer line. Whenever this condition cannot be met, and upon direction from the Engineer, the water line shall be uncovered and encased with concrete per the standard encasement detail.

3.7.3 Crossing Water and Sewer Lines. Wherever sewer lines and water lines cross, it is desirable, if practical, that the sewer line be at least twenty-four inches (24") below the water line.

Where it is not practical to provide such a separation, care shall be taken to ascertain that the existing water line or existing sewer line is in good sound condition and that no evidence of joint leakage is known in that vicinity. If any such evidence does exist, the existing line shall be exposed by the Contractor at least ten feet (10') each side of the new pipe crossing, carefully examined and any defects positively corrected. The Owner will arrange for examining and correcting any defects in the existing lines, but the Contractor shall cooperate in every way possible.

When the water line must be below or less than two feet (2') above the sewer line, the Contractor shall encase the water line five feet (5') in each direction from the crossing as directed by the Engineer. This encasement should only be accomplished when directed by the Engineer and shall be accomplished in accordance with the details shown on the drawings. The encasement is a separate pay item.

3.8 SEEDING AND SODDING

Upon completion of the installation of the work, the Contractor shall remove all debris and surplus construction materials resulting from the work. The Contractor shall fine grade all the disturbed surfaces around the area of the work in an uniform and neat manner leaving the construction area in a condition as near as possible to the original ground line or to the lines as directed by the Engineer. The Contractor shall provide effective clean-up of the work as it progresses. Procrastiration of clean-up will not be tolerated.

All graded areas shall be left smooth and thickly sown with a mixture of grasses. The mixture of grasses shall consist of one-third (1/3) Rye grass, one-third (1/3) Kentucky Fescue and one-third (1/3) Kentucky Bluegrass by weight, and shall be applied to the graded areas at a rate of not less than 1 pound of seed per one thousand square feet of area. When the final grading has been completed, the entire graded area to be seeded shall be fertilized with 12-12-12 fertilizer, applied at the rate of 6 pounds per one thousand square feet of area. After the seed and fertilizer have both been applied, the Contractor shall then lightly cover the seed

by use of a drag or other approved device. The seeded area shall then be covered with straw to a depth of approximately one inch (1").

Where existing lawns have been disturbed, the existing sod will be removed and stored and replaced to its original position once the work is in place. If the Contractor damages or destroys the original sod, it shall be replaced with a sod having at least 60% good quality Kentucky Bluegrass, strongly rooted and free of pernicious weeds and shall be so laid that no voids occur between strips. When placing sod, it shall be tamped or rolled immediately after it is laid and the finished surface shall be true to grade, even and equally firm at all points. Well screened top soil shall be lightly sprinkled over the sodded areas and shall be raked to insure sealing the sod joints. The sodded areas shall be thoroughly watered. Sod damaged by the Contractor shall be replaced with new sod by the Contractor at no cost to the Owner.

The fine grading, seeding, sodding and clean-up shall be considered as incidental expense and shall not be separate pay items.

Meadows and hay fields will require replacement in kind unless the Contractor secures a release from the property Owner agreeing to no replacement or alternate replacement.

3.9 PAVEMENT AND OTHER STRUCTURE REPLACEMENT

The Contractor shall replace all pavement cut or disturbed, with pavement similar in all respects to existing pavement in accordance with the Standard Details and at those locations approved by the Engineer. Every effort shall be made to avoid cutting the pavement. In restoring pavement, new pavement is required, except that granite paving blocks, sound brick or sound asphalt paving blocks may be reused. No permanent paving shall be placed within thirty (30) days after the backfilling has been completed. All concrete and asphalt paving materials shall be in conformance with the Standard Details shown in the plans. The pipeline trench through all paved areas (parking lots, driveways, roads, etc.) shall be fully backfilled with crushed stone.

3.9.1 Installation of Pavement Replacement. The Contractor shall cut back the surfacing adjacent to the trench for twelve inches (12") on both sides of the trench and shall cut down the dense graded aggregate he has placed to a depth required for either type of pavement replacement. The resulting surface shall be rolled to yield a smooth, dense surface and a uniform depth.

The concrete shall be placed in accordance with standard practice, with the welded wire mesh if required in proper position and thoroughly vibrated into place. The Contractor shall produce a surface consistent with the existing pavement. The Contractor shall apply a liquid curing component, sprayed on the

surface of the concrete, and shall provide adequate protection to the pavement until it has set.

For bituminous concrete, the Contractor shall clean and broom the prepared surface, then apply the prime coat at the rate of 0.20 to 0.25 gallons per square yard, with a pressure distributor or approved pressure spray method. When the prime coat has become tacky but not dry and hard, the bituminous binder course, or base course, whichever applies, shall be placed and compacted. The Contractor shall then apply the surface course. It is recommended, but not required, that the base course remain in place for approximately one week before placing the surface course. The finished course shall be compacted and the completed surface shall match the grades and slopes of the adjacent existing surfacing and be free of offsets, depressions, raised places and all other irregular surfaces.

3.9.2 Seasonal and Weather Limitations for Pavement Replacement. In the event the progress and scheduling of the work is such that the bituminous pavement replacement would occur in the winter months, during adverse cold weather and/or during such times the asphalt plants are not in operation, then the final pavement replacement shall be postponed until favorable weather occurs in the spring and the asphalt plants resume normal operations. No bituminous concrete shall be laid when the temperature is below 40^{O}F except by written permission of the Engineer.

Concrete pavement shall not be placed when the temperature is such that the pavement placed will freeze before it has had adequate time to set and shall be placed in conformance with the temperature conditions specified in this section of these specifications.

The Contractor shall be responsible for replacement of pavement which he has placed which has been damaged by cold weather or freezing without additional compensation.

In the meantime, the Contractor will be required to maintain the temporary surfacing until the permanent pavement is placed. Such labor, materials and equipment as is required for temporary maintenance of the streets, roadways and driveways shall be provided at the Contractor's expense and is not a pay item. The Contractor will be required to use a cold mix asphaltic concrete as a temporary surface for trenches under heavy traffic use.

3.9.3 Guarantee. The one year guarantee as specified in the contract documents is also applicable to trench settlement and pavement replacement.

3.10 SIDEWALK AND DRIVEWAY REPLACEMENT

Sidewalks and driveways will be replaced if damaged by the Contractor in any way. Payment will be made for those pavements necessarily damaged by the line installation in accordance with the Standard Details. No pavements are to be replaced over a backfilled trench for at least thirty (30) days after filling. Pavements damaged otherwise are to be replaced immediately at the Contractor's expense.

Materials and dimensions are to be at least equal to existing pavement and are to conform with the Standard Details.

3.11 PAYMENT FOR WATER

All water used from the Utility shall be metered with meters supplied by the Contractor. The Contractor shall pay for such water monthly at the rates published by the Utility. Unmetered water lost through water line breakage shall also be paid at the rates published by the Utility. The quantity lost shall be computed on the basis of a discharge velocity of 7 feet/second, the diameter of the line, and the estimate duration of free uncontrolled discharge.

3.12 FINAL CLEAN-UP

The Contractor shall provide effective cleanup of the work as it progresses. Procrastination of cleanup will not be tolerated. At the time of final inspection, no trenchs shall show any undue evidence of the previous construction. All areas shall be left free of ruts due to construction equipment and shall have a clean and neat appearance without rubble or debris. The areas shall not be mounded up and shall be completely restored, and all yards and fields shall be reseeded so land may be cultivated, mowed, etc. Straw and fertilizing shall accompany the seeding in accordance with Section 3.8—Seeding and Sodding of this section. If necessary to hasten proper restoration of terraces, principally along ditch lines, the Contractor shall sod such areas at the Engineer's direction. For all line segments, final cleanup shall be performed within 30 days from day of installation.

3.13 PROTECTION OF ADJACENT LANDSCAPE

Reasonable care shall be taken during construction of the water lines to avoid damage to vegetation. Ornamental shrubbery and tree branches shall be temporarily tied back, where appropriate, to minimize damage. Trees which receive damage to branches shall be trimmed of those branches to improve the appearance of the tree. Tree trunks receiving damage from equipment shall be treated with a tree dressing.

In the course of construction, the Contractor may deflect horizontal alignment of the water line to avoid trees and to keep from damaging their roots. The Contractor shall be fully responsible for settling all claims by private property owners concerning damage to trees and shrubs.

4.0 PAYMENT

Casing pipe will be paid according to the unit bid price for boring or open cutting, as appropriate. The price shall include, as necessary, the cost of the casing pipe, the cost of boring or cutting, and the cost of special requirements for the road or railroad crossing. Carrier pipe will be paid according to Section 15100.

The unit price bid per linear foot for free boring, as measured from edge of pavement to edge of pavement, regardless of size of bore, shall constitute full compensation for the work specified.

Payment for special creek crossings will be at the unit price bid per linear foot for that item and shall include encasement pipe, crushed stone, concrete, solid rock excavation and all other work necessary for a satisfactory installation. The carrier pipe installed in the casing shall be paid separately under the unit price bid for pipe installed.

Payment for Bypass Test Meter or Leak Detection Test Meter shall include a meter setting (5/8" x ¾") and taps on both sides of a gate valve. The gate valve, sized for the line, is a separate pay item, covered in Section 15110.

Additional costs for normal earth creek crossings shall be included in the unit price bid for pipe installation and no special payment will be made for these crossings.

Payment for directional bore creek crossings will be at the lump sum price for that item and shall include all work and material necessary to make the crossing regardless of the distance. The unit bid price per linear foot for creek crossings will not be paid if the stream is directional bored, this is a separate pay item and is only paid if the stream is in a no flow condition and does not require a directional bore.

Payment for asphalt and concrete pavement replacement will not be based on the quantities purchased by the Contractor. Payment for surfacing will be paid on the basis of linear feet installed in accordance with the Standard Drawings with a maximum width of pipe diameter plus twenty-four inches (24"). Crushed stone sub-grade under paving shall be included in paving price and not paid for separately. Any additional cost estimated by the Contractor must be included in the cost of pipe in place.

Sidewalk /driveway crossings when included as a bid item shall include the extra cost of free-boring or the removal and disposal of existing pavement and replacement with new construction. Payment for pavement replacement will be on the basis of linear feet installed. Width for payment for a standard trench crossing is shown in the Standard Details. When sidewalk/driveway crossings or replacement are not included as a bid item, their costs shall be considered subsidiary to the bid for pipe installation.

Where required by the Special Provisions or the Bid Proposal, the cost of pavement replacement, boring, crossings of all types and other incidental construction shall be included in the unit price bid for pipe line installation and shall comprise total compensation for all such work.

All clean-up associated with installing water lines is incidental to the cost of installing the water lines. There is no separate pay item for clean-up.

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DIVISION 16 - ELECTRICAL

SECTION 16000 - ELECTRICAL GENERAL PROVISIONS

1. RELATED DOCUMENTS

A. General Provisions of Contract, General and Supplementary Conditions, and General Requirements, apply to this Section.

B. This Section shall be governed by alternates insofar as they apply to this work.

2. DESCRIPTION OF WORK

A. Provide labor, equipment, materials, supplies and components, including lamps and fuses; and perform all operations including cutting, channeling, chasing, trenching and backfilling necessary for installation of complete electrical system.

B. Appliances, equipment, and fixtures shall be current models for which replacement parts are available. Store and protect materials and equipment delivered to site in such a manner as to effectively prevent damage from climatic conditions, condensation, dust, and physical abuse. Install and connect materials and equipment in accordance with manufacturer's instructions and recommendations. Each major component of equipment shall have manufacturer's name, address, model number, and ratings on a plate securely affixed in a conspicuous place.

C. It is not the intent of this section to make any Contractor, other than the General Contractor alone, the single responsible party to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be done through the General Contractor. No attempt has been made to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, subdivision and assignment of work shall be General Contractor's responsibility.

D. Facilities and systems of electrical work are described (but not by way of limitation) as follows:

(1) Electrical connecting of equipment not specified to be connected as work of another Division.

(2) Motor starters and control/protection work as indicated.

(3) Electric equipment and motor connections.

(4) Control/monitoring work as indicated.

E. Each CONTRACTOR bidding on the work included in these Specifications shall view the site and carefully examine the Contract Drawings and Specifications, so that he/she may fully understand what is to be done, and to document existing conditions.

3. QUALITY ASSURANCE

A. Minimum standards for all electrical work shall be latest revision of NEC. Whenever and wherever OSHA, Federal and State laws, regulations and design require higher standards than NEC, these laws, regulations, and designs shall be followed.

B. Provide electrical inspection by a licensed and recognized Electrical Inspector. Notify Electrical

(1) Inspector in writing, immediately upon start of work with a copy of notice to Engineer. Schedule inspection for rough as well as finished work. Approval from Electrical Inspector will not be allowed as reason for deviation from Contract Documents. All costs incidental to Electrical Inspection shall be borne by Contractor. Prior to final acceptance of work and release of final payment, deliver to Engineer the certificate of final inspection.

C. Obtain all permits required for entire construction of electrical system from authorities governing such work. Bear all costs of these permits.

D. All materials shall be new and best of their respective kinds unless otherwise specified and shall be listed by UL and shall be so labeled. All equipment shall conform to latest approved standards of I.E.E.E., N.E.M.A., A.N.S.I., U.L. and O.S.H.A. See individual specification sections for other specific requirements.

4. CONTRACT DOCUMENTS

A. Contract Documents are intended to cover furnishing and installing of complete electrical systems (interior and exterior) including miscellaneous systems, all tested and ready for operation.

B. Contract Documents are complementary, each to the other, and work required by either shall be included in the contract as if called for by both. Necessary items or work omitted, not clearly included, specified or indicated and material or apparatus believed inadequate or unsuitable, in violation of laws, ordinances, or rules shall be clarified by a written request to Engineer prior to bidding. In absence of such written notice, Contractor shall be responsible for approved satisfactory functioning of entire system without extra compensation.

C. Drawings other than electrical drawings, and other sections of this specification, may show or specify electrically operated equipment and wiring diagrams. Examine all such drawings and specifications. Determine characteristics and provide necessary wiring and connections for all such equipment.

D. Keep electrical record drawings up to date each day. Record drawings will be reviewed by Engineer each month with Contractor's pay request review. Entries and notes shall be made in a neat and legible manner and these drawings delivered to the ENGINEER after completion of the construction, for use in preparation of Record Drawings.

E. Naming of a certain brand or make or manufacturer in specifications is to establish style or quality standard for articles desired. Contractor is not restricted to use of specific brand of manufacturer named unless so indicated in specifications. However, where a substitution is requested, a substitution will be permitted only with written approval of Engineer. Proposed substitutions prior to bidding shall be submitted prior to bid date. Submit three bound copies of manufacturer's data showing all pertinent data, and samples, if requested.

5. COORDINATION

A. Coordinate work of different trades so that:

(1) Interference between mechanical, electrical, architectural, and structural work including existing services shall be avoided.

(2) Within limits indicated on Drawings, the maximum practicable space for operation, repair, removal, and testing of electrical equipment shall be provided.

B. All electrical materials and equipment shall be kept close as possible to ceiling, walls and columns, to take up a minimum amount of space.

C. Provide all offsets, fittings and similar items necessary in order to accomplish requirements of coordination without additional expense to Owner.

D. Drawings are diagrammatic and indicate general location of material and equipment. Refer to architectural and structural drawings and specifications for general construction of building, for floors and ceiling heights and for locations of walls, partitions, beams, and equipment, and be guided accordingly for setting of all equipment. Do not scale electrical drawings to determine exact locations.

E. Motor horsepowers and apparatus wattage ratings indicated on Drawings or specified herein are estimated values, and corresponding sizes of feeders and other electrical equipment indicated to serve them are minimum sizes. Motors of greater horsepower and apparatus with larger wattage ratings may be provided if necessary to meet requirements of various sections of specification in which they are specified. Where larger motors or apparatus with larger wattage ratings are provided, feeders and other electrical equipment serving them shall be increased in capacity to correspond. Increase in capacity of feeder and other apparatus shall be furnished at no additional cost to the Owner.

F. Be responsible for locating all openings required in walls, floors, ceilings or roof, for all materials and equipment provided under Electrical sections.

(1) Check with other trades on scope of their work and coordinate on all locations of various items of equipment and outlets before they are finally placed and connected. Relocation of material or equipment necessitated by failure to coordinate work shall be at no cost to Owner.

(2) Do not cut work of any other trade without first consulting Engineer's representative. Repair work damaged employing services of trade whose work is damaged. Where openings or sleeves have been omitted, they shall be drilled or sawed as directed by Architect. All cutting and patching shall be responsibility of this Section.

(3) Wherever slots, sleeves or other openings are provided in floors or walls, for the passage of conduits or other forms of raceway, including bus ducts, such openings, if unused, or spaces left in such openings after installation of conduit or raceway shall be filled. Filling materials for openings in walls and floors generally shall be fire resistive and constructed and installed so as to prevent passage of water, smoke and fumes. Where conduits passing through openings are exposed in finished rooms, finishes of filling materials shall match and be flush with adjoining floor, ceiling or wall finishes.

(4) Provide exposed conduit passing through floors, walls, or ceilings of finished rooms with chrome plated escutcheons. Plates shall be split, hinged type of sufficient outside diameter to amply cover up sleeve openings for pipe.

6. WARRANTY

A. Contractor shall be responsible for warranting all work, including equipment, materials, and workmanship provided under this section. This warranty shall be against all defects of the above and shall run a minimum period of one (1) year from date of acceptance of the work, concurrent with the one year guarantee period designated for the general construction contract under which electrical work is performed. Date of acceptance shall be considered to be the date on which all "punchlist" items are completed ("punchlist" is defined to be the written listing of work that is incomplete or deficient that must be finished or replaced/repaired before the CONTRACTOR receives final payment).

B. Defective work, equipment, materials and workmanship that develops within warranty period, which is not caused by ordinary wear, damage or abuse by others, shall be replaced or corrected without additional cost to Owner.

C. Repair or maintenance for the guarantee period is the responsibility of the CONTRACTOR and shall include all repairs and maintenance other than that which is considered as routine. (That is replacement of lamps, oiling, greasing, etc.)

7. EXCAVATING FOR ELECTRICAL WORK

A. Include whatever excavating and backfilling is necessary to install electrical work. Coordinate work with other excavating and backfilling in same area, including dewatering, flood protection provisions and other temporary facilities. Coordinate work with other work in same area, including other underground services (existing and new), landscape development, paving, and floor slabs on grade. Coordinate with weather conditions and provide temporary facilities needed for protection and proper performance of excavating and backfilling.

B. Except as otherwise indicated, comply with applicable provisions of Section 02200 for electrical work excavating and backfilling. Refer instances of uncertain applicability to Engineer for resolution before proceeding.

C. Where conduit is less than 2' 6" below surface of roadway, provide encasement in Class 2500 concrete, 4" minimum coverage all around.

D. After backfilling has been completed disturbed areas shall be returned to their original condition and shall match adjoining area, or in areas to be covered under site work, area shall be finished as directed by Engineer.

E. Where it is necessary to remove and replace landscape work, pavement, flooring and similar exposed finished work, engage original installer to install replacement work; except where work existed prior to work of this Contract, engage only experienced and expert firms and tradespersons to replace work.

8. CONCRETE FOR ELECTRICAL WORK

A. Work of this article is defined to include whatever concrete work is necessary or indicated specifically to install electrical work. Except as otherwise indicated, comply with applicable provisions of Division 3 for electrical work concrete, including formwork, reinforcement, mix design, materials (use mix designs and materials accepted for Division 3 work where possible), admixtures, accessories (including waterstops), placing of wet concrete, finishing, curing, protecting, testing, submittals, and other requirements of the concrete work. Refer instances of uncertain applicability to Engineer for resolution before proceeding.

B. Except as otherwise indicated, provide strength classes as follows, with the following cement content and water/cement ratios; for the indicated applications and similar required applications.

(1) 4000 psi Class: 565 lbs. cement/yd. (6.0 sacks); 0.57 water/cement ratio. Provide 4000 Class for vaults, beam type foundations and similar structures.

(2) 3000 psi Class: 500 lbs. cement/yd. (5.25 sacks); 0.68 water/cement ratio. Provide 3000 Class for miscellaneous underground structural concrete, reinforced encasement, block type foundations (with smallest dimension at least 0.2 x largest dimension), curbs, pads, and similar structural support work.

(3) 2500 psi Class: 450 lbs. cement/yd. (4.75 sacks); 0.75 water/cement ratio. Provide 2500 Class for plain encasement, filling steel framed units, and similar work.

(4) Rough Grouting Class: 565 lbs. cement/yd. (6.0 sacks); 0.75 water/cement ratio; adjust aggregate sizes to facilitate placement. Use for rough grouting, not for setting equipment bases.

(5) Backfill Class (Lean Concrete): 375 lbs. cement/yd. (4.0 sacks); 0.87 water/cement ratio. Use for backfilling where excavations are extended below point of support for electrical work.

C. Anchor Bolts-Concrete: Provide all anchor bolts required for equipment furnished under Contract. Set anchor bolts in a substantial manner so they will not be displaced. Anchor bolts shall be set in new concrete construction before pouring. Anchor bolts shall be stainless steel.

9. TESTING AND BALANCING

A. Feeders and branch circuits shall have their insulation tested after installation, and before connection to fixtures and equipment. Perform with a 500 volt megger. Conductors shall test free from short circuits and grounds. Test conductors phase to phase and phase to ground. Test readings shall be recorded and delivered to Engineer.

B. Verify rotation of all three phase motors with trade furnishing equipment. Bump or run these motors uncoupled in presence of trade furnishing equipment to insure proper rotation.

C. Circuit numbers are indicated on Drawings for reference; however Contractor shall make corrections as necessary to obtain proper phase balance under operating conditions.

D. After the wiring system is completed, and at such time as the ENGINEER may direct, the CONTRACTOR shall conduct an operating test for acceptance. The equipment shall be demonstrated to operate in accordance with the requirements of these Specifications and the Contract Drawings. The test shall be performed in the presence of the ENGINEER or his authorized representative. The CONTRACTOR shall furnish all instruments and personnel required for the tests, as well as the necessary electrical power.

E. Before energizing the system, the CONTRACTOR shall check all connections and set all relays and instruments for proper operation. He shall obtain all necessary clearances, approvals, and instructions from the serving utility company prior to placing power on the equipment.

1.10 TRAINING

A. All manufacturers supplying equipment for this division shall provide the OWNER'S operations staff with training in the operation and maintenance on the equipment being furnished. The training shall be conducted at the project site by a qualified representative of the manufacturer.

B. The cost of this training shall be included in the bid price.

C. The required training shall consist of both classroom and hands-on situation. Classroom training shall include instruction on how the equipment works, its relationship to all accessories and other related units, detailed review of shop drawings, detailed presentation of written O&M instructions, troubleshooting and record-keeping recommendations. Hands-on training shall include a review of the manufacturer's O&M instructions, check out of each operator to identifying key elements of the equipment, tear down as appropriate, calibration, adjustment, greasing and oiling points, and operating manipulations of all electrical and mechanical controls.

D. The training shall be scheduled through the CONTRACTOR with the OWNER. The timing of the training shall closely coincide with the startup of the equipment, but no training shall be conducted until the equipment is operational.

E. The minimum number of training hours to be provided by manufacturer supplying equipment on this project shall be in accordance with the following tables:

Item	Training Hours	
	Classroom	Hands-on
Motor Control/Telemetry Control Systems	3	3

F. At least 60 days prior to the training the manufacturer shall submit through the CONTRACTOR to the ENGINEER an outline of the training proposed for the ENGINEER'S review and concurrence.

G. The OWNER reserves the right to videotape all training sessions.

1.11 STORAGE AND CLEANING

A. All work, equipment, and materials shall be protected against dirt, water, or other damage during the period of construction.

B. Sensitive electrical equipment such as light fixtures, motor starters and controls, delivered to the job site, shall be protected against damage or corrosion due to atmospheric conditions or physical damage by other means. Protection is interpreted to mean that equipment shall be stored under roof, in a structure properly heated in cold weather and ventilated in hot weather. Provision shall be made to control the humidity in the storage area to 50 percent relative. The stored equipment shall be inspected periodically, and if it is found that the protection is inadequate, further protective measures shall be employed.

C. The CONTRACTOR shall not store submersible pump units in the wet well. If it is absolutely necessary to do so, the open power cable ends are to be suspended above the maximum flood elevation or maximum expected water level. If not stored in this manner, the CONTRACTOR may be called upon to replace the pump motors and cables with new units to ensure that water has not penetrated the cable and entered the motor housing.

D. At completion of work required under this Contract and just prior to acceptance by Owner, thoroughly clean all exposed equipment fittings, fixtures and accessories.

E. During construction, cover all OWNER equipment and furnishings subject to mechanical damage or contamination in any way.

1.12 SUPPORT OF ELECTRICAL ITEMS

A. Unless otherwise indicated, all electrical items or their supporting hardware, including but not limited to, conduits, raceways, cable trays, busways, cabinets, panelboards, wall mounted transformers, starters, boxes, and disconnect switches shall be securely fastened to building structures with the following methods. Fastening shall be by wood screws or screw type nails on wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; by machine screws, welded threaded studs, or spring tension clamps on steel work. Threaded studs driven in by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts or machine or wood screws. Threaded C clamps with retainers may be used on rigid steel conduit only. Conduits or pipe straps shall not be welded to steel structures. In partitions of light steel construction, sheet metal screws shall be used.

B. Equipment supports at process structures remote from buildings shall be as detailed and/or noted on Drawings. Where a particular support type is not noted, aluminum channel (uni-strut) shall be used. Channel type supports shall not be used in lieu of other supports noted unless approved by Engineer.

(1) All mounting brackets and strut used outside shall be aluminum. Fasteners used to mount equipment outside shall be stainless steel. The only exception to the above shall be anchor bolts for area lightpoles which shall be allowed to have galvanized threads and galvanized nuts.

a. All mounting brackets and strut used inside shall be aluminum.

b. All free standing equipment shall be anchored to its foundation using expansion bolts of the size and number recommended by the equipment manufacturer.

c. The load applied to any fastener shall not exceed one of the proof test load. Fasteners attached to concrete ceilings shall be vibration and shock resistant.

C. Since this project is in Seismic Zone 1, the CONTRACTOR shall be sure that all supports are consistent with the KBC requirements in this regard.

1.13 IDENTIFICATION

A. Equipment disconnect switches, motor starters, pushbutton stations, panels, switchgear, special device plates, and similar material shall be clearly marked. Coordinate size of lettering and wording with Engineer.

B. Mark panels, giving panel designation in one half inch letters and voltage in one quarter inch letters centered above door on exterior trim. Mark equipment mounted remotely from source of power (such as roof exhaust fans) with equipment number and source of power. Where starters are remotely mounted, marking shall include equipment name and number.

C. Except as indicated, mark all equipment with engraved lamacoid plates having black foreground and white letters. Attach interior mounted plates with contact type permanent adhesive and exterior mounted plates with self tapping stainless steel screws except where screws should not penetrate substrate use waterproof contact adhesive. Align plates on equipment being marked in center near top.

(1) All control panels, disconnects, [instruments,] etc., shall be marked to indicate the circuit they control, [or variable monitored.] Marking is to be done with engraved laminated nameplates and shall bear the designation shown on the Contract Drawings where this information is given. Nameplates shall be fastened to equipment with stainless steel screws, minimum of one each side. In no way shall the installation of mounting screws void the NEMA enclosure rating of the equipment in which they are installed. If there are more than one identical unit, they shall be given consecutive numbers or other descriptions as designated by the ENGINEER. Nameplate background color shall be white, with black engraved letters, unless otherwise noted.

(2) Control panels and disconnect switches shall be labeled with vinyl self-adhesive signs that warn of "High Voltage" (state the specific voltage). Other major equipment such as transformers, transfer switches, pump control panels, etc., shall be labeled as such. The type of labels to be used shall have orange as the basic color to conform with OSHA requirements, letters shall be black. The labels shall be of proper size to fit flatly on the surface of the enclosure to make for a neat appearance and not interfere with the operating functions of the device it is attached to. These labels shall be as manufactured by the Brady Identification Systems Division, Safety Sign Company, Westline Products Company, or equal.

D. Provide warning signs where there is hazardous exposure or danger associated with access to or operation of electrical facilities, such as pad mount transformers. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with recognized industry standards for color and design.

E. Bury a continuous, pre printed, bright colored plastic ribbon cable marker with each underground power or signal circuit, regardless of whether conductors are in conduit or concrete encasement. Locate each directly over cables, 6" to 8" below finished grade.

F. Provide adequate marking of conduits containing conductors operating above 600 volts, which are exposed or concealed in accessible spaces. Except as otherwise indicated use orange banding

with black lettering. Provide self adhesive or snap on type plastic markers. Indicate voltage ratings of conductors. Locate markers at ends of conduit runs, near switches and other control devices, near items of equipment served by conductors, at points where conduits pass through walls or floors or enter non accessible construction, and at spacings of not more than 50' along each run of exposed conduit.

1.14 SUBMITTALS

A. Refer to the Division 1 sections for general requirements concerning work related submittals. For electrical work, the following quantities are required for each category of submittal (in lieu of quantities specified in Division 1), unless otherwise indicated in individual work sections (quantity does not include copies required by governing authorities, or by Contractor for its own purpose.)

(1) Shop Drawings: Minimum 6 sets, including 3 for maintenance manuals.

(2) Product Data: Minimum 6 sets, including 3 sets for maintenance manuals.

(3) Samples: 4 sets for final submission.

(4) Certifications: 3 copies.

(5) Test Reports: 3 copies.

(6) Warranties (Guarantees): 6 copies, including 3 for maintenance manuals.

(7) Maintenance Manuals: 3 final copies, including wiring diagrams, maintenance and operating instructions, parts listings, and copies of other submittals indicated for inclusion.

B. Each submittal shall have Engineer's Project Number, Specification Section Number, Schedule, Material and Date Submitted, indicated on its cover sheet so Engineer may readily determine particular item Contractor proposes to furnish.

C. An example of above requirements is indicated by:

(Job Number)

Division 16 ELECTRICAL

Section 16510 Building Lighting Fixtures

Date Submitted:

D. Operating and Maintenance Manual

(1) Submit to Engineer prior to substantial completion three (3) copies of complete operating and maintenance instructions for equipment provided under this Contract. Provide complete parts lists for all new major equipment items.

(2) Organize each maintenance manual with index and thumb tab marker for each section of information; bind in 2", 3 ring, vinyl covered binder with pockets to contain folded sheets, properly labeled on spine and face of binder with the following:

TITLE: (Project Name)

Electrical System Operation and Maintenance Data

Name and Address of Architect/Engineer

Name and Address of Consultants/Contractors

(3) Index of contents shall include equipment vendor's name and address.

(4) Include Brochures, data, all approved shop drawings, parts lists, warranties, wiring diagrams and manufacturers operating and maintenance instructions.

E. Contractor shall refer to each separate section of these specifications for information on electrical items requirement shop drawing submission and additional maintenance manual documentation.

1.15 MATERIALS

A. All materials used shall be new and at least meet the minimum standards as established by the NEC and/or National Electrical Manufacturers Association (NEMA). All materials shall be UL listed for the application, where a listing exists. Additional requirements are found in Division 1. All equipment shall meet applicable FCC requirements and restrictions.

B. The material and equipment described herein has been specified according to a particular trade name or make to set quality standards. However, each CONTRACTOR has the right to substitute other material and equipment in lieu of that specified, other than those specifically mentioned as matching or for standardization, providing such material and equipment meets all of the requirements of those specified and is accepted, in writing by the ENGINEER.

C. The reuse of salvaged electrical equipment and/or wiring will not be permitted unless specified herein or indicated on the Contract Drawings.

D. All salvaged or abandoned electrical materials shall become the property of the OWNER and shall be removed from the job site upon completion of the project as directed by OWNER.

1.16 TEMPORARY FACILITIES

A. Refer to Division 1 sections for general requirements for temporary facilities.

B. The CONTRACTOR is responsible for coordinating all activities onsite by the Power Company

C. The CONTRACTOR shall be responsible for providing temporary electrical power as required during the course of construction and shall remove temporary service equipment when no longer required. Temporary power is also addressed in Division 1.

D. All such equipment shall be removed when permanent connections have been completed. Where it is determined, during construction, that temporary facilities, as installed, interfere with construction operations, relocate said facilities in an approved manner at no cost to Owner. Temporary connections shall be in accordance with NEC and OSHA requirements. Repair damage or injury to equipment, materials, or personnel caused by improperly protected temporary installations. The Contractor shall be responsible for all costs for materials and installation for temporary electrical facilities and energy for their operation.

1.17 ERRORS, CORRECTIONS AND/OR OMISSIONS

A. Should a piece of utilization equipment be supplied of a different size or horsepower than shown on the Contract Drawings, the CONTRACTOR shall be responsible for installing the proper size

wiring, conduit, starters, circuit breakers, etc., for proper operation of that unit and the complete electrical system at no extra cost to the OWNER.

B. It is the intent of these Specifications to provide for an electrical system installation complete in every respect, to operate in the manner and under conditions as shown in these Specifications and on the Contract Drawings. The CONTRACTOR shall notify the ENGINEER, in writing, of any omission or error at least 10 days prior to opening of bids. In the event of the CONTRACTOR'S failure to give such notice, CONTRACTOR may be required to correct work and/or furnish items omitted without additional cost. Further requirements on this subject may be found in the General Requirements, Division 1.

(1) Necessary changes or revisions in electrical work to meet any code or power company requirements shall be made by the CONTRACTOR without additional charge.

1.18 MAINTAINING CONTINUOUS ELECTRICAL SYSTEM AND SERVICE

A. Existing service(s) continuity shall be maintained at all times. In no way shall the installation and/or alteration of the electrical work interfere with or stop the normal operation of the existing facilities, except when prior arrangements have been made.

B. When additions and taps to existing service(s) require electrical outages of duration in excess of a few minutes, arrangements shall be made in advance for such outages. All outages shall be held to an acceptable minimum with none exceeding 4 hours continuous duration. If necessary, work shall be performed on premium time. If performed at night, requiring a general outage, the CONTRACTOR shall furnish an auxiliary source of light and power as required. Under no circumstances shall an electrical outage of any duration be initiated until the OWNER and ENGINEER have concurred, and as far as possible in advance.

1.19 SERVICE ENTRANCE

A. Conductors and terminations for service entrances shall be furnished and installed by the CONTRACTOR. Voltage, phase, and number of wires shall be as shown on the Drawings. Clearances for overhead entrance wires shall be per Power Company, NEC, and NESC requirements.

B. Any details not shown on the Drawings or written in the Specifications pertaining to the service entrance shall be per power company requirements. It is the CONTRACTOR'S responsibility to contact the utility prior to bidding and obtain any special requirements or costs they will be imposing. Those costs shall be included in the bid.

C. On underground service entrances from pad mounted transformers, the CONTRACTOR shall be responsible for furnishing and installing all primary, secondary, and metering conduits, as well as secondary service/metering conductors. The CONTRACTOR shall be responsible for furnishing pull wires in primary conduits for use by the power company. The CONTRACTOR shall be responsible for fabricating the required concrete pad that the transformer will be mounted on. The CONTRACTOR shall also mount the meter base furnished by the power company.

END SECTION

SECTION 16051 - BASIC MATERIALS AND METHODS

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements apply to this Section.

B. Requirements of Electrical General Provision Sections govern this Section, where applicable.

C. Requirements of the sections govern work specified in this section, where applicable.

2. DESCRIPTION OF WORK

A. Provide labor, material, equipment and services necessary for complete and proper Basic Materials and Methods.

B. Requirements of this section apply to electrical work specified elsewhere.

3. BASIC MATERIALS AND METHODS

A. Unless otherwise indicated, install all wiring in rigid metal conduit, electric metallic tubing, or flexible metallic conduit specified below or as indicated on Drawings. Do not use surface metal raceways on floor. Do not use nonmetallic sheathed cable, or armored cable (Bx or Type AC).

B. Provide complete wiring from point of service connection to all receptacles, lighting fixtures, devices, utilization equipment and outlets for future extensions, as indicated on Drawings. Provide ample slack wire for connections. Unless otherwise specified, provide No. 12 AWG or larger for all branch circuit conductors. In outlet boxes designated for future use, tape ends of wires and install blank covers. Do not install telephone signal wires unless otherwise specified.

C. Do not bend cables, either permanently or temporarily during installation, to radii less than 10 times outer diameters, except where shorter radii are approved by engineer for conditions making specified radius impracticable.

D. All conductors No. 10 and smaller located in branch circuit panelboards, signal cabinets, signal control boards, switchboards and motor control centers shall be neatly and securely bundled. For conductors larger than No. 10 located in switchboards, motor control centers and pull boxes, neatly and securely cable in individual circuits. Use nylon straps made of self extinguishing nylon having a temperature range of 65 degrees F. to + 350 degrees F. Construct each strap with a locking hub or head on one end and a taper on other.

E. Where two or more conduits have been installed in place of a single conduit because of space conditions, use duplicate conductors in each conduit, including neutrals where required, and total capacity of duplicate conductors shall be not less than capacity of conductors replaced.

F. Where length of a branch circuit , from panel to first outlet, exceeds 75 feet for a 120 volt, 20 amp. circuit or 175 feet for a 277 volt circuit, use No. 10 AWG conductor size.

G. Where homerun circuit numbers are indicated on Drawings, follow such numbers in connecting circuits to panelboards. Where homerun circuit numbers are not indicated on Drawings, divide similar types of connected loads among phase buses in such a manner that, in normal usage, phase bus currents will be approximately equal. Connect each branch circuit homerun containing two or more circuits to circuit breakers or switch in a three wire or four wire branch circuit panelboard in such a manner that no two circuits will be fed from same bus. Where panelboard cabinets are recessed, conduits with sufficient capacity to carry required number and size of future conductors for all spare branch circuit protective devices and

spaces in panelboard shall be stubbed up concealed to a junction box for future connections and extensions located as follows:

(1) In an area with removable ceiling, junction box shall be accessible above suspended ceiling.

(2) In an area with nonremovable ceiling, recess junction box in ceiling directly over panelboard location.

(3) In an area without finished ceiling but with finished walls, recess junction box in wall directly above panelboard location at ceiling line.

(4) In an area without suspended ceiling but with unfinished walls, recess junction box on ceiling directly over panelboard location.

H. Provide all junction boxes in accordance with NEC as to conductor capacity for future conductors with adequate knock outs on all four sides and a blank screw cover. Plates shall match those installed in that particular area.

I. Install only one 277 volt circuit in a wall switch outlet box. Where more than one 277 volt circuit (on different phases) is indicated on drawings as being run to multi wall switch units from a ceiling branch circuit outlet box, provide individual conduit with phase and lighting fixture control wiring and separate outlet boxes with separated wall plates to segregate each phase.

END SECTION

SECTION 16110 - ELECTRICAL RACEWAYS

1.1 RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements.

B. Requirements of Electrical General Provision Sections govern this Section, where applicable.

C. This section shall be governed by Alternates insofar as they apply to this work.

1.2 DESCRIPTION OF WORK

A. Provide labor, materials, equipment and services necessary for proper and complete installation of electrical raceways.

B. The requirements of this section apply to electrical raceway work specified elsewhere in these specifications.

1.3 QUALITY ASSURANCE

A. Comply with applicable portions of National Electrical Manufacturers Association standards pertaining to metallic and nonmetallic conduit, duct and EMT.

B. Comply with applicable portions of Underwriters' Laboratories safety standards pertaining to electrical raceways; and provide products which have been UL listed and labeled.

C. Comply with National Electrical Code (NFPA No. 70) as applicable to construction and installation of electrical raceways.

D. Raceways shall be marked with the manufacturer's name or trademark as well as type of raceway and size. This marking shall appear at least once every 10 feet and shall be of sufficient durability to withstand the environment involved. All raceways shall be furnished and installed as outlined under the following sections of this Specification.

1.4 SUBMITTALS

A. Submit manufacturer's standard data sheets for rigid metal conduit, EMT, wireways, rigid PVC conduit, flexible metal conduit, bitumastic coatings and fittings for all types of raceways.

1.5 MATERIAL

A. Types/acceptable manufacturers of electrical raceways:

Electrical metallic tubing – Allied Tube, Wheatland Tube

Liquid tight flexible metal conduit – Allied Tube, Eastern Wire

Rigid steel conduit – Allied Tube, Maverick Tube

Rigid aluminum conduit – Wheatland Tube, Allied tube, Indalex

Raintight wireways – Square "D"; Cooper B-Line

Rigid PVC conduit – Carlon, Allied Tube, Can Tex

B. For each electrical raceway system indicated, provide assembly of conduit, tubing or duct, and fittings, including, but not necessarily limited to, connectors, couplings, offsets, elbows, straps, bushings, expansion joints, hangers, and other components and accessories needed for a complete system.

(1) Provide metal conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) for each service indicated. Where types and grades are not indicated, provide proper selection determined by Installer to fulfill wiring requirements, and comply with applicable portions of National Electrical Code for electrical raceways.

a. Provide threaded steel conduit and fittings in accordance with U.L. 6 and ANSI C80.1, zinc coated or coated with and approved corrosion resistant coating on inside. Conduits not completely encased in concrete but laid directly in or in contact with ground or on a vapor barrier shall be field coated on outside with asphaltum before installation or shall have an additional outside factory coating of polyvinyl chloride or phenolic resin epoxy material or other equally flexible and chemical resistant material.

b. Provide electrical metallic tubing, EMT and fittings in accordance with U.L. 797 and ANSI C80.3, zinc coated on outside and either zinc coated or coated with an approved corrosion resistant coating on inside.

c. Liquid tight flexible metal conduit shall consist of a core of flexible galvanized steel tubing over which is extruded a liquid tight jacket of poly vinyl chloride (PVC). Liquid tight flexible conduits not larger than 1 1/4 inch size shall be provided with a continuous copper bonding conductor wound spirally between convolutions. Products shall comply with U.L. 1 and U.L. 360.

d. Flexible metal conduit (commercial Greenfield) and fittings shall be in accordance with U.L. 1 and U.L. 1479.

e. Fittings for threaded steel and thin wall (EMT type) conduit shall be either iron or steel only.

f. Compression type threadless fitting shall not be used with threaded steel conduit. Where it is impractical (due to limited working space when employing normal installation practices) to use common construction tools for installation of threaded steel conduit with standard couplings, locknuts and bushings, steel set screw connectors and couplings will be permitted provided they meet the following requirements: body of steel set screw connector and coupling shall have a wall thickness at least equal to wall thickness of conduit with which it is to be used. Set screws shall be of case hardened steel with hex head, and with cup point to firmly seat in wall of conduit for positive ground. Set screws shall be tightened to embed in conduit wall. Tightening screws with pliers will not be permitted.

1/2 through 2 inch connectors shall have one set screw each.

2 1/2 through 4 inch connectors shall have two set screws each.

1/2 through 2 inch couplings shall have two set screws each.

2 1/2 through 4 inch couplings shall have four set screws each.

Conduit nipples with running threads shall not be used.

g. Couplings and connectors for EMT shall be made of either steel or malleable iron only, shall be "Concretetight" or "Raintight" and shall be of either gland and ring compression type, or stainless steel multiple point locking type. All connectors shall have insulated throats. Fittings using indentations as a means of attachment shall not be used.

h. Bushings for threaded steel conduit and connectors for EMT shall be insulated type, designed to prevent abrasion of wires without impairing continuity of conduit grounding system. Insulating insert shall be made of thermosetting or fiber material which conforms to flame test requirements of UL 514, molded or locked into metallic body of fitting. Conduit bushings made entirely of nonmetallic material shall not be used.

i. Fittings for liquid tight flexible conduit shall be in accordance with U.L. 1 and U.L. 360 of a type incorporating a threaded grounding cone, a steel, nylon or equal plastic compression ring, and a gland for tightening. Fitting shall be made of either steel or malleable iron only, shall have insulated throats and shall be of a type having a male thread and locknut or male bushing with or without "O" ring seal.

j. Die cast zinc alloy fittings and fittings made of inferior materials, such as "pot metal", shall not be used on any type of rigid or flexible conduit or EMT.

(2) Wireways

a. Provide wireways of sizes indicated. Constructed of galvanized steel with screw on covers and knockouts approximately 6" o.c. Provide raceway fittings indicated which match and mate with raceway. Finish wireways with gray epoxy paint over corrosion resistant primer.

b. Use wireways only where indicated on Drawings.

c. Effectively ground all wireways.

(3) PVC Conduit

a. Provide nonmetallic conduit, ducts and fittings of types, sizes and weights (wall thicknesses) for each service indicated. Where types and grades are not indicated, provide proper selection determined by Installer to fulfill wiring requirements, and comply with applicable portions of National Electrical Code for electrical raceways. Products shall be in accordance with NEMA TC-2 and U.L. 651.

b. PVC Conduit and Tubing Fittings: NEMA Standards Pub. No. TC 3 and U.L. 514B.

c. Except as otherwise indicated, provide conduit, tubing and duct accessories of types, sizes, and materials indicated, including, but not necessarily limited to, hangers, clamps, rollers, traps, fasteners, brackets, expansion and deflection fittings, complying with manufacturer's published product information, and designed and constructed by manufacturer for use in applications indicated.

(4) Provide watertight hub connections at all conduits connecting to NEMA 3R or 4 enclosures. Myers or equal.

(5) Aluminum Conduit

a. Aluminum conduit shall be extruded from alloy 6063 and shall be the rigid type, non-toxic, corrosion resistant, and non-staining. It shall be manufactured per UL standards as well as listed/labeled by same.

b. Fittings, boxes and accessories used in conjunction with aluminum conduit shall be die cast aluminum, copper free type. They shall be resistant to both chemical and galvanic corrosion. All covers shall have neoprene gaskets.

c. Standard threaded couplings, locknuts, bushings, and elbows made only of aluminum alloy materials. Aluminum fittings containing more than 0.4 percent copper are prohibited.

d. Locknuts and bushings: As specified for rigid steel conduit, except of aluminum materials.

e. Set screw fittings: Not permitted for use with aluminum conduit.

C. Conduit Supports

(1) Pipe straps and supports shall be PVC coated steel in pipe galleries and chemical feed rooms. All others shall be zinc coated steel.

(2) Provide individual pipe hangers, multiple (trapeze) pipe hangers, and riser clamps as necessary to support conduits. All parts and hardware shall be zinc coated throughout. Provide all U bolts, clamps, attachments, and other hardware necessary for hanger assembly, and for securing hanger rods and conduits. Design each multiple hanger to support a load equal to or greater than sum of weights of conduits, wires, hanger itself, and 200 pounds.

(3) Fasten pipe straps and hanger rods to surfaces as specified under "Support of Electrical Items" paragraph in the `ELECTRICAL, GENERAL PROVISIONS' section.

(4) All EMT and conduits not embedded in concrete or masonry shall be securely and independently supported so that no strain will be transmitted to outlet box and pull box supports. Supports shall be rigid enough to prevent distortion of conduits during wire pulling.

(5) Support individual horizontal conduits by one hole pipe straps or separate pipe hangers for sizes 1 1/2 inch and smaller, and by separate pipe hangers for larger sizes. Spring steel fasteners may be used in lieu of pipe straps or hangers for sizes 1 1/2 inch and smaller in dry locations only. Hanger rods used with spring steel fasteners shall be not less than 1/4 inch diameter steel with corrosion resistant finish. Spring steel fasteners shall be specifically designed for supporting single conduits or EMT. Unless otherwise specified, do not use wire as a means of support.

(6) Where two or more horizontal conduits or EMT run parallel and at same elevation, they shall be supported on multiple (trapeze) pipe hangers. Secure each conduit or EMT to horizontal hanger member by a U bolt, one hole strap or other specially designed and approved fastener.

(7) Branch circuit conduits and raceways above suspended ceilings may be supported from floor construction above or from main ceiling support members, however, finished installation shall not interfere with removability of ceiling panels.

1.6 INSTALLATION

A. Install conduit, tubing and wireway products as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and complying with recognized industry practices to ensure that products serve intended functions. Handle conduit and tubing carefully to prevent bending and end damage, and to avoid scoring finish. Store pipe and tubing inside and protect from weather. When necessary to store outdoors, elevate well above grade and enclose with durable, watertight wrapping. Provide color coded end cap thread protectors on exposed threads of metal conduit.

B. Conduit buried in concrete shall be rigid steel unless otherwise indicated. Do not install EMT underground, in slabs on grade, in wet locations, in hazardous areas, or for circuits operating at more than 600 volts. Do not use EMT in concrete placements where vibrators will be used. Metallic conduit buried in concrete shall be threaded steel only. Outside diameter of conduit buried in concrete shall not exceed one third of the thickness of structural slab, wall or beam in which it is placed. Locate conduit entirely within middle third of member wherever possible. Lateral spacing of conduits buried in concrete slabs shall be not less than three diameters except where drawings definitely indicate that concrete slab has been specially designed to accommodate a closer spacing of conduits entering wire closets, panelboards, or electrical boxes or arrangements is approved by Engineer.

C. Use flexible conduits for connections to motors and other electrical equipment when it is subject to movement, vibrations, misalignment, cramped quarters or where noise transmission is to be eliminated or reduced. Flexible conduit used to meet the above requirements shall in addition be liquid tight type when installed under any of the following conditions:

(1) Exterior locations

(2) Moisture or humidity laden atmosphere where it is possible for condensation to accumulate.

(3) Corrosive atmosphere.

(4) Where water or spray due to wash down operations is frequent or possible.

(5) Wherever there is a possibility of seepage or dripping of oil, grease, or water.

D. Run concealed conduit and EMT in as direct lines as possible with a minimum number of bends of longest possible radius. Run exposed conduits and EMT parallel to or at right angles to lines of building. All bends shall be free from dents or flattening.

E. Conduit and EMT runs shall be mechanically and electrically continuous from service entrance to all outlets. Unless otherwise specified, each conduit shall enter and be securely connected to a cabinet, junction box, pull box or outlet box by means of a locknut on outside and a bushing on inside or by means of a liquid tight, threaded, self locking, cold weld type wedge adapter. Where nominal circuit voltage exceeds 250 volts, (1) in rigid conduit, an additional locknut shall be provided, one locknut being inside and one locknut outside and (2) in EMT or flexible metal conduit, the one locknut shall be made wrench tight. All locknuts shall be bonding type with sharp edges for digging into metal wall of an enclosure and shall be installed in a manner that will assure a locking installation. Locknuts and bushings or self locking adapters will not be required where conduits are screwed into tapped connections. All vertical runs of conduit or EMT terminating in bottoms of wall boxes or cabinets shall be protected from entrance of foreign material prior to installation of conductors.

F. The minimum size of threaded conduit, EMT, and flexible metallic conduit shall be 3/4" except as follows:

(1) Unless otherwise specified or indicated on drawings.

(2) Unless otherwise indicated on Drawings, telephone, telemetry and control circuit conduits shall be not less than 1 inch trade size.

G. Check size of all raceways to determine that green equipment ground conductor, specified, indicated or required can be installed in same raceway with phase and neutral conductors in accordance with percentage of fill requirements of NEC. If necessary, sizes of duct, conduit, tubing or raceway indicated or specified shall be increased to accommodate all conductors without additional cost to Owner.

H. Unless otherwise specified or indicated on Drawings, all conduit and EMT shall be installed concealed. Unless otherwise indicated on Drawings, conduit and EMT may be run exposed on unfinished walls, on unfurred basement ceilings, in penthouses, attics and roof spaces.

I. In wood construction, run conduits and EMT in rough underflooring, on top of joists or between joists. Furring strips may be notched at any point but joists may be notched only at points not more than one foot from a point of support and notches may not be deeper than 1 3/8". Conduits and EMT may be run exposed on bottoms of joists only in unfinished rooms where permitted by Engineer.

J. Horizontal cross runs of conduit or EMT may be installed in partitions only where explicitly permitted by Architect. Install exposed horizontal runs, where permitted, close to ceiling or ceiling beams and

above water, steam or other piping. Run conduits and EMT connected to wall outlets in such a manner that they will not cross water, steam or waste pipes or radiator branches. Do not run conduits and EMT through beams, except where clearly indicated on Drawings or where permitted by Architect.

K. Install every conduit system complete before conductors are drawn in.

L. Expansion Fittings: Each conduit that is buried in or rigidly secured to building construction on opposite sides of a building expansion joint and each long run of exposed conduit that may be subject to excessive stresses shall be provided with an expansion fitting. Expansion fitting shall be made of hot dipped galvanized malleable iron and shall have a factory installed packing, which will prevent entrance of water, a pressure ring, and a grounding ring.

(1) In addition to grounding ring, provide a separate external copper bonding jumper secured by grounding straps on each end of fitting.

(2) Where conduits are buried in concrete, they shall cross building expansion joints at right angles, and expansion fittings shall be installed in accordance with manufacturer's instructions. Provide free ends of conduits with insulated bushings.

M. Sealing Fittings: Sealing fittings for use with threaded steel conduits shall be threaded, zinc or cadmium coated and cast or malleable iron type fittings. Fittings used to prevent passage of water vapor shall be of the continuous drain type.

(1) Install and seal sealing fittings in accordance with manufacturer's recommendations at suitable, approved, accessible locations. In concealed work, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates.

(2) Install sealing fittings at the following points, and elsewhere as indicated.

a. Where conduits enter or leave hazardous areas equipped with explosion proof lighting fixtures, switches or receptacles to prevent passage of explosive vapors.

b. Where conduits pass from warm locations to cold locations, such as refrigerated spaces and air conditioned spaces, to prevent passage of water vapor.

c. Where required by NEC.

N. Expansion and Deflection Couplings

(1) Accommodate 1.9 cm (0.75 inch) deflection, expansion, or contraction in any direction and allow 30 degree angular deflections.

(2) Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents in accordance with UL, and the NEC code tables for ground conductors.

(3) Watertight, seismically qualified, corrosion-resistant, threaded for and compatible with rigid metal conduit.

(4) Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material and stainless steel jacket clamps.

1.7 SPECIAL INSTALLATION INSTRUCTIONS

A. The following installation requirements are specific to this project and shall be strictly enforced.

(1) All exterior below grade conduits shall be Schedule 80 PVC except as noted on Drawings for telephone and power company circuits. Above grade shall be rigid aluminum. Rigid steel below grade shall be asphaltum coated with minimum two (2) coats Carboline Bitumastic 50 or equal.

(2) All conduit installed within pump station building shall be rigid aluminum.

(3) Aluminum conduit in contact with concrete and/or where installed below grade or in direct contact with concrete shall have polytape applied per Section 16200.

END SECTION

SECTION 16120 - CABLE, WIRE AND CONNECTORS

1.1 RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements apply to work specified in this section.

B. Requirements of Electrical General Provision Sections govern this Section, where applicable.

C. This section shall be governed by Alternates insofar as they affect this work.

1.2 DESCRIPTION OF WORK

A. Provide labor, materials, equipment and services necessary for proper and complete installation of cable, wire and connectors.

B. Requirements of this section apply to cable and wire work specified elsewhere in these specifications.

1.3 QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of electrical cable, wire and connectors.

B. Provide electrical cable, wire and connectors which have been listed and labeled by Underwriters Laboratories.

C. Comply with National Electrical Manufacturers Association/Insulated Power Cable Engineers Association Standards publications pertaining to materials, construction and testing wire cable, where applicable.

D. Manufacturers offering products complying with requirements include:

(1) Cable and Wire:

Paige Pump Wire

Southwire Company

Triangle PWC, Inc.

Belden

Clifford of Vermont

E. Connectors:

Buchanan

Burndy Corporation

3M Company

Thomas and Betts Co.

King Innovation

1.4 SUBMITTALS

A. Submit manufacturer's product data on all 4-20MA signal cables and Telemetry System shielded cables.

B. Submit manufacturer's product data for watertight wire connectors.

1.5 MATERIALS

A. Cable and Wire

(1) Provide factory fabricated cable, wire and connectors of sizes, ratings, materials and types indicated for each service. Where not indicated, provide proper selection as determined by equipment manufacturer to comply with project's equipment installation requirements and NEC standards, including equipment control and instrumentation requirements.

(2) Use single conductor annealed copper type for all wires and cables for secondary service, feeders and branch circuits, unless specified otherwise.

(3) Use No. 12 or No. 10 solid conductor for branch circuit wiring connected to receptacles, lighting switches and snap switches.

(4) Use minimum 75 degrees C rated insulation unless specified otherwise, indicated on Drawings, or required by NEC.

(5) Wire #12 - #1 shall be applied based on a 60 degree Celsius temperature rise. Building wire larger than #1 may be applied at its 75 degree Celsius temperature rise.

(6) Use 600 volt insulation rating unless specified or indicated otherwise. Where operating voltage is less than 100 volts, wires or cables may be insulated for 300 volts provided they are isolated from higher voltage systems.

B. Use (1) 16 ga. twisted/shielded pair cable for 4-20ma signal circuits from flow, level, alarm transmitters, V.F. drives, etc. Cable shall be Belden No. 8719, or General Cable type VNTC with 100% shield coverage and stranded/tinned 18 ga. drain wire, 600V rated.

C. Valves, valve controllers, start-stop selector switches, etc. Use minimum 75 degrees C rated insulation unless specified otherwise, indicated on Drawings, or required by NEC. Use 600 volt insulation rating unless specified or indicated otherwise.

D. Connectors

(1) All circuit wire connectors for wiring #6 AWG and smaller shall be made using watertight type connectors which have been prefilled with silicone sealant. Connectors shall have lifetime guarantee and be UL 50 raintight/watertight listed. Connectors shall have a temperature rating of 105 degrees C. minimum and silicone sealant shall be rated for -45 to 400 degrees F.

(2) Watertight type wire connectors shall be King Innovation DryConn or equivalent.

E. Electrical Lugs

(1) Lugs from #6 AWG - 1000 MCM shall be compression types with barrels to provide maximum conductor contact and tensile strength. They shall be manufactured from high conductivity copper

and entirely tin plated. The lugs must have a current carrying capacity equal to the conductors for which they are rated and must also meet all UL requirements. All lugs above 4/0 shall be 2 hole lugs with NEMA spacing. The lugs shall be rated for operation through 35 KV. The lugs shall be of closed end construction to exclude moisture migration into the cable conductor.

1.6 INSTALLATION

A. Install electrical cable wire and connectors as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure products serve intended functions.

B. Store cable, wire and connectors in factory installed coverings in a clean, dry indoor space which provides protection against weather.

C. Pull conductors together where more than one is being installed in a raceway.

D. Use pulling compound or lubricant, when necessary; compound must not deteriorate conductor and insulation.

E. Do not use a pulling means, including fish tape, cable or rope which can damage raceway.

F. Install exposed cable, parallel and perpendicular to surface or exposed structural members and follow surface contours, where possible.

G. Color Code: All secondary service, feeder and branch circuit conductors throughout projects as follows:

208Y/120 volts	Phase	480y/277 volts
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	White
Green	Ground	Green

H. Keep conductor splices to a minimum.

I. Install splices and taps for power wiring which has equivalent or better mechanical strength and insulation as conductor.

J. Use splice and tap connectors on power wiring which is compatible with conductor material.

K. Do not install more than three conductors in any one splice.

L. Install poly pull line in all spare/empty conduits.

M. Prior to energization, check cable and wire for continuity of circuitry and for short circuits. Correct malfunction when detected.

N. Subsequent to wire and cable hook ups, energize circuitry and demonstrate functioning in accordance with requirements.

O. Multi conductor cables shall not be spliced but shall run continuous from point of supply to equipment connection.

P. Shielded pair cable shall be grounded at one end only and as close to signal source as possible.

Q. A minimum separation of 12 inches between analog signal leads and a-c power leads should be maintained. For a-c power leads carrying 100 amps or greater, a 24 inch separation should be maintained. Parallel runs should be limited to less than 500 feet. Perpendicular runs may be as close as 6 inches.

1.7 SPECIAL INSTALLATION INSTRUCTIONS

A. Wire or cable splices for control and instrumentation circuits shall not be accepted.

B. Do not install any control or instrumentation cable or wiring in same conduit or J-box with electrical power wiring, unless otherwise noted.

C. NOTE: Electrical Contractor shall be responsible for providing and installing all power, control and instrumentation wiring and cable from all remote devices to the pump station control panel (MCP). This shall include the termination of wires/cables on both ends and installation of wire No. markers.

END SECTION

SECTION 16130 - ELECTRICAL BOXES AND FITTINGS

1. RELATED DOCUMENTS

A. General provisions of contract General and Supplementary Conditions and General Requirements.

B. Requirements of Electrical General Provision Sections govern this Section, where applicable.

C. This Section shall be governed by Alternates insofar as they affect this work.

2. DESCRIPTION OF WORK

A. Provide labor, materials, equipment, and services for proper and complete installation of electrical boxes and fittings.

B. Extent of electrical box and electrical fitting work is indicated by drawings and schedules, and requirements of this section.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of electrical boxes and fittings.

B. Provide boxes and fittings which have been listed and labeled by Underwriters' Laboratories.

C. Comply with National Electrical Manufacturers Association standards as applicable to nonmetallic fittings for underground installation.

4. MATERIAL

A. Provide boxes, cabinets, and fittings as indicated on Drawings, schedules, and as required for job.

B. Interior Outlet Boxes: Provide galvanized steel interior outlet wiring boxes, of type, shape and size, including depth of box, to suit each respective location and installation; constructed with stamped knockouts in back and sides, and with threaded holes with screws for securing box covers or wiring devices.

C. Interior Outlet Box Accessories: Provide outlet box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, compatible with outlet boxes being used and meeting requirements of individual wiring situations. Choice of accessories is Installer's option.

D. Weatherproof Outlet Boxes: Provide corrosion resistant cast metal weatherproof outlet wiring boxes, of type, shape and size, including depth of box, with threaded conduit ends and cast metal face plate, including face plate gasket and corrosion proof fasteners.

E. Junction and Pull Boxes: Provide galvanized sheet steel junction and pull boxes, with screw on covers; of type, shape and size, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws and washers.

F. Conduit Bodies: Provide galvanized or aluminum cast metal conduit bodies, of type, shape, and size, to suit each respective location and installation, constructed with threaded conduit ends, removable cover, and corrosion resistant screws.

G. Bushings, Knockout Closures and Locknuts: Provide corrosion resistant punched steel box knockout closures, conduit locknuts and malleable iron conduit bushings of type and size to suit each respective use and installation.

H. Acceptable Manufacturers

(1) Appleton, Crouse-Hinds, Hoffman or T&B or equal.

5. INSTALLATION

A. Install electrical boxes and fittings as indicated, or in compliance with NEC requirements, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that boxes and fittings serve intended purposes.

B. Provide weatherproof outlets for interior and exterior locations exposed to weather or moisture exposure.

C. Provide knockout closures to cap unused knockout holes where blanks have been removed.

D. Locate boxes and conduit bodies so as to ensure accessibility of electrical wiring.

E. Avoid using round boxes where conduit must enter box through side of box, which would result in a difficult and insecure connection with a locknut or bushing on rounded surface.

F. Secure boxes rigidly to substrate upon which they are being mounted, or solidly embed boxes in concrete or masonry.

G. Do not use sectional (gangable) boxes.

H. Use threaded hub type outlet boxes (NEMA 4X) with gasketed weatherproof covers and stainless steel hardware where surface mounted at following locations:

(1) Exterior locations

(2) Where exposed to moisture laden atmosphere

(3) Where indicated on drawings

(4) At pump station and valve vault areas.

I. Measure mounting height from finished floor or finished grade to center line of cover plate.

J. NEMA 4 junction and pull boxes shall be stainless steel, unless otherwise noted.

K. Junction boxes for use in wet-wells and other hazardous areas shall be water tight, rust proof, corrosion resistant, and explosion proof with threaded conduit openings (5 ½ full threads - minimum) and provided with rust proof hardware.

L. Explosion proof sealing fittings shall be furnished and installed in accordance with NEC requirements.

M. Outlet or junction boxes for use with exposed aluminum conduit shall be copper free, cast aluminum type, or stainless steel.

N. Saw cut openings for boxes in exposed masonry walls.

END SECTION

SECTION 16135 - ELECTRICAL EQUIPMENT SUPPORTS

1. RELATED DOCUMENTS

A. General provisions of contract General and Supplementary Conditions and General Requirements.

B. Requirements of Electrical General Provision Sections govern this Section, where applicable.

C. This Section shall be governed by Alternates insofar as they affect this work.

2. DESCRIPTION OF WORK

A. Provide labor, materials, equipment, and services for proper and complete installation of electrical equipment supports.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of electrical equipment supports.

B. Provide fittings which have been listed and labeled by Underwriters' Laboratories.

C. Acceptable Manufacturers: Kindorf, Unistrut, Allied or equal.

4. MATERIALS

A. All exterior and interior mounting brackets and strut shall be aluminum. Fasteners used to mount equipment where exposed to weather or in corrosive environments shall be non-magnetic stainless steel.

5. INSTALLATION

A. All electrical equipment shall be rigidly mounted, and installed using supporting devices as indicated on the Contract Drawings, as required by the work, and described herein.

B. All free standing equipment shall be anchored to its foundation using expansion bolts with stainless steel fasteners of the size and number recommended by the equipment manufacturer.

C. Where indicated, seismic restraints shall be provided for electrical equipment.

END SECTION

SECTION 16140 - WIRING DEVICES

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements.

B. Requirements of Electrical General Provision sections govern this Section, where applicable.

C. This section shall be governed by alternates insofar as they affect this work.

2. DESCRIPTION OF WORK

A. Provide labor, material, equipment and services for proper and complete installation of wiring devices.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA No. 70) as applicable to construction and installation of electrical wiring devices.

B. Provide electrical wiring devices which have been tested, listed and labeled by Underwriters' Laboratories.

C. Comply with National Electrical Manufacturers Association standards for wiring devices.

4. SUBMITTALS

A. Submit manufacturer's data on wiring devices and plates.

B. Device manufacturers other than those listed below must have ten day written prior approval.

C. It is the responsibility of the contractor to provide data that devices are equal other than by catalog numbers.

5. MATERIAL

A. Provide factory fabricated wiring devices, in type, color, and electrical rating for service indicated and as described below. Where type and grade are not indicated, provide proper selection as determined by Installer to fulfill wiring requirements, and comply with NEC and NEMA standards for wiring devices.

B. Devices and Plates

(1) All receptacles, switches, and non-metallic device plates shall be gray in color unless otherwise indicated.

C. Device Plates - Standard

(1) All plates shall be of 302 stainless steel (non magnetic) with rounded or beveled edges. All device plate screws shall be stainless steel with countersunk heads. Plates shall be installed vertically and with an alignment tolerance of 1/16 inch. Device plates shall be of the one-piece type, of suitable shape for the devices to be covered. Plates shall have a smooth finish with no crevices to collect dirt. Oversize plates are not acceptable.

(2) All non-weatherproof metal wall plates shall be corrosion resistant 302 super stainless steel unless otherwise noted.

D. Device Plates - Weatherproof

(1) All devices in dusty and or wet locations shall use weatherproof corrosion resistant cover plates of cast aluminum, rustproof, weatherproof, with spring loaded "in use" cover for receptacle and external handle or neoprene cover for switch. Similar to Hubbell 1795 for switches and Hubbell WP8M or WP26MH for receptacles.

E. Switches

(1) All switches shall be 20 ampere for 120/277 volt AC lighting circuits.

(2) All switches shall be specification grade side wired.

(3) Switches shall be of the following mfg.

	HUBBELL	BRYANT
Single Pole	1221	1121
Double Pole	1122	1122
Three Way	C5320	1123
Four Way	1124	1124
Pilot Light	1121 PL	1121 PL

F. Receptacles – Specification Grade

(1) GFCI Receptacles

1. Ground fault shall have solid state sensing circuitry and a circuit interrupter switch. It shall be rated for operation on a 60 Hz, 120V, 20A branch circuit. Device shall have nominal sensitivity to ground leakage current of four to six milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes on load side of the device. Device shall have a minimum nominal tripping time of 1/30th of a second.

2. Device shall be of the following mfg.

	HUBBELL	BRYANT
15A 125V 5 15R	GF5252	GF5262
20A 125V 5 20R	GF5352	GF5362

(2) Duplex Receptacles Corrosion Resistant

1. Receptacles shall be 5-20R 20A, 125V, 2 pole, 3 wire as required.

2. Receptacles shall have the following characteristics:

1) "T" type contacts for phase and neutral female connections.

2) Female ground connections shall be riveted to bridge.

3) Bridge shall be of hot dipped steel.

4) Face plate shall be impact resistant nylon.

5) Receptacle body shall be of heat resistant thermoset material.

6) Face plate to bridge connecting rivet shall be spun brass.

7) Automatic self grounding clip.

8) Receptacles shall be of the following mfg.

HUBBELL

20A 125V 5-20R	HBL53CM62 (Marine Grade)

9) Corrosion resistant GFCI receptacles shall be Hubbell GF8300A (Hospital Grade).

6. INSTALLATION

A. Install wiring devices where indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to ensure that products serve intended function.

B. Delay installation of devices until wiring is completed.

C. Install receptacles and switches only in electrical boxes which are clean; free from excess building materials and debris.

D. Install receptacles with ground pin on top.

E. All devices and plates shall be of the same manufacturer.

F. Do not use sectional plates.

G. Upon installation of wall plates, receptacles and switches, advise Contractor regarding proper and cautious use of convenience outlets. At time of Substantial Completion, replace those items which have been damaged, including those burned and scored by faulty plugs.

H. Test wiring devices to ensure electrical continuity of grounding connections, and after energizing circuitry, to demonstrate compliance with requirements.

I. All outlet boxes shall have a cover plate.

J. Device mounting heights above finished floor (AFF) or other reference to center of device. Verify exact mounting heights with Architectural Drawings.

Receptacles above countertops.	4" above countertop backsplash. Mount long axis horizontal.
General receptacles	18" AFF

Receptacles in storage and Mechanical Rooms	45" AFF
Toggle Switches	45" AFF
Thermostats	54" AFF
Telephones-Desk	18" AFF
Telephones-Wall	48" AFF
Switches above countertops	6" above countertop mount long axis vertical.

END SECTION

SECTION 16150 - MOTORS

1.1 RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions, and General Requirements, apply to this Section.

B. Requirements of Electrical General Provisions sections govern work specified in this Section.

C. This section shall be governed by alternates insofar as they affect this work.

1.2 DESCRIPTION OF WORK

A. Provide labor, materials, equipment and services necessary for proper and complete installation of motors.

B. Motors are to be furnished with driven equipment. All motors shall conform to the following Specifications and any special requirements of the driven equipment. Special requirements of the driven equipment shall take precedence over these Specifications should a discrepancy occur. Starting torque and slip ratings shall conform to the requirements of the driven equipment. [All motors 15 horsepower and larger (230 volt) or 25 horsepower and larger (480 volt) shall be started via solid state reduced voltage starters unless otherwise noted on the Contract Drawings.]

C. Polyphase motors shall be of the squirrel cage induction type and single phase of the capacitor start-induction run type except as otherwise noted.

1.3 QUALITY ASSURANCE

A. Manufacturers offering products complying with requirements include:

General Electric

Westinghouse

U.S. Motors

Gould Century

Baldor

Marathon

Reliance

Magnatek

Siemens

Or Equal

B. Provide motors which have been listed and labeled by Underwriters Laboratories.

C. Comply with National Electrical Code (NFPA No. 70) as applicable to installation and construction of electrical power/distribution transformers.

D. Comply with applicable portions of National Electrical Manufacturers Association Standards ST20 pertaining to power/distribution transformers.

E. Comply with applicable American National Standards Institute (ANSI) standards pertaining to power/distribution transformers.

F. Comply with applicable portions of Institute of Electrical and Electronic Engineers (IEEE) standards pertaining to motors.

1.4 SUBMITTALS

A. Shop drawings shall consist of motor dimensions, name¬plate data from each motor and tests as outlined above. Also included shall be efficiency and power factor at 100, 75, and 50 percent load. Operation, maintenance, and lubrication information (including bearing catalog numbers) shall be submitted with shop drawings for review.

1.5 EQUIPMENT

A. Motors 200 Horsepower and Under for Service Under 600 Volts

(1) Ratings and Electrical Characteristics

a. Time: All motors shall be rated for continuous duty.

b. Temperature: Based on NEMA standards for a maximum ambient temperature of 40 degrees Celsius and an altitude of 3,300 feet or less, according to service factor and insulation class employed.

c. Voltage: All single phase motors shall be rated 120/208/230 volts and all polyphase motors 230/460 volts. All motors shall be capable of normal operation at balanced voltages in the range of ±1 0 percent from rated winding voltage.

d. Frequency: All a-c motors shall be rated for 60 Hz. operation. All motors shall be capable of normal operation at frequencies 5 percent above or below the nominal rating of 60 Hz.

e. Horsepower: Horsepower of the motors shall be as given in the specification division on the driven equipment or as shown on the Contract Drawings. Submersible motors shall be allowed to be furnished even though the horsepower rating may not be in accordance with standard NEMA assignments. In many cases, the horsepower specified is a minimum requirement and certain alternate manufacturers may require larger horsepower motors. The larger motor shall be furnished at no extra cost to the OWNER.

f. Locked Rotor Current: Locked rotor current shall be in accordance with NEMA standards.

g. Efficiency and Power Factor: Efficiency and power factor shall be given consideration during shop drawing review. The ratings at full, 3/4, and 1 /2 load shall be compared to similar motors manufactured by acceptable

suppliers listed in these Specifications. Excessive variation shall be considered grounds for rejection.

h. Speed: Synchronous speed of motors shall correspond to standard NEMA ratings. Actual speed shall be as given in the specification division on the driven equipment. Slip shall not exceed 5 percent at full load.

i. Service Factor: The service factor shall be 1.0 unless requirements of the driven load necessitate a higher service factor.

j. Insulation Class: Insulation class for submersible motors shall be NEMA Class F. Motors to be operated at variable speed shall also be Class F. Class F insulated motors shall operate at a Class B rise at nameplate horsepower loading.

k. Design Level: Motors shall be NEMA design B, except as otherwise noted.

l. Enclosure: Submersible motors shall be air [or oil filled] and of watertight construction.

m. Frame Size: Frame designations shall be in accordance with NEMA standards.

n. Winding Over-temperature Sensors: All submersible motors shall be provided with motor winding thermostats. The devices shall be hermetically sealed, snap-acting thermal switches, actuated by a thermally responsive bi-metallic disk. A minimum of 1 per phase is required; with switches wired into the control circuit of the starter to provide de-energization should overheating threaten.

o. All submersible pump/motor assemblies shall be equipped to detect presence of moisture and alarm at the controller.

p. Motors to be controlled by VFD's shall be inverter duty rated, NEMA MG-1.

(2) Mechanical Characteristics

a. Submersible Motor Construction

1) See Equipment Specifications.

(3) Tests, Nameplates and Shop Drawings

a. Tests

1) Tests shall be required on integral horsepower motors only. A factory certified test report of "electrically duplicate motors previously tested" shall be supplied on all motors under 200 horsepower. The test shall be certified by the factory and shall contain a statement to the effect that complete tests affirm the guaranteed characteristics published in the manufacturer's catalogs or descriptive literature.

2) Tests will be in accordance with IEEE test procedures.

b. Nameplates

1) Each motor shall have a permanently affixed nameplate of brass, stainless steel, or other metal of durability and corrosion resistance. The data contained on the nameplate shall be in accordance with NEMA standards.

(4) Efficiency Requirements

a. The following motor full load efficiency requirements shall be met as a minimum for premium efficiency totally enclosed 3 phase integral horsepower motors (per NEMA test Methods):

Horsepower	Nominal 3600 RPM (Minimum %)	Nominal 1800 RPM (Minimum %)	Nominal 1200 RPM (Minimum %)	Nominal 900 RPM (Minimum %)
1		77.0	72.0	68.0
1.5	75.5	78.5	80.0	72.0
2	78.5	80.0	80.0	80.0
3	80.0	81.5	81.5	78.5
	82.5	82.5	82.5	81.5
7.5	82.5	85.5	85.5	82.5
10	85.5	85.5	85.5	85.5
15	85.5	86.5	87.5	86.5
20	86.5	88.5	87.5	87.5
25	87.5	89.5	88.5	87.5
30	87.5	89.5	89.5	88.5
40	88.5	90.2	90.2	88.5
50	88.5	91.0	90.2	89.5
60	90.2	91.7	90.2	90.2
75	91.0	91.7	91.7	91.7
100	91.7	92.4	91.7	91.7
125	91.7	92.4	91.7	92.4
150	91.7	93.0	93.0	92.4
200	93.0	93.6	93.0	93.0

b. Where indicated on the Contract Drawings or in the Contract Specifications motors shall be of the energy efficient line offered by the motor manufacturer, having comparable performance characteristics to their standard line as far as torque and horsepower are concerned. Efficiency and power factor however, shall be higher than the manufacturer's standard line of motors and shall be documented in the shop drawings submittal in sufficient detail to allow the ENGINEER complete review of what is offered. Motors shall be referred to simply as "premium efficiency" in Specifications and Contract Drawings.

c. All motors to be installed for connection to V.F. drives shall be inverter duty rated, NEMA MG-1.

1.6 INSTALLATION

A. All electric motors shall be protected against the accumulation of moisture, dust and debris and physical damage during the course of installation of the job.

B. Handle motors carefully to avoid damage to components, enclosures and finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

C. Store motors in a clean dry place and protect from weather and construction traffic.

D. Install motors in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that motors comply with requirements of National Electrical Code, and applicable portions of ANSI/NEMA standards pertaining to installation of electrical motors and ancillary equipment.

E. All motors shall be manufactured and installed in accordance with applicable NEMA standards and NEC provisions, latest revisions.

END SECTION

SECTION 16155 - MOTOR STARTERS

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements apply to this Section.

B. Requirements of Section 16000 General Provisions govern work specified in this section.

C. This section shall be governed by alternates insofar as they apply to this section.

2. DESCRIPTION OF WORK

A. Provide labor, materials, equipment and accessories necessary for a complete and proper motor starter system.

B. Unless otherwise specified, required for a particular application, or indicated by details or control diagrams on Drawings, provide each motor with a motor starter.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of motor starters.

B. Provide motor starters which have been listed and labeled by Underwriters' Laboratories.

C. Comply with National Electrical Manufacturers Association Standards.

D. Acceptable manufacturers offering products complying with requirements:

Allen Bradley

Square D

GE

Cutler-Hammer

4. SUBMITTALS

A. Submit manufacturer's data on motor starters.

5. EQUIPMENT

A. Each starter and its component and related parts shall be properly designed and coordinated to suit characteristics of motor it controls and driven equipment. Starters provided with automatic control shall be capable of making as frequent starts as control devices may demand.

(1) Equip each starter with contacts to break each ungrounded line to motor. Provide a thermal overload device to open all contacts simultaneously, as an integral part of starter, in each ungrounded line to motor. Provide a suitable reset device for resetting overload trip. Overload devices shall be rated in amperes to correspond to motor nameplate rating but rating shall not exceed that recommended by motor manufacturer for application.

(2) Unless otherwise specified or indicated, starters shall have NEMA type 12 dust tight enclosures with doors arranged for padlocking. Each enclosure shall be so designed that entire starter can be readily removed and shall be of sufficient size to permit easy access for repair, replacement, and making of connections. Separately mounted starters shall be arranged for wall, floor or panel mounting and shall be complete with necessary frames and supports.

B. Unless otherwise indicated on Drawings, locate starters within sight of their associated motors. Where starter is not within sight of motor, provide a disconnect device within sight of motor.

(1) Unless otherwise specified or indicated on Drawings, disconnect device shall be either an unfused switch or a non automatic circuit breaker. Disconnect device for motors rated over 50 horsepower shall be a non automatic circuit breaker. Switches shall be unfused and circuit breakers shall be without overcurrent devices.

C. Provide magnetic starters for 1/2 horsepower and larger motors. Magnetic starters shall be full voltage (across the line) type with under voltage release for automatic control, and undervoltage protection for manual control. Magnetic starters shall be combination type with fused disconnect switch or circuit breaker, except where panelboard containing motor circuit protection is within sight of starter. Circuit breakers shall have interrupting capacity adequate for fault current available at particular location.

(1) All magnetic starters shall have both cover mounted Hand Off Automatic selector switch and start stop pushbutton unless otherwise noted. This applies to both starters in NEMA 12 and NEMA 4 enclosures.

(2) Do not connect selector switches in any manner which interferes with intended operation of safety devices or safety interlocks.

(3) All starters shall have four (4) auxiliary contacts (NO/NC) and (1) set of fail contacts.

D. Magnetic starters for two speed motors shall be designed for use with two speed motors having two separate windings. Starter shall have two separate sets of contacts, mechanically and electrically interlocked to prevent simultaneous closing. Provide overcurrent protection for each winding. Manual control stations shall be three button type, with "Slow", "Fast" and "Stop" positions. Provide pilot lights to indicate speed position.

E. Reduced voltage and increment starters, where specified, shall also comply with the following requirements:

(1) Maximum line current and current increments shall conform to local power company limits.

(2) Line shall not be opened at any time during starting period (closed transition).

(3) Starting torque shall be suitable for driven machine, and shall cause motor to break away from rest on first step.

(4) Starting period shall not be long enough to result in excessive heating of or damage to motor.

(5) Resistors, if used, shall be mounted within starter case in rear of contactor panel, unless otherwise indicated or specified.

(6) Adequately ventilate case.

(7) Disconnect means for starters may be separate from starter in lieu of combination type, but shall be as hereinbefore specified for magnetic starters.

F. Unless otherwise indicated on Drawings, provide manual starters for all motors under 1/2 horsepower. Equip each starter with a manually operated trip free switch. Provide a separately mounted safety disconnect switch except where panelboard containing disconnect and circuit protection for motor is within sight of disconnect switch for starters. Provide hand off automatic selector switches where starters are controlled by automatic devices. Functions, locations, and like, shall be as specified for magnetic starters.

G. Unless otherwise specified or indicated, control circuits and indicating lights shall operate at not over 120 volts, provided, where necessary, by individual dry type control transformers located within starter cases. Each transformer shall have adequate capacity to operate both starter and other connected control equipment, if any. Protect each control transformer by one fuse on secondary side. Control circuit conductors shall be connected, grounded, and protected against overcurrent in accordance with National Electrical Code, and shall be arranged so that an accidental ground will not start any motor.

H. Where interlocking or sequence starting of motors is specified or indicated on Drawings, it shall be done in such a manner that, when main switch or breaker on any starter is open, no part of starter will be left energized. Furnish all equipment, such as relays or auxiliary contacts on breakers or disconnect switches, necessary to accomplish the above.

6. INSTALLATION

A. Install motor starters in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to ensure that products serve the intended function.

B. Motor starter installation work with electrical raceway and cable work, as necessary for proper interface.

7. SPECIAL INSTALLATION INSTRUCTIONS

A. All starters noted to have a NEMA 4 enclosure shall be stainless steel.

END SECTION

SECTION 16157 - VARIABLE SPEED DRIVES (VFD)

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements apply to this Section.

B. Requirements of Section 16000 General Provisions govern work specified in this section.

C. This section shall be governed by alternates insofar as they apply to this section.

2. DESCRIPTION OF WORK

A. Provide labor, materials, equipment and accessories necessary for a complete and proper motor control system.

B. This section provides specification requirements for adjustable frequency drives, variable speed drives or herein identified as AC Drives or VFD for use with NEMA® Design AC motors.

C. The manufacturer shall furnish, field test, adjust and certify all installed AC Drives for satisfactory operation.

D. Any exceptions or deviations to this specification shall be indicated in writing and submitted with no less than two (2) weeks prior to bid date.

3. QUALITY ASSURANCE

A. Comply with:

(1) ANSI®/NFPA® 70 - National Electrical Code® (NEC®)

(2) CSA® C22.2 No. 14-M91 - Industrial Control Equipment

(3) IEC 61000 - Electromagnetic Compatibility

(4) NEMA 250 Enclosures for Electrical Equipment

(5) NEMA ICS7 - Industrial Control and Systems Adjustable Speed Drives

(6) NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection Installation and Operation of Adjustable Speed Drives

(7) UL® 50 – Enclosures for Electrical Equipment

(8) UL 98 – Disconnect Switches

(9) UL 507 – Electric Fans

(10) UL 508 – Industrial Control Equipment

(11) UL 508C – Power Conversion Equipment

(12) UL 991 – Safety Tests for Safety Related Controls employing Solid State Devices

(13) OSHA® 1910.95 -- AC Drive Controller Acoustical Noise

(14) The manufacturer of the AC Drive shall be a certified ISO 9001 facility.

(15) The AC Drive and all associated optional equipment shall be UL Listed according to UL508C Power Conversion Equipment. A UL label shall be attached inside each enclosure as verification.

(16) The AC Drive shall be designed constructed and tested in accordance with UL, CSA, NEMA and NEC standards.

(17) Every power converter shall be quality assurance tested with an AC induction motor under load conditions and subjected to a hi-pot test with all enclosed devices mounted and wired, prior to shipment.

(18) Quality Assurance documentation shall be furnished to verify successful completion upon written request of the engineer.

(19) A 12-month parts warranty shall be provided on materials and workmanship from the date of project substantial completion and acceptance of installation by manufacturer.

4. **SUBMITTALS**

A. [6] Copies of approval drawings shall be furnished for Engineer's approval prior to factory assembly of the AC Drives. These drawings shall consist of elementary power and control wiring diagrams and enclosure outline drawings. The enclosure drawings shall include front and side views of the enclosures with overall dimensions and weights shown, conduit entrance locations and nameplate legends.

B. Standard catalog sheets showing voltage, horsepower, maximum current ratings and recommended replacement parts with part numbers shall be furnished for each different horsepower rated AC Drive shall be provided.

C. Submit with the delivery of the VFD an Installation and Maintenance Manual and one (1) copy of the manufacturer's drawings per shipping block.

D. A submittal package, including drawings shall be furnished for the Engineers' approval prior to factory assembly of the AC Drives. These packages shall consist of elementary power and control wiring diagrams on one drawing and enclosure outline drawings. The enclosure drawings shall include front and side views of the enclosures with overall dimensions and weights shown, and conduit entrance locations. Standard catalog specification sheets showing voltage, horsepower and maximum current ratings shall be furnished as part of the submittal package.

5. **EQUIPMENT**

A. Acceptable Manufacturers

(1) The AC Drive VFD units shall be Square "D" E-Flex 6 Pulse or prior approved equal. Substitutions must be submitted in writing three (3) weeks prior to original bid date with supporting documentation demonstrating that the alternative manufacturer meets all aspects of the specifications herein.

(2) Alternate control techniques other than pulse width modulated technology (PWM) are not acceptable.

B. General Description

(1) The AC Drive shall convert the input AC mains power to an adjustable frequency and voltage.

(2) The input power section shall utilize a full wave bridge design incorporating diode rectifiers. The diode rectifiers shall convert fixed voltage and frequency, AC line power to fixed DC voltage.

(3) The output power section shall change fixed DC voltage to adjustable frequency AC voltage.

(4) The adjustable frequency NEMA 3R drive package shall consist of a circuit breaker disconnect, line reactor, EMI/RFI filter (if drive design requires RFI interference protection), 120V control transformer, control circuit terminal board for digital and analog field wiring. AC line fuses do not meet specification.

(5) The drive door shall have mounted and wired, Hand-Off-Auto switch, Manual Speed Potentiometer and AFC-Off switch.

(6) The entire drive package shall be UL508C listed and coordinated with NEMA ICS 7.1. A UL508A panel builders label does not meet specification.

C. Construction

(1) The AC Drive power converter shall be enclosed in a NEMA Type 3R enclosure with a circuit breaker disconnect, user terminal strip connections. The enclosure shall provide dedicated user terminals for power and control device connection.

(2) Provisions shall be included for locking the disconnect in the OFF position with a padlock.

(3) All enclosure and heat sink fans shall be accessible from the front and shall not require the removal of the AC drive power converter for fan replacement.

D. Application Data

(1) The AC Drive shall be sized to operate a variable torque load.

(2) The speed range shall be from a minimum speed of 1.0 Hz to a maximum speed of 72 Hz.

E. Environmental Ratings

(1) The AC Drive shall meet IEC 60664-1 Annex A and NEMA ICS 1, UL, and CSA standards.

(2) The AC Drive shall be designed to operate in an ambient temperature from -10 to 40 °C (14 to 104 °F).

(3) AC Drives in Type 3R enclosures shall be designed to operate in an ambient temperature from -10 to 50 °C (14 to 122 °F) and in full sunlight.

(4) The storage temperature range shall be -25 to 65 °C (-13 to 149 °F).

(5) The maximum relative humidity shall be 95%, non-condensing.

(6) The AC Drive shall be rated to operate at altitudes less than or equal to 3300 ft (1000 m). For altitudes above 3300 ft (1000 m), the AC Drive should be de-rated per drive specifications.

(7) The AC Drive shall meet the IEC 60721-3-3-3M3 operational vibration specification.

(8) The AC Drive shall be Seismic Qualified to 2000 IBC Level 3 "Extreme" rating with an Importance Factor 1p=1.5

F. Ratings

(1) The AC Drive shall be designed to operate at the input line voltage indicated on the equipment schedule.

(2) The AC Drive shall operate from an input frequency range of 60 Hz (±) 5%.

(3) The displacement power factor shall not be less than .98 lagging under any speed or load condition.

(4) The efficiency of the AC Drive at 100% speed and load shall not be less than 97%.

(5) The variable torque rated AC Drive over current capacity shall be not less than 110% for 1 minute.

(6) The output carrier frequency of the AC Drive shall be programmable at 0.5, 1, 2, 4 or 8 kHz. In addition, the output carrier frequency shall be randomly modulated about the selected frequency.

G. Protection

(1) Upon power-up, the AC Drive shall automatically test for valid operation of memory, loss of analog reference input, loss of communication, DC-to-DC power supply, control power and pre-charge circuit.

(2) The enclosure shall provide a fully coordinated 100,000 AIC current rating marked on the enclosure nameplate. Short circuit coordination to UL 508C Power Conversion Equipment and NEMA ICS 7.1.

(3) The AC Drive shall be protected against short circuits, between output phases and to ground.

(4) The AC Drive shall have a minimum AC undervoltage power loss ride-through of 200 milliseconds (12 cycles).

(5) The AC drive shall have a programmable ride-through function, which will allow the logic to maintain control for a minimum of one-second (60 cycles) without faulting.

(6) For a fault condition other than a ground fault, short circuit or internal fault, an auto restart function will provide up to 6 programmable restart attempts. The time delay before restart attempts will be 30 seconds.

(7) Upon loss of the analog process follower reference signal, the AC Drive shall be programmable to display a fault.

(8) The AC Drive shall have a solid-state UL 508C listed overload protective device and meet IEC 60947.

(9) The output frequency shall be software enabled to fold back when the motor is overloaded.

(10) There shall be three skip frequency ranges that can be programmed to a bandwidth of (±) 2.5 Hz.

H. Adjustments & Configurations

(1) The AC Drive will be factory programmed to operate all specified optional devices.

(2) The acceleration and deceleration ramp times shall be adjustable from 0.05 to 999.9 seconds.

(3) The memory shall retain and record run status and fault type of the past eight faults.

(4) The software shall have an energy economy function that, when selected, will reduce the voltage to the motor when selected for variable torque loads. A constant volts/Hz ratio will be maintained during acceleration. The output voltage will then automatically adjust to meet the torque requirement of the load. Selectable volts/Hz ratio patterns does not meet specification, the function must be automatically optimized.

I. Keypad Display Interface

(1) A keypad display interface shall offer the modification of AC Drive adjustments through a touch keypad. All electrical values, configuration parameters, I/O assignments, application and activity function access, faults, local control, and adjustment storage, and diagnostics shall be accessible.

(2) The AC Drive model number, torque type, software revision number, horsepower, output current, motor frequency and motor voltage shall be listed on the drive identification portion of the LCD display.

(3) The keypad display shall have a hardware selector switch that allows the keypad to be locked out from unauthorized personnel.

J. Operator Controls

(1) The control power for the digital inputs and outputs shall be 24 Vdc.

(2) The internal power supply shall incorporate automatic current fold-back that protects the internal power supply if incorrectly connected or shorted. The transistor logic outputs will be current limited and will not be damaged if shorted.

(3) Pull-apart terminal strips shall be used on all logic and analog signal connections in the power converter

(4) Two voltage-free relay output contacts will be provided. One of the contacts will indicate AC Drive fault status. The other contact shall indicate a drive run status.

(5) The combination enclosure shall have the following dedicated operator controls:

(a) Hand-Off-Auto switch

(b) Manual Speed Potentiometer

(6) The combination enclosure shall include terminal point connection for fire /freeze state interlock, to prevent drive operation. The interlock must shut down the motor in the drive modes.

K. Serial Communication

(1) The AC Drive shall have serial communications capability.

L. Harmonic Mitigation

(1) Each drive shall include a line reactor mounted inside the drive enclosure to reduce power system harmonics and provide power quality protection for the drive. DC bus chokes do not meet specification and shall not be substituted.

6. **INSTALLATION**

A. Handle VFD's and enclosures carefully to prevent breakage, denting and scoring finish.

B. Store VFD's indoors and protect from weather.

C. Install in accordance with manufacturer's written instructions, applicable requirements of NECA and in accordance with recognized industry practices to ensure that products comply with requirements and serves intended purposes.

D. Coordinate installation of VFD's and enclosures with cable and raceway installation work.

E. The AC Drive manufacturer shall provide a factory certified technical representative to supervise the contractor's installation, testing and start-up of the AC Drive(s) furnished under this specification for a maximum total of 1 day. The start-up service shall be quoted as a separate line item.

F. An on-site training course of 1 training day shall be provided by a representative of the AC Drive manufacturer to plant and/or maintenance personnel.

G. The AC Drive supplier shall supply a comprehensive 8-1/2 x 11-inch bound instruction and installation manual that includes wiring diagrams, layout diagrams, and outline dimensions. This manual must be 3-hole punched for insertion in a shop manual supplied by the installing contractor.

7. **SPECIAL INSTALLATION INSTRUCTIONS**

A. **Drives shall have contacts as required for interfacing with new telemetry control and 4-20MA input/output for drive speed control.**

B. **Drives (Sand Knob Pump Station) shall be capable of single phase input voltage and three phase output. Drives furnished for this project shall be min. 15 HP rated due to single phase input and connected to 7.5 HP three phase pumps.**

C. **Drives shall be in NEMA 3R enclosures.**

END SECTION

SECTION 16160 - PANELBOARDS

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary conditions and General Requirements, apply to this section.

B. Requirements of Electrical General Provision sections govern this section, where applicable.

C. This section shall be governed by alternates insofar as they apply to this work.

2. DESCRIPTION OF WORK

A. Provide all labor, materials, equipment and services necessary for proper and complete installation of panelboards.

B. Refer to other Division 16 sections for cable/wire, connectors and electrical raceway work required in conjunction with panelboards and enclosures, not work of this section.

3. QUALITY ASSURANCE

A. Special Use Markings: Provide panelboards, constructed for special use, with UL marks indicating that special usage, i.e., "suitable for use as service entrance equipment".

B. UL Compliance: Comply with applicable UL publications pertaining to panelboards, enclosures and panelboard accessories. Provide units which have been listed and labeled by Underwriters Laboratories.

C. NEC Compliance: Comply with National Electrical Code (NFPA 70/ANSI C1) as applicable to installation of cabinets, cutout boxes and panelboards. Comply with applicable NEC Articles pertaining to installation of wiring and equipment in hazardous locations.

D. NEMA Compliance: Comply with National Electrical Manufacturers Association Stds. Pub. No. 250, "Enclosures for Electrical Equipment (1000 volt maximum)"; Pub. No. 250, "Enclosures for Electrical Equipment (1000 volt maximum)"; Pub. No. PB 1, "Panelboards,"; installation portion of Pub. No. PB 1.1, " Instructions for Safe Installation, Operation and Maintenance of Panelboards" and Pub. No. PB 1.2, "Application Guide for Ground Protective Devices and Equipment."

4. SUBMITTALS

A. Submit manufacturer's data on panelboards and enclosures.

B. Submit dimensioned drawings of panelboards and enclosures indicating accurately scaled layout of enclosures and required individual panelboard devices, including but not necessarily limited to, circuit breakers, fusible switches, fuses, ground fault circuit interrupters and accessories.

5. EQUIPMENT

A. Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials, design and construction in accordance with published product information. Equip with number of unit panelboard devices as required for a complete installation. Where types, sizes, or ratings are not otherwise indicated, comply with NEC, UL and established industry standards for applications indicated.

(1) All terminals for wiring connections shall be suitable for copper or aluminum.

(2) **Buses shall be tin plated copper.** Bus capacity shall be as indicated on drawings, otherwise, bus capacity shall be equal to or greater than panelboard feeder overcurrent protective device.

(3) Provide a bare uninsulated equipment grounding bar suitably brazed or bolted to interior of each enclosure. This bar shall be equivalent in current carrying capacity to incoming feeder ground conductor and shall be suitable for brazed or approved pressure connector terminations of ground conductors for associated feeders and branch circuits.

(4) A neutral bar, where required, shall be mounted at opposite end of each panelboard from main lugs and shall have numbered terminals for connection of neutral wires.

(5) Bus bar connections to branch circuit overcurrent protection devices shall be of sequence phased type.

(6) Where "provision for," "future," or "space" is indicated on drawings, space shall be equipped with bus connections to future over current device with suitable insulation and bracing to maintain proper short circuit rating and voltage clearances. All provisions shall be made for ready insertion of a future device.

(7) All panelboards shall be dead front type.

B. Provide galvanized sheet steel cabinet type enclosures, in sizes and NEMA types as indicated, code gauge, minimum 16 gauge thickness. Construct with multiple knockouts and wiring gutters. Provide fronts with adjustable indicating trim clamps, and doors with flush locks and keys, all panelboard enclosures keyed alike, with concealed door hinges. Provide enamel finish over a rust inhibitor. Design enclosure for recessed or surface mounting as indicated. Provide enclosures fabricated by same manufacturer as panelboards, and which fit properly with panelboards to be enclosed.

(1) Provide typewritten directories placed under a clear plastic cover on interior of doors. Directories shall identify panelboards and indicate each circuit number and description of associated branch circuit. Directories for fuse and switch panels shall also indicate switch, fuse, and branch feeder size. For panelboards without doors, provide a separate laminated phenolic identification plate on or near each device cover and provide same information that directories described above require.

(2) Where feeders go through panelboard cabinets to serve panelboards above or beyond same, wiring gutters in panelboard cabinets shall be a minimum of 8 inches on sides and 8 inches top and bottom. Cables shall be neatly bundled, routed and supported within gutters. Do not reduce minimum bending radii as recommended by cable manufacturer.

(3) Top and bottom feeding through panelboard buses will not be permitted. Panels served by a common feeder shall have through feeder gutter tapped or provide auxiliary gutter with a feeder tap to each panel.

(4) Lighting and power panelboards less than 49 inches wide for surface mounting shall be equipped with a one piece sheet steel frame and shall have a hinged door. Frame shall be same size as cabinet and shall completely cover wiring gutters. Equip doors over 48 inches in height with a vault handle and a three point catch. Cabinets greater than 48 inches wide shall have sectionalized frames and multiple doors.

C. Provide panelboard accessories and devices including, but not necessarily limited to, cartridge time delay type fuses, circuit breakers and ground fault protection units, as recommended by panelboard manufacturer for ratings and applications indicated.

(1) Circuit breaker protective devices shall be rated for circuit voltage on which they are used; have trip rating and number of poles indicated on drawings; be molded case breakers of quick make, quick break, bolt on, thermal magnetic type and be trip free. Automatic tripping shall be indicated by a handle position between manual OFF and ON position.

a. All similar units of all panelboards shall be same manufacture, except where a manufacturer does not produce a frame size or type called for, and like units shall be interchangeable.

b. Adjustable magnetic trip devices shall be adjusted at factory to "low " trip setting ampere values.

c. Circuit breakers shall have a minimum interrupting rating of 10,000 amperes symmetrical, unless a greater rating is indicated on drawings. In all cases circuit breakers shall have an interrupting current rating equal or greater than available fault current at their locations in electrical system.

(2) Fusible switch branch circuit protective devices shall be as indicated on drawings, shall be interrupter switches of quick make, quick break type, and shall have sufficient load break capacity to properly coordinate with time current characteristics of current limiting fuses, where required, to provide an integrated switch and fuse device. Provide each switch pole with cartridge fuses as indicated on drawings. Interrupter switches shall have a load break capacity in excess of normal horsepower rating. Each unit shall be capable of withstanding let through current available before its fuse operates without damage or change in rating. Short circuit interrupting rating of circuit switch fuse combination shall be 100,000 RMS symmetrical amperes. Each unit shall be operable from front by means of an external operating handle and provided with an interlocking mechanism which allows access to de energized fuses and wiring only when in OFF position. Unit cover shall be so interlocked that it may not be removed or opened when switch is in ON position, except that interlock shall be tool releasable by a qualified person for inspection of contacts and mechanism. All similar switch units of all panelboards shall be of same manufacturer.

D. Manufacturers of panelboards shall be Square “D”, Cutler-Hammer or equal as approved by this Engineer.

6. INSTALLATION

A. Handle panelboards and enclosures carefully to prevent breakage, denting and scoring finish.

B. Store panelboards and enclosures indoors and protect from weather. When necessary to store outdoors, elevate well above grade and enclose with durable, waterproof wrapping.

C. Install panelboards and enclosures, in accordance with manufacturer's written instructions, applicable requirements of NECA and in accordance with recognized industry practices to ensure that products comply with requirements and serves intended purposes.

(1) Install lighting and power panelboards with tops 6 feet 6 inches above floor and bottoms not less than 12 inches above floor (multi section panels shall be provided to meet these spacings) arranged for conduit or bus duct connections. Mount on metal channels. Where panelboards are equipped with remotely controlled switches or contactors, top of cabinet may be mounted above 6 feet provided height above floor of highest circuit breaker handle is not over 6 feet 6 inches.

D. Coordinate installation of panelboards and enclosures with cable and raceway installation work.

E. Anchor enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically secure.

F. Provide electrical connections within enclosures.

G. Fill out panelboard's circuit directory card upon completion of the work.

7. SPECIAL INSTALLATION REQUIREMENTS

A. Main service distribution panel shall have distribution class lightning arrestors.

B. Mini-powerzone type combination transformer panels shall have stainless steel enclosures.

END SECTION

SECTION 16170 - SAFETY AND DISCONNECT SWITCHES

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements, apply to this section.

B. Requirements of electrical general provision sections govern work specified in this section.

C. This section shall be governed by alternates insofar as they affect this work.

2. DESCRIPTION OF WORK

A. Provide labor, materials, equipment and services necessary for proper and complete installation of safety and disconnect switches.

B. Types of safety and disconnect switches required for project include the following:

Equipment disconnects.

Appliance disconnects.

Motor circuit disconnects.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of electrical safety and disconnect switches.

B. Provide safety and disconnect switches which have been listed and labeled by Underwriters Laboratories.

C. Comply with National Electrical Manufacturers Association Stds. Pub. No. KS1.

D. Manufacturers of safety and disconnect switches shall be Square "D", Allen-Bradley or Cutler-Hammer.

4. SUBMITTALS

A. Submit manufacturer's data on electrical safety and disconnect switches.

5. EQUIPMENT

A. Provide heavy duty type, sheet steel enclosed safety switches, of type, size and rating indicated; incorporating quick make, quick break type switches, constructed so switch blades are visible in "OFF" position with door open; equipped with operating handle which is an integral part of enclosure base and whose position is easily recognizable and is padlockable in "OFF" position.

B. Mount switches in NEMA 12 enclosures unless otherwise indicated. Boxes exposed to wet or rain conditions shall be NEMA 4 type unless otherwise noted. Switches shall be rated at 240 or 600 minimum volts as required by voltage of circuit on which they are utilized and shall be rated in horsepower. Each shall be capable of interrupting locked rotor current of motor for which it is to be used. Current shall be assumed as ten (10) times full rated load current.

C. Mount switch parts on insulating bases to permit replacement of parts from front of switch. All current carrying parts shall be designed to carry rated load without excessive heating. Switch contacts shall be silver tungsten type or plated to prevent corrosion, pitting and oxidation and to assure suitable conductivity. Fuse clips shall be of positive pressure type and switch operating mechanism shall be designed to retain its effectiveness with continuous use at rated capacity without use of auxiliary springs in current path. Switches shall be capable of withstanding available fault current or let through current before fuse operates without damage or change in rating. Fuse clips shall be designed and coordinated to accommodate class and type of fuse specified or indicated to be used with switch.

6. INSTALLATION

A. Deliver switches individually wrapped in factory fabricated fiber board type containers.

B. Handle switches carefully to avoid damage to material components, enclosures and finish. Do not install damaged switches; remove from project site.

C. Store switches in a clean dry space. Protect switches from dirt, fumes, water and physical damage.

D. Install safety and disconnect switches where indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices.

E. Coordinate safety and disconnect switch installation work with electrical raceway and cable work, as necessary for proper interface.

F. Install disconnect switches used with motor driven appliances larger than 1/8 h.p. and motors and controllers within sight of controller position unless otherwise indicated.

7. SPECIAL INSTALLATION INSTRUCTIONS

A. All disconnect switches noted to have a NEMA 4 enclosure shall be stainless steel.

B. Main service disconnect switches shall have distribution class lightning arrestors.

END SECTION

SECTION 16181 - FUSES

1. RELATED DOCUMENTS

A. General Provisions of Contract, General and Supplementary Conditions and General Requirements, apply to this section.

B. Requirements of electrical general provision sections govern work specified in this section.

C. This section shall be governed by alternates insofar as they affect this work.

2. DESCRIPTION OF WORK

A. Provide all labor, materials, equipment and services necessary for proper and complete installation of fuses.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of fuses.

B. Fuses shall be listed by Underwriters Laboratories.

4. SUBMITTALS

A. Submit manufacturer's data on fuses.

5. EQUIPMENT

A. Except as otherwise specified herein, provide complete sets of fuses for all switches requiring fuses. Fuses shall be of size indicated on drawings. Provide spare fuses in original boxes of the following quantities: one complete set for each different size, type and class.

B. Install current limiting fuses in lieu of regular fuses where fault current exceeds 10,000 RMS amperes. Fuses rated over 600 amperes shall be NEMA Class L. Unless otherwise specified, fuses for use with switches rated 600 amperes and less shall be UL Class RK 1, and have interrupting rating of 200,000 RMS amperes. Class RK 1 fuses shall be dual element type with minimum time delay of ten seconds at 500 percent of rating.

C. Current limiting high interrupting capacity fuses manufacturer with each unit as required for complete coordination.

D. Provide all project fuses supplied by same manufacturer. Proper selectivity with associated protective equipment shall be substantiated by published catalog data.

E. Switch size and fuse ratings indicated on Drawings and/or specified are based on general approximate values for each motor horsepower delineated. Since characteristics of fuses for motor short circuit protection vary with different manufacturers, coordinate fuse values with switch sizes for each motor.

6. INSTALLATION

A. Install fuses where indicated and required in accordance with manufacturer's written instructions, applicable requirements of N.E.C., and in accordance with recognized industry practice.

END SECTION

SECTION 16200 - MISCELLANEOUS ELECTRICAL EQUIPMENT

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary conditions and General Requirements, apply to this section.

B. Requirements of Electrical General Provision sections govern this section, where applicable.

C. This section shall be governed by alternates insofar as they apply to this work.

2. DESCRIPTION OF WORK

A. Provide all labor, materials, equipment and services necessary for proper and complete installation of equipment specified.

B. Refer to other Division 16 sections for additional work required in conjunction with electrical equipment, not work of this section.

3. QUALITY ASSURANCE

A. Special Use Markings: Provide equipment, constructed for special use, with UL marks indicating that special usage, i.e., "suitable for use in Class 1, Division 1 Environments".

B. UL Compliance: Comply with applicable UL publications pertaining to miscellaneous equipment. Provide units which have been listed and labeled by Underwriters Laboratories.

C. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation of miscellaneous electrical equipment. Comply with applicable NEC Articles pertaining to installation of wiring and equipment in hazardous locations.

4. SUBMITTALS

A. Submit manufacturer's data on **all** miscellaneous electrical equipment items.

B. Submit dimensioned drawings of equipment and enclosures indicating accurately scaled layout of enclosures and required individual devices.

5. EQUIPMENT

A. Bitumastic Coatings

1. Coatings for use on conduits and between metal and concrete contact points shall be of self priming type.

2. Coatings shall be black, high build type single component coal tar mastic capable of maximum 30 mil dry film thickness.

3. Coatings shall be applied in two (2) coats to achieve average of 18 mil dry film thickness over surface to be protected.

4. Coatings shall be Carboline Bitumastic 50 or equal.

B. Corrosion Control Tape

1. **Corrosion control tape shall be applied to all rigid aluminum conduit where in contact with concrete (passing thru slabs, etc.) and where installed below concrete or in contact with earth.**

2. Corrosion control tape shall be Polyken No. 826 yellow in color, 12 mil thickness, 2" or 4" wide as required. Use Polyken No. 1027 primer prior to tape installation per manufacturer requirements.

C. Exothermic Ground Connections

1. Exothermic welding systems shall be approved by Underwriters Laboratories to ANSI UL 467 "Grounding and Bonding Equipment."

2. Exothermic welding shall be used for making electrical connections of copper to copper, copper to steel or copper to cast iron for grounding and cathodic applications.

3. Exterior connections shall be suitable for exposure to the elements of direct burial in earth or concrete without degradation over the lifetime of the grounding system.

4. Interior connections in occupied building shall be made using a low smoke producing process.

5. Products for exothermic connections shall be Cadweld, Thermoweld, Permaweld or equal.

6. INSTALLATION

A. Handle miscellaneous equipment carefully to prevent breakage, denting and scoring finish.

B. Store miscellaneous electrical equipment indoors and protect from weather. When necessary to store outdoors, elevate well above grade and enclose with durable, waterproof wrapping.

C. Install miscellaneous electrical equipment, in accordance with manufacturer's written instructions, applicable requirements of NECA and in accordance with recognized industry practices to ensure that products comply with requirements and serves intended purposes.

D. Coordinate installation of miscellaneous electrical equipment with cable and raceway installation work and work of other trades.

E. Anchor equipment firmly to walls and structural surfaces, ensuring that they are permanently and mechanically secure.

END SECTION

SECTION 16450 - ELECTRICAL GROUNDING

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements, apply to this section.

B. Electrical general provision sections govern this section, where applicable.

C. This section shall be governed by Alternates insofar as they apply to this work.

2. DESCRIPTION OF WORK

A. Provide labor, material, equipment and services for proper and complete electrical grounding system.

B. Grounding of electrical installations comprises both system and equipment grounding, and includes, but is not necessarily limited to, metal raceways, transformer frames, switchgear enclosures, metal enclosures of electrical devices, and circuit conductors.

C. Requirements of this section apply to electrical grounding work specified elsewhere in these specifications.

D. Electrical cable, wire, connectors, clamps, and raceway work are specified in applicable Division 16 basic material sections.

E. Method

(1) Supplement grounded neutral of secondary distribution system by and equipment grounding systems to properly safeguard equipment and personnel. Design equipment grounding system so all metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, portable equipment, and other conductive items in close proximity with electrical circuits operate continuously at ground potential and provide a low impedance path for possible ground fault currents.

(2) The AC secondary system ground shall be connected using exothermic welds to at least three ground rods minimum 3/4 inch by 10 feet. Where required to meet requirements of herein specified tests, install extra rods at no additional cost to Owner. Locate rods a minimum of 10 feet from each other or any other electrode and loop interconnect with each other by a minimum No. 6 AWG bare copper conductor brazed to each rod below grade. Do not splice grounding electrode conductor.

(3) In addition, provide in conduit a minimum 3/0 or as required green insulated copper ground conductor to main metallic water service entrance and connect to same by means of adequate ground clamps. Where a dielectric main water fitting is installed, connect this ground conductor to street side of dielectric water fitting. Do not install a jumper around this fitting. Bond to ground conductor at each end. Provide with ground clamps a 3/0 jumper around water meter.

(4) Connect system neutral ground and equipment ground system to common ground bus as indicated on Drawings, or if not indicated, as required by NEC.

(5) Ground secondary services at supply side of secondary disconnecting means and at related transformers in accordance with NEC. Provide each service disconnect enclosure with a neutral disconnecting means and an insulated neutral stud which interconnects with insulated neutral and uninsulated equipment ground buses to establish system common ground point. Locate neutral

disconnecting link or links so that low voltage neutral bar with all interior secondary neutrals can be isolated from common ground bus and service entrance conductors.

(6) Size required equipment grounding conductors and straps in compliance with NEC. Provide equipment grounding conductors with green insulation equivalent to insulation on associated phase conductors. Braze related feeder and branch circuit grounding conductors to grounding bar or connect with approved pressure connectors. A feeder serving several panelboards shall have a continuous grounding conductor which shall be connected to each related cabinet bar. Aluminum, straps or bars may be substituted for proposed copper items if this is consistent with materials proposed for low voltage distribution system. Aluminum materials shall be comparable in current carrying capacity, temperature, rise, and mechanical strength, and installation shall include all necessary precautions regarding electrical connections with dissimilar metals.

(7) Provide low voltage distribution systems with a separate green insulated equipment grounding conductor for each single or three phase feeder and each branch circuit. Install required grounding conductor in common conduit with related phase and/or neutral conductors. Where there are parallel feeders installed in more than one raceway, each raceway shall have a green insulated equipment ground conductor. Single phase branch circuits required for 120 and 277 volt lighting, receptacles, and motors shall consist of phase, neutral and grounding conductors installed in common metallic conduit. Provide flexible metallic conduit equipment connections utilized in conjunction with the above single phase branch circuits with suitable green insulated grounding conductors connected to approved grounding terminals at each end of flexible conduit. Provide single phase branch circuits required for special equipment and all branch circuits installed in nonmetallic or flexible conduits with a separate grounding conductor.

(8) Determine number and size of pressure connectors to be provided on all equipment grounding bars required in panelboards and other electrical equipment for termination of equipment grounding conductors. In addition to active circuits, provide pressure connectors for all three phase spares and spaces.

(9) Provide a green colored equipment ground conductor and connected as described below. Provide each ground conductor with spade tongue terminals or solderless pressure connectors to suit conditions.

a. From green ground terminal of all receptacles to green 10 32 "washer in head" outlet box machine screw. Note: Receptacles with special cast boxes and factory designed and approved ground path will not require a separate ground jumper.

b. From green 10 32 "washer in head" machine screw in ceiling outlet box or junction box through flexible metallic conduit to ground terminal in fixture.

c. From green 10 32 "washer in head" machine screw in ceiling outlet box or junction box through flexible metallic conduit to green 10 32 "washer in head" machine screw in switch outlet box in movable partitions.

d. From green 10 32 "washer in head" machine screw in junction box or disconnect switch through flexible metallic conduit to ground terminal in connection box mounted on single phase fractional horsepower motor.

e. From equipment ground bus in motor control center through conduit and flexible metallic conduit to ground terminal in connection box mounted on three phase motor. Note: where motor has separate starter and disconnect device, ground conductor shall originate at ground bar in panelboard supplying these motors and be bonded to each starter and disconnect device enclosure also.

f. From equipment ground bar to equipment grounding bar on a busway, install and connect by an approved method a ground conductor.

g. From a computer area power panel ground bar, provide each branch circuit with a green insulated equipment ground conductor. Minimum size of this conductor shall be per NEC but no ground conductor circuit shall exceed 3 ohms resistance to building ground system.

(10) Nonmetallic conduits or ducts shall contain a green insulated grounding conductor unless otherwise specified.

a. Equipment grounding conductors are not required for telephone ducts.

(11) Where electric devices such as electric air cleaners or heaters are installed in air ducts, provide a green insulated equipment ground conductor. Bond conductor to each unit, air duct, and to ground in panelboard.

(12) Where electric immersion type water heater or surface anti frost heating cables are installed, provide a green insulated equipment ground conductor. Bond this conductor to water piping at unit and to ground bar in panelboard.

(13) Subject completed equipment grounding system to a megger test at each service disconnect enclosure ground bar to insure that ground resistance, without chemical treatment or other artificial means, does not exceed twenty five (25) ohms. Certified test reports of ground resistance shall be submitted to Engineer for approval. Necessary modifications for compliance with the twenty five (25) ohm value shall be performed without additional expense to Owner.

(14) Where steel conduit(s) terminate without mechanical connection to a metallic housing of electrical equipment by means of locknut and bushings or adapters such as switchboards, switchgear, motor control centers, the following procedure shall be followed: Provide each conduit with a ground bushing and each bushing connecting with a bare copper conductor to ground bus in electrical equipment. Ground conductor shall be in accordance with article on Grounding of NEC. Bond electrically non continuous metallic conduits containing ground wiring only to ground wire at both conduit entrance and exit in a manner similar to that described above.

3. QUALITY ASSURANCE

A. Comply with NFPA No. 70, National Electrical Code, as applicable to materials and installation of electrical grounding systems and associated equipment and wiring.

B. Comply with UL standards and IEEE Greenbook pertaining to electrical grounding and bonding.

C. Manufacturers offering products complying with requirements include: Cadweld, ITT Blackburn, ITT Weaver, Copperweld Bimetallics Group, Cathodic Engineering Equipment Co., or equal.

4. SUBMITTALS

A. Submit manufacturer's information on exothermic type connection system. Submit written results of grounding system megger test.

5. EQUIPMENT

A. Except as otherwise indicated, provide for each electrical grounding indicated, a complete assembly of materials including but not necessarily limited to cable, wire, connectors, terminals (solderless lugs), grounding rods/electrodes and plate electrodes, bonding jumper braid, and other items and accessories needed for a complete installation. Where more than one type meets indicated requirements, selections is Installer's option. Where material or component is not otherwise indicated, provide products complying with NEC, and established industry standards.

B. Unless otherwise indicated, provide electrical grounding conductors for grounding connections matching power supply wiring materials and sized according to NEC.

C. Provide electrical connectors, terminals and clamps as recommended by connector, terminal and clamp manufacturer for intended applications.

D. Steel ground rods with copper welded exterior, 3/4" dia. x 10'.

E. Acceptable Manufacturers:

(1) Grounding equipment shall be Cadweld, ITT Blackburn, ITT Weaver, Copperweld Bimetallics Group, Cathodic Engineering Equipment Co., or equal.

6. INSTALLATION

A. Testing

(1) The CONTRACTOR shall be required to provide all labor, tools, instruments, and materials as necessary to perform testing of the grounding electrode system. Results shall be submitted in writing to the ENGINEER. The testing shall be done to determine the effectiveness of the selected grounding scheme and to see that it conforms with resistance specified (2.5 ohms maximum).

(2) The testing should be done using a fall-of-potential method test at the point of grounding electrode conductor connection to main power distribution equipment and at each separately derived system or MCC. The test shall be performed no sooner than 48 hours after a rainfall event.

(3) The written report should contain the following information:

a. Type of ground scheme used, i.e., building steel, driven rod, mat, etc.

b. Type of instrument used.

1) Mfr.

2) Model number

3) Confirm fall-of-potential test

4) *Serial number

5) *Where instrument was obtained

* These 2 items are required so that the same instrument may be utilized should reproduction of the test be necessary due to unsatisfactory readings/instrument miscalibration.

c. Ground resistance readings obtained at various test distances.

d. Ground resistance/distance curve.

e. Value of Grounding Electrode Resistance at knee of curve.

f. Sketch showing setup of instrumentation and location electrode and test probes.

g. Proposed method to achieve the specified resistance, should an unacceptable reading be obtained.

h. Ground resistance readings obtained (if applicable) after modification incorporated.

B. Ground Enhancement Material

(1) Where indicated on the Drawings or as deemed necessary by the CONTRACTOR to achieve design grounding electrode system resistance, a ground enhancement material shall be utilized, in accordance with manufacturer's recommendations.

(2) The ground enhancement material must be permanent and maintenance free (no recharging with salts or chemicals which may be corrosive) and maintain its earth resistance for the life of the system. It must set up firmly and not dissolve or decompose, or otherwise pollute the soil or local water table. The material shall be capable of being applied dry or in a slurry form, and shall reduce resistance by at least 40 percent.

(3) Basic components of this material shall be carbon, hydraulic cements, and hydrous aluminum silicates. Minimum 4-inch diameter holes shall be used with ground rod installations, with depth 6" shorter than length of rod, completely filled with the material. Trenches for grounding electrode conductor shall also utilize this material the full length from electrode to building, in accordance with manufacturer installation recommendations, except trench depth shall allow buried conductor to be at least 2'-6" deep.

(4) Ground enhancement material shall be GEM by Erico Products, Powerfill by Cathodic Engineering Equipment Company, or equal.

(5) Should ground rods be impractical for use due to rocky conditions, then grounding electrode plates may be used after acceptance by the ENGINEER or a case by case basis.

(6) Install electrical grounding systems where indicated, in accordance with manufacturer's instructions and NEC as necessary to interface installation of electrical grounding system with other work.

C. Special Installation Instructions

(1) Contractor shall coordinate with General Contractor and connect main AC system ground to exposed rebar stub at main service disconnect per 2011 N.E.C. requirements.

(2) All connections to ground rods shall be made using exothermic (Cadweld) type connections.

END SECTION

SECTION 16510 - BUILDING LIGHTING FIXTURES

1. RELATED DOCUMENTS

A. General provisions of Contract, General and Supplementary Conditions and General Requirements, apply to this section.

B. Requirements of electrical general provision sections govern the work specified in this section, where applicable.

C. This Section shall be governed by alternates insofar as they affect this work.

2. DESCRIPTION OF WORK

A. Provide material, equipment, labor and services necessary for proper and complete installation of interior lighting fixtures.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA No. 70) as applicable to installation and construction of interior lighting fixtures.

B. Comply with applicable portions of National Electrical Manufacturers Association standards pertaining to lighting equipment.

C. Comply with applicable American National Standards Institute standards pertaining to lamp materials, and lamp ballasts and transformers, and interior lighting fixtures.

D. Provide interior lighting fixtures which have been listed and labeled by Underwriters Laboratories.

E. Provide fluorescent-lamp ballasts which comply with Certified Ballast Manufacturers Association standards and carry CBM label.

F. Comply with additional fixture requirements contained in Interior Lighting Fixture Schedule at end of this section or indicated on Drawings.

4. SUBSTITUTIONS

A. Lighting fixtures detailed on drawings and specified in schedules are intended to indicate general fixture type. Fixture products of other manufacturers may be proposed, provided these are of similar design, equally efficient, have aesthetically acceptable appearance, and are approved by Architect or Engineer.

B. In addition to requirements of Section 16000 Products, proposal shall consist of three (3) bound copies of cuts on lighting fixtures and shall include the following information:

(1) Name of Manufacturer

(2) Catalog Number

(3) Fixture drawings, showing metal gauges and finish.

(4) Photometric distribution curves.

(5) Coefficient of utilization as determined by an independent testing laboratory.

5. SUBMITTALS

A. Submit fixture shop drawings and manufacturer's data in booklet form with a separate sheet for each fixture, assembled in luminaire "type" numerical/alphabetical order, with proposed fixture and accessories clearly indicated on each sheet.

6. LIGHT FIXTURES

A. Light fixtures shall consist of, but not be limited to lamps, lampholders, reflectors, ballasts, starters, and wiring.

B. Provide all recessed fixtures installed in plaster or drywall ceilings with plaster frames supplied by fixture manufacturer.

C. All ferrous metal surfaces of fixtures and plaster frames shall be treated and given rust inhibiting and finish coat adherence properties before finish coats are applied. Finish coats shall be enamel baked on at approximately 320 degrees F or dry powder electrostatically applied.

D. Unless otherwise specified, metal baffles and plastic or glass diffuser panels and low-brightness lens panels shall be contained in rigid, hinged or safety chained metal frames. Diffusers and lens panel shall be replaceable without the use of tools other than screwdriver or pliers. Frames and lens shall provide proper tolerance for normal expansion and contraction without damage to panels.

E. Plastic members shall be uncolored 100 percent virgin acrylic.

F. Fixtures shall allow replacement of ballasts without removal of fixture.

G. It shall be possible to remove and install lamps in fixtures without tools.

7. LAMPS

A. Provide new and unused lamps for all fixtures.

B. Provide mercury vapor and metal Halide lamps with extinguishing mechanisms to prevent operation of lamps when outer globe is broken.

C. Incandescent lamps shall be rated 130 volts.

8. BALLASTS

A. Each ballast shall meet requirements of "Certified Ballast Manufacturer's Association". Securely fasten ballasts in place with mounting surface of ballast making as complete contact with surface of ballast mounting area of fixture as practical. Attach ballasts to mounting surface of fixture by one bolt and nut or sheet metal screw for each ballast mounting hole or as recommended by ballast manufacturer for optimum heat transfer. Ballasts shall have an "A" sound rating.

B. Equip all fixtures with ballasts with external GLR line fuses in HLR holders. Fuse size shall be determined by fixture manufacturer.

C. Provide low temperature fluorescent ballasts in fixtures mounted in cold rooms, outdoors, and as indicated.

D. H.I.D. ballasts shall be constant wattage autotransformer, high power factor type, unless otherwise indicated.

E. Fluorescent ballast to be high performance electronic to operate at a frequency of 25KHz or

higher with less than 2% lamp flicker, at an input voltage of 108 to 132 VAC (120 volt line) or 249 to 305 VAC (277 volt line) at an input frequency of 60 Hz minimum of .99 power factor. Light output to remain constant for line voltage of ± 5%. Ballast to comply with EMI and RFI limits set by FCC (CFR 47 part 18) for normal electrical equipment and have less than 1.5 lamp current crest factor (LCCF). Units shall be full rapid start except slimline and maintain full cathode heat during operation. Ballast to meet ANSI standard (82.41) and UL listed Class P Type 1 outdoor. Ballast shall be non-PCB. Ballast to have less than 10% total harmonic distortion less than 6% third harmonic distortion. Ballast to have A sound rating with a power factor greater than .99 and have a twenty year rated lamp life. Ballast to operate 1, 2, 3 or 4 T8 or T12 or T5 lamps as specified in fixture specification. Number of ballasts in multi-lamped fixture to be determined by switching or multiple fed luminaries. Responsibility for correct number of ballasts in luminaries and correct voltage to be responsibility of fixture suppliers. Motorola, Advance or Universal are acceptable manufacturers.

9. INSTALLATION

A. Deliver lighting fixtures individually wrapped in factory-fabricated fiberboard type containers.

B. Handle fixtures carefully to prevent breakage, denting and scoring of fixture finishes. Do not install damaged lighting fixtures; replace and return damaged units to equipment manufacturer.

C. Store lighting fixtures in a clean, dry space. Store in original cartons and protect from dirt and debris, physical damage, weather and construction traffic.

D. Install lighting fixtures of types indicated, where indicated, and at indicated heights; in accordance with lighting fixture manufacturer's written instructions and with recognized industry practices; to ensure that fixtures comply with requirements and serve intended purposes. Comply with NEMA standards, and requirements of National Electrical Code pertaining to installation of lighting fixtures.

E. Set lighting fixtures and equipment plumb, square, and level and secure to structural support members of building. Provide all steel supports necessary for lighting fixtures in addition to those specified under general building construction. Recessed and semi-recessed fixtures may be supported from suspended ceilings and ceiling tees if ceiling system support rods or wires are provided not more than 6 inches from each edge of each fixture. Secure fixtures in suspended ceilings to framing members in accordance with NEC 410-16 by using standard clips made for the purpose. Sheet metal screws are not acceptable.

F. Mounting heights specified or indicated shall be to bottom of fixture. Coordinate exact mounting of lighting fixtures with type, style and pattern of ceiling being installed.

G. Clean interior lighting fixtures of dirt and debris upon completion of installation. Protect installed fixtures from damage during remainder of construction period.

H. Upon completion of installation of lighting fixtures, and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

I. At date of substantial completion, replace lamps in lighting fixtures which are observed to be noticeably dimmed after Contractor's use and testing, as judged by Engineer.

BUILDING LIGHTING FIXTURE SCHEDULE

LF-1 4'-0" surface mounted industrial with aluminum housing, UL listing for wet location, acrylic diffuser secured to fully gasketed housing by cast aluminum hangers latches, electronic ballast with less than 10% THD, and two (2) 54W-T5 lamps.
Holophane Prismatite 7300-4-AL-K42-YP-GLR

LF-2 Surface mounted self-contained emergency light with thermoplastic housing, dual voltage input capability, solid state charger, short-circuit protection, thermal protection, AC/LVD reset, 36 watt capacity sealed maintenance free lead calcium battery, brownout protection, low voltage disconnect, UL label, and three (3) year total customer satisfaction warranty. Unit to be supplied with (2) H2012 lamp heads.
Lithonia IND 1254-H2012
Chloride equal
Holophane equal

OLF-1 Exterior wall pack type light fixture, 120V with photocell. Fused. Die cast aluminum housing, 140 poly-carbonate lens. One (1) 42W TRT lamp.
Luminaire Lighting YWP-610-HO-PC-GLR

END SECTION

SECTION 16800 - SURGE PROTECTIVE DEVICES

1. RELATED DOCUMENTS

A. General Provisions of Contract, General and Supplementary Conditions and General Requirements, apply to this section.

B. Requirements of electrical general provision sections govern this section, where applicable.

C. This section shall be governed by alternates insofar as they apply to this section.

2. DESCRIPTION OF WORK

A. This Section includes Surge Protection Devices for low-voltage power, control and communication equipment.

B. Provide labor, material, equipment and services necessary for proper and complete installation of secondary surge (lightning) arresters and surge protective devices.

C. In addition to this section, the Contractor shall refer to other specification sections and drawings to ascertain the extent of work included.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code Article 285 as applicable to construction and installation of surge arresters.

B. Provide surge arresters which have been listed and labeled by Underwriters Laboratories.

(1) UL1449 3rd Edition: Surge Protective Devices (SPD)

(2) UL1283 5th Edition: Electromagnetic Interference Filters

C. Comply with applicable portions of ANSI/IEEE:

(1) C62.41.1: 2002 IEEE Guide on the Surge Environment in Low-Voltage (1000V and less) AC Power Circuits

(2) C62.41.2: 2002 IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits

(3) C62.45: 2002 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits

(4) C62.62: 2000 IEEE Standard Test Specifications for Surge Protective Devices for Low Voltage (1000V and Less) AC Power Circuits

(5) C62.72: 2007 IEEE Guide for the Application of Surge Protective Devices for Low Voltage (1000V and Less) AC Power Circuits

D. Surge protective devices selected for project shall comply with short circuit current ratings per N.E.C. 285.6.

E. Surge protective devices selected for project shall comply with NFPA 780 – Standard for the Installation of Lightning Protection Systems.

F. Source Limitations: All secondary service suppression devices and accessories shall be from a single manufacturer.

4. SUBMITTALS

A. Submit manufacturer's data on secondary lightning arresters.

B. Submit manufacturer's data on surge protective devices.

5. PRODUCTS

A. The types of surge protective devices required for project shall include the following as noted within plans and specifications:

(1) Surge protective devices (modular-replaceable module solid state type).

(2) Surge protective devices (non-modular encapsulated non-replaceable component- solid state type).

(3) Telephone, data, signal and instrumentation surge protective devices.

B. Surge Protective Devices (SPDs)

(1) Description

(a) This section describes the materials and installation requirements for transient voltage surge suppressors (TVSS) for the protection of all AC electrical circuits from the effects of lightning induced currents, substation switching surges and internally generated surges resulting from inductive and/or capacitive load switching.

(2) Modular Surge Protection (Type 1)

(a) Configured as shown on the riser diagram and/or panel schedules.

(b) The SPD surge current ratings shall be based on the electrical system ampacity listed in the table below.

Electrical System Ampacity @ SPD Install Point	Surge Protection (kA)	
	Per Mode	Per Phase
2500 – 6000A	300	600
1200 – 2000A	250	500
600 – 1000A	200	400
225 – 400A	150	300
125 – 225A	100	200

(c) The SPD shall be rated for voltage, phase and wye or Delta configuration as indicated on Drawings or noted in specifications.

(d) Modes of Protection: The SPD system shall provide surge protection in all possible modes (L-N, L-G, L-L, and N-G) for the circuit or service to be protected. Each replaceable module must provide the uncompromising ability to deliver full surge current rating per mode.

(e) SPD modules shall be configured to isolate individual suppression component failures without causing total loss of surge protection in that mode.

(f) Opening of supplementary protective devices, internal or external, is not permissible during UL1449 3rd Edition Nominal Discharge testing.

(g) Optional Connection Methods: [Fused Disconnect, 60A, #6AWG] [Surge Rated Disconnect, 100A, #2AWG] [Distribution Block, 100A, #2AWG] [Terminal Block, 60A #6AWG].

(h) Each individual module shall feature an LED indicating the individual module has all surge protection devices active. If any module is taken off-line, the LED will turn off and/or a "fail" LED will illuminate, providing individual module status.

(i) Monitoring: Units shall have Status Indication Lights, Surge Counter with Audible Alarm and Form "C" Contacts.

(j) The modular SPD shall be provided in a NEMA 4 enclosure for exterior use and NEMA 12 enclosure for interior use unless otherwise noted.

(k) The SPD shall provide EMI/RFI electrical noise attenuation of 36 to 44dB in the range of 50kHz to 100MHz as defined by MIL-STD-220A test procedures.

(l) Voltage Protection Ratings: The UL1449 3rd Edition Voltage Protection Ratings "VPR" (6kV, 3000 Amps, 8/20μs waveform) must not exceed the UL assigned values listed below.

	208/120V	480/277V
Line to Neutral	900V	1200V
Line to Ground	800V	1200V
Neutral to Ground	700V	1200V
Line to Line	1200V	2000V

(m) The SPD shall have a minimum UL 1449 3rd Edition Nominal Discharge Current Rating (In) of 10,000 Amps. When used in conjunction with a UL 96A certified Lightning Protection System the (In) rating shall be 20,000 Amps.

(n) Approved Manufacturers: The following SPD manufacturers and respective models are acceptable, subject to conformance with indicated requirements:

Current Technologies TSr Product Series

THOR SYSTEMS SL2 Product Series

Liebert Intercepter II Series

(3) NON-MODULAR SURGE PROTECTION (Type 2)

(a) Configured as shown on the riser diagram and/or panel schedules.

(b) The SPD surge current ratings shall be based on the electrical system ampacity listed in the table below.

Electrical System Ampacity @ SPD Install Point	Surge Protection (kA)	
	Per Mode	Per Phase
400 – 800A	150	300
125 – 225A	100	200
15-100A	50	100

(c) The SPD shall be rated for voltage, phase and wye or Delta configuration as indicated on Drawings or noted in specifications.

(d) Modes of Protection: The SPD system shall provide surge protection in all possible modes (L-N, L-G, L-L, and N-G) for the circuit or service to be protected. Each replaceable module must provide the uncompromising ability to deliver full surge current rating per mode.

(e) All non-modular units shall be factory wired for each phase conductor and for Neutral and Ground conductors.

(f) Continuous LED indication of the system integrity (including N-G mode for a Wye system) utilizing LEDs. Monitoring: Units shall have Solid State Status Indication Lights, Surge Counter with Audible Alarm and Form "C" Contacts.

(g) The non-modular SPD shall be provided in a NEMA 4 enclosure for exterior locations or NEMA 12 enclosure for interior locations unless otherwise noted.

(h) The SPD shall provide EMI/RFI electrical noise attenuation of 32 to 37dB in the range of 50kHz to 100MHz as defined by MIL-STD-220A test procedures.

(i) Voltage Protection Ratings: The let-through voltage test results used to obtain the UL1449 3rd Edition Voltage Performance Ratings "VPR" (6kV, 3000 Amps, 8/20μs waveform) must not exceed the UL assigned values listed below.

	208/120V	480/277V
Line to Neutral	700V	1200V
Line to Ground	700V	1200V
Neutral to Ground	800V	1200V
Line to Line	1000V	2000V

(j) The SPD shall have a minimum UL 1449 3rd Edition Nominal Discharge Current Rating (In) of 10,000 Amps. When used in conjunction with a UL 96A certified Lightning Protection System the (In) rating shall be 20,000 Amps.

(k) Approved Manufacturers: The following NON-MODULAR SPD manufacturers and respective models are acceptable, subject to conformance with indicated requirements:

Current Technologies	TSn Product Series
THOR SYSTEMS	TG Product Series
Liebert	Accuvar All Product Series

(4) Transient Voltage Surge Suppressors - Telephone, Data, Signal and Instrumentation.

(a) TVSS shall be listed in accordance with UL 497A where applicable.

(b) TVSS shall be of compact in-line design and have low shunt capacitance for minimum signal loss.

(c) TVSS shall utilize high speed avalanche diodes for protection.

(d) TVSS units shall meet or exceed the following criteria:

1) Response time < 10ns

2) Maximum shunt capacitance < 40pf except coaxial. Devices which shall be < 30AR.

3) Coaxial cable devices shall have -0.5db insertion loss and no series resistance.

4) Telephone/Data units shall exceed Category 5.

5) Standard clamp voltages/peak pulse currents shall meet or exceed the following as applicable to respective system requirements:

Ethernet 10-base T	7.5V/750A
Telephone Dial-up	240V/250A
CSU/DSU	60V/200A
T-1	60V/200A
DDS	60V/200A
Cable TV	7.5V/750A
Satellite TV	18V/340A
4-20MA Instrumentation (Analog)	30V/370A

(e) TVSS shall have a warranty for a period of five years.

(f) Manufacturers

1) Surge protectors shall be as manufactured by Current Technologies, TSC, DDC, MTC and CCC Series or equal. EDCO Series SS65 (4-20ma instrumentation) or equal.

(5) Transient Voltage Surge Suppressors - 120VAC Hardwired Equipment

(a) TVSS shall be listed in accordance with UL 1449 Third Edition and UL 1283.

(b) TVSS shall provide surge current diversion paths for all modes of protection; L-N, L-G, N-G.

(c) TVSS shall have operational status indicators and each MOV shall be fused.

(d) Unit shall be housed in NEMA 4 enclosure, have terminal screw connections and each MOV shall be fused.

(e) TVSS shall meet or exceed the following criteria:

1) Maximum surge current capability (single pulse rated) PER PHASE (2 x per mode) shall be:

a) Hardwired equipment (40) kA per phase or as noted on drawings.

(f) Manufacturers

Surge protectors shall be as manufactured by EDCO, HSP Series or equivalent.

6. INSTALLATION

A. Deliver each piece of equipment in durable shipping cartons. Maintain cartons through shipping, storage and handling as required to prevent damage and eliminate dirt and moisture. Store cartons inside and protect from weather.

B. Install system and materials in accordance with manufacturer's instructions and roughing in drawings, and details on drawings. Install electrical work and use electrical products complying with requirements of applicable Division 16 sections of these specifications.

C. Term "wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connecting devices.

D. Install a complete wiring system as required for system(s) surge protection.

E. Number Code or Color Code conductors, appropriately and permanently for identification and servicing of systems.

F. Contractor shall install surge protective devices and lightning arresters.

G. Surge Protective Devices shall be provided in quantities such that all modes of protection of the secondary service is protected. This protection shall be provided at the main service panel.

H. Surge Protective Devices shall be installed such that both line and ground lead lengths are as short as possible. Splicing of additional conductor to increase lead length as provided by manufacturer will not be accepted.

I. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others except when permitted and then only after arranging to provide temporary utility services according to requirements indicated. Notify and coordinate with the engineer when an interrupt is required and prior to interrupting.

J. Coordinate location of field-mounted surge protective devices to allow adequate clearances for maintenance.

K. All devices must be installed on the load side of the facility after the first overcurrent protection or disconnect unless otherwise noted.

L. Products shall be installed external to service, distribution, and branch panel equipment. All SPDs must have the same or greater AIC, Interrupting or Fault rating of the equipment the SPD is protecting.

M. Continuity measurements shall be made between the Neutral and Ground connections to verify the Neutral-to-Ground bond.

7. WARRANTY

A. All Surge Protective Devices (SPDs), associated hardware, and supporting components shall be warranted to be free from defects in materials and workmanship, under normal use and in accordance with the instructions provided, for a period of five (5) years.

B. Any component or subassembly contained within the surge protection system that shows evidence of failure or incorrect operation during the five (5) year warranty period, shall be replaced by the manufacturer.

8. SPECIAL INSTALLATION INSTRUCTIONS

A. Contractor shall furnish and install (1) Type "2" SPD on all new and existing services fed from utility company transformers.

END SECTION

SECTION 16941 - CONTROL AND INSTRUMENTATION CABLE AND WIRE

1. RELATED DOCUMENTS

A. General Provisions of Contract, General and Supplementary Conditions and General Requirements apply to work specified in this section.

B. Requirements of Electrical General Provision Sections govern this Section, where applicable.

C. This section shall be governed by Alternates insofar as they affect this work.

2. DESCRIPTION OF WORK

A. Provide labor, materials, equipment and services necessary for proper and complete installation of control and instrumentation cable and wire.

B. Requirements of this section apply to cable and wire work specified elsewhere in these specifications.

C. Unless specified otherwise in this Section or indicated on Drawings, control and instrumentation device/equipment power wiring is specified under Section 16120.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of control cable and wire.

B. Provide cable and wire which has been listed and labeled by Underwriters Laboratories.

C. Comply with National Electrical Manufacturers Association/Insulated Power Cable Engineers Association Standards publications pertaining to materials, construction and testing wire cable, where applicable.

D. Manufacturers offering products complying with requirements include:

(1) Wire:
Southwire Company
Triangle PWC, Inc.
Or equal

(2) Cable:
Belden
Or equal

4. SUBMITTALS

A. Submit manufacturers' product data on all 4-20MA signal cables and power cables.

5. MATERIALS

A. Provide factory-fabricated cable and wire of sizes, ratings, materials and types indicated. Where not indicated, provide proper selection as determined by main control and instrumentation panel supplier to comply with project's installation requirements and NEC standards.

B. Use (1) 16 ga. twisted/shielded pair cable for 4-20ma signal circuits from transmitters etc. Cable shall be Belden No. 8719, or General Cable type VNTC with 100% shield coverage and stranded/tinned 18 ga. drain wire.

C. Use No. 12 stranded conductor for control circuit wiring connected to lighting switches and snap switches.

D. Valves, valve controllers, start-stop selector switches etc. Use minimum 75 degrees C rated insulation unless specified otherwise, indicated on Drawings, or required by NEC. Use 600 volt insulation rating unless specified or indicated otherwise.

6. INSTALLATION

A. Install cable and wire as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure products serve intended functions.

B. Store cable, wire and connectors in factory-installed coverings in a clean, dry indoor space which provides protection against weather.

C. Pull conductors together where more than one is being installed in a raceway.

D. Use pulling compound or lubricant, when necessary; compound must not deteriorate conductor and insulation.

E. Do not use a pulling means, including fish tape, cable or rope which can damage raceway.

F. Install exposed cable, parallel and perpendicular to surface or exposed structural members and follow surface contours, where possible.

G. Wire or cable splices for control and instrumentation circuits shall not be accepted.

H. Install poly pull line in all spare control and instrumentation circuit conduits.

I. Prior to energization, check cable and wire for continuity of circuitry and for short circuits. Correct malfunction when detected.

J. Do not install any control or instrumentation cable or wiring in same conduit or J-box with electrical power wiring.

K. **NOTE:** Electrical Contractor shall be responsible for providing and installing all control and instrumentation wiring and cable from all remote devices to the main control panel (MCP). This shall include the termination of wires/cables on both ends and installation of wire No. markers.

7. SPECIAL INSTALLATION INSTRUCTIONS

A. Wire or cable splices for control and instrumentation circuits shall not be accepted.

B. Do not install any control or instrumentation cable or wiring in same conduit or J-box with electrical power wiring, unless otherwise noted.

C. All 4-20MA signal cables shall be run complete without splice in minimum 3/4" conduit. These cables shall not be run in same conduit or through exterior pull boxes which contain power wiring.

END SECTION