SECTION 01025

MEASUREMENT AND PAYMENT

PART 1 - GENERAL

1.01 RELATED SECTIONS

A. Section 00410 – Bid Form

B. Section 00710 – General Conditions

C. Section 00715 – Supplementary Conditions

1.02 CONDITIONS FOR PAYMENT

A. The Owner will make payments for acceptable Work in place and materials properly stored on-site. The value of payment shall be as established on the approved construction schedule and Application for Payment, EXCEPT the Owner will retain a percent of the Work in place and a percentage as hereinafter listed for items properly stored or untested.

B. No payment will be made for stored materials unless an invoice from the supplier is attached to the pay request. Furthermore, no payment for stored materials will be made if the value of the stored materials does not exceed $1,000.00.

D. Allowable Payments

Equipment and Lump Sum Items: Payment for equipment and lump sum items will be based on the percent complete (as approved by the Engineer) at end of period for application for payment. Payment for equipment and lump sum items installed shall be limited to ninety five percent (95%) of their scheduled value until they are ready for operation, have been certified by manufacturer, and accepted by the Engineer. Ninety five percent (95%) payment shall be contingent on proper on-site storage and proper routine maintenance as recommended by manufacturer or Engineer.

1.03 CLAIMS FOR EXTRA WORK

A. If the Contractor claims that any instructions by Drawings or otherwise involve extra cost, he shall give the Engineer written notice of said claim within ten (10) days after the receipt of such instructions, and in any event before proceeding to execute the Work, stating clearly and in detail the basis of his claim or claims. No such claim shall be valid unless so made.

B. Claims for additional compensation for extra Work will not be recognized unless accompanied with supporting data clearly demonstrating the additional quantities, labor and time.

C. Any discrepancies which may be discovered between actual conditions and those represented by the maps and Drawings shall at once be reported to the Engineer, and Work shall not proceed, except at the Contractor's risk, until written instructions have been received by him from the Engineer.

1.04 DETERMINATION OF THE VALUE OF EXTRA (ADDITIONAL) OR OMITTED WORK

A. The value of extra (additional) or omitted Work shall be determined in one or more of the following ways:

1. On the basis of the actual cost of all the items of labor (including on-the-job supervision), materials and use of equipment plus a maximum of fifteen percent (15%) which shall cover the Contractor's and Subcontractor's general supervision, overhead and profit. The cost of labor shall include required insurance, taxes, and fringe benefits. Equipment costs shall be based on current rental rates in the areas where the Work is being performed, but in no case shall such costs be greater than the current rates published by the Associated Equipment Distributors, Chicago, Illinois.

2. By estimate and acceptance in a lump sum.

3. By unit prices named in the Contract or subsequently agreed upon.

B. Provided, however, that the cost or estimated cost of all extra (additional) Work shall be determined in advance of authorization by the Engineer and approved by the Owner.

C. All extra (additional) Work shall be executed under the conditions of the original Contract. Any claim for extension of time shall be adjusted according to the proportionate increase or decrease in the final total cost of the Work unless negotiated on another basis.

D. Except for overruns in Contract unit price items, no extra (additional) Work shall be done except upon a written Change Order from the Engineer, and no claim on the part of the Contractor for pay for extra (additional) Work shall be recognized unless so ordered in writing by the Engineer.

1.05 VALUE ENGINEERING

A. Value engineering is producing an equivalent or better option to that specified in the Contract at a lesser cost. The Owner may consider as a value engineering proposal any cost reduction that is initiated, developed, and submitted to the Owner. The Owner will share equally the net savings resulting from a value engineering proposal that is approved.

The Owner will only consider value engineering proposals that may potentially result in savings without impairing essential functions and characteristics in the facility. Essential functions and characteristics include, but are not limited to,

service, life, reliability, economy of operation, ease of maintenance, standardized features, safety, satisfaction of customer needs, desired ability, and special design requirements.

B. The Contractor shall formally submit, as a minimum, the following information to be reviewed for the value engineering proposal.

1. A statement that the proposal is submitted as a value engineering proposal.

2. A detailed description of the existing work and the proposed changes for performing the work. Include a discussion of the comparative advantages and disadvantages of each.

3. A statement of the time by which the Owner must execute an agreement adopting the proposal to obtain the maximum cost reduction during the remainder of the Contract, and the reasoning for this time schedule.

4. A complete set of Plans and construction details when necessary, showing proposed revisions to the original Contract prepared by a registered Professional Engineer licensed in the state of Kentucky.

5. A complete engineering analysis of the proposed changes prepared by a registered Professional Engineer licensed in the state of Kentucky. The analysis shall include sufficient detail and information to indicate that the proposal changes will perform or function in an equivalent of superior function to the existing design.

6. A detailed cost estimate for performing work under the existing Contract and under the proposed change. Include pay items, pay units, quantities, and unit prices. Include in the unit prices all costs for labor, materials, supplies, equipment tools, and all incidentals required for the complete incorporation of the option into the work.

7. A detailed cost estimate for costs other than those in the Contract, such as future construction, design, utilities, maintenance and operation costs, and the cost to prepare the value engineering proposal.

8. A prediction of any effects the proposed changes would have on Owner's costs, other than construction, such as maintenance and operating costs and life cycle costs.

9. A statement of the effect the proposal would have on the time for completion of the Contract.

The Engineer will review the formal proposal and, if acceptable, will execute a change order that incorporates the necessary Contract modifications. Unless and until the Owner executes a change order, perform all work according to the terms of the existing Contract. The Engineer reserves the right to include in the change order any conditions deemed appropriate for consideration, approval, and the implementation of the value engineering proposal.

The Engineer's approval of a value engineering proposal voids any restrictions that the Contractor had imposed on the use or disclosure of the information that the Contractor included in the value engineering proposal. The Owner and the Engineer then have the right to use, duplicate, and disclose in whole or in part, any data necessary to implement any portion of the proposal on this project and all other projects.

The Owner and the Engineer will not be liable for any delay in acting upon any value engineering proposal. The Owner and the Engineer will allow the withdrawal, in whole or in part, of any value engineering proposal that has not been accepted within the period specified with the proposal.

The decision of the Engineer to accept or reject a value engineering proposal will be final. The Engineer will make written notification of the decision to accept or reject each value engineering proposal submitted under the provisions of this section. The Owner reserves the right not to consider any value engineering proposal.

C. The Engineer will adjust the Contract completion time for any time savings realized by implementing a value engineering proposal. The Owner will not provide any incentive pay for early completion days resulting from a time savings related to an approved value engineering proposal. The Engineer will grant additional contract time when specified in the change order.

D. The Engineer will measure the net savings in cost by subtracting the estimated construction costs of the proposed and accepted option and all other costs associated with the option such as design, right-of-way, utilities, the cost of preparing the value engineering proposal, and the Engineering review costs form the estimated construction costs in original Contract for the option.

E. The Owner will make payment for 50 percent of the net savings in cost. The Owner will consider payment as full compensation for all work required under this section.

PART 2 - PRODUCTS

2.01 MOBILIZATION/DEMOBILIZATION

A. Measurement for payment shall be on the basis of a lump sum price. In no case shall the lump sum unit price exceed three (3.0%) of the total Bid amount.

B. This work consists of all costs incurred for moving/removing equipment and materials onto/from the Project area and any pertinent costs related thereto.

C. Payment will be made at 50% once the equipment is on-site and 50% after all equipment is removed from the site.

2.02 GENERAL CONDITIONS

A. Measurement for payment shall be on the basis of a lump sum price. In no case shall the lump sum unit price exceed two percent (2.0%) of the total Bid amount.

B. This work consists of insurance, performance, payment and warranty bonds, establishing temporary utilities, setting up field offices, constructing project sign, and any other items required under bidding requirements, contract forms, and conditions of the Contract.

C. Payment will be made as a percentage of the total project completed to date.

- END OF SECTION –

SECTION 02112

SITE CLEARING AND GRUBBING

PART 1 - GENERAL

1.01 SUMMARY

The Contractor shall furnish all labor, materials, and equipment necessary to perform all clearing, grubbing, and top soil removal in accordance with the Drawings and Specifications.

1.02 SUBMITTALS

There are no submittals required for this section.

1.03 REGULATORY COMPLIANCE

The Contractor shall conform to all applicable local, state, and federal codes and ordinances for disposal of debris.

PART 2 - PRODUCTS

2.01 EQUIPMENT

The equipment used for site clearing and grubbing will be of the Contractors option.

PART 3 - EXECUTION

3.01 SITE CLEARING

A. All trees, stumps, snags, shrubs, brush, saplings, and vines shall be cleared in the designated project area.

B. Necessary care shall be exercised by the Contractor when operating equipment near utility lines, structures, roadways, or other facilities in order to prevent damage. The Contractor will be responsible for all damages to such facilities that may occur.

C. Top soil shall be stockpiled and used to establish final grade lines.

3.02 GRUBBING

A. All stumps, roots, and root systems having a diameter of 1/2-inch diameter or larger shall be grubbed out to a depth of at least 18 inches below the surface in all designated areas. The depth shall be measured from the existing ground surface or the proposed finished grade, whichever is lower.

B. No debris shall be allowed to be left in the fill area.

3.03 DISPOSAL

A. All trees shall be removed from the fill sites to an area designated by the OWNER.

B. All other excess material from the clearing and grubbing operation shall be disposed of by the Contractor in a manner approved by the Engineer. The Contractor shall be responsible for determining and complying with all local ordinances relating to disposal and/or burning of clearing and grubbing material.

- END OF SECTION -

SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

The Contractor shall furnish all labor, materials, and equipment necessary for the construction of the areas requiring the Earthwork in accordance with the Drawings and Specifications. This includes hauling, placing, compacting, screening, crushing, processing, moisture addition, disking, scarification, and all other incidental items required in the work.

1.02 SUBMITTALS

There are no submittals required for this section.

1.03 TESTS

RESERVED

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. The equipment used for the earthwork will be of the Contractors option, unless otherwise called for herein. The equipment used shall have sufficient capabilities to produce a product meeting the desired final performance.

2.02 MATERIALS

A. The materials used for the structural fill and access road shall be crushed stone aggregate No. 9, or approved equal. Structural fill is any material placed to achieve subgrade elevation below concrete slabs, structures, and roadways. The material shall be clean and void of natural soil or other deleterious materials such as vegetation, roots, or other debris.

B. The material used for the vegetative layer shall be as designated or approved by the Engineer. The material shall be soil removed from the work site or imported from a designated borrow area. Material used from the work site shall be void of brush, tree limbs, waste or any other deleterious materials. The maximum rock size shall be two (2) inches in any dimension. The material shall have a maximum rock content of 20 percent. The final six (6) inches of the vegetative layer shall be topsoil as required in Section 02940.

PART 3 - EXECUTION

3.01 SUBGRADE PREPARATION

A. Areas to receive fill of overlying constructed materials shall be compacted.

B. The Contractor shall inform the Engineer or his representative prior to placement of material over the subgrade. The Engineer or his representative shall visually inspect the exposed surface to evaluate the suitability of the subgrade and ensure that the surface is properly compacted, smooth, uniform, and has positive surface drainage. No fill may be placed on the subgrade until approval from the Engineer has been received.

C. The Contractor shall remove any areas of the subgrade deemed to be soft. These areas shall be over-excavated to suitable material as approved by the Engineer or his representative. The excavated area shall be brought up to grade using compacted fill. There shall be no extra cost to the Owner to rework soft subgrade areas.

3.02 PLACEMENT OF FILL

A. The placement of the fill material shall be to the lines and grade as shown in the Drawings.

B. The Contractor shall inform the Engineer or his representative of the intent to perform work prior to the commencement of work. All work shall be performed in the presence of the Engineer or his representative.

C. Structural fill located under slabs, structures, and/or roadways shall be constructed in loose lifts not to exceed six (6) inches. Each lift shall be compacted. The layer shall be compacted to a density of 90 percent of maximum standard Proctor dry density.

D. The fill for the **vegetative layer** shall be constructed in loose lifts not to exceed six (6) inches. Each lift shall be compacted. The vegetative layer shall be compacted to a density of 90 percent of maximum standard Proctor dry density.

E. Compact each lift as required before depositing material for the next lift. Provide equipment that will satisfy the density requirements at all times. Run the hauling equipment, as much as possible, along the full width of the cross section.

F. Compaction of the fill may be tested by the Engineer using a nuclear density meter.

G. The Contractor shall remove any areas of the fill deemed to be unacceptable. These areas shall be over-excavated to suitable material as approved by the Engineer or his representative. The excavated area shall be brought up to grade using compacted fill as described previously and retested by the Engineer at the Contractor's expense.

H. The Contractor shall be responsible to rework any areas that are deemed unsuitable or unacceptable by the Engineer or his representative. The areas shall be reworked as previously discussed and then reinspected.

3.03 TOLERANCES

Top Surface of Fill Material: Plus or minus one-tenth (0.1) foot.

- END OF SECTION -

SECTION 02222

EXCAVATION

PART 1 - GENERAL

1.01 SUMMARY

The Contractor shall furnish all labor, materials, and equipment necessary for the unclassified excavation as shown on the Drawings.

1.02 RELATED SECTIONS

Section 02200 - Earthwork

1.03 SAFETY

A. Conform to all federal, state, and local codes and regulations regarding safety.

B. Protect excavations by shoring, bracing, sheet piling, underpinning, or other methods required to prevent cave-in or loose soil from falling into excavation.

C. Underpin adjacent structures which may be damaged by excavation work, including service utilities and pipe chases.

D. Notify Engineer of unexpected subsurface conditions and discontinue affected work in area until notified to resume work.

E. Protect bottom of excavations and soil adjacent to and beneath foundations from frost.

F. Grade excavation top perimeter to prevent surface water run-off into excavation.

G. Contractor shall provide ample means and devices with which to intercept any water entering the excavation area.

PART 2 - PRODUCTS

2.01 RESERVED

PART 3 – EXECUTION

3.01 CLASSIFICATION

Without regard to the materials encountered, all excavation is unclassified and the Owner will consider it Unclassified Excavation. Any reference to rock, earth, or any other material on the Drawings or cross sections, whether in numbers, words, letters, or lines, is solely for the Owner's information and is not an indication of classified excavation or the quantity of either rock, earth, or any other material involved. The Bidder must draw his own conclusions as to the conditions to be encountered. The Owner does not give any guarantee as to the accuracy of the data and will not consider

any claim for additional compensation when the materials encountered are not in accord with the classification shown.

3.02 EXCAVATION

All unclassified excavation shall be done in accordance with Section 204 – Roadway and Drainage Excavation in the Kentucky Transportation *Cabinet's Standard Specifications for Road and Bridge Construction*, Latest Edition.

3.03 DEWATERING

A. The Contractor, at his own expense, shall provide adequate facilities for promptly and continuously removing water from all excavation.

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

C. All water pumped or drained from the work shall be disposed of in a suitable manner without undue interference with other work, damage to pavements, other surfaces, or property. Suitable temporary pipes, flumes, or channels shall be provided for water that may flow along or across the site of the work.

D. If necessary, the Contractor shall dewater the excavations by means of an efficient drainage wellpoint system which will drain the soil and prevent saturated soil from flowing into the excavation. The wellpoints shall be designed especially for this type of service. The pumping unit shall be designed for use with the wellpoints, and shall be capable of maintaining a high vacuum and of handling large volumes of air and water at the same time.

E. The installation of the wellpoints and pump shall be done under the supervision of a competent representative of the manufacturer. The Contractor shall do all special work such as surrounding the wellpoints with sand or gravel or other work which is necessary for the wellpoint system to operate for the successful dewatering of the excavation.

3.04 UNAUTHORIZED EXCAVATION

If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled at the Contractor's expense with thoroughly compacted earth material in accordance with Section 02200, or with 4000 psi concrete, if the excavation was for a structure.

3.05 EXISTING UTILITIES AND OTHER OBSTRUCTIONS

Prior to the commencement of construction on the project, the Contractor shall contact the utility companies whose lines, above and below ground, may be affected during construction and verify the locations of the utilities as shown on the drawings. The

Contractor shall ascertain from said companies if he will be allowed to displace or alter, by necessity, those lines encountered or replace those lines disturbed by accident during construction, or if the companies themselves are only permitted by policy to perform such work. If the Contractor is permitted to perform such work, he shall leave the lines in as good condition as were originally encountered and complete the work as quickly as possible. All such lines or underground structures damaged or molested in the construction shall be replaced at the Contractor's expense, unless in the opinion of the Engineer, such damage was caused through no fault of the Contractor.

- END OF SECTION -

SECTION 02378

EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.01 SUMMARY

The Contractor shall furnish all labor, equipment, materials, and routine maintenance for the construction of temporary erosion and sediment control measures in accordance with the Drawings and Specifications, or as otherwise directed by the Engineer.

1.02 WORK INCLUDED

A. The Contractor shall not employ any construction method that violates a rule, regulation, guideline, or procedure established by federal, state, or local agencies having jurisdiction over the environment effect of construction.

B. The Contractor shall take all measures necessary to control soil erosion resulting from construction operations, shall prevent the flow of sediment from the construction site, and shall contain construction materials (including excavation and backfill) within his protected working area so as to prevent damage to wetlands and water courses.

C. Pollutants such as chemicals, fuels, lubricants, bitumen, raw sewage, and other harmful waste shall not be discharged into or alongside of any body of water or into natural or man-made channels leading thereto.

PART 2 - PRODUCTS

2.01 SILT FENCE

A. Silt fences shall be installed as shown on the Drawings, or as directed by the Engineer.

B. Material

Silt Fence filter fabric shall be specifically recommended for this purpose by the manufacturer and shall meet or exceed the following criteria:

Silt Fence Filter Fabric

Property	Conformance	Specification
Bursting Strength	ASTM D 751	150 psi
Grab Strength	ASTM D 1682	100 psi
Permeability		0.02 - 0.03 cm/sec

C. The silt fence shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six (6) months of expected usable construction life at a temperature range of 0°F to 120°F.

D. Posts for the silt fence shall be either 2-inch diameter wood or 1.33 pounds per linear foot steel with a minimum length of five (5) feet. The posts shall be set to sufficient depth to provide a sound anchor for the filter fabric. Steel posts shall have projectiles for fastening the silt fence.

2.02 ROCK CHECK DAM

A. Rock Check Dams shall be installed as shown on the Drawings, or as directed by the Engineer.

B. The Rock Check Dams shall be constructed of Class I channel lining.

C. The channel lining shall be clean, hard, durable limestone and meet the Specifications as set forth in Section 805 and Section 703 of the Kentucky Transportation Cabinet *Standard Specifications for Road and Bridge Construction*, latest edition.

D. The Rock Check Dams shall be shaped to the configuration shown in Rock Check Dam detail.

E. The Rock Check Dams shall have a maximum height of two (2) feet.

PART 3 - EXECUTION

3.01 GENERAL

A. All sediment and erosion control devices shall be installed prior to the initiation of site clearing and grubbing and/or excavation/construction to prevent sediment generated by the operation from escaping downstream of the work site.

B. The Contractor shall monitor and maintain all sediment and erosion control devices throughout the construction period.

3.02 METHODS OF CONSTRUCTION

A. The Contractor shall use any of the acceptable methods necessary to control soil erosion and prevent the flow of sediment to the maximum extent possible. These methods shall include, but not be limited to, the use of silt fences, rock checks, water diversion structures, diversion ditches, and settling basins.

B. Construction operations shall be restricted to the areas of Work indicated on the Drawings and to the area that must be entered for the construction of temporary or permanent facilities. The Engineer has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow, and

fill operations and to direct the Contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of wetlands and adjacent watercourses. Such Work may involve the construction of temporary berms, dikes, dams, sediment basins, slope drains, and use of temporary mulches, mats, or other control devices or methods as necessary to control erosion.

C. Excavated soil material shall not be placed adjacent to wetlands or watercourses in a manner that will cause it to be washed away by high water or runoff. Earth berms or diversions shall be constructed to intercept and divert runoff water away from critical areas. Diversion outlets shall be stable or shall be stabilized by means acceptable to the Engineer. If for any reason construction materials are washed away during the course of construction, the Contractor shall remove those materials from the fouled areas as directed by the Engineer.

D. For Work within easements or rights-of-way, all materials used in construction such as excavation, backfill, roadway, and pipe bedding and equipment shall be kept within the limits of these easements or rights-of-way.

E. The Contractor shall not pump silt-laden water from trenches or other excavation into wetlands, or adjacent watercourses. Instead, silt-laden water from his excavations shall be discharged within areas surrounded by sediment control measures or into sediment traps or ensure that only sediment-free water is returned to the watercourses. Damage to vegetation by excessive watering or silt accumulation in the discharge area shall be avoided.

F. Prohibited construction procedures include, but are not limited to, the following:

1. Dumping of spoil material into any streams, wetlands, surface waters, or unspecified locations.

2. Indiscriminate, arbitrary, or capricious operation of equipment in wetlands or surface waters.

3. Pumping of silt-laden water from trenches or excavations into surface waters, or wetlands.

4. Damaging vegetation adjacent to or outside of the construction area limits.

5. Disposal of trees, brush, debris, paints, chemicals, asphalt products, concrete curing compounds, fuels, lubricants, insecticides, washwater from concrete trucks or hydroseeders, or any other pollutant in wetlands, surface waters, or unspecified locations.

6. Permanent or unauthorized alteration of the flow line of any stream.

3.03 SILT FENCE INSTALLATION

A. The silt fence posts shall be installed six (6) to ten (10) feet apart on a slight angle toward the anticipated run-off source.

B. A trench four (4) to six (6) inches deep shall be dug along the uphill side of the

fence line.

C. The silt fence shall then be attached to the posts with a maximum height of three (3) feet.

D. The lower four (4) to six (6) inches of the silt fence shall be laid in the trench and curled toward the erosion source.

E. The trench shall then be backfilled with any available soil.

3.04 ROCK CHECK DAM

A. The stone for the rock check dam shall be placed in an orderly fashion and not dumped. Care shall be taken by the Contractor when placing the crushed stone on geotextiles as to not puncture the geotextile material during the installation process.

B. The rock check dam shall have a 5(horizontal) to 1(vertical), 5:1, slope on the upstream slope and a 2.5(horizontal) to 1(vertical), 2.5:1, slope on the downstream slope.

C. The maximum height of the rock check dam shall be two (2) feet.

D. A non-woven geotextile shall be installed on the upstream slope of the rock check dam for filtration purposes.

3.05 MAINTENANCE

All sediment and erosion control devices shall be maintained in a sound condition during the period of construction. Accumulations of silt, which may threaten their effectiveness, shall be removed. The sediment and erosion control devices shall be inspected after each storm event. Any required repairs shall be made promptly to insure the devices continue to function properly.

- END OF SECTION -

SECTION 02920

REVEGETATION

PART 1 - GENERAL

1.01 SUMMARY

The Contractor shall furnish all labor, materials, and equipment necessary to perform all temporary and permanent revegetation of the site in accordance with the Drawings and Specifications. All areas disturbed, including Borrow Areas, shall be revegetated.

1.02 SUBMITTALS

A. Contractor shall submit to Engineer information for the following materials:

1. Fertilizer
2. Lime
3. Seed
4. Mulch
5. Bituminous Materials for Mulch

PART 2 - PRODUCTS

2.01 EQUIPMENT

The equipment used for revegetation shall be of the Contractor's option.

2.02 MATERIALS

The materials utilized for revegetation shall meet the following requirements:

A. Topsoil. The topsoil shall be fertile, natural soil, typical of the locality, free from large stones, roots, sticks, peat, weeds, and sod, and obtained form naturally well drained areas. It shall not be excessively acid or alkaline nor contain other toxic material harmful to plant growth. Topsoil stockpiled from other operations on-site may be used, but the Contractor shall furnish additional topsoil at his own expense, if required.

B. Fertilizer. The Fertilizer shall be completed commercial fertilizer, 10-10-10 grade. It shall be delivered to the site in the original unopened containers each showing the manufacture's guarantee analysis, net weight, brand and grade, and name and address of manufacturer. The fertilizer shall be stored so that when used it shall be dry and free flowing.

C. Lime. Lime shall be agricultural ground limestone meeting the requirements as specified in Section 827 of the Kentucky Transportation Cabinet, *Standard Specifications for Road and Bridge Construction*, latest edition.

D. Seed. Seed shall be from the same or previous year's crop. All seed shall be capable of meeting the requirements for germination, purity, and weed content as specified in Section 827 of the Kentucky Transportation Cabinet, *Standard Specifications for Road and Bridge Construction*, latest edition. The appropriate seed mixture, as specified in the following table, shall be used on the prepared surface. Seed shall be applied at a minimum rate of 4 pounds per 1,000 square feet. Seed shall be delivered in sealed containers bearing the dealer's guaranteed analysis.

Seed Species	**Permanent Seed Mixtures Percent Content**
Kentucky 31 Fescue *Festuca arundinacea*	70 %
Creeping Red Fescue *Festuca ruba*	15 %
Red Top *Agrostis alba*	10 %
White Dutch Clover *Trifolium repens*	5 %

E. Mulch. Mulch materials shall consist of wheat, oat barley, or rye straw. The mulch shall not be musty, moldy, or otherwise of low quality. The use of mulch that contains noxious weeds shall not be allowed.

F. Bituminous Materials for Mulch. The bituminous materials for mulch shall meet the requirements as specified in Section 827 of the Kentucky Transportation Cabinet, *Standard Specifications for Road and Bridge Construction*, latest edition.

PART 3 - EXECUTION

3.01 APPLICATION RATES

A. Topsoil: Topsoil shall be placed to a minimum depth of three (3) inches on soil material and six (6) inches on rock material.

B. Fertilizer: Fertilizer shall be applied at the rate of two (2) tons per acre.

C. Lime: Lime shall be applied at the rate of six (6) tons per acre.

D. Seed: Seed shall be applied at a minimum rate of four (4) pounds per 1,000 square feet.

E. Mulch: Mulch shall be applied to a loose depth of two (2) inches, approximately two (2) tons per acre.

F. Bituminous Materials for Mulch: Bituminous material shall be applied at a rate of 250 gallons per acre.

3.02 INSTALLATION

A. The subgrade of all areas to receive topsoil and to be seeded shall be raked and all rubbish, sticks, roots, and stones larger than two (2) inches shall be removed. Topsoil shall be spread to a depth sufficiently greater than that of the final grade so that after natural settling and light rolling the completed grades, lines and elevations will conform to those shown in the Drawings. No topsoil shall be spread in water or while frozen or muddy.

B. After the topsoil has been spread, it shall be prepared by loosening the topsoil to a minimum depth of three (3) inches by rotary tools, discs, harrows, or other approved methods.

C. Lime and fertilizer shall be uniformly spread at the specified rate and immediately mixed into the full depth of the loosened topsoil.

D. Immediately following this presentation the seed shall be uniformly applied at the specified rate and lightly raked into the surface of the topsoil. Lightly roll the surface and water with fine spray.

E. 1. All seeded areas shall be mulched following seed placement. Bituminous treated mulch shall be spread on the area seeded in a uniform manner by equipment that will not appreciably cut or break the mulch. The Contractor shall heat the bituminous material during cool weather, or as directed by the Engineer, to insure uniform distribution.

2. The Contractor shall take all necessary precautions to not deface other structures with the bituminous materials. The Contractor shall be responsible to clean any other structure defaced by the bituminous materials as directed by the Engineer. This shall be done at the cost of the Contractor.

F. The Contractor shall keep all seeded areas watered and in good condition, reseeding if, and when necessary, until a good, healthy, uniform growth is established over the entire area seeded, and shall maintain these areas in an approved condition until one year after substantial completion of the project.

G. The Contractor shall maintain the areas in grass in a neat manner by watering, mowing, and raking clippings and leaves until the project is completed.

- END OF SECTION -

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. Provide all labor, material, equipment, and services to complete all cast-in-place concrete work stipulated by the project, shown on the Drawings, or as herein specified. Generally, the work is to include, but not limited to, the following:

1. Entire concrete work shown on the contract Drawings.
2. Steel reinforcement including welded wire fabric.
3. Exterior concrete pavements, walks, and concrete curbs.
4. Concrete accessories.
5. Openings, pockets, chases, blockouts required, or as shown on the Drawings.
6. Forming, finishing, curing, and patching.
7. Construction, control, and expansion joints.
8. Granular base course under floors and all exterior pavements as indicated.
9. Moisture barrier under floor slab as specified.
10. Sealing of construction joints, exterior concrete pavements, and walks.
11. Non-shrink grout, grout, and patching mortar.
12. Waterstops.

B. All work shall be performed to provide homogeneous concrete having required strength, durability, weather resistance, and watertight basins without any structural defects such as, but not limited to, planes of weakness, pronounced honeycombs, voids, and air pockets.

1.02 REFERENCES (Latest Editions)

A. ACI 211.1- Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete

B. ACI 301 – Standard Specifications for Structural Concrete

C. ACI 302 – Guide for Concrete Floor and Slab Construction

D. ACI 304 – Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete

E. ACI 305R – Hot Weather Concreting

F. ACI 306R – Cold Weather Concreting

G. ACI 308 – Standard Practice for Curing Concrete

H. ACI 311 – Recommended Practice for Concrete Inspection

I. ACI 315 – Details and Detailing of Concrete Reinforcement

J. ACI 318 – Building Code Requirements for Reinforced Concrete

K. ACI 350R – Environmental Engineering Concrete Structures

L. ASTM C33 – Concrete Aggregates

M. ASTM C94 - Ready-Mixed Concrete

N. ASTM C150 - Portland Cement

O. ASTM C260 - Air Entraining Admixtures for Concrete

P. ASTM C494 - Chemical Admixtures for Concrete

Q. ASTM C618 - Fly Ash and Raw or Calcinated Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete

R. ASTM C948 - Test Method for Dry and Wet Bulk Density, Water Absorption and Apparent Porosity of Thin Sections of Glass-Fiber-Reinforced Concrete

S. ASTM D994 - Preformed Expansion Joint Filler for Concrete (Bituminous Type)

T. ASTM D1190 - Concrete Joint Sealer, Hot-Poured Elastic Type

U. ASTM D1751 - Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)

V. ASTM D1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

W. ASTM E1155 – Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers

1.03 SUBMITTALS

A. Product Data

For each manufactured material and product utilized under this section including, but not limited to, aggregates, admixtures, method of adding admixtures, materials and method of curing, method of developing bond at joints, joint materials, waterstops, and vapor barriers.

B. Design Mixes

For each concrete mix indicated. 4,000 psi minimum design strength unless noted otherwise.

C. Shop Drawings

Include details of steel reinforcement placement including material, grade, bar schedules, stirrup spacing, bent bar diagrams, arrangement, and supports. Shop drawings to include the proposed construction and control joint locations.

D. Material Certificates

E. Testing agency to perform service required in ACI 301.

F. Laboratory tests on concrete.

G. If ready-mixed concrete is used, provide the following:

1. Physical capacity of mixing plant.
2. Trucking facilities available.
3. Estimated average amount which can be produced and delivered to the site during a normal 8-hour day excluding the output to other customers.
4. Delivery Tickets: Furnish copies of all delivery tickets for each load of concrete delivered to the site. Provide items of information as specified in ASTM C 94.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications

A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

B. Comply with ACI 301, "Specifications for Structural Concrete", including the following unless modified by the requirements of the Contract Documents.

1. General requirements including submittals, quality assurance, acceptance of structure, and protection of in-place concrete.

2. Formwork and form accessories.

3. Steel reinforcement and supports.

4. Concrete mixtures.

5. Handling, placing, and constructing concrete.

C. Conform to ACI 305R when concreting during hot weather.

D. Conform to ACI 306R when concreting during cold weather.

E. Acquire cement and aggregate from same source for all work.

F. Preinstallation Conference

Conduct conference at project site if requested by Owner.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Formwork

Furnish formwork and form accessories according to ACI 301.

B. Steel Reinforcement

1. Reinforcing Bars: ASTM A 615, Grade 60, deformed.

2. Dowel Bars: Dowel bars shall be plain steel bars conforming to ASTM A 615, Grade 60, and shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the construction site, a minimum of two-thirds of the length of each dowel bar shall be painted with one coat of zinc chromate. If plastic or epoxy-coated steel dowels are used no zinc chromate coating is required, except when specified for a particular situation on the contract plans. Coated dowels shall conform to the requirements given in AASHTO M 254. The sleeves for dowel bars used in expansion joints shall be metal, of an approved design to cover 2 to 3 inches of the dowel, with a closed end and with a suitable stop to hold the end of the bar at least 1 inch from the closed end of the sleeve. Sleeves shall be of such design that they will not collapse during construction.

3. Plain-Steel Tie Wire: ASTM A 82, as drawn.

4. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

5. Supports for Reinforcement: 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.

a. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.

b. For exposed-to-view concrete surfaces where legs of support are in contact with forms, provide supports with legs that are protected by plastic (CRSI, Class 1) or stainless steel (CRSI, Class 2).

C. Concrete Materials

1. Portland Cement: ASTM C 150, Type I or II. Air-entrained Portland cements shall not be utilized.

2. Normal-Weight Aggregate: ASTM C 33, uniformly graded, not exceeding 1½-inch nominal size for foundation mats, and not exceeding 3/4-inch for others.

3. Water: Complying with ASTM C 94.

D. Admixtures

1. Air-Entraining Admixture: ASTM C 260.

2. Water-Reducing Admixture: ASTM C 494, Type A.

3. High-Range, Water-Reducing Admixture (Superplasticizers): ASTM C 494, Type F.

4. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.

5. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

6. Fly Ash: ASTM C 618, Type F.

7. General

a. Submit method of adding mixtures.

b. All admixtures shall be approved by the cement manufacturer.

c. Use water-reducing admixture or high-range water-reducing admixture (superplasticizers), (ASTM C 494, type F) in concrete, as required, for placement and workability.

d. Use accelerating admixture in concrete slabs placed at ambient temperatures below 50°F.

e. Use high-range water-reducing admixture in pumped concrete, architectural concrete, concrete required to be watertight, and concrete with water-cement ratios below 0.50.

f. Use air-entraining admixture in exterior exposed concrete unless otherwise indicated. 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 minimum 1½ percent within the following limits:

(1) Concrete structures and slabs exposed to freezing and thawing; deicers, chemicals, or hydraulic pressure:

(1a) 4.5 percent (moderate exposure); 5.5 percent (severe exposure) for 1½-inch maximum aggregate.

(1b) 4.5 percent (moderate exposure); 6.0 percent (severe exposure) for 1-inch maximum aggregate.

(1c) 5.0 percent (moderate exposure); 6.0 percent (severe exposure) for ¾-inch maximum aggregate.

(1d) 5.5 percent (moderate exposure); 7.0 percent (severe exposure) for ½-inch maximum aggregate.

(2) Other concrete not exposed to freezing, thawing, or hydraulic pressure, or to receive a surface hardener: 2 to 4 percent.

(3) Air content of trowel-finished interior concrete floor shall not exceed 3.0 percent.

g. Use admixtures for water reduction and set accelerating or retarding in strict compliance with manufacturer's directions.

E. Form Materials

1. Forms for Exposed Finish Concrete

Plywood, metal, 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.

2. Forms for Unexposed Finish Concrete

Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.

3. Form Coatings

Provide commercial formulation form-coating compounds with a maximum VOC of 350 mg/L that will not bond with, stain, or adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces.

4. Form Ties

Factory-fabricated, adjustable length, removable, or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units that will leave no metal closer than 1½ inches to exposed surface.

F. Vapor Retarder

1. Multi-ply reinforced polyethylene sheet, ASTM E 1745, Class C, not less than 7.8 mils thick.

2. Fine-Graded Granular Material: Clean mixture of crushed stone, crushed gravel, and manufactured or natural sand; ASTM D 448, Size 10, with 100 percent passing a No. 4 sieve and 10 to 30 percent passing a No. 100 sieve; complying with deleterious substance limits of ASTM C 33 for fine aggregates.

G. Joint Filler Strip

ASTM D 1752; closed cell polyvinyl chloride or molded vinyl foam, resiliency recovery of 95 percent if not compressed more than 50 percent of original thickness. Asphalt impregnated fiberboard (ASTM D 1751) may be used with Engineer's approval.

H. Curing Materials

General curing and sealing compounds shall be clear such that the finished work maintain the concrete gray color without any noticeable discoloring.

1. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

2. Absorptive Cover: ASHTO M 182, Class 2, burlap cloth made from jute or kenaf.

3. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

4. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 209, Type 1, Class B, manufactured by Sonneborn, W.R. Meadow, The Euclid Chemical Company, or equal.

5. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound (Non-Yellowing): ASTM C 1315, Type 1, Class A, for concrete floors manufactured by Sonneborn, W.R. Meadow, The Euclid Chemical Company, or equal.

I. Concrete Construction Joint Sealants

Two-component, non-sag, polyurethane base, elastomeric sealants shall be utilized at all construction joints. Sealants shall perform properly under water submersion with no adverse chemical reactions. Joint sealants shall be Sikaflex-2C NS, manufactured by Sika Corporation, or equal. Primer shall be utilized where the joints are subjected to water submersion after cure, and other locations as instructed by the manufacturer. Installation shall be per manufacturer's instructions.

J. Self-Leveling Floor, Deck, and Sidewalk Joint sealant

1. One-part self-leveling polyurethane sealant for concrete floors, decks, sidewalks, and other horizontal contraction and expansion joints shall be Sonolastic SL1, complying with Federal Specification TT-S-0023oC, Type 1, Class A and ASTM C 920. Sealant shall be manufactured by Sonneborn or W.R. Grace Company or equal.

2. Sealant color shall be limestone or gray as selected by the Engineer unless otherwise required.

K. Joint Sealants and Backing for Sealant

1. For sealing vertical exposed faces of joint fillers, use Sonneborn-Contech Sonolastic NP1 or NP2 (one or two component urethane) or equivalent W.R. Grace Co. products, or equal. For water immersion, prime with Sonneborn-Contech Primer No.733 for concrete and masonry or Primer No. 758 for glass and metals or as required by manufacturers of equivalent acceptable sealants.

2. For sealing horizontal exposed faces of joint fillers, use Sonneborn-Contech Sonolastic SL1, one-part, self-leveling, polyurethane sealant with Primer No. 733 or equivalent W.R. Grace Co. products, or equal.

3. Where additional sealant backing is needed to control the depth of sealant in relation to joint width, use Sonneborn-Contech Sonoflex F foam expansion joint filler or Sonofoam Backer Rod (closed cell polyethylene foam) or equivalent W.R. Grace Co. products or equal.

L. Epoxy Bonding Agent

1. Provide an epoxy-resin bonding agent, two component, polysulfide type.

2. Product and Manufacturer - provide one of the following:

   a. Sikadur Hi-Mod LPL by Sika Corporation.

   b. Eucopoxy LPL by the Euclid Chemical Company, or equal.

M. Patching Mortar

Use free flowing, polymer modified cementitious mortar, "Euco Thin Coat, Concrete Coat" (horizontal repairs), "verticoat" (vertical and overhead repairs) by the Euclid Chemical Company or "Sikatop 121 or 122" (horizontal repairs), "Sikatop 123" (vertical and overhead repairs) by Sika Corp.

N. Waterstop

1. Watershops shall be Envirostop Retrofit 629 as manufactured by Westec or approved equal.

2. Waterstops shall be furnished in maximum lengths available to reduce the number of joints to the minimum.

3. Provide factory fabrications for all intersections, transitions, and changes of direction, leaving only straight butt joint splices for the field.

4. Swellable waterstops shall be as SikaSwell as manufactured by Sika or approved equal.

O. Construction Joint Devices

Integral galvanized steel, formed to tongue and groove profile, with removable top strip exposing sealant trough, knockout holes spaced at six (6) inches, ribbed steel spikes with tongue to fit top screed edge.

P. Non-Shrink Grout

Premixed compound consisting of non-metallic aggregate, cement, water-reducing and plasticizing agents; capable of developing minimum compressive strength of 2,400 psi in 48 hours and 7,000 psi in 28 days.

Q. Chemical Adhesive and Expansion Anchors

Chemical adhesive and expansion anchors shall be manufactures by Hilt, Corporation, and installed per manufacturer's instructions.

2.02 CONCRETE PROPORTIONING AND DESIGNING MIXES

A. Comply with ACI 301 requirements for concrete mixtures unless otherwise specified herein.

B. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use an independent testing agency acceptable to Engineer for preparing and reporting proposed mix design.

1. Do not use the same testing agency for field quality control testing.

2. Limit use of fly ash to not exceed 20 percent of cement content by weight.

C. 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 proposed mix designs have been reviewed.

D. Design mixes to provide normal weight concrete with the following properties:

1. 4000 psi, 28-day compressive strength; water-cement ratio, 0.44 maximum (non air-entrained), 0.35 maximum (air-entrained).

E. Water-Cement Ratio

Provide concrete for following conditions with maximum water-cement (W/C) ratios as follows:

1. Subjected to freezing and thawing: W/C 0.45.
2. Subjected to de-icers/watertight: W/C 0.40.
3. Subjected to brackish water, salt spray, or de-icers: W/C 0.40.

F. Slump Limits

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

1. Ramps, slabs, and sloping surfaces: Not more than three (3) inches.
2. Reinforced foundation system: Not less than one (1) inch and not more than three (3) inches.
3. Concrete containing high-range water-reducing admixture (superplasticizer): Not more than eight (8) inches after adding admixture to site-verified 2- to 3-inch clump concrete.
4. Other concrete: Not more than four (4) inches.

G. Adjustment to Concrete Mixes

Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Owner. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Owner before using in work.

H. Ready-Mixed Concrete (Comply with ASTM C 94)

When air temperature is between 85 and 95°F, reducing mixing and delivery time from 1½ hours to 75 minutes; when air temperature is above 90°F, reduce mixing and delivery time to 60 minutes.

I. Provide batch ticket for each batch discharged and used in the work, indicating project identification name and number, date, mix type, mix time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 – EXECUTION

3.01 INSTALLATION, GENERAL

A. Examination

1. Verify site conditions.

2. Verify requirements for concrete cover over reinforcement. Where not shown, use minimum as specified in ACI 318 and ACI 35 or whichever is deeper.

3. Verify that anchors, plates, reinforcements, and other items to be cast into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete.

B. Formwork

Design, construct, erect, shore, brace, and maintain formwork according to ACI 301.

C. Vapor Retarder

1. Install, protect, and repair vapor retarder sheets according to ASTM E 1643. Place sheets in position with longest dimensional parallel with direction of pour.

2. Lap joints six (6) inches and seal with manufacturer's recommended tape.

3. Cover vapor retarder with fine-graded granular material, moisten, and compact with mechanical equipment to elevation tolerances of plus 0 inch or minimum 3/4-inch.

D. Steel Reinforcement

1. Comply with ACI 315 and CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

2. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

E. Joints

1. Construct joints true to line with faces perpendicular to surface plane of concrete.

2. Construction Joints: Locate and install so as not to impair strength or appearance of concrete at locations indicated on the reviewed shop drawings. Any deviation from the shop drawings shall be approved by Engineer.

3. Isolation Joints: Install joint-filler strips at junctions with slabs-on-grade and vertical surfaces such as column pedestals, foundation walls, and other locations as indicated.

   a. Extend joint fillers full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated or where joint sealants are specified. Keep top of joint filler ½ inch lower than with finished concrete surface.

4. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated unless otherwise is shown. Construct contraction joints, where shown, for a depth equal to at least one-fourth of the concrete thickness, as follows:

   a. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with groover tool to a radium of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.

   b. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into 1/4-inch depth of slab thickness when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

F. Tolerances

Comply with ACI 117, "Specifications for Tolerances for Concrete Construction and Materials".

G. Preparation

1. Prepare previously placed concrete by cleaning with steel brush and applying epoxy bonding agent in accordance with manufacturer's instructions.

2. Coordinate the placement of joint devices with erection of concrete formwork and placement of form accessories.

3.02 CONCRETE PLACEMENT

A. Comply with recommendations in ACI 304 R for measuring, mixing, transporting, and placing concrete.

B. Do not add water to concrete during delivery at project site or during placement.

C. Consolidate concrete with mechanical vibrating equipment.

D. Notify Owner a minimum of 24 hours prior to commencement of operations.

E. Ensure reinforcement, inserts, embedded parts, and formed construction and contraction joints are not disturbed during concrete placement.

F. Separate slabs on grade from vertical surface with 1/4 to 3/8-inch joint filler unless otherwise indicated.

G. Extend joint filler from bottom of slab to within about 1/2 inch of finished slab surface. Conform to finish joint sealer manufacturer's requirements.

H. Install preformed metal tongue and groove joint devices, if used, in accordance with manufacturer's instructions.

I. Apply sealants in joint devices in accordance with manufacturer's guidelines.

J. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

K. Place concrete continuously between predetermined expansion, control, and construction joints.

L. Do not interrupt successive placement; do not permit cold joints to occur.

M. Provide 3/4-inch chamfers as exposed edges of concrete.

N. Allow a minimum of three (3) days before placing concrete against a new slab or wall already in place.

O. All embedded aluminum materials in concrete shall be coated as specified.

P. Screed floors in accordance to ASTM E 1155 with slab-on-grade floor utilizing flatness (F_F), SOV = 25, MLV = 17, and floor levelness (F_L), SOV = 20, MLV = 15. For elevated floor utilizing flatness (F_F), SOV = 30, MLV = 24, and floor levelness (F_L), SOV = 20, MLV = 15. Measuring the levelness of elevated floors shall be while the shoring is in place. ACI 302.1R includes a construction guide on how to achieve these flatness and levelness values.

3.03 FINISHING FORMED SURFACES

A. Rough-Formed Finish

1. As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched, and fins and other projections exceeding 1/4- inch in height rubbed down or chipped off.

2. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish

1. As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and

patch tie holes and defective areas. Completely remove fins and other projections.

2. Apply to concrete surfaces exposed to public view or to be covered with a coating or covering material applied directly to concrete, such as waterproofing, dampproofing, veneer plaster, or painting. "Concrete surfaces exposed to public view" shall include inside walls and floors of water holding basins except for covered clearwells and covered pump station wet wells.

3. Apply smooth-rubbed finish, defined in ACI 301, to smooth-formed finished concrete.

C. Related Unformed Surfaces

At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off 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.

3.04 FINISHING UNFORMED SURFACES

A. General

Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Screed surfaces with a straight-edge and strike off. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane before excess moisture or bleedwater appears on the surface.

1. Do not further disturb surfaces before starting finishing operations.

C. Scratch Finish

Apply scratch finish to surfaces to receive concrete floor topping or mortar setting beds for ceramic or quarry tile, portland cement terrazzo, and other bonded cementitious floor finish unless other indicated.

D. Float Finish

Apply float finish to surfaces to receive trowel finish and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo, or any other surfaces not specified.

E. Trowel Finish

Apply a hard trowel finish to floor and slab surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin film-finish coating system.

F. Trowel and Fine-Broom Finish

Apply a partial trowel finish, stopping after second troweling, to surfaces indicated and to surfaces where ceramic or quarry tile is to be installed by either thickset or thin-set methods. Immediately after second troweling, and when concrete is still plastic, slightly scarify surface with a fine broom.

G. Nonslip Broom Finish

Apply a nonslip broom finish to exterior concrete platforms, steps, sidewalks, and ramps. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.

H. Floor Drains

In areas with floor drains, maintain floor elevations at walls; slope surfaces uniformly to drains at 1:100 minimum, but not less than shown on the Drawings.

3.05 CONCRETE PROTECTION AND CURING

A. General

Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection, and follow recommendations in ACI 305R for hot-weather protection during curing.

B. Evaporation Retarder

Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions occur before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Begin curing after finishing concrete, but not before free water has disappeared from concrete surface.

D. Cure formed and unformed concrete in accordance with ACI 301 and ACI 308, and for at least seven (7) days as follows:

1. Moisture-Retaining Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

2. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three (3) hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.06 FIELD QUALITY CONTROL

A. Testing Agency

Contractor shall engage a qualified independent testing and inspecting agency, acceptable to the Owner, to sample materials, perform tests, and submit test reports during concrete placement. All testing costs shall be borne by the Contractor. Tests will be performed according to ACI 301 except as modified herein. Contractor shall provide testing services for qualification of proposed materials and establishment of design mixture.

B. Provide free access to work and cooperate with appointed testing agency.

C. Submit proposed mix design of each class of concrete to testing firm and Engineer for review prior to commencement of work.

D. Tests of cement and aggregates may be performed to ensure conformance with specified requirements.

E. Contractor shall have a minimum of four (4) concrete cylinders taken for every 25 c.y. of concrete or discreet concrete delivery should the amount be less than 25 c.y. even though placement may be at multiple locations. Cylinders shall be submitted to independent laboratory for testing of strength by breaking at 7 days, 14 days, and 28 days by the testing agency. Additional cylinders may be taken as deemed necessary by the Engineer and all costs shall be borne by Contractor. Cylinders shall be cured on-site in same condition as poured concrete.

F. One additional test cylinder will be taken during cold weather concreting, cured on job site under same conditions as concrete it represents.

G. One slump test will be taken for each set of test cylinders taken.

H. All concrete for liquid retaining structures, and all concrete in contact with earth, water, or exposed directly to the elements shall be watertight and shall be tested for leakage in accordance with ACI 3350R.

3.07 PATCHING

A. Allow inspection of concrete surfaces immediately upon removal of forms.

B. Excessive honeycomb or embedded debris in concrete is not acceptable. Notify Owner upon discovery.

C. Patch imperfections in accordance with ACI 301.

3.08 DEFECTIVE CONCRETE

A. Defective Concrete

Concrete not conforming to required lines, details, dimensions, tolerances, or specified requirements.

B. Repair or replacement of defective concrete will be determined by the Owner.

C. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Owner for each individual area.

3.09 SCHEDULE – CONCRETE TYPES

A. Below grade footings: 4000 psi.

B. Thrust blocks: 3500 psi.

C. Curbing: 4000 psi.

D. All other concrete: 4000 psi.

- END OF SECTION -

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) Emergency power system equipment and distribution circuits.

E. Each CONTRACTOR bidding on the work included in these Specifications shall visit 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**
Generator, Transfer Switches and Control Systems	4	4

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.

F. Electronic (PDF) Submittals

Submittals sent electronically shall have a cover sheet with all information as noted in items B. and C. above. Each separate section, i.e. 16120, 16155, etc., shall have a separate cover sheet for the sections submitted. All items covered in a separate section of specs, i.e. 16510, shall be combined within a single PDF submittal file for that section (i.e. Do not submit 5 separate PDF files for 5 different light fixtures). Do not combine Division 16 electronic submittals with submittals of a different division. Submittals/sections without cover sheets and without information as listed in 1.14, B. above will not be reviewed and returned for resubmittal.

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/out to a junction box for future connections and extensions.

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

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, 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 buildings 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.

1.4 SUBMITTALS

A. Submit manufacturer's product data on all power and signal cable.

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 power 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 their respective system control panels. 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 non-metallic 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 and 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 required, seismic restraints shall be provided for electrical equipment.

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.

C. Acceptable manufacturers offering products complying with requirements:

Square D

GE

Cutler-Hammer

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.

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 and spare fuse cabinet.

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 (3 fuses) for each different size, type and class. A spare fuse cabinet, Bussmann type SFC or equal, shall be provided and installed as directed by owner..

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 16190 – SYSTEM SHORT CIRCUIT COORDINATION STUDY & ARC FLASH ANALYSIS

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. The work covered under this Section shall include this Contractor providing an engineering analysis and coordination study for the electrical distribution system, The analysis shall include a short circuit analysis with protective device evaluation, a protective device coordination study arc-flash hazard analysis.

B. The project shall begin at the point of utility service for the facility, through the Main switch/switchboard/motor control center (MCC) and continue down through the system, to all downstream 480 volt and 240 volt distribution and branch circuit panelboards and other motor control centers and distribution panels.

C. The project shall include generators and any associated emergency power distribution equipment, including automatic transfer switches and generator ground fault protection, if equipped.

1.3 QUALITY ASSURANCE

A. The short-circuit /coordination studies and arc-flash hazard analysis shall be conducted by personnel with a minimum of five (5) years experience who is skilled in performing and interpreting power system studies and who is a full-time employee of a firm experienced in the analysis, evaluation, and coordination of electrical distribution systems, similar to the system for this project. The firm/company must have at a minimum four (4) year record of successful in-service performance.

B. The studies shall be prepared in accordance with the latest edition of NETA Std. ATS, NFPA 70B, the "National Electrical Code", ANSI C2 "National Electrical Safety Code", and ANSI/IEEE Guidelines, as well as manufacturer's recommendations.

1.4 SUBMITTALS

A. Submittals are required in accordance with SECTION 16000 of these specifications.

B. The short-circuit and protective device coordination studies shall be submitted to this project's Design Engineer of record prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If completion of the studies may cause delay

in equipment manufacturing, approval from the Design Engineer of record may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory. Generally, shop drawing submittals for equipment effected by the coordination study will not be reviewed until the short-circuit/coordination study has been submitted and successfully reviewed.

C. The results of the short-circuit, protective device coordination, and arc-flash hazard analysis studies shall be summarized in a final report. Submit bound copies of the final report with tabbed sections, in the quantities required. Additional copies, where required, shall be provided in PDF format.

D. The report shall include, but not be limited to, the following sections:

1. One-line diagram showing protective device ampere ratings and associated designations, cable size & lengths, transformer kVA and voltage ratings, motor and generator kVA ratings, switchboard and panelboard designations.

2. Descriptions, purpose, basis and scope of the study.

3. Tabulations of the worst-case calculated short circuit duties as a percentage of the applied device rating (automatic transfer switches, circuit breakers, fuses, etc.); the short circuit duties shall be upward adjusted for X/R ratios that are above the device design ratings.

4. Protective device time versus current coordination curves with associated one line diagram identifying the plotted devices, tabulations of ANSI protective relay functions and adjustable circuit breaker trip unit settings.

5. Fault study input data, case descriptions, and current calculations including a definition of terms and guide for interpretation of the computer printout.

6. Details of the incident energy and flash protection boundary calculations.

7. Sample of an arc-flash hazard warning label.

8. Comments and recommendations for system improvements, where needed, including extending of feeder or other conductors necessary to lower the fault-current to an acceptable level.

2.1 STUDY AND ANALYSIS

A. Contractor shall furnish short-circuit and protective device coordination studies as prepared by the electrical distribution equipment manufacturer or an approved engineering firm.

B. Contractor shall furnish an Arc-Flash Hazard Analysis Study performed in compliance with the latest edition of IEEE Standard 1584 – "IEEE Guide for Performing Arc-Flash Hazard Calculations" and per NFPA 70E – "Standard for Electrical Safety in the Workplace", reference Article 130.3 and Annex D, prepared by the electrical distribution equipment manufacturer or an approved engineering firm.

2.2 DATA COLLECTION

A. Contractor shall furnish all field data as required by the power system studies and arc-flash hazard analysis. The Study Preparer shall furnish the Contractor with a listing of required data. The Contractor shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source contribution may include present and future utility supply, motors, and generators.

C. Load data utilized may include existing and proposed loads.

D. Include fault contribution of new/existing motors in the study.

2.3 SHORT-CIRCUIT ANALYSIS WITH PROTECTIVE DEVICE EVALUATION

A. Systematically calculate fault currents based on the available fault current at the facility service entrance. Study preparer shall obtain the available fault current from the local utility.

B. Short-circuit calculations shall be prepared by means of a digital computer utilizing a commercially available software package. Motor contribution shall be incorporated in determining fault levels. Results of short-circuit calculations shall be presented in tabular form and shall include momentary and interrupting fault values for three-phase and phase-to-ground faults.

C. Analyze the short-circuit currents by preparing a tabulation comparing the fault levels to the device interrupting ratings. Indicate areas in which integrated/series ratings are utilized. The following information shall be included in the tabulation:

1. Bus identification number.
2. Location identification.
3. Voltage
4. Manufacturer and type of equipment.
5. Device rating.
6. Calculated short-circuit current.

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Prepare coordination time-current characteristic curves to determine the required settings/sizes of the protective devices to maximize selectivity. The utility upstream protective device feeding the facility shall be maintained as the upper limit for coordination. These settings shall be obtained by the preparer, along with any other protective device setting requirements. The coordination curves shall be prepared on log-log paper and illustrate adequate clearing times between series devices. The curves shall be created through the use of the study software package, but must reflect actual protective devices to be installed. Adequate time-current curves shall be generated to depict coordination. In addition, protective device characteristics shall be suitably determined to reflect calculated short-circuit levels at the location.

B. A narrative analysis shall accompany each coordination curve sheet and describe the coordination and protection in explicit detail. All curve sheets shall be multi-color for improved clarity. Areas lacking complete coordination shall be

highlighted and reasons provided for allowing condition to remain or provide solution to resolve situation. The following information shall be provided on all curve sheets:

1. Device identification and associated settings/size.
2. Voltage at which curves are plotted.
3. Current multiplier.
4. ANSI frequent fault damage curve.
5. Cable insulation damage curves.
6. Transformer inrush point.
7. Single-line for the portion of the system.
8. Motor starting profiles (where applicable).

2.5 ARC-FLASH HAZARD ANALYSIS

A. The Arc-Flash Hazard Analysis shall be performed by a computer aided circuit simulation of the distribution system specific to this project. These calculations shall determine the Arc-Flash Incident Energy (AFIE) levels and flash protection boundary distances. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, panelboards, busway, generators, automatic transfer switches, and motor-control centers) where work could be performed on energized parts.

B. The Arc-Flash Hazard Analysis shall be performed in conjunction with the Short-Circuit/Coordination Study.

C. Results of the analysis shall be submitted in tabular form and shall include as a minimum the bus name, bolted fault current and arcing fault current level, flash protection boundary distances, personal protective equipment (PPE) hazard risk category and the AFIE levels.

D. The analysis shall be performed under worst-case Arc-Flash conditions, and the final report shall describe the worst-case conditions when different from worstcase bolted fault conditions.

D. Arc-Flash Warning Labels:

1. The Contractor of the Arc-Flash Hazard analysis shall provide Arc-Flash Warning labels for all electrical equipment that may be opened or accessed while energized. Labels shall be minimum 3.5 inch x 5 inch thermal transfer type of high adhesion polyester. Labels shall be machine printed, with no field markings.

2. All labels shall be based on recommended overcurrent device settings and shall be provided after the results of the analysis have been presented to the Owner and after any system changes, upgrades or modifications have been incorporated in the system. The labels shall identify the flash protection boundary, the arc-flash incident energy (AFIE) level, working distances, required personal protective equipment (PPE) hazard risk category, nominal voltage, and engineering report number, revision number and issue date.

2.6 SINGLE-LINE DIAGRAM

A. The final report shall include a multi-color single-line diagram of the electrical distribution system within the scope of the project. The single-line shall include:

1. Transformer rating, voltage ratio, impedance, and winding connection.

2. Feeder cable phase, neutral and ground sizes, length of cable, conductor material, and conduit size and type.

3. Switchgear, switchboards, panelboards, MCC's, fuses, circuit breakers, ATS's and switches continuous current ratings.

4. Protective relays with appropriate device numbers and CT's and PT's with associated ratios.

5. Detailed legend indicating device type identification and other significant details.

3.1 SUMMARY

A. The results of the system studies shall be summarized in a final report. One "as-built" copy shall be posted in each main electric room.

3.2 FIELD SETTINGS AND ADJUSTMENTS

A. This Contractor shall engage the equipment manufacturer's service group or alternately a qualified independent testing firm to perform field adjustments of the protective devices as required for placing the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study and protective device evaluation/coordination study.

B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with the approved short-circuit and protective device coordination study, shall be carried out by the equipment manufacturer's service group or qualified independent testing firm

C. Notify Owner in writing of any required major equipment modifications.

D. Major additions, deletions, upgrades or modifications to any part of the electrical distribution system will require re-calculation of the studies and analysis' for the portions of the system that has been changed from the original studies. These re-calculations shall be completed by the same engineer or firm that did the original studies, at no additional cost to the Owner.

3.3 ARC-FLASH WARNING LABELS

A. Apply arc-flash warning labels to equipment. The labels shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

3.4 ARC-FLASH TRAINING

A. The supplier of the Arc-Flash Hazard Analysis shall train the Owner's qualified electrical personnel of the potential arc-flash hazards associated with working on energized equipment (minimum of 3 hours).

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

D. Duct Seal

(1) All underground power and signal service raceways entering building/structures and pull boxes shall be sealed in accordance with the requirements of NEC 230.8 and 300.5(G). Empty 'future use' raceways shall also be sealed.

(2) Sealing compound shall be Hubbell type DSC 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 16301 - VAULTS, MANHOLES AND HANDHOLES

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 this Section.

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 necessary to provide only those units which are used for installation of electrical cable, wire and equipment.

B. Types of vaults, manholes, and handholes required may include, but are not necessarily limited to, the following:

Utility Vaults
Junction Boxes
Pull Boxes
Transformer pads
Splice boxes

3. QUALITY ASSURANCE

A. Excavation and backfilling for vaults, manholes and handholes are specified in Electrical General Provisions sections.

B. Concrete for vaults, manholes, and handholes is specified in Electrical General Provisions sections.

C. Comply with applicable Division 7 sections for waterproofing and dampproofing of vaults, manholes and handholes.

D. ASTM Compliance: Comply with applicable provisions of American Society for Testing and Materials (ASTM) standards pertaining to concrete materials in vaults, manholes and handholes.

E. Comply with NEC 314.30.

F. Comply with ANSI/SCTE 77 testing requirements.

4. SUBMITTALS

A. Submit prefabricator's data on factory-fabricated vaults, manholes and handholes.

B. Submit manufacturer's data on vault, manhole and handhole components (covers, steps, pulling irons, etc.) and specialty products.

5. MATERIALS

A. **Field-Fabricated Units:**

(1) Concrete Vaults and Manholes: Concrete Materials: Comply with Electrical General Provision sections for applicable product requirements of concrete materials, except

as otherwise indicated.

(2) Concrete Masonry Units: ASTM C 139.

(3) Masonry Mortar: ASTM C 270, Type M.

a. For minor amounts of mortar, comprising less than 2.0 cu. ft., packaged mortar materials complying with ASTM C 387 may be substituted at Contractor's option.

(4) Manhole Frames and Covers:

a. Grey cast iron, ASTM A 48, Class 30B.

b. Comply with requirements of FS RR-F-621 for type and style indicated.

c. Furnish covers with cast-in legend "ELECTRIC" on roadway face.

(5) Vault and Manhole Steps:

a. Grey cast iron, ASTM A 48, Class 30B, integrally cast into vault and manhole sidewalls, unless otherwise indicated or except for shallow vaults and manholes.

B. **Factory-Fabricated Units**

a. Concrete Vaults and Manholes: Provide watertight precast concrete vaults and manholes in types and sizes indicated, with access knockouts for conduit or cable, cast iron manhole access cover and frame with machined bearing surfaces, suitable for street loading, with pulling/lift irons, sump/drainage box and bolting inserts. Provide reinforced concrete for vaults and manholes. Provide vault, manhole and handhole accessories, including mastics, sealants, cable support brackets, and manhole/vault ladders as recommended by fabricator

b. Handholes: Provide handholes and boxes, for pulling, splicing and terminating conductors, in types and sizes indicated, with watertight cover and penta-head bolts, knockout access holes, and base equipped with sump/drainage box for large units; as follows:

c. Concrete body with cast iron cover and ring.

b. Polymer/fiberglass reinforced concrete body and cover. Construct structure of polymer concrete suitable for burial below grade. Material shall be stable for all temperatures from -50 degrees through 250 degrees F. Cover of like material shall be furnished capable of supporting 5000# evenly distributed on any 10" x 10" area. Secure cover with stainless steel hardware provided with unit. Install manhole top at grade level and set base on 8" of tamped #6 crushed stone. Crushed stone base shall extend under full area of manhole and 12" beyond its outer perimeter. Strongwell-Quazite or approved equal.

(3) Exterior Pull Boxes

a. Provide and install pull boxes. Furnish covers with "electric" logo.

Enclosures and covers shall be concrete gray color and rated for Tier 15. Material compressive strength shall be min. 11000PSI. Constructed of fiberglass reinforced concrete and shall permit installation flush with grade. Boxes shall be stackable for extra depth.

b. Boxes shall be Strongwell quazite composolite "PG" style with bolt down covers.

c. Enclosures, boxes and covers are required to conform to all test provisions of the most current ANSI/SCTE 77 "Specification For Underground Enclosure Integrity" for Tier15 applications. When multiple "Tiers" are specified the boxes must physically accommodate and structurally support compatible covers while possessing the highest Tier rating. All covers are required to have the Tier level rating embossed on the surface. In no assembly can the cover design load exceed the design load of the box. Independent third party verification or test reports stamped by a registered Professional Engineer certifying that all test provisions of this specification have been met are required with each submittal.

(4) Provide vault, manhole and handhole accessories, including mastics, sealants, cable support brackets, and manhole/vault ladders as recommended by fabricator.

6. INSTALLATION

A. Field Fabricated Units

(1) General: Fabricate vaults, manholes, and handholes, of type and size indicated, watertight, equipped with manhole metal access cover, steps, access holes for conduit or cable, sump/drainage box and bolting inserts.

(2) Masonry Construction Manholes:

a. Use concrete masonry units to construct masonry manholes and vaults.

b. Mix mortar with only enough water for workability. Reterpering of mortar is not permitted. Keep mortar mixing and conveying equipment clean. Do not deposit mortar upon, or permit contact with, the ground.

c. Lay masonry in mortar to form full-bed joints, with end and side joints formed in one operation, and with bed and vertical joints not more than 5/8" wide. Protect fresh masonry from freezing and from too rapid freezing and from too rapid drying.

d. Apply a 1/2" thick mortar coating on both interior and exterior wall surfaces.

e. Where manholes occur in pavements, set tops of frames and covers flush with finish surface. Elsewhere, set tops 3" above finish surface, unless otherwise indicated.

f. Use an epoxy bonding compound where manhole steps are mortared into masonry walls.

(3) Cast-In-Place Concrete Manholes:

a. Use cast-in-place concrete to construct manholes and vaults.

b. Set cast iron frames and covers to elevations indicated, and cast-in-place.

c. Coordinate damp-proofing and waterproofing work with installation of field-fabricated units, as necessary, for proper interface.

d. Install damp-proofing and waterproofing materials as indicated.

B. **Factory-Fabricated Units**

(1) General: Install vaults, manholes, and handholes in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that vaults, manholes and handholes comply with requirements and serve their intended purpose.

(2) Precast Concrete Units

a. Place precast concrete sections as indicated on Drawings. Where units occur in pavements, set tops of frames and covers flush with finish surface, unless otherwise indicated. Use epoxy bonding compound where steps are mortared into unit walls.

b. Install rubber joint gasket, complying with ASTM C 433, at joints between sections.

c. Apply bituminous mastic coating at joints between sections.

d. Coordinate damp-proofing and waterproofing work with installation of precast concrete units, as necessary as proper interface.

e. Install damp-proofing and waterproofing materials as indicated.

f. Delay backfilling of excavations surrounding vaults, manholes and handholes until after initial inspection has been completed.

g. Equip and protect factory-fabricated vaults, manholes and handholes to prevent damage, including chipping and cracking during transportation, storage and handling. Do not install damaged units; remove from project site.

7. SPECIAL INSTALLATION INSTRUCTIONS

A. All power and control circuits for this project shall be run complete and without splice from source to load/control point due to sites flood plain location. Furnish and install duct seal at all cable entry/exits from grade level pull boxes.

END SECTION

SECTION 16440 - SERVICE 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.

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 necessary for proper and complete installation of service equipment.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA No. 70) as applicable to construction and installation of service equipment.

B. Provide service equipment which has been listed and labeled by Underwriters Laboratories and comply with UL 869.

4. SUBMITTALS

A. Submit manufacturer's data on service equipment.

B. Submit dimensioned drawings of service equipment indicating accurately scaled basic sections including, but not necessarily limited to, auxiliary compartments, section components, and combination sections.

5. EQUIPMENT

A. General Requirements

(1) Service equipment shall consist of a service disconnect. All switches and circuit breakers used for service entrance disconnecting means shall be Underwriters Laboratories approved for use as service equipment by complying with UL Standard 869. If disconnecting device does not interrupt grounded conductor as well as ungrounded conductors, include provision in service entrance enclosure for disconnecting grounded conductor from interior wiring. Provide each service entrance equipment enclosure with an equipment ground bar suitably brazed to housing wall. Ground bar shall be equivalent in current carrying capacity to outgoing feeder ground conductor and shall be arranged for capacity to outgoing feeder ground conductor and shall be arranged for brazed or approved pressure connector terminations of related feeder ground conductors. Ground bar shall be suitable interconnected with related insulated neutral bar or stud to establish system common ground point. All service entrance disconnecting devices shall conform to local codes and utility requirements. Provide two complete sets of fuses for all switches requiring fuses.

(2) Unless otherwise noted, molded case circuit breakers used as service equipment shall have an interrupting current rating equal to or greater than the available fault current at their locations in the electrical system. Circuit breaker shall be of the ambient compensated type.

(3) Where available short circuit current exceeds interrupting ratings of molded case circuit breakers, provide circuit breaker with integral current limiters. This circuit breaker and limiter combination shall be a coordinated unit so designed that normal thermal magnetic overcurrent devices provide coordinated protection against overloads and short circuits up to a predetermined value. At this point current

limiters shall assume fault-clearing duty and extend short circuit protection up to and including 100,000 RMS amperes, as required. Unless magnitude of short circuit reaches cross-over point, limiters shall be unaffected and standard long time delay overcurrent devices of circuit breaker shall perform their normal functions. Mount limiters in a molded housing which shall plug into load side of circuit breaker. Provide two sets of current limiters for each combination circuit breaker.

(4) Provide ground-fault protective equipment on any 480y/277 volt service, and on any 150 to 600 volt service of 1,000 amperes or more, to detect and interrupt low values of ground current and be independent of phase-to phase currents. Keep operating time to a minimum to prevent extensive damage to protected apparatus. Coordinate ground-fault equipment with downstream overcurrent devices to prevent nuisance trippings.

B. **Service Disconnect**

(1) Disconnecting device shall be either a safety switch or a circuit breaker. Circuit breakers shall meet requirements as specified above. Mount switches in NEMA Type 12 enclosure unless otherwise specified. Boxes exposed to weather shall be NEMA 4 type. Current and voltage ratings shall be as indicated on drawings.

(2) Provide fuses of adequate interrupting capacity for switches. Size of fuses shall be as indicated on Drawings. Interlock switch doors with switch handle so that door cannot be opened when switch is "closed".

6. **INSTALLATION**

A. Deliver service equipment wrapped in factory- fabricated containers and mounted on shipping skids.

B. Handle service equipment carefully to prevent internal components damage, breakage, denting, and scoring enclosure finish. Do not install damaged equipment.

C. Store service equipment in clean dry space. Protect units from dirt, fumes, water, construction debris and traffic.

D. Install service equipment where indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that switchgear and switchboards comply with requirements of NEMA and NEC standards for installation of service equipment.

E. Tighten bus connections and mechanical fasteners.

F. Install fuses, if any, in each unit.

G. Adjust operating mechanisms for free mechanical movement.

H. Touch-up scratched or marred surfaces to match original finish.

I. Prior to energization of service equipment, megger check phase-to-phase and phase-to-ground insulation resistance levels.

J. Prior to energization, check service equipment for continuity of circuits and for short circuits.

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 clad 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 16460 - TRANSFORMERS

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.

2. DESCRIPTION OF WORK

A. Provide labor, materials, equipment and services necessary for proper and complete installation of transformers.

B. Types of transformers required for this project include the following:

Dry type distribution transformers.

3. QUALITY ASSURANCE

A. Manufacturers offering products complying with requirements include:

Square D Co.

Cutler-Hammer

Or equal

B. Provide transformers 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 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 power/distribution transformers.

4. SUBMITTALS

A. Submit manufacturer's data on power/distribution transformers, including certification of transformer performance efficiency at indicated loads, percentage regulation at 100% and 80% power factor, no load and full load losses in watts, % impedance at 75 degrees C, hot spot and average temperature rise above 40 degrees C ambient, sound level in decibels, and standard published data.

5. EQUIPMENT

A. Except as otherwise indicated, provide manufacturer's standard materials and components as indicated by published product information designed and constructed as recommended by manufacturer, and as required for a complete installation.

B. Dry Type Distribution Transformers

(1) Provide factory assembled general purpose air cooled dry type distribution transformers where shown, of size, characteristics, and rated capacity as indicated; single phase, or three phase, 60 hertz, standard impedance. Provide NEMA ST 20 TAP arrangements (2) 2 1/2% ANFC and (4) 2 1/2% BNFC). Insulate with Class 220 insulation and rate for continuous operation at rated KVA. Limit transformer surface temperature rise to maximum of 65 degrees C. Provide terminal enclosure, with cover, to accommodate primary and secondary coil wiring connections and electrical supply raceway terminal connector. Equip terminal leads with connectors installed. Limit terminal compartment temperature to 75 degrees C when transformer is operating continuously at rated load with ambient temperature of 40 degrees C. Provide wiring connectors suitable for copper or aluminum wiring. Electrically ground core and coils to transformer enclosure by means of flexible metal grounding strap. Provide transformers with fully enclosed sheet steel enclosures. Apply manufacturer's standard light gray indoor enamel over cleaned and phosphatized steel enclosure. Cushion mount transformer with external vibration isolation supports recommended by manufacturer to limit sound level rating to 50 d.b. as determined in accordance with NEMA standards.

6. INSTALLATION

A. Deliver transformers with factory installed shipping skids; package transformers in watertight containers or wrappings.

B. Handle transformers carefully to avoid damage to components, enclosures and finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

C. Store transformers in a clean dry place and protect from weather and construction traffic.

D. Install transformers in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that transformers comply with requirements of National Electrical Code, and applicable portions of ANSI/NEMA standards pertaining to installation of electrical transformers and ancillary equipment.

E. Provide positive equipment ground and bond for transformer equipment where indicated.

F. Upon completion of installation of transformers, energize primary circuit at rated voltage and frequency from normal power source and test transformer, including, but not limited to, audible sound levels, to demonstrate compliance; otherwise, remove and replace with new units and with retesting.

END SECTION

SECTION 16470 - SWITCHGEAR AND SWITCHBOARDS

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. Provide labor, material, equipment and services necessary for proper and complete installation of switchgear and switchboards.

3. QUALITY ASSURANCE

A. Comply with National Electrical Code (NFPA No. 70) as applicable to construction and installation of electrical switchgear and switchboards.

B. Provide switchgear and switchboards which have been listed and labeled by Underwriters Laboratories.

C. Comply with ANSI/IEEE standards pertaining to power switchgear assemblies.

D. Comply with applicable portions of National Electrical Manufacturers Association Stds. Pub. No. PB 2, "Deadfront Distribution Switchboards"; No. PB 2.1, "Instructions for Safe Handling Installation, Operation, and Maintenance of Switchboards"; and No. SG 5, "Power Switchgear Assemblies".

4. SUBMITTALS

A. Submit manufacturer's data on switchgear and switchboards.

B. Submit dimensioned drawings of switchgear and switchboards indicating accurately scaled basic sections including, but not necessarily limited to, auxiliary compartments, section components, and combination sections.

5. PRODUCTS

A. Except as otherwise indicated, provide switchgear and switchboards of types, sizes, characteristics, and ratings indicated, which comply with manufacturer's standard design, materials, components and construction in accordance with published product information, and as required for a complete installation.

B. Dead-Front Distribution Switchboards

(1) Provide factory-assembled, dead-front, metal- enclosed, self-supporting secondary power switchboards, of types, sizes and electrical ratings and characteristics indicated; consisting of panel (vertical) units, and containing circuit breakers and fusible switch assemblies of quantities, ratings and types indicated. Provide copper main bus and connections to switching devices of sufficient capacity to limit rated continuous current operating temperature rise to 54 degrees f. (12 degrees C), and 90 degrees F (32 degrees C) for circuit breaker branches; with main bus and tap connections silver-surfaced and tightly bolted for maximum conductivity. Brace bus for short circuit

stresses up to 600 mVA interrupting capacity. Provide accessibility of line and load terminations from rear of switchboard. Bonderize and paint switchboard with manufacturer's standard color and finish. Equip units with built-in lifting eyes and yokes; and provide individual panel (vertical) units, suitable for bolting together at project site, and constructed for the following environment:

Installation: Indoors, NEMA Type 3R.
Installation: Outdoors, NEMA Type 3R.

(2) Circuit Breakers: Provide circuit breakers of types, ratings. and number of poles indicated, constructed as follows:

Type: Stationary-mounted
Type: Molded-case
Type: Draw-out

(3) Fusible Switches: Provide fusible switch assemblies, 3-pole, quick-make, quick-break type mounted in a metal enclosure with an externally operated handled which can be locked in "ON" or "OFF" positions.

(4) Current-Limiting Circuit Breakers: Provide current-limiting circuit breaker assemblies with time-delay thermal trip, instantaneous magnetic-trip, and fault-current limiting protection, ampere ratings as indicated, with an interrupting rating of 35,000 symmetrical rms amps at 277/480 volts, with current-limiting fuses mounted in housings with safety covers accessible from front of board.

(5) Ground-Fault Protectors: Provide solid-state ground-fault protection units of types, and ratings indicated, equip with static relays, sensors, pilot lights, and push- buttons for fault indication and reset, fuse blocks, fuses and control power transformer. Provide ground break system which operates at 120 volts.

C. Metal-Enclosed Switchgear

(1) Provide factory-assembled, metal-enclosed switchgear, of types, sizes and electrical ratings and characteristics indicated; consisting of stationary structures containing air circuit breaker units, transfer switches, overcurrent devices, buses, instruments and associated transformers, and relays of the quantities, ratings, and types indicated. Form section framework of steel, braced and welded into a rigid structure. Enclose frames on front, rear, bottom (except cable compartment), top and sides with sheet steel removable covers and hinged doors, with doors accessible from the rear. Design units for incoming service of 120/208 volts, 3-phase, 4-wire, main busing and connections of copper, silver- surfaced and tightly bolted for maximum conductivity. Brace bus for short circuit stresses up to 200 MVA interrupting capacity. Provide mimic bus on front of switchgear. Bonderize and paint switchgear with manufacturer's standard color and finish. Equip with built-in lifting eyes and yokes; and construct for the following environment:

Installation: Indoors, NEMA Type 3R.
Installation: Outdoors, NEMA Type 3R.

(2) Breaker Unit: Provide power air circuit breaker, 3-pole, single-throw, electrically-operated with closing relays; primary and secondary disconnecting devices; control switch with indicating lamps; and terminal blocks, small wiring, ground bus and control buses, where required.

(3) Interrupter Switch and Fuse Unit: Provide interrupter switch and fuse unit; consisting of 3-pole, single- throw switch with 3 power fuses; front-mounted operating handle with mechanical interlock between switch and access door to fuses; with underground cable entry and set of terminal blocks, small wiring and ground bus, where required.

(4) Feeder Unit: Provide feeder units for power source with indicated ratings, consisting of breaker unit, ammeter, 3-phase transfer switch, and current transformer with single secondary.

D. Manufacturers of switchgear and switchboards shall be Square "D", Cutler-Hammer or equal as approved by this Engineer.

6. INSTALLATION

A. Deliver switchgear and switchboards individually wrapped in factory-fabricated containers and mounted on shipping skids.

B. Handle switchgear and switchboards carefully to prevent internal components damage, breakage, denting, and scoring enclosure finish. Do not install damaged switchgear and switchboards.

C. Store switchgear and switchboards in clean dry space. Protect units from dirt, fumes, water, construction debris and traffic.

D. Install switchgear and switchboards where indicated, in accordance with manufacturer's written instruction and with recognized industry practices to ensure that switchgear and switchboards comply with requirements of NEMA and NEC standards, for installation of switchboards.

(1) Tighten bus connections and mechanical fasteners.

(2) Install fuses, if any, in each switchgear or switchboard.

E. Adjust operating mechanisms for free mechanical movement.

F. Touch-up scratched or marred surfaces to match original finish.

G. Prior to energization of switchgear and switchboards, megger check phase-to-phase and phase-to-ground insulation resistance levels.

H. Prior to energization, check switchgear and switchboards for continuity of circuits, and for short circuits.

I. Subsequent to wire and cable hook-ups, energize switchgear and switchboards and demonstrate functioning in accordance with requirements.

END SECTION

SECTION 16610 – STANDBY POWER GENERATOR SETS AND EMERGENCY POWER SYSTEMS

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 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 all labor, material, equipment and services necessary for proper and complete installation of one (1) new standby power generator set with custom enclosure.

   B. Intent of Specifications – The Contractor shall secure a standby diesel powered generator set in custom weatherproof enclosure and NEMA 4 automatic transfer switches of the latest commercial type and design as specified herein. To insure one source of responsibility, all equipment in this specification section is to be furnished by the generator set supplier.

   C. System Test – A complete system load test shall be performed after all equipment is installed per Guidelines in the Start-Up Section.

3. QUALITY AND SERVICE ASSURANCE

   A. Comply with applicable portions of National Electrical Code (NFPA No. 70) including, but not limited to, emergency and stand-by power generation systems, and with NFPA 37, "Installation and Use of Stationary Combustion Engines and Gas Turbines."

   B. Comply with applicable portions of National Electrical Manufacturers Association standards for generators.

   C. Provide automatic transfer switches and other electrical components which have been listed and labeled by Underwriters' Laboratories.

   D. The generator set covered by these specifications shall be designed, tested, rated, assembled and installed in strict accordance with all applicable standards below:

      1. CSA C22.2 No 14

      2. CSA 282

      3. CSA 100

      4. EN61000-6

      5. EN55011

      6. FCC Part 15 Subpart B

      7. ISO8528

8. IEC61000

9. UL508

10. UL2200

11. UL142

12. Designed to allow for installed compliance to NFPA 70, NFPA99 and NFPA 110

E. Requirements, Codes and Regulations

1. The equipment supplied and installed shall meet the requirements of the NEC and all applicable local codes and regulations. All equipment shall be of new and current production by a MANUFACTURER who has 25 years of experience building this type of equipment. Manufacturer shall be ISO9001 certified.

4. SUBMITTALS

A. Engine-generator submittals shall include the following information:

1. Factory published specification sheet.

2. Manufacturer's catalog cut sheets of all auxiliary components such as battery charger, control panel, enclosure, transfer switch, etc.

3. Dimensional elevation and layout drawings of the generator set, enclosure and transfer switchgear and related accessories.

4. Weights of all equipment.

5. Concrete pad recommendation, layout and stub-up locations of electrical and fuel systems.

6. Interconnect wiring diagram of complete emergency system, including generator, switchgear, day tank, remote pumps, battery charger, control panel, and remote alarm indications.

7. Engine mechanical data, including heat rejection, exhaust gas flows, combustion air and ventilation air flows, fuel consumption, etc.

8. Generator electrical data including temperature and insulation data, cooling requirements, excitation ratings, voltage regulation, voltage regulator, efficiencies, waveform distortion and telephone influence factor.

9. Generator resistances, reactances and time constants.

10. Generator locked rotor motor starting curves.

11. Manufacturer's documentation showing maximum expected transient voltage and frequency dips, and recovery time during operation of the generator set at the specified site conditions with the specified loads.

12. Manufacturer's and dealers written warranty.

5. SYSTEM RESPONSIBILITY

A. Generator Set Dealer - The completed engine generator set shall be supplied by the Manufacturer's authorized dealer only.

B. Requirements, Codes and Regulations - The equipment supplied and installed shall meet the requirements of NEC and all-applicable local codes and regulations. All equipment shall be new, of current production. There shall be one source responsibility for warranty; parts and service through a local representative with factory trained service personnel.

C. Automatic Transfer Switch - The automatic transfer switches specified shall be supplied by the generator set dealer in order to establish and maintain a single source of system responsibility and coordination.

D. Fuel System

1. The Contractor shall provide a full tank of diesel fuel for the completion of all testing.

6. WARRANTY

A. Two Year Standby (ISO 8528-1: ESP) Generator Set Warranty

1. The manufacturer's standard warranty shall in no event be for a period of less than two (2) years from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Running hours shall be limited to 500 hours annually for the system warranty by both the manufacturer and servicing dealer. Submittals received without written warranties as specified will be rejected in their entirety.

7. PARTS AND SERVICE QUALIFICATIONS

A. Service Facility - The engine-generator supplier shall maintain 24-hour parts and service capability within 100 miles (2 hours) of the project site. The engine-generator supplier shall stock parts as needed to support the generator set package for this specific project. The engine-generator supplier must carry sufficient inventory to cover no less than 80% parts service within 24hrs and 95% within 48 hours. Service facility location(s) and parts inventory information to be documented with submittals

B. Service Personnel - The engine-generator dealer shall maintain qualified factory trained service personnel specifically trained for the manufacturer brand type/series to be supplied. Service personnel qualifications and location(s) are to be documented with submittals.

8. SUBSTITUTIONS

A. Proposed deviations from the specifications shall be treated as follows:

B. Substitution Time Requirement

1. Requests for substitutions shall be made a minimum of ten (10) days prior to bid date. Manufacturers catalog data and complete list of exceptions and deviations to the specification shall accompany each request and authorized acceptance shall be addenda only.

C. Substitution Responsibility

1. The power system has been designed to the specified manufacturer's electrical and physical characteristics. The equipment sizing, spacing, amounts, electrical wiring, ventilation equipment, fuel, and exhaust components have all been sized and designed around CATERPILLAR supplied equipment. Should any substitutions be made, the CONTRACTOR shall bear responsibility for the installation, coordination and operation of the system as well as any engineering and redesign costs, which may result from such substitutions.

2. Acceptable engine-generator manufacturers for this project subject to compliance with Item 8. SUBSTITUTIONS, C. Substitution Responsibility, Paragraph (1) above are Cummins Diesel and Kohler.

3. Requests to bid substitute engine-generators shall be made from a generator manufacturer authorized licensed dealer complying with the requirements of item 7. PARTS AND SERVICE QUALIFICATIONS, Paragraphs A. and B. above. Any requests to bid alternate/substitute engine-generators by distributors/resellers with an alliance with an authorized licensed dealer shall be considered for review only when accompanied by the distributors/resellers associated authorized licensed dealer statement of compliance with the requirements of item 7. PARTS AND SERVICE QUALIFICATIONS, Paragraphs A. and B. above.

9. MATERIALS

A. Genset Requirements

1. The generator set shall be Standby Duty rated at 1000.0 ekW, 375.0 kVA, 1800 RPM, 0.8 power factor, 480 V, 3-Phase, 60 hertz, including radiator fan and all parasitic loads. Generator set shall be sized to operate at the specified load at a maximum ambient of 77F (25.0C) and altitude of 500.0 feet (152.4 m).

a. Standby Power Rating:

b. Power is available for the duration of an emergency outage

c. Average Power Output = 70% of standby power

d. Load = Varying

e. Typical Hours/Year = 200 Hours

f. Maximum Expected Usage = 500 hours/year

g. Typical Application = Standby

B. Material and Parts

1. All materials and parts comprising the unit shall be new and unused.

C. Engine

1. The engine shall be diesel fueled, four (4) cycle, water-cooled, while operating with nominal speed not exceeding 1800 RPM. The engine will utilize in-cylinder combustion technology, as required, to meet applicable EPA non-road mobile regulations and/or the EPA NSPS rule for stationary reciprocating compression ignition engines. Additionally, the engine shall comply with the State Emission regulations at the time of installation/commissioning. Actual engine emissions values must be in compliance with applicable EPA emissions standards per ISO 8178 D2 Emissions Cycle at specified ekW / bHP rating. Emissions requirements / certifications of this package: EPA ESE

2. Generator

   a. Generator Specifications

      i. The synchronous three phase generator shall be a single bearing, self-ventilated, drip-proof design in accordance with NEMA MG 1 and directly connected to the engine flywheel housing with a flex coupling. The alternator shall not exceed 125C rise with a generator pitch of .667. The generator shall meet performance class G3 of ISO 8528. The excitation system shall enable the alternator to sustain 300% of rated current for ten seconds during a fault condition and shall improve the immunity of the voltage regulator to non-linear distorting loads. The excitation system shall be of brushless construction and be independent of main stator windings. The excitation system shall be permanent magnet style. The alternator windings are to also include a anti-condensation heater that will automatically shutoff upon engine start signal.

      ii.

3. Voltage Regulator

   a. Digital Voltage Regulator

      i. The digital voltage regulator shall be microprocessor based with fully programmable operating and protection characteristics. The regulator shall maintain generator output voltage within +/- 0.25% for any constant load between no load and full load. The regulator shall be capable of sensing true RMS in three phases of alternator output voltage, or operating in single phase sensing mode. The voltage regulator shall include a VAR/Pf control feature as standard. The regulator shall provide an adjustable dual slope regulation characteristic in order to optimize voltage and frequency response for site conditions. The voltage regulator shall include standard the capability to provide generator paralleling with reactive droop compensation and reactive differential compensation.

      ii. The voltage regulator shall communicate with the Generator Control Panel via a J1939 communication network with generator voltage adjustments made via the controller keypad. Additionally, the controller shall allow system parameter setup

and monitoring, and provide fault alarm and shutdown information through the controller. A PC-based user interface shall be available to allow viewing and modifying operating parameters in a windows compatible environment.

b. Motor Starting

i. Provide a minimum locked rotor motor starting capability of 1,595 sKVA @ 20% voltage dip when measured at .4pf per Nema MG1. Sustained voltage dip data is not acceptable.

4. Circuit Breaker

a. Circuit Breaker Specifications

i. Provide a generator mounted 100% GFI type circuit breaker, insulated case, electrically operated 1600 amp trip, 3 pole, NEMA 1/IP22. Breaker shall utilize a solid state trip unit and have LSI adjustable settings. The breaker shall be UL/CSA Listed, connected to engine/generator safety shutdowns, and automatically controlled by the package mounted generator set controls. Breaker shall be housed in an extension terminal box which is isolated from vibrations induced by the generator set. Mechanical type lugs, sized for the circuit breaker feeders shown on drawing, shall be supplied on the load side of breaker. The generator mounted circuit breaker to include a 24VDC Shunt trip and a set of 24VDC position indicating aux. contacts.

5. Controls – Generator Set Mounted (EMCP 4.2)

a. Provide a fully solid-state, microprocessor based, generator set control. The control panel shall be designed and built by the engine manufacturer. The control shall provide all operating, monitoring, and control functions for the generator set. The control panel shall provide real time digital communications to all engine and regulator controls via SAE J1939.

b. Environmental

i. The generator set control shall be tested and certified to the following environmental conditions:

a) –40°C to +70°C Operating Range

b) 100% condensing humidity, 30°C to 60°C

c) IP22 protection for rear of controller; IP55 when installed in control panel

d) 5% salt spray, 48 hours, +38°C, 36.8V system voltage

e) Sinusoidal vibration 4.3G's RMS, 24-1000Hz

f) Electromagnetic Capability (89/336/EEC, 91/368/EEC, 93/44/EEC, 93/68/EEC, BS EN 50081-2, 50082-2)

g) Shock: withstand 15G

c. Functional Requirements

i. The following functionality shall be integral to the control panel.

ii. The control shall include a minimum 33 x 132 pixel, 24mm x 95mm, positive image, transflective LCD display with text based alarm/event descriptions.

iii. The control shall include a minimum of 3-line data display

iv. Audible horn for alarm and shutdown with horn silence switch

v. Standard ISO labeling

vi. Multiple language capability

vii. Remote start/stop control

viii. Local run/off/auto control integral to system microprocessor

ix. Cool down timer

x. Speed adjust

xi. Lamp test

xii. Emergency stop push button

xiii. Voltage adjust

xiv. Voltage regulator V/Hz slope - adjustable

xv. Password protected system programming

d. Digital Monitoring Capability

i. The controls shall provide the following digital readouts for the engine and generator. All readings shall be indicated in either metric or English units

ii. Engine

a) Engine oil pressure

b) Engine oil temperature

c) Engine coolant temperature

d) Engine RPM

e) Battery volts

f) Engine hours

g) Engine crank attempt counter

h) Engine successful start counter

i) Service maintenance interval

j) Real time clock

k) Engine exhaust stack temperature

l) Engine main bearing temperature

iii. Generator

a) Generator AC volts (Line to Line, Line to Neutral and Average)

b) Generator AC current (Avg and Per Phase)

c) Generator AC Frequency

d) Generator kW (Total and Per Phase)

e) Generator kVA (Total and Per Phase)

f) Generator kVAR (Total and Per Phase)

g) Power Factor (Avg and Per Phase)

h) Total kW-hr

i) Total kVAR-hr

j) % kW

k) % kVA

l) % kVAR

m) Generator bearing temperature

n) Generator stator winding temperature

iv. Voltage Regulation

a) Excitation voltage

b) Excitation current

e. Alarms and Shutdowns

i. The control shall monitor and provide alarm indication and subsequent shutdown for the following conditions. All alarms and

shutdowns are accompanied by a time, date, and engine hour stamp that are stored by the control panel for first and last occurrence:

ii. Engine Alarm/Shutdown

a) Low oil pressure alarm/shutdown

b) High coolant temperature alarm/shutdown

c) Loss of coolant shutdown

d) Overspeed shutdown

e) Overcrank shutdown

f) Emergency stop shutdown

g) Low coolant temperature alarm

h) Low battery voltage alarm

i) High battery voltage alarm

j) Control switch not in auto position alarm

k) Battery charger failure alarm

iii. Generator Alarm/Shutdown

a) Generator phase sequence

b) Generator over voltage

c) Generator under voltage

d) Generator over frequency

e) Generator under frequency

f) Generator reverse power (real and reactive)

g) Generator overcurrent

f. Voltage Regulator Alarm/Shutdown

i. Loss of excitation alarm/shutdown

ii. Instantaneous over excitation alarm/shutdown

iii. Time over excitation alarm/shutdown

iv. Rotating diode failure

v. Loss of sensing

vi. Loss of PMG

6. Inputs and Outputs

a. Programmable Digital Inputs

i. The Controller shall include the ability to accept programmable digital input signals. The signals may be programmed for either high or low activation using programmable Normally Open or Normally Closed contacts.

b. Programmable Relay Outputs (Alarm Contacts for Owner Telemetry System)

i. The control shall include the ability to operate programmable relay output signals, integral to the controller. The output relays shall be rated for 2A @ 30VDC and consist of six (6) Form A (Normally Open) contacts and two (2) Form C (Normally Open & Normally Closed) contacts.

c. Programmable Discrete Outputs

i. The control shall include the ability to operate two (2) discrete outputs, integral to the controller, which are capable of sinking up to 300mA.

7. Maintenance

a. All engine, voltage regulator, control panel and accessory units shall be accessible through a single electronic service tool. The following maintenance functionality shall be integral to the generator set control

i. Engine running hours display

ii. Service maintenance interval (running hours or calendar days)

iii. Engine crank attempt counter

iv. Engine successful starts counter

v. 40 events are stored in control panel memory

vi. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 7 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:

a) Day of week

b) Time of day to start

c) Duration of cycle

8. Remote Communications

   a. The control shall include Modbus RTU communications as standard via RS-485 half duplex with configurable baud rates from 2.4k to 57.6k.

9. Remote Monitoring Software

   a. The control shall provide Monitoring Software with the following functionality

      i. Monitor up to eight (8) generator sets, plus ATS and UPS.

      ii. Provide access to all date and events on generator set communications network

      iii. Provide remote control capability for the generator set(s)

      iv. Ability to communicate via Modbus RTU or remote modem

10. Local and Remote Annunciation

   a. Local Annunciator (NFPA 99/110, CSA 282)

      i. Provide a local, control panel mounted, annunciator to meet the requirements of NFPA 110, Level 1.

         a) Annunciators shall be networked directly to the generator set control

         b) Local Annunciator shall include a lamp test pushbutton, alarm horn and alarm acknowledge pushbutton

         c) Provide the following individual light indications for protection and diagnostics

            i) Overcrank

            ii) Low coolant temperature

            iii) High coolant temperature warning

            iv) High coolant temperature shutdown

            v) Low oil pressure warning

            vi) Low oil pressure shutdown

            vii) Overspeed

            viii) Low coolant level

            ix) EPS supplying load

            x) Control switch not in auto

xi) High battery voltage

xii) Low battery voltage

xiii) Battery charger AC failure

xiv) Emergency stop

xv) Spare

xvi) Spare

11. Cooling System

a. The generator set shall be equipped with a rail-mounted, engine-driven radiator with blower fan and all accessories. The cooling system shall be sized to operate at full load conditions and 109 F* ambient air entering the room or enclosure (If an enclosure is specified). The generator set supplier is responsible for providing a properly sized cooling system based on the enclosure static pressure restriction.

12. Fuel System

a. The fuel system shall be integral with the engine. Provide a UL-142 double wall fuel tank with 110% containment sized to provide for a minimum 24 hours of fuel at 100% load. In addition to the standard fuel filters provided by the engine manufacturer, there shall also be installed a primary fuel filter/water separator in the fuel inlet line to the engine. All fuel piping shall be black iron or flexible fuel hose rated for this service. No galvanized piping will be permitted. Flexible fuel lines shall be minimally rated for 300 degrees F and 100 psi.

13. Fuel Sub Base Tank

a. Provide a double wall sub-base tank constructed to meet all local codes and requirements. A fuel tank base of 24 hour capacity shall be provided as an integral part of the enclosure. It shall be contained in a rupture basin with 110% capacity. The tank shall meet UL142 standards. A locking fill cap, a mechanical reading fuel level gauge, low fuel level alarm contact, and fuel tank rupture alarm contact shall be provided.

14. Exhaust System

a. Silencer

i. A critical grade silencer, companion flanges, and flexible stainless steel exhaust fitting properly sized shall be furnished and installed according to the manufacturer's recommendation. Mounting shall be provided by the contractor as shown on the drawings. The silencer shall be mounted so that its weight is not supported by the engine nor will exhaust system growth due to thermal expansion be imposed on the engine. Exhaust pipe size shall be sufficient to ensure that exhaust backpressure does not exceed the maximum limitations specified by the engine manufacturer.

15. Starting System

a. Starting Motor

i. A DC electric starting system with positive engagement shall be furnished. The motor voltage shall be as recommended by the engine manufacturer.

b. Jacket Water Heater

i. Jacket water heater shall be provided and shall be sized to insure that genset will start within the specified time period and ambient conditions. The minimum acceptable rating on the jacket water heater is 9KW.

c. Batteries

i. Battery set for the 1000kw generator pkg. to be a minimum rating of 380amp hr. 1300CCA . The starting batteries are to be connected to a interior enclosure mounted 10A Battery charger with 120VAC Input. It is to be dual rate fully automatic float / equalize type and include the standard NFPA99 / 110 Alarm contacts. The Engine Driven Generator is also to include a 45amp 24VDC battery charging alternator.

d. Battery Charger

i. A UL listed/CSA certified 10 amp voltage regulated battery charger shall be provided for each engine-generator set. Input AC voltage and DC output voltage shall be as required. Chargers shall be equipped with float and equalize charge settings, with provisions to automatically switch between the two modes. It shall maintain its rated output voltage within ±0.2% with AC input variation of ±10%. Operational monitors shall provide with individual form C contacts rated at 4 amps, 120 VAC, 30VDC for remote indication of battery charger malfunction, low battery voltage, and high battery voltage. Charger shall include an Analog DC voltmeter and ammeter and fused AC input and DC output, and shall be wall mount type in a NEMA 1 enclosure.

16. Enclosure

A. Walk-in Style Attenuated Enclosure WIND RATED UP TO 100MPHThe complete diesel engine generator set, including generator control panel, engine starting batteries and fuel oil tank, shall be enclosed in sound attenuated enclosure mounted on the fuel tank base.

1. A weather resistant, sound attenuated enclosure shall have a resulting sound level of 82dba @ 7 meters with the genset running under full load. It shall consist of a roof, side walls, and end walls. Fasteners shall be either zinc plated or stainless steel.

2. Provide a UL2200 Weather Resistive Enclosure - This enclosure shall be constructed of powder painted, .080 Aluminum panels secured to a 6063 T52 welded aluminum frame

secured with 3m high grade double sided tape. The enclosure shall be support by a 6" aluminum C-channel base frame for easy enclosure lifting.

3. The roof will be constructed of .125 aluminum fully welded one piece roof. Door frames, roof gutters and trim to be of aluminum construction.

4. 2" Mineral wool sound attenuated and thermal insulation installed throughout the interior of the enclosure and covered with perforated galvanized steel sheeting.

5. Rear fixed blade air intake louver for horizontal air intake.

6. Front mounted plenum with bird (rodent) screening for vertical radiator air discharge fitted with galvanized gravity fed discharge louvers.

7. Flexible duct and accessory hardware shall be mounted on radiator outlet.

8. Two single maintenance access doors on each side. Doors with interior emergency release handle allowing door to be opened from inside when locked. All fitted with watertight rubber seals, drip ledges and all fitted with heavy duty refrigeration style chrome plated steel hinges and keyed-alike lockable handles. Handles are also pad lockable. Doors will be fitted with a door-hold-back latch and bulb seals.

9. Inlet and exhaust air handling shall be designed so as to maintain a combined total maximum static pressure drop of 0.5 inches of water gauge through the enclosure.

10. Sloped roof construction.

11. Critical Grade Silencer shall be internally mounted and sized to suit the above sound attenuation and fitted with a stainless steel flexible connector to engine. "Disk" design silencer shall be internally acoustically and thermally insulated. Exhaust will extend through roof to outside of enclosure with rain cap. Exhaust shall hang down from roof and not be supported by any means through the engine.

12. Lube oil and coolant drains plus fumes disposal lines from generator set plumbed to exterior of enclosure and terminated with drain valves.

13. Fumes disposal lines from generator set plumbed to exterior of enclosure or plumbed to discharge plenum of sound attenuated enclosure.

14. Provide and install a distribution panel with AC/DC lights, receptacles, outlets, and wiring for heaters and charger.

15. Automatic transfer switch 'XS1' shall be installed inside of the enclosure and pre-wired from emergency contacts to the generator distribution panel 'GDP'. Suitable conduit stub-up area shall be provided for normal and load wiring. All wiring is to be through the base of the enclosure.

16. **NOTE:** Contractor shall coordinate with custom generator enclosure supplier and switchgear manufacturers for inclusion of Main Service Switch 'MS1' and Generator Distribution Panel

'GDP' to all be installed within the enclosure along with transfer switch 'XS1' as noted in .15 above. Suitable conduit entries and allowance for conduit stub-out areas shall be provided within the custom enclosure to allow for future feeds, control circuits etc. to allow for installation of all alternates circuits as designed for this project.

B. Provide OSHA approved access stairs/platforms with hand rails at each entry door into the enclosure.

10. AUTOMATIC TRANSFER SWITCHES

A. General

1. Scope And Related Work

a. Furnish and install Automatic Transfer Switches with number of poles, amperage and voltage as shown on drawings. UL Withstand and Close-on ratings as listed in this specification are provided as a minimum requirement.

b. Related Work: this section shall be used in conjunction with related specification sections and related contract documents, including drawings, to establish the total requirements for the automatic transfer switches. Use of this section exclusively may result in the omission of basic requirements.

2. Codes And Standards

a. The Automatic Transfer Switches and controls shall conform to the requirements of the following:

i. UL 1008: Underwriters Laboratories Standard for Transfer Switch Equipment

ii. NFPA 70 National Electrical Code

iii. NFPA 99 Essential Electrical Systems for Health Care Facilities

iv. NFPA 110 Standard for emergency and standby power systems

v. ANSI/IEEE 446 Recommended Practice for Emergency and Standby Power Systems for Commercial Applications

vi. NEMA ICS 10 P1 Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment

vii. IBC-2006 International Building Code-Seismic Certified

viii. UL 508 Standard for Industrial Control

3. Submittals

a. Submittals shall be provided in accordance with the contract documents. Submittals shall include the manufacturer's original data sheets and

detailed shop drawings. Shop drawings shall include a detailed specification sheet listing the project name, supplier, and a description of each item supplied. The description shall include model number, voltage, number of poles, and enclosure type. Submittals shall include schematic wiring diagram, complete dimensions information, and a listing of accessories proposed for each item. In order to avoid confusion, all drawings shall be accurate and specific for the equipment being supplied. Marked up generic drawings are not acceptable.

b. Operation and maintenance data shall be supplied after shipment in accordance with the contract documents.

4. Installation, Operation And Maintenance Data

a. The manufacturer shall supply three (3) copies of installation, operation and maintenance manuals to the owner after delivery of the equipment.

5. Warranty

a. The automatic transfer switch shall be provided with a five year warranty, covering all parts, labor, travel and expenses during the first two years, followed by three years of replacement parts coverage. Warranty shall commence on startup or six months from date of shipment, whichever occurs first. Warranty shall not be dependent upon customer purchase of additional equipment or preventive maintenance contracts.

B. Products

1. Acceptable Manufacturers

a. Automatic Transfer Switch shall be manufactured in the United States of America and of type RTS03 as supplied by Russelectric. Requests for substitutions shall be made a minimum of ten (10) days prior to bid date. Manufacturers catalog data and complete list of exceptions and deviations to the specification shall accompany each request and authorized acceptance shall be addenda only.

2. General

a. Transfer switches shall be electrically operated and mechanically held with double throw construction. Ratings shall be as shown on the drawings.

b. Switches shall be four pole type. Where four pole switches are required, a true four pole switch shall be supplied, with all four poles mounted on a common shaft. The entire fourth pole assembly, including contacts, arc chutes, etc. shall be identical to the other power poles. The fourth pole shall be switched simultaneously with, and by the same mechanism as, the main power poles. The short circuit rating of the fourth pole shall be identical to the ratings of the main power poles. The complete assembly shall be factory tested to ensure proper operation and compliance with the specifications requirements. Overlapping neutral designs are not acceptable.

3. The transfer switch shall be mounted in a special 59" deep freestanding NEMA 3R, enclosure, unless otherwise indicated on the drawings. Enclosures shall be fabricated from 12 gauge steel. The enclosure shall be sized to exceed minimum wire bending space required by UL 1008, even when compression lugs are provided.

4. The transfer switch shall be seismic certified, capable of operating successfully after being subjected to a minimum IBC 200% g Earthquake Test. Testing shall be performed and verified by an independent, A2LA accredited, testing laboratory, in accordance with IBC 2006. Any additional bracing, structural changes, and/or accessories required to pass seismic testing shall be included. Certification must be obtained via actual shake table testing. Certification by calculation only is not acceptable.

5. The automatic transfer switch shall be capable of transferring successfully in either direction with 70% of rated voltage applied to the switch terminals.

6. Where open transition transfer switches are indicated, the Source 1 and Source 2 contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Designs relying on electrical interlocks only are not acceptable. Main contacts shall be mechanically locked in both the positions without the use hooks, latches, magnets or springs. Main contacts on all size switches shall be segmented with tungsten arcing tips. Contacts shall be machined from solid copper. Separate arcing contacts with magnetic blowouts shall be provided on all transfer switches. Interlocked molded case circuit breakers or contactors are not acceptable.

7. All open transition transfer switches shall be equipped with a safe manual operator designed to prevent injury to operating personnel. The manual operator shall provide the same contact to contact transfer speed as the electrical operator to prevent a flash-over from switching the main contacts slowly. Manual operation shall not require prior disconnection of electrical operators or control wiring, and shall be safe even if the electrical operator becomes energized during manual operation. The manual operator shall be external type, operable through the door of the enclosure. Safe manual transfer shall be possible under all load conditions, either energized or non-energized.

8. The automatic transfer switch shall be double throw, actuated by two electrical operators, momentarily energized, and connected to the transfer mechanism by a simple over-center type linkage providing inherent quick break, quick make operation when operated electrically or manually.

9. For large motor and transformer switching applications, and for transfer switches used for load shedding, where indicated by the "dual" operator designation on the drawings, the transfer switch shall be double throw, actuated by two electrical operators. The adjustable time delay between the opening of the closed contacts and the closing of the open contacts shall allow the loads to be demagnetized before transfer. The dual operator transfer switch shall allow the motor and transformer loads to be re-energized after transfer with normal inrush current. The manufacturer shall have a minimum of 5 years experience in building dual operators style switches. In phase monitor or sync check designs shall not be acceptable.

10. All bolted bus connections shall have Belleville compression type washers.

11. All control components and wiring shall be front accessible. All control wires shall be multiconductor 18 gauge 600-volt SIS switchboard type point to point harness. All control wire terminations shall be identified with tubular sleeve-type markers.

12. The switch shall be equipped with 90 degrees C rated copper/aluminum solderless mechanical type lugs, unless otherwise indicated on the drawings. If compression lugs are indicated on the drawings, these lugs shall be supplied by the ATS supplier, and the UL listing of the switch shall not be compromised. The load side of the ATS shall have double the quantity of the standard lugs

13. Controller

    a. The transfer switch shall be equipped with a Microprocessor Controller with a Power Supply Module, CPU and I/O Modules. The Microprocessor shall be identical for all voltage and ampere ratings. The controller shall be capable of serial communications.

    b. The controller shall contain voltage sensing modules capable of direct single phase or three phase sensing of each source from 120 VAC to 600 VAC. The Power Supply Module shall accept a 24 VDC external power source allowing controller communications in the event of a power outage.

    c. Voltage sensing shall be true RMS type and accurate to +/- 1% of nominal voltage. Frequency sensing shall be accurate to +/- 0.05Hz. The operating temperature range shall be –20 to +50 degrees C and storage from –40 to +90 C.

    d. The controller shall connect to the transfer switch through an interconnecting wiring harness. Interfacing relays shall be provided to isolate the controller from abnormal voltages applied to any and all customer input and output wiring terminals.

    e. All customer interface connections shall be wired to a common DIN rail Cage Clamp terminal block. Sufficient space shall be provided to allow for future modifications and upgrades.

    f. The controller shall meet or exceed the requirements for Electromagnetic Compatibility as follows:

        i. EN55022 (CISPR11) Conducted and Radiated emissions, Class B

        ii. EN61000-4-2 (Level 4) ESD immunity test

        iii. ENG6100-4-3 (ENV50140) Radiated RF

        iv. EN61000-4-4 Electrical fast transient/burst immunity test

        v. EN61000-4-5 IEEE C62.41 Surge immunity test

        vi. EN61000-4-6 (ENV50141) Conducted immunity test

        vii. EN61000-4-11 Voltage dips and interruption immunity

viii. IEEE 472 (ANSI C37.90A) Ring wave immunity

g. Controller Display and Keypad

i. A color, ¼ VGA minimum, graphical display shall be provided for viewing data and setting operational parameters. Parameters shall also be available for viewing remotely and limited control through a front accessible USB communications port. All programming functions shall be pass code protected.

ii. The Controller shall provide high intensity LED's for the following:

a) Source Availability - Indicates the source voltage and frequency are within pre-set parameters.

b) Source Connected - Indicates the source main contacts closed and the load being served from the source.

c) XFER Inhibit - Indicates that the ATS is being inhibited from automatic operation to the unconnected source.

d) Alarm: Indicates an alarm condition is active.

e) TD Active: Indicates that a transfer switch time delay is actively timing.

iii. For ease of navigation, the display shall include the following:

a) Soft Keys – Change function based on user location in the menu structure.

b) Dedicated Navigational Keys – Home, Scroll Up, End, Escape and Enter.

c) Dedicated Pushbuttons for Alarm Reset, Test, Control and Information.

h. Voltage, Frequency and Phase Rotation Sensing

i. The transfer switch controller has programmable voltage and frequency sensing of both Source 1 and Source 2, and shall be capable of detecting a single or three phase losses. The Controller shall have adjustable pickup and dropout settings for each source. Set point ranges for both Source 1 and Source 2 shall be as follows:

Parameter	Dropout/Trip	Pickup/Reset
Under-voltage	72 to 100%	70 to 98%
Over-voltage	100 to 108%	102 to 110%
Under-frequency	45.1 to 60.0 Hz	45.0 to 59.9%
Over-frequency	50.0 to 69.7 Hz	50.1 to 69.8 Hz

ii. The controller shall monitor phase rotation of both sources and inhibit transfer if both sources are not the same phase rotation. Source rotation shall be field selectable as either ABC or CBA.

iii. Settings shall be adjustable in 1% increments either through the keypad, USB port or remotely via communications.

iv. A single source status screen shall be provided to allow for viewing of the status of both sources including three phase voltage, power and frequency.

i. Time Delays: The transfer switch controller shall provide the following time delays:

i. The controller shall include an adjustable time delay of 0 to 10 seconds to momentarily override Source 1 power outages and to delay engine starting. The time delay shall be expandable up to 60 minutes if an external 24 VDC power supply is provided for ATS control.

ii. The controller shall include an adjustable 0 to 60 minute time delay on transfer to Source 2, factory set at 3 seconds.

iii. The controller shall include a time delay on retransfer to the preferred source adjustable 0 to 259 minutes, factory set at 5 minutes.

iv. The controller shall include a time delay on engine cool down adjustable 0 to 60 minutes, factory set at 5 minutes.

v. All time delays shall be adjustable in 1second increments. All time delays shall be adjustable via the graphical display, the front USB port or configuration software using the USB, serial or Ethernet communications port.

14. Sequence Of Operation

a. The transfer switch shall be designed to transfer load between two sources, as follows:

i. Source 1 Utility

ii. Source 2 Standby Generator

b. When the voltage on any phase of Source 1 is outside of the acceptable parameters, as defined later in this specification, and after a programmable time delay period to allow for momentary voltage dips, the engine starting contacts shall close to initiate starting of the standby generator.

c. The transfer switch shall transfer to Source 2 when that source has reached specified voltage and frequency on all phases.

d. After restoration of Source 1 voltage and frequency on all phases, as specified later in this specification, an adjustable time delay shall delay

the retransfer to Source 1 to assure stabilization of that source. After expiration of that time delay period, the transfer switch shall retransfer to Source 1. Should Source 2 fail anytime during the time delay period, the transfer switch shall bypass the time delay and immediately retransfer to an available Source 1.

e. After retransfer to Source 1, the standby generator shall be allowed to operate at no load for a programmable period of time. The transfer switch cool-down timer shall be coordinated with any engine control cool-down timers to avoid excessive unloaded operation.

15. Additional Features And Accessories

a. Test Switch – The controller shall be provided with a two position, password protected, test switch to simulate a Source 1 failure. An external Key operated maintained contact test switch shall also be provided.

b. Engine Start Signal – A SPDT contact, rated 10 amps at 30 VDC, shall be provided to start the engine generator in the event of a Source 1 outage or customer initiated test.

c. Source connected contacts rated 10 amps at 120 VAC shall be provided to signal when the ATS is connected to each source. Quantity of 3 for each position.

d. Source Connected LED's - The controller shall include LED's to indicate when the ATS is connected to each source.

e. Source Availability LED's and Contacts - The controller shall include LED's to indicate the availability of each source. In addition, two voltage free form "C" contacts shall be provided to indicate availability of Source 1, and two voltage free form "C" contacts shall be provided to indicate availability of Source 2. The lights and relays shall provide true source availability indication, as determined by the voltage sensing settings for each source.

f. Commit/No-Commit Transfer Selector – The controller shall include a programmable selector to configure the controller to commit, or not to commit, to transferring the load to Source 2 in the event the Source 1 power returns prior to Source 2 being ready to accept load.

g. Inhibit Transfer Signals – The controller shall be capable of accepting transfer control inputs that inhibit transfer of the ATS to either source for load control purposes for use with generator control switchgear.

h. Auto/Manual Selector – The controller shall include a programmable function to select either Automatic or Manual operation.

i. ATS/Engine Exerciser: The controller shall include a user configurable exerciser. Exerciser shall be configurable for daily, 7 day, 14 day or 28 day exercise periods, each with (7) programmable events. The exerciser shall also be configurable as a full, 365 day exerciser with up to 24 independent exercise events. Each event shall be configurable for Test with Load and Test Without Load. Each event shall include user adjustable start time, date and test duration. All time and date settings

shall be stored in non- volatile EEPROMM memory. The controller shall include full programmability for daylight savings time.

j. Diagnostics: The controller shall contain self and system diagnostic screens for the purpose of detecting and troubleshooting abnormal system events.

k. Communications Interface: The controller shall be capable of interfacing via serial/RS485 or optional Ethernet TCP/IP communications ports integral to the controller. All communications parameters (baud rate, parity, IP Address, etc.) shall be accessible and programmable via the front keypad. Both serial and Ethernet communication shall be Modbus open protocol.

l. Event Logger: The controller shall have the ability to log data and to maintain the last 256 events, even in the event of a power failure. Time and date stamping of events will be accurate to 1 ms. Controller shall be capable of synchronizing its date/time setting with a main PC via Network Time Protocol over an Ethernet TCP/IP network connection.

m. The following events shall be time and date stamped:

   i. Last Primary Source Failure

   ii. Last reason for transfer.

   iii. Last transfer to alternate source

   iv. Last retransfer to primary source

   v. Time load is without power

   vi. Time ATS powered up

   vii. Total time on source 1

   viii. Total time on source 2

   ix. Total number of primary source failures

   x. Total number of transfers

n. Communications Modules

   i. Ethernet Communications: Where indicated on the drawings, the controller shall be capable of supporting an optional Ethernet TCP/IP communications, in lieu of the standard serial communications, via an internally mounted and self powered communications card. Ethernet shall be 10/100 MBit, auto sensing and include an RJ45 network connector.

   ii. Open Protocol: Both serial and Ethernet communications shall be Modbus protocol. Proprietary communications protocols shall not be acceptable.

iii. External Power Supply: The controller shall be capable of being connected to an external 24 VDC power supply to permit full operation and communications of the controller when both sources are de-energized.

iv. Auto Load Shed: The controller shall be capable of being programmed to automatically shed the connected load in the event of a user configurable under frequency condition.

v. Customer Configurable Alarms – The controller shall be capable of being configured to display customer configured alarm points. Alarms shall be capable of being reset via a remote contact or the front panel RESET pushbutton.

16. POWER QUALITY METERING

A. If indicated on the drawings, the ATS shall be provided with optional metering for the parameters listed below. Metering shall be true RMS type, with 1% accuracy for voltage and 0.5% accuracy for currents. The transfer switch shall be provided with solid core current transformers with 5 amp secondary current. CT's shall be wired to a shorting block for safety purposes.

The following meter parameters shall be provided:

1. Phase current: Ia, Ib, Ic, In and average current (Iavg)
2. Phase voltage: Va, Vb, Vc, Vab, Vac, Vbc
3. Voltage and Current unbalance
4. Hz, PF, W, Var, VA
5. Wh, VAh, VARh
6. Voltage and Current Harmonics (% THD up to 8^{th} order)
7. Phase Rotation Sensing
8. Synchroscope (lead/lag)

B. The ATS shall be capable of monitoring and capturing waveform data in the event of a utility power outage or other user specified event.

1. A total of 10 active channels of waveform capture may be user configured.
2. Each channel shall be capable of capturing up to 256 cycles of waveform information.
3. Analog channels may be configured for 4, 8, 16 or 32 samples/cycle.
4. Digital channels shall be configured for 1 sample/cycle.
5. Waveform data shall be stored in industry standard COMTRADE format for broadest compatibility and ease of downloading to a PC.

C. The controller shall be capable of logging digital and analog measured parameters and storing the data in non-volatile memory.

D. The controller shall contain a 10 channel Data Logger. Each channel shall be capable of being configured to monitor a digital on/off or analog measured parameter.

E. The sampling rate of each channel shall be configurable from 1 cycle to 60 minutes per sample. The data shall be stored in non-volatile memory in a first in, first out method.

17. Withstand Ratings

a. The transfer switch shall be UL listed in accordance with UL 1008 for 3 cycle close and withstand ratings. Switches that are not tested and labeled by UL for 3 cycles are not acceptable. The minimum UL listed close and withstand ratings at 480 VAC shall be as follows:

Size Amps	3 Cycle	Current Limiting Fuses
100 – 400	42 Ka	200,000 Ka
600 – 800	65 Ka	200,000 Ka
1000 – 1200	85 Ka	200,000 Ka
1600 – 4000	100 Ka	200,000 Ka

b. During 3 cycle closing and withstand tests, there shall be no contact welding or damage. The 3 cycle test shall be performed without the use of current limiting fuses. The tests shall verify that contact separation has not occurred, and there is contact continuity across all phases. Test procedures shall be done in accordance with UL-1008, and testing shall be certified by Underwriters Laboratories, Inc.

c. In accordance with UL-1008, after completion of the short time closing and withstand testing, the same sample shall successfully pass the Temperature Test and the Dielectric Voltage-Withstand Test to verify the ability of the ATS to carry full rated current after completing the short time tests.

11. INSTALLATION - TRANSFER SWITCHES

A. Transfer switch shall be installed as indicated in accordance with the equipment manufacturer's written instructions, and recognized industry practices to ensure that system equipment complies with requirements of NEC and applicable portions of NECA's "Standard of Installation" pertaining to general electrical installation practices.

B. The electrical contractor shall examine areas and conditions under which the transfer switch shall be installed, and notify engineer in writing of conditions detrimental to proper completion of work.

C. Coordinate with other electrical work, including cables, wires, raceways, electrical boxes and fittings as appropriate.

D. Provide appropriate safety and arc flash labels, as required.

E. Ground equipment according to Division 16 section on Grounding and Bonding.

F. Connect wiring according to Division 16 section on "Conductors and Cables.

G. Wire to remote components: Match type and number of cables and conductors to control and wiring communication requirements of transfer switch(es) as recommended by the manufacturer.

H. Tighten electrical connectors and terminals according manufacturer's published torque tightening values. If manufacturer's torque values are not available, use those as specified in UL486A and UL 486B.

I. Prior to shipment, the transfer switch shall be factory tested and inspected to ensure proper operation. Tests shall include voltage, frequency, and time delay settings for compliance with specifications.

J. Manufacturer shall perform a dielectric test complying with NEMA ICS 1.

K. After installing the equipment, and after electrical circuitry has been energized, the installing contractor shall test for compliance with requirements, as follows:

1. Perform each electrical test and visual and mechanical inspection.

2. Check for electrical continuity of circuits and for short circuits.

3. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.

4. Verify manual transfer operation (if applicable).

5. Simulate at least three power failures, verifying operation of transfer equipment from Source 1 to Source 2, and return to Source 1.

6. Verify time delay settings as desired by the owner.

L. Coordinate ATS testing concurrently with testing of engine generator, and run concurrently.

M. The transfer switch manufacturer shall employ a nationwide, factory direct field service organizations. All field service personnel shall be direct employees of the manufacturer. Third party service organizations are not acceptable.

N. The transfer switch manufacturer shall include an "800" telephone number for field service support. Support shall be available 24 hours a day, 365 days a year. The field service number shall be displayed on the outside of each enclosure.

O. The manufacturer shall maintain complete records and schematic drawings, along with replacement parts, for all switches by serial number, for a minimum of 20 years.

P. Warranty

1. The automatic transfer switch shall be provided with a five year warranty, covering all parts, labor, travel and expenses during the first two years, followed by three years of replacement parts coverage. Warranty shall commence on startup or six months from date of shipment, whichever occurs first. Warranty

shall not be dependent upon customer purchase of additional equipment or preventive maintenance contracts.

12. INSTALLATION - GENERATORS

A. Install equipment in accordance with manufacturer's recommendations, the project drawings and specifications, and all applicable codes.

B. Start-Up and Testing

1. NFPA 110 Load Test Reqs

a. Verify that the equipment is installed properly.

b. Check all auxiliary devices for proper operation, including battery charger, jacket water heater(s), generator space heater, remote annunciator, etc.

c. Test all alarms and safety shutdown devices for proper operation and annunciation.

d. Check all fluid levels.

e. Start engine and check for exhaust, oil, fuel leaks, vibrations, etc.

f. Verify proper voltage and phase rotation at the transfer switch before connecting to the load.

g. Connect the generator to building load and verify that the generator will start and run all designated loads.

h. The system shall be tested under full load and monitor the following readings:

i. Oil pressure

ii. Coolant temperature

iii. Battery charge rate

iv. AC volts

v. AC Amperes- all phases

vi. Frequency

vii. Kilowatts

viii. Ambient Temperature

i. Coordinate all start-up and testing activities with the Generator Supplier and Owner.

2. Operation and Maintenance Manuals

a. Provide three (3) sets of operation and maintenance manuals covering the generator, switchgear, and auxiliary components. Include final as-built wiring interconnect diagrams and recommended preventative maintenance schedules.

3. Training

a. On-Site Training

i. Provide on-site training to instruct the owner's personnel in the proper operation and maintenance of the equipment. Review operation and maintenance manuals, parts manuals, and emergency service procedures.

ii. End user reserves the right to request additional training at any time during the standard warranty. Generator supplier shall furnish additional training at no cost to owner during standard warranty period.

END SECTION