PART 1 - GENERAL

1.01 RELATED DOCUMENTS:
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:
   A. This Section includes computer-based fault-current, arc flash hazard analysis, and overcurrent protective device coordination studies.
   B. The study shall be provided for the electrical distribution system and include all power sources (normal and emergency) down to the branch circuit overcurrent protective device and equipment.
   C. The study shall be performed for the Cooley east Pump Station.

1.03 RELATED REQUIREMENTS:
   A. Section 26 05 53 – Identification for Electrical Systems.

1.04 REFERENCE STANDARDS:
   A. The study shall be completed in accordance with the latest edition of the following standards:
   B. The arc flash hazard analysis shall be completed in accordance with latest editions of the following standards:
      2. NFPA70E – Standard for Electrical Safety Requirements for Employee Workplaces.

1.05 PERFORMANCE/DESIGN CRITERIA:
   A. The study shall calculate the available short-circuit current at each point in the electrical distribution system. The overcurrent protective devices shall have an interrupting rating equal to or greater than the available short-circuit current at the point of application.
   B. The study shall examine proper protection of electrical system components and utilization equipment such that the equipment has a sufficient short-circuit current rating.
   C. The overcurrent protective devices shall be analyzed for selective coordination. This analysis shall identify any potential selective coordination problems up to the available short-circuit current. Any areas where the overcurrent protective devices are not selectively coordinated shall be explicitly noted and recommendations shall be made to achieve selective coordination.
   D. The study shall include an arc flash hazard analysis for electrical distribution equipment. The analysis shall determine the flash protection boundary, incident energy, and required level of personal protective equipment (PPE) for workers at the electrical distribution equipment. The electrical distribution equipment shall be labeled with this information in accordance with codes and standards.

1.06 SUBMITTALS:
   A. Submit as specified in Division 01.
   B. Product Data: Submit computer analysis software to be used for the specified studies.
   C. The results of the studies shall be summarized in report format with explanation of how to interpret the data.
D. As a minimum the report shall include the following:

1. Short Circuit Study:
   a. A printout of input data, calculated results and an explanation of how to interpret the data.
   b. A one-line diagram identifying all bus locations and the maximum available three-phase and line-to-ground short-circuit currents at each bus.
   c. A bus-to-bus listing of the maximum available short-circuit current expressed in RMS symmetrical amperes and the X over R ratio of that fault current.
   d. A table of specified equipment short-circuit ratings versus calculated short-circuit current values with notations of locations where are specified equipment short-circuit ratings are less or greater than required at the point of application.
   e. An analysis of the results in which any overrating or inadequacies shall be called to the attention of the Engineer and recommendations made for improvements.

2. Protective Device Coordination Study:
   a. Time-current characteristic curve drawings on log-log printouts which illustrate:
      (1) The recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices provided for the project.
      (2) The key or limiting overcurrent device characteristics, load characteristics, and protection requirements affecting the settings or ratings of the overcurrent protective devices supplied.
      (3) The degree of selective coordination achieved with the overcurrent protective devices supplied.
   b. A tabulation of the recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices and type selections for fuse protective devices supplied.
   c. An analysis of the results in which any inadequacies related to selective coordination shall be called to the attention of the Engineer with recommendations for improved coordination.

3. Arc Flash Hazard Analysis Study:
   a. The following for each piece of switchgear, switchboard, motor control center, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker, disconnect switch, and equipment control panel installed on the project:
      (1) Minimum Arc Fault Current, Arc Flash Boundary and Arc Fault Incident Energy Level (cal/cm2).
      (2) Risk of personnel injury as a result of exposure to incident energy released during an arc flash event.
      (3) Appropriate ratings of personal protective equipment (PPE).
      (4) The Flash Protection Boundary (approach limit distance).
      (5) Information for equipment specific arc-flash hazard warning labels.
   b. Recommendations and methods to mitigate the hazard risk, where applicable, in order to reduce PPE requirements.

4. Cut sheets and submittal information on the Arc Flash warning labels being provided.
   Coordinate with Section 26 05 53 – Identification for Electrical Systems.

1.07 QUALITY ASSURANCE:
A. The company and individual(s) performing the study shall have a minimum 5 years documented experience in power system analysis and completed projects of similar size and scope. The individual(s) performing the study shall be a registered Professional Engineer in
the state where Project is located. All elements of the study shall be performed under the direct supervision and control of Engineer.

B. The company performing the study shall have the capability and experience to provide assistance during system start up.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

E. Comply with IEEE 1584 or NFPA 70E for arc flash hazard analysis.

1.08 SEQUENCING AND SCHEDULING:

A. The selection of the company and the individual performing the study shall be submitted and approved by the design Engineer prior to the start of the study.

B. The study shall be completed and submitted and approved prior to the facility startup.

PART 2 - PRODUCTS

2.01 GENERAL:

A. The short circuit, protective device coordination, and flash hazard analysis study shall be completed with the aid of a computer software program such as SKM Power Tools.

B. The Contractor shall provide all lengths of cable for use in the studies.

C. All equipment ratings, make, and model information shall be obtained by the Contractor from the equipment manufacturers and/or suppliers and provided for use in the studies.

D. Information on the electrical service including available fault current, transformer impedance, primary fuse ratings, primary cable size, and any other required information shall be obtained from the local utility for inclusion in the studies.

E. The study shall be inclusive of the entire electrical distribution system from all power sources (normal and emergency) down to the branch circuit overcurrent protective device and equipment.

F. Separate calculations shall be performed for both the normal and emergency sources. Device settings shall be based upon the normal source study.

G. The Arc Flash Study shall be based on the study that results in the highest incident energy.

2.02 SHORT CIRCUIT COORDINATION STUDY:

A. The short circuit study shall as minimum include the following:

1. A schematic one-line drawing of the entire electrical system included in the study, from the power company system including the point of delivery, to each primary transformer, and including all main secondary buses of each transformer included in the study. Secondary buses shall include multiple secondary transformations within the scope of the study. Each device shall be identified using project assigned identification labels. Each motor 10 hp and larger shall be shown and identified. Each bus shall be assigned an identification number.

2. Source voltage and impedance data shall be given in the analysis, including reactance and resistance in OHMS to the source, and available symmetrical and asymmetrical short circuit amperes at the point of delivery of electrical power. Short circuit amperes shall be based on an assumed bolted three-phase and line-to-ground short circuits.

3. At each bus, including buses of all primary protective and switching devices, primary and secondary of all transformers, all secondary main and feeder breakers, and all secondary devices and panelboards within the scope of the study, the following shall be calculated:
a. Symmetrical RMS short circuit amperes, calculated using total source and motor contribution reactance and resistance values.
b. Asymmetrical average 3 phase RMS amperes at 1/2 cycle, calculated using actual total source and motor contribution X/R ratio.
c. Reactance ("X") and Resistance ("R") in OHMS at the voltage of the device being examined, including both The Power Company source and all motor contributions.

4. Calculation sheets for cable sections shall indicate voltage, wire size, cable length, reactance and resistance of the section in OHMS and total "X" and "R" to the source.

5. Calculation sheets for transformer sections shall indicate transformer kVA, secondary voltage, percent impedance, percent reactance, percent resistance, and total "X" and "R" value in OHMS at the secondary voltage to source, including The Power Company source impedance plus any primary motor contribution.

6. Calculation sheets for busway and miscellaneous devices shall provide all pertinent parameters including operating voltage, section "X" and "R" values in OHMS, and total "X" and "R" values in OHMS to the source, based on source impedance plus any motor contribution.

7. Bus summary sheets shall be provided giving consecutive bus numbers, description, voltage, "X" and "R" values in OHMS including The Power Company plus all motor contributions, symmetrical and asymmetrical short circuit amperes, X/R ration, and asymmetrical factor.

8. Motor summary sheets shall provide motor description and all pertinent motor data including subtransient reactance for each motor 10 hp and larger. Symmetrical short circuit amperes shall be given for each motor at the motor terminals.

2.03 PROTECTIVE DEVICE COORDINATION STUDY:

A. The protective device coordination study shall as a minimum include the following:

1. Time-current coordination plots shall be made on log-log software generated plots and shall graphically indicate the coordination proposed for all of the key systems. The plots shall include complete titles, one-line diagram and legend.

2. The Power Company's relay, fuse, or protective device shall be plotted with all load protective devices at the same voltage.

3. Transformer primary protective device, transformer magnetic inrush, transformer ANSI withstand points, secondary voltage fuse or circuit breaker and largest feeder fuse or circuit breaker shall be plotted at the secondary voltage. Circuit breaker curves shall include complete operating bands, terminating with the appropriate available short circuit current. Fuse curves shall be identified as either total clearing time or damage time as applicable.

4. Low voltage circuit breakers shall have instantaneous, short delay, long-time pick-up and ground fault trip settings and ground fault ampere and time delay settings identified as plotted. Sensor or monitor rating shall be stated for each circuit breaker. All regions of the circuit breaker curve shall be identified.

5. The coordination plots shall include significant motor starting characteristics and large motor protective devices.

6. Feeder circuit breakers shall have the time-damage curve of the feeder conductors plotted to indicate protection of the conductor insulation at the total clearing time of the circuit breaker or fuse. The time-damage point shall be calculated for the specific parameters of conductor insulation used, with average 3 phase RMS asymmetrical amperes as 1/2 cycle
calculated using actual resistance and reactance values of the source plus all motor contributions which exist at the load end of the feeder conductors.

7. A determination of settings or ratings for the overcurrent and ground fault protective devices supplied. Where necessary, an appropriate compromise shall be made between selective coordination and service continuity with selective coordination considered more important than system service continuity. The time-current coordination analysis shall be performed with the aid appropriate software.

8. A summary tabulation shall be provided listing manufacturer and type for all overcurrent protective devices and all recommended settings of each adjustable band included in each device.

9. Settings of protective devices shall minimize the arc flash hazard while maintaining selective coordination.

2.04 ARC FLASH HAZARD ANALYSIS STUDY:

A. The arc flash hazard analysis study shall as minimum include the following:
   1. Calculate incident energy levels and flash protection boundaries at all relevant equipment busses based on available short-circuit current, protective device clearing time and other applicable one-line diagram information.
   2. As a minimum, the following shall be calculated for each piece of switchgear, switchboard, motor control center, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker, disconnect switch, and equipment control panel to be installed on the project:
      b. Risk of personnel injury as a result of exposure to incident energy released during an arc flash event.
      c. The appropriate ratings of personal protective equipment (PPE).
      d. The Flash Protection Boundary (approach limit distance) as required by NFPA 70E.
   3. Provide equipment specific arc-flash hazard warning label requirements per NEC Section 110.16, including all information specified to be provided on individual equipment warning labels.
   4. Provide recommendations and incorporate with the protective coordination study methods to mitigate the hazard risk, where applicable, in order to reduce PPE requirements.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are as indicated on Drawings.

B. Proceed with coordination study only after relevant equipment submittals have been approved and assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.02 PROTECTIVE DEVICE SELECTION AND SETTINGS:

A. Prior to project Substantial Completion, the Contractor shall set all relays, overcurrent devices and ground fault protection devices and confirm selection of fuse overcurrent devices as follows:
SECTION 26 05 73 – OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: continued

1. Relays: Reset all adjustable relay settings from the factory default settings to the settings recommended in the studies specified in this Section.
2. Circuit Breakers and Motor Circuit Protectors: Reset all adjustable trip settings from the factory default settings to the settings recommended in the studies specified in this Section.
3. Ground Fault Protection Devices: Reset all adjustable device settings from the factory default settings to the settings recommended in the studies specified in this Section.
4. Fuses: Confirm that fuse types installed on the project are as recommended in the studies specified in this Section.

B. Certification: Prior to project Substantial Completion, the Contractor shall submit a document certifying that the Contractor has completed the settings and selection scope specified to the Engineer.

3.03 INSTALLATION:
A. Install arc flash and available fault current labels on equipment as specified in Section 26 05 53 – Identification for Electrical Systems.

END OF SECTION 26 05 73