SECTION 26 05 73 – SHORT CIRCUIT AND LOAD FLOW COORDINATION STUDY

1.01 SUMMARY:

A. **Basic Function (Functional Requirement)**: The Contractor shall perform [A17]short circuit studies, [A17] Load Flow Studies and Protection Coordination Studies of the proposed electrical system design of each locks complex, in order to comply with the specified requirements, codes and standards. With the aid of the studies, the Contractor shall optimize the electrical design to avoid over-sizing, other that over-sizing for the sake of spare capacity, optimize the protection system to ensure reliable and effective protection of all electrical equipment with proper coordination to avoid unnecessary downtime. The final study shall not include any assumed parameters; all parameters shall be from as built equipment values and nameplates.

B. **Scope**: This Section contains the performance and prescriptive specifications for conducting a Short Circuit Coordination Study and a Load Flow Study of the electrical system of each lock to ensure that the selection of device ratings and characteristics and protection settings are satisfactory. The studies shall include all portions of the medium voltage and low voltage distribution systems. The studies shall be performed with the aid of a digital computer program and in compliance with the latest applicable NFPA 70, IEEE 242, IEEE 399 and ANSI C37 standards. The studies shall enable and oblige the Contractor to optimize circuit usage, ensure proper voltage profiles, minimize losses (kW and kVAR), and correctly size and set protection and operating parameters of each equipment. [A5]This Section also includes the requirements for an arc-flash study for the medium voltage distribution system only, in compliance with IEEE 1584. An arc flash study is not required for the low voltage distribution system. Low voltage distribution equipment will be worked de-energized. [A5]

[A16]1.02 REFERENCES [A16]

A. **American National Standard Institute (ANSI) Standard**

C37.50-89 (R-00)	Switchgear – Low Voltage AC Power Circuit Breakers Used in Enclosures – Test Procedures

B. **Institute of Electrical and Electronics Engineers (IEEE) Standard**

242-01	Recommended Practice for Protection and Coordination of Industrial and Commercial
399-97	Recommended Practice for Industrial and Commercial Power Systems Analysis
C37.010-99 (R-05)	Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Basis.
C37.13-90	Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures

[A5]1584-02 Guide for Performing Arc-Flash Hazard Calculations [A5]

C. **National Fire Protection Association (NFPA) Publication**

[A16]70-08 National Electrical Code (NFPA). [A16]

1.03. REQUIREMENTS:

A. **General**: [A5]For[A5] the Short Circuit Study, Protective Device Coordination Study [A5], [A5] the Load Flow Study [A5], and the Arc-Flash Study [A5] to be conducted by the Contractor, [A5]it [A5] is required for the Contractor to correctly coordinate the protection schemes, in order to prolong the life of the electrical equipment, provide the utmost of safety to personnel, cause the least disruption to the power supply service, and provide the utmost uptime reliability of the equipment and the Locks operation. The studies shall be conducted to cover all of the possible operating conditions of the Employer's prescribed electrical grid, to provide protection under all operating conditions. The Employer's Representative will provide the [A17]Contractor [A17] with the model of the existing electrical system in the Canal area, in ASPEN database format. The studies shall be conducted utilizing the following software: ASPEN One Liner, ASPEN Distri View and ASPEN Power Flow, from ASPEN, Inc. 34 N. San Mateo Dr. Ca. 94401. However, the Contractor may choose to use another software that gives similar accurate results, in which case the Contractor, shall convert the model database to the chosen software database, in addition to [A17]providing [A17] a copy of each software employed with its corresponding licenses. Copies of each the alternate software and license shall be delivered to the Employer's Representative.

1.04 DESIGN AND PERFORMANCE REQUIREMENT:

A. **Short Circuit Study**: The study shall include complete fault calculations at all busses. In the short-circuit study, the Contractor shall provide the calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data including power external source system characteristics, typical calculations, tabulations of calculation quantities and results, equipment rating and setting selected. Calculate short-circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault at each medium voltage supply switchgear lineup, secondary transformer terminals, low-voltage switchgear lineup, motor control center, distribution panel-board, pertinent branch circuit panel-board, and other significant over-current protective device locations throughout the system. Provide a ground fault current study for the same system areas, including the associated zero sequence impedance data. Include in tabulations fault impedance, X to R ratios, asymmetry factors, motor fault contribution, short circuit kVA, and symmetrical and asymmetrical fault currents.

B. **Protective Device Coordination Study**: The protective device coordination study shall ensure that transformers, capacitor banks, electric motors, cables and any other electrical equipment load, are properly protected and coordinated to cause the least disruption to the power supply in case of electrical equipment malfunctioning. The study shall provide time-current curves graphically indicating the coordination proposed for the system, centered on conventional, full-size, log-log forms. Included with each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered by that particular curve sheet. Include a detailed description of each

protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.

Include on the curve sheets and fuse characteristics, medium-voltage protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, pertinent transformer characteristics, pertinent motor and generator characteristics, and characteristics of other system load protective devices. In addition, include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, and main breaker in branch panel-boards. Also include the medium and low voltage main feeders' insulation damage curve properly coordinated. Include all adjustable settings for ground fault protective devices.
Include manufacturing tolerance and damage bands in plotted fuse characteristics. Show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and significant symmetrical fault currents. Terminate device characteristic curves at a point reflecting the maximum symmetrical fault current to which the device is exposed. Select each primary protective device required for a delta-wye connected transformer so that its characteristic or operating band is within the transformer characteristics including a point equal to 58 percent of the ANSI withstand point, to provide secondary line-to-ground fault protection. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by a 16 percent current margin to provide proper coordination and protection in the event of secondary line-to-line faults. Separate medium-voltage relay characteristic curves from curves for other devices by at least a 0.4-second time margin. Considerations for the Diesel Generator set shall include phase and ground coordination of the generator protective devices. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices. Contractor shall obtain the information from the Contractor´s recommended generator manufacturer and include the generator recommended actual impedance value, time constants and current boost data in the study.

C. **Load Flow Study:** The load flow analysis shall be performed to determine the steady-state loading profile of the system under all possible grid configurations including contingency conditions such as loss of transformer, loss of load and one incoming power source line. The study shall provide information of real and reactive power flow, bus voltages, and power factor in each branch of the system. The need and justification for power factor correction shall be clearly identified, and optimized for each location as required. The study shall clearly identify each transformer tap settings and each feeder's expected load and spare capacities. Tabulation shall be provided showing voltage, watts, VARs, at each bus location, in addition to total system losses and individual line losses.

[A5]D. **Arc-Flash Study**: [A17]The Arc-Flash analysis shall be performed to provide the switchgear design and construction requirement for a fully integrated and coordinated arc-flash evaluation with the short circuit and over-current coordination of the switchgear. The study shall comply with IEEE 1584 as the minimum standard for determining trip times for the protective device settings and protection to be provided from arcing fault current values and in support of compliance with IEEE C37.20.7. [A17] The study shall generate reports and labels for Arc-Flash warnings for all medium voltage equipment, in compliance with NFPA 70 (NEC article 110.16), and provide the design-built minimum room requirement for lodging medium voltage equipment. [A5]

1.05 SUBMITTALS:

A. [A5]**General**: All submittals shall be submitted in accordance with Section 01 33 00 (*Submittal Procedures*) and as described herein. Electronic data shall be in a form that can be modified by the Employer in the future. [A5]

B. [A7]The Contractor shall submit within 119 days of the Commencement Date qualification data for the person(s) complying with the Quality Assurance experience requirements to perform the studies specified. Include list of projects with project names, addresses, names of owner and engineer point of contact. [A7]

[A16]C. **After Commencement Date; before construction:** [A16]

1. **Preliminary Study Drawings and Data**:

a. Description of study approach, assumptions made, and scope

b. One line diagram for each grid configuration studied

c. Tabulations of each protective device ratings, versus calculated short circuit duties, and justification commentaries.

d. Protective device versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection and justification commentaries.

e. Fault current calculations including a definition of terms and guide for interpreting the computer outputs.

f. Tabulation of each bus with the kW and kVAR flow and voltage for the various scenarios and contingencies in the power system.

g. [A5]Proposed [A5] setting of all protective devices.

h. If applicable: Deliver software employed for the study. Software and License

[A5]i. Arc-flash calculations data [A5]

2. **Intermediate Study Data, Before Testing and Inspection**:

a. Description of study approach, assumptions made, and scope

b. One line diagram for each grid configuration studied

c. Tabulations of each protective device ratings, versus calculated short circuit duties, and justification commentaries.

d. Protective device versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection and justification commentaries.

e. Fault current calculations including a definition of terms and guide for interpreting the computer outputs.

f. Tabulation of each bus with the kW and kVAR flow and voltage for the various scenarios and contingencies in the power system.

[A5]g. Arc-flash calculations tabulated data. [A5]

3. **Final Report:** The results of the power system study shall be summarized in a final report. The report shall include the following sections:

a. One line diagram for each electrical grid configuration, scenario and contingency, identifying buses, equipment ratings, circuit impedances and connection configurations.

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

c. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short-circuit duties, and commentaries regarding same.

d. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentaries regarding same.

e. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

f. Load flow (kW and kVAR), bus voltage, voltage drop, circuit impedances, equipment impedances-rating and characteristics.

g. Setting of each protective device derived from the study and the actual setting performed in the field.

[A5]h. Arc-flash calculations tabulated data. [A5]

D. **Taking-Over Submittal**:

1. **General**: The Contractor shall comply with the requirements of Section [A5]01 77 00[A5] (*Taking*[A5]-[A5]*Over Procedures*).

2. [A17]**Software and License**: Alternate software and license other than ASPEN software as required by [A17] [A5]Subparagraph 1.07 A., with preliminary drawings and study data shall be submitted in accordance with Section 01 33 00 (*Submittal Procedures*) and as described herein.[A5]

3. [A5]**As-built** [A5] **Drawings**: [A5]As-built drawings shall be submitted in accordance with Section 01 33 00 (*Submittal Procedures*) and as described herein. Drawings shall show electrical grid nodes and electrical parameters for each condition of the grid. Drawings shall also show all of the values rendered by the studies. [A5]

4. **Studies Final Reports**: [A5]The studies final reports shall be submitted in accordance with Section 01 33 00 (*Submittal Procedures*) and as described herein. These reports shall document all calculations, assumptions, input

database, graphics, curves, tabulations, equipment device characteristics, and equipment settings in a printout and in digital form. [A5]

1.06 QUALITY ASSURANCE:

A. **Qualifications of [A5]Personnel [A5]**: The firm or persons that will perform the studies, analysis, evaluation and coordination of the electrical distribution grid for the locks shall have a minimum of 5 year experience record of successful in service performance. The responsible personnel for the studies shall be a registered [A17]professional engineer [A17] with no less than 8 years experience in the analysis, evaluation, and coordination of electrical distribution systems.

B. **Testing and [A5]Inspection [A5]**:

[A16]1. The Contractor shall perform adjustments of the protective devices in the field in accordance with the reviewed short circuit and coordination study. [A16]

2. The Contractor shall verify that all equipment ratings are sufficient for the short circuit duties and loadings determined by the studies.

3. The field testing shall be in accordance with the specification Section 26 90 00 (*Testing Electrical Systems*).

END OF SECTION