SECTION 16425 – POWER SYSTEM STUDIES

PART 1 – GENERAL

1.1 GENERAL

A. Short Circuit Studies, Protective Device Evaluation Studies, Protective Device Coordination Studies and Flash Protection Studies shall be performed by the distribution equipment manufacturer or a firm engaged by the distribution equipment manufacturer.

B. The studies shall be submitted to the Architect prior to receiving final approval of the distribution equipment shop drawings and prior to release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval from the Architect may be obtained for a preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.

C. The studies shall include all portions of the electrical distribution system from the normal power incoming secondary source, the emergency standby source, down to and including all panels and distribution equipment in the distribution system. Normal system connections and those which result in maximum fault conditions shall be adequately covered in the study.

D. The firm should be currently involved in high and low voltage power system evaluation. The study shall be performed, stamped and signed by a registered professional engineer in the State of Maine. Credentials of the individual(s) performing the study and background of the firm shall be submitted to the Engineer for approval prior to start of the work. A minimum of five (5) years experience in power system analysis is required for the individual in charge of the project.

E. The firm performing the study shall demonstrate capability and experience to provide assistance during start up as required.

F. The power system studies are required to confirm the adequacy of the ratings of all electrical system components and proper coordination settings of all circuit breakers to the satisfaction of the Electrical Engineer. These studies shall not be used as a basis to compromise the electrical system and do not imply that short circuit ratings of distribution equipment and devices may be lower than those indicated on the drawings or specified herein.

G. The switchgear equipment manufacturer shall carry in his bid to the Electrical Subcontractor, a sufficient allowance to provide modifications to the equipment, if necessary, based on the results of the studies identified herein.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

3.1 DATA COLLECTION FOR THE STUDY

A. The Electrical Subcontractor shall provide the required data for preparation of the studies. The Engineer performing the system studies shall furnish the Electrical Subcontractor with a listing of the required data immediately after award of the contract.

B. The Electrical Subcontractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and prior to release of the equipment for manufacture.

3.2 SHORT CIRCUIT AND PROTECTIVE DEVICE EVALUATION AND COORDINATION STUDY

A. The short circuit study shall be performed with the aid of a digital computer program and shall be in accordance with the latest applicable IEEE and ANSI standards.

B. In the short circuit study, provide calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data including power company system characteristics, typical calculations, tabulations of calculation quantities and results, conclusions, and recommendations. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault at each supply switchgear lineup, unit substation primary and secondary terminals, low-voltage switchgear lineup, switchboard, motor control center, distribution panelboard, branch circuit panelboards, and all other distribution equipment 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 contribution, short circuit kVA, and symmetrical and asymmetrical fault currents.

C. In the protective device coordination study, provide time-current curves graphically indicating the coordination proposed for the system, centered on conventional, full-size, log-log forms. Include 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.

D. Include on the curve sheets power company relay and fuse characteristics, system medium-voltage equipment relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices. Include all devices down to largest branch circuit and largest feeder circuit breaker in each motor control center, and main breaker in branch panelboards.

E. Include all adjustable settings for ground fault protective devices. Include manufacturing tolerance and damage bands in plotted fuse characteristics. Show transformer full load and 150, 400, or 600 percent currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and significant symmetrical and asymmetrical fault currents. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed.

F. 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. Where the primary device characteristic is not within the transformer characteristics, show a transformer damage curve. 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.

G. Include complete fault calculations as specified herein for each proposed and ultimate source combination. Note that source combinations may include present and future supply circuits, large motors, or generators as noted on Drawing one-lines.

H. Submit qualifications of individual(s) who will perform the work for approval prior to commencement of the studies. Provide studies in conjunction with equipment submittals to verify equipment ratings required. Submit a draft of the study to the Architect for review prior to delivery of the study to the Owner. Make all additions or changes as required by the reviewer.

I. Include fault contribution of all motors in the study. Notify the Architect, in writing, of circuit protective devices not properly rated for fault conditions.

J. Provide settings for the chiller motor starters or obtain from the Mechanical Subcontractor, include in the study package, and comment.

K. When an emergency generator is provided, 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. Obtain the information from the generator manufacturer and include the generator actual impedance value, time constants and current boost data in the study. Do not use typical values for the generator.

L. Evaluate proper operation of the ground relays in 4-wire distributions with more than one main service circuit breaker, or when generators are provided, and discuss the neutral grounds and ground fault current flows during a neutral to ground fault.

M. For motor control circuits, show the MCC full-load current plus symmetrical and asymmetrical of the largest motor starting current and time to ensure protective devices will not trip during major or group start operation.

N. For distribution transformer primary protection, the system study engineer shall use 12.0 times the transformer full load amps to determine transformer in-rush. If a miscoordination occurs between the calculated in-rush and the primary circuit breaker, prior to issuance of the study, the system study engineer shall contact the manufacturer and obtain the actual in-rush for the transformer(s) in question and/or change the circuit breaker to a type that will coordinate the transformer in-rush with the circuit breaker trip curve. If, after determination of actual in-rush and proper selection of primary circuit breaker, a miscoordination still exists, it shall be reported in the submitted study.

3.3 FLASH PROTECTION STUDY

A. Flash Protection Boundaries

1. Calculation of flash protection boundaries shall be performed on all parts of the electrical system, for the Owner's documentation and implementation of details of limits of approach boundaries as required by NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces.
2. Flash protection boundaries shall be calculated for equipment required to be worked on while energized electrical conductors or circuit parts are exposed. Calculations shall be provided for the following equipment including but not limited to:

    a. Substation and switchboard assemblies
    b. Motor control centers
    c. Panelboards
    d. Disconnect switches
    e. Controller equipment such as variable frequency/adjustable speed drives
    f. Fuses and circuit breakers
    g. Rotating equipment
    h. Batteries
    i. Generators
    j. Automatic transfer switches
    k. Premises wiring

3. Flash protection boundaries for circuits rated 600V and less shall be calculated utilizing one of the following formulae:

$$D_c = [\ 2.65 \times MVA_{bf} \times f\ ]^{1/2}$$

or,

$$D_c = [\ 53 \times MVA \times f\ ]^{1/2}$$

where:

D_c = distance of person from an arc source for a just curable burn in feet

MVA_{bf} = bolted fault MVA at point involved

MVA = MVA rating of transformer. For transformers with MVA ratings below 0.75 MVA, multiply the transformer MVA rating by 1.25

t = time of arc exposure in seconds

B. Incident Energy Exposures

1. Calculation of incident energy exposures shall be performed on all parts of the electrical system, for the Owner's determination and implementation of details of personal protective equipment as required by NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces.
2. Incident energy exposures shall be calculated for equipment required to be worked on while energized electrical conductors or circuit parts are exposed. Incident energy exposures for circuits rated 600V and less and emanating from any of the equipment listed in Paragraph titled Flash Protection Boundaries shall be calculated utilizing the 'Arc in a Cubic Box' formula listed as follows with results expressed in calories/square centimeter (cal/cm^2):

$$E_{MB} = 1038.7 \times D_B^{-1.4738} \times t_A \times [(0.0093 \times F^2) - (0.3453 \times F) + 5.9675]$$

where:

E_{MB} = maximum 20 in. cubic box incident energy, cal/cm2

D_B = distance from arc electrodes, inches (for distances 18 in. and greater)[Note 1]

t_A = arc duration, seconds

F = bolted fault short circuit current, kA (for the range of 16 to 50 kA)

Note 1: Incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Utilize 18 inches for all calculations.

3. Incident energy exposure calculations for lower level (downstream) components shall be considered the same as for higher level (upstream) components of the same feeder or branch circuit where the same overcurrent protective device serves both higher and lower components and where the available short circuit current is not depreciably reduced due to increased system impedances such as would be introduced with long conductor lengths.

3.4 STUDY REPORT

A. The results of the power system study shall be summarized in a final report. Six (6) bound copies of the final report shall be submitted to the Architect.

B. The report shall include the following sections:

1. Descriptions, purpose, basis and scope of the study.
2. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties, and commentary regarding same.
3. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
4. Fault current calculations including a definition of terms and guide for interpretation of computer printout.
5. Flash protection boundaries indicted on scaled drawings for inclusion in the electric rooms. Refer to Specification Section 16050.
6. Flash protection incident energy exposures including a definition of terms and guide for interpretation of calculations.

3.5 POWER COMPANY APPROVAL

A. Where required, copies of the final report shall be submitted to the power company for their review and approval. Approved copies of the report shall be submitted to the Architect.

END OF SECTION