SECTION 16938

POWER SYSTEM STUDY

# GENERAl

## REQUIREMENTS

### The Contractor shall prepare a short circuit (SC), load flow (LF), and protective device evaluation/coordination (PDEC) and arc flash study for the electrical power system in accordance with the requirements of these Specifications and as shown on the contract documents.

### The study shall include all portions of the electrical distribution system from the utility service for utility power sources and standby power sources down to and including the 480V and lower voltage distribution system. This shall include all new electrical equipment as shown on the single-line diagram.

### It is the responsibility of the Contractor to obtain the short circuit information required for the study from the power utility company. The equipment characteristics and data in the study shall match the equipment and associated impedance actually being installed.

### The Contractor shall expedite and be fully responsible for collection of data from equipment suppliers, from the DISTRICT to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to release of the equipment for manufacture.

### The study shall be performed with SKM Electrical Engineering software.

## QUALIFICATIONS OF ORGANIZATION RESPONSIBLE FOR THE STUDY

### Short circuit studies, protective device evaluation studies, and protective device coordination studies shall be performed by a professional electrical engineer from the low voltage switchgear manufacturer or an electrical testing agency who has been regularly engaged in short circuit and protective device coordination services for a period of at least 10 years. The study shall utilize proven computer programs for making three-phase fault duty and single phase ground fault duty calculations. The studies shall be signed and stamped by a professional electrical engineer, registered in the State of California, responsible for the studies. This service shall be performed by Square D Engineering services, Emerson Electric Reliability Services, Eaton Engineering Services, or ABB/General Electric Engineering Services.

## REFERENCE SPECIFICATIONS, CODES AND STANDARDS

### The short circuit and protective device coordination study shall be conducted under the applicable standards of the American National Standards Institute (ANSI), and the latest edition of the National Electrical Code (NEC). Specifically, the following standards shall apply.

#### ANSI/IEEE 141 – Recommended Practice for Electrical Power Distribution for Industrial Plants

#### ANSI/IEEE 242 – Recommended Practice for Protection, and Coordination of Industrial, and Commercial Power Systems

#### ANSI/IEEE C 37.010 – Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

#### ANSI/IEEE C 37.13 – Low-Voltage AC Power Circuit Breakers Used in Enclosures

#### ANSI/IEEE C 57.109 – Guide for Transformer Through-Fault-Current Duration

## CONTRACTOR SUBMITTAL

### The short circuit protective device coordination report shall conform to the requirements of this Section entitled “Power Systems Study.”

### Studies related to distribution system protection and coordination shall be submitted to the DISTRICT prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval from the Engineer may be obtained for a preliminary submittal of sufficient detail to ensure that device selection will be adequate. Preliminary submittal shall indicate the computer program (preferably SKM) for use in performing the work of this section. Submit both hard copy and electronic version including completed SKM databases to the DISTRICT. A copy of a full size 22” x 34” single-line diagram folded in a plastic 8.5” x 11” holder shall be submitted as part of the submittal.

### Protective device and coordination evaluation studies must be approved by the DISTRICT and the Engineer prior to system implementation and testing.

# PRODUCTS

## GENERAL

### The study organization shall prepare a single-line diagram of the power system. This single-line diagram shall identify all specific components considered in the study, and the ratings as well as contributions of all power devices (This includes, but is not limited to: transformers, circuit breakers, relays, fuses, buses, conduit material and cables). The study input data shall include the power company's short circuit contribution, resistance and reactance components of the branch impedances, the X/R ratios, base quantities selected, and other source impedances.

## SHORT CIRCUIT STUDY (SC)

### The short circuit study shall be performed with the aid of a digital computer program and shall be in accordance with ANSI C37.5, IEEE Standard 242, and IEEE Standard 141. The short circuit study shall include a minimum of two general groups of system-wide calculations including 3-phase bolted faults and single-phase line-to-ground faults. The study shall produce a minimum of 4 complete system-wide sets of data and calculation results including 4 sets covering 3-phase bolted faults and 6 sets covering single-phase line-to-ground faults. The 4 sets of data and results for each group shall correspond to switching, motor and power supply operating arrangements for the worst-case faults on the bus of:

#### Main service distribution switchboard \_\_\_\_\_

### Typical operating arrangements for worst-case faults are indicated in Table 1

|  |  |  |
| --- | --- | --- |
| **SHORT CIRCUIT STUDY**  **OPERATING ARRANGEMENTS FOR WORST-CASE FAULTS**  **TABLE 1** | | |
| **Short Circuit Case** | **Main Bus In** | **Notes** |
| 480V service available  (bolted 3-phase fault) symmetrical | Main Service Distribution Switchboard \_\_\_\_\_ | Assume all pumps and all auxiliaries are operating  On Utility Power |
| Same as above  (ground fault) | Main Service Distribution Switchboard \_\_\_\_\_ | Same as above |
| 480V service available  (bolted 3-phase fault) symmetrical | Main Service Distribution Switchboard \_\_\_\_\_ | Assume 60% of total loads are operating on emergency generator power |
| Same as above  (ground fault) | Main Service Distribution Switchboard \_\_\_\_\_ | Assume 60% of total loads are operating on emergency generator power |

## PROTECTIVE DEVICE EVALUATION STUDY (PDEC)

### A protective device evaluation study shall be performed to determine the adequacy of current transformers, circuit breakers, molded case switches, relays, fuses, and other protective devices by tabulating and comparing the short circuit ratings of these devices with the calculated fault currents. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the Engineer’s attention.

## PROTECTIVE DEVICE COORDINATION STUDY (PDEC)

### A protective device coordination study shall be performed to provide the necessary calculations required to select or check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristics and settings.

## TIME / CURRENT COORDINATION CURVES (PDEC)

### As a minimum, the time current coordination curves for the power distribution system shall include the following on 5 cycle log-log graph paper:

#### Time-current curve for each circuit breaker, protective relay or fuse showing graphically that the settings will provide protection and selectivity within industry standards. Each curve shall be identified; relay taps and time dial settings shall be specified. Curves shall be provided for ground fault settings as well as phase bolted fault settings.

#### Time-current curves for each device shall be positioned to provide the maximum selectivity to minimize system disturbances during fault clearing. Where selectivity cannot be achieved, the Engineer shall be notified as to the cause.

#### Time-current curves and points for transformer, motor, bus, cable and equipment damage.

#### Circuit interrupting device operating and interrupting times.

#### Indicate maximum fault values on the graph.

#### Sketch of bus and breaker arrangement.

#### Magnetizing inrush points of transformers.

#### Motor starting currents and thermal limits of motors 100 HP and above.

#### All restrictions of the ANSI and National Electrical Code shall be adhered to and proper coordination intervals and separation of characteristics curves shall be maintained.

## LOAD FLOW (LF)

### Several steady state load flow studies shall be conducted. The initial tap settings of all the 480 volt transformers shall deliver the nominal 480 volts at the associated switchboard and MC main buses, and all transformers seeing all connected load running at full load. For any power system with a combined 100hp of motor loads or larger, a steady state load flow with the above initial conditions shall be provided for the following cases and shall be submitted for Engineer review.

#### Load flow studies shall be provided for the two switching and operational arrangements described in Table 1 for the short circuit calculations.

#### Load flow studies shall show all major node voltages and branch currents including motor terminals, associated MCC, and associated transformers both secondary and primary. A summary of identified branch voltage drops shall be provided to identify voltage drop problems.

## ARC FLASH HAZARD ANALYSIS

### Perform an arc flash hazard analysis after the short circuit and protective device coordination study has been completed.

### The analysis shall be calculated by means of the SKM Power Tools for Windows computer software package. Pertinent data, rationale employed, and assumptions in developing the calculations shall be incorporated in the introductory remarks of the study.

### The analysis shall be in accordance with latest applicable NFPA 70E, OSHA 29-CFR, Part 1910 Sub part S and IEEE 1584 Standards.

### The arc flash analysis will determine the following:

#### Flash Hazard Protection Boundary

#### Limited Approach Boundary

#### Restricted Boundary

#### Prohibited Boundary

#### Incident Energy Level

#### Required Personal Protective Equipment Class

#### Type of Fire Rated Clothing

### Produce an Arc Flash Warning label table listing items above for each of the major equipment covered in the scope of work. Also include the bus name and voltage. Labels shall be printed in color and be printed on adhesive backed heavy duty vinyl Labels.

### Produce Bus Detail sheets that list the items D 1-7 from above and the following additional items:

#### Bus Name

#### Upstream Protective Device Name, Type, and Settings

#### Bus Line-to-Line Voltage

### Produce Arc Flash Evaluation Summary Sheet listing the following additional items:

#### Bus Name

#### Upstream Protective Device Name, Type, and Settings

#### Bus Line to Line Voltage

#### Bus Bolted Fault

#### Protective Device Bolted Fault Current

#### Arcing Fault Current

#### Protective Device Trip / Delay Time

#### Breaker Opening Time

#### Solidly Grounded Column

#### Equipment Type

#### Gap

#### Arc Flash Boundary

#### Working Distance

#### Incident Energy

#### Required Protective Fire Rated Clothing Type and Class

## STUDY REPORT

The results of the power system study shall be summarized in a final report signed and stamped by a California registered professional engineer. The report shall include the following minimum sections:

### Introduction, executive summary and recommendations, assumptions, reduced copy of the one-line drawing and a folded full size one-line drawing.

### Arc Flash Evaluations Summary Spreadsheet

### Bus Detail Sheets

### Coordination curves and settings of protective devices

### Arc Flash Hazard Warning Labels printed in color on adhesive backed labels. On each label, date, name, address and phone of the organization performing the study shall be indicated. Each label shall not be smaller than 4” by 6”. For outdoor electrical equipment, the labels shall be suitable for outdoor usage and shall be water-proof.

# EXECUTION

## FIELD INVESTIGATION

### The Contractor shall provide a field data of motor, transformer, conduit, buses, cable, switchboard, protective device, interlocks, operational and setting data and nameplate information from new electrical equipment in the field for input into the studies.

## PROTECTIVE DEVICE TESTING, CALIBRATION TESTING, CALIBRATION AND ADJUSTMENT

### For breakers with multi-function electronic settings, the Low Voltage 600V equipment manufacturer may have an option to provide the services of a qualified field engineer and necessary tools and equipment to test, calibrate, and adjust the protective relays, motor protection devices, and circuit breaker trip devices as recommended in the power system coordination study.

## STUDY REPORT

### The results of the power system study shall be summarized in a final report. Four bound copies of the final report signed and sealed with PE stamp and signature shall be submitted. The report shall include the following:

#### Description, purpose, basis, criteria, scope and assumptions of the study.

#### Single-line diagram drawing with detailed short circuit data and details.

#### Tabulation of all protective devices, which shall be identified on the single-line diagram. Devices ratings versus calculated short circuit duties, and commentary regarding same. Device settings versus transformer inrush currents, motor staring currents and calculated short circuit currents and commentary regarding same.

#### Time/current coordination, colored curves for all protective devices.

#### Computerized fault current calculations and input data.

#### Specific recommendations on equipment ratings, protective device settings and ratings.

#### Equipment and wire input data impedances shall be clearly listed.

#### Instrumentation, condition, and connections for each study

#### Transformer, motor and cable damage curves.

#### Equipment hazard category and labels.

## RECOMMANDED CHANGES

### If recommended changes in breakers or fuses or protective devices will provide coordination where coordination was not originally possible, the Contractor shall incorporate these changes at no additional cost to the DISTRICT. Additional protective devices recommended by this study, not shown or specified in the Contract Documents, may be proposed, but are not part of the requirements of the Contract Documents.

## FINAL STUDY REPORT

### After all the DISTRICT’s submittal comments and any setting revisions to the equipment have been incorporated, a Final Study Report (hard copy and electronic version) shall be submitted to the Engineer prior to implementation of the settings and affixing the arc flash labels on the electrical equipment..

### Computer disk copies of the report input and output SKM data bases shall be submitted with the final report in addition to the 4 bound copies. The SC, LF and PDEC computer program name version and phone number and address of the manufacturer shall be indicated.

## LABEL IMPLEMENTATION

### Affix all respective arc flash labels on all electrical equipment that have been covered by the study. In addition, furnish and install the following reflective tapes for the following indoor electrical equipment:

#### At 48” in front of each 480V electrical power panel, switchboard, MCC, starters, disconnects, transformers etc.

#### At 36” in front of each 120/208/240V electrical power panel, control panel, disconnect.

#### Reflective floor warning tapes shall be 2” wide, vinyl, and self-adhesive, yellow and black slanted stripes. The tapes shall be manufactured by 3M, or equal. Clean floor thoroughly prior to affixing the tapes on the floor.

#### Provide one spare 10-yard rolls of warning tapes to the DISTRICT for their use.

#### Provide spare 100 generic arc flash labels to the DISTRICT for their use.

END OF SECTION