

DIVISION 26 – ELECTRICAL
SECTION 26 05 73 – SHORT-CIRCUIT/COORDINATION/ARC FLASH STUDY

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes
1. Short-Circuit, Protective Device Coordination and Arc Flash Studies
 2. Labels

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems.
 2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
 3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis.
 4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings.
 5. IEEE 1015 – Recommended Practice for Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
 6. IEEE 1584-2004a, IEEE Guide for Performing Arc Flash Hazard Calculations.
- B. American National Standards Institute (ANSI):
1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 2. ANSI C37.13 – Standard for Low Voltage ac Power Circuit Breakers Used in Enclosures.
 3. ANSI C37.010 – Standard Application Guide for ac High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
 4. ANSI C37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.
 5. ANSI C37.5 – Methods for Determining the rms Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage, and for Simplified Calculation of Fault Currents.

- C. The National Fire Protection Association 70, National Electrical Code, latest edition.

1.03 SUBMITTALS

- A. Submit in accordance with the requirements of Section 01 33 00.
- B. The short-circuit, protective device coordination and arc flash studies shall be submitted to the Authority prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Authority may be obtained for preliminary submittal of sufficient study data to ensure that the selection of devices and characteristics will be satisfactory.
- C. The results of the short circuit, coordination and arc flash studies shall be summarized in a final report. Submit three (3) bound copies of the final report. Additional copies, where required, shall be provided on CD in PDF format.
- D. Reports:
 - 1. One-line diagram showing protective device ampere ratings and associated designations, cable size & lengths, transformer kVA & voltage ratings, motor & generator kVA ratings, and switchgear/switchboard/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. Incident energy level (calories/cm²) for each equipment location and recommended PPE.
 - 7. Comments and recommendations for system improvements, where needed.
 - 8. Executive summary.

1.04 QUALITY ASSURANCE

- A. Qualifications:
 - 1. The short-circuit and coordination studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the Engineering Services Organization.

PART 2 – PRODUCT

2.01 STUDIES

- A. Contractor to furnish short-circuit, protective device coordination and arc flash studies as prepared by equipment manufacturer.

2.02 DATA COLLECTION

- A. Contractor shall furnish all field data as required by the power system studies. The Engineer performing the short-circuit and coordination studies shall furnish the Contractor with a listing of required data. The Contractor shall expedite collection of the data to eliminate unnecessary delays and ensure 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 obtained from Contract Documents provided by Owner or Contractor.
- D. Include fault contribution of existing motors in the study, with motors < 50 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.03 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

- A. Use typical conductor impedances based on IEEE Standard 141, latest edition.
- B. Transformer design impedances and standard X/R ratios shall be used when test values are not available.
- C. Provide the following:
 - 1. Calculation methods and assumptions.
 - 2. Selected base per unit quantities.
 - 3. One-line diagram of the system being evaluated.
 - 4. Source impedance data, including electric utility system and motor fault contribution characteristics.
 - 5. Typical calculations.
 - 6. Tabulations of calculated quantities.
 - 7. Results, conclusions and recommendations.
- D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:
 - 1. Electric utility's supply termination point.
 - 2. Incoming switchgear.

3. Unit substation primary and secondary terminals.
 4. Low voltage switchgear.
 5. Motor control centers.
 6. Standby generators and automatic transfer switches.
 7. Branch circuit panelboards.
 8. Other significant locations throughout the system.
- E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.
- F. Protective device evaluation:
1. Evaluate equipment and protective devices and compare to short circuit ratings.
 2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses.
 3. Adequacy of transformer windings to withstand short-circuit stresses.
 4. Cable and busway sizes for ability to withstand short-circuit heating.
 5. Notify Owner in writing of existing circuit protective devices improperly rated for the calculated available fault current.

2.04 PROTECTIVE DEVICE COORDINATION STUDY

- A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.
- B. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.
- C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
- D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay and instantaneous settings recommended.
- E. Plot the following characteristics on the curve sheets, where applicable:
1. Electric utility's protective device.
 2. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands.
 3. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters.
 4. Conductor damage curves.
 5. Ground fault protective devices, as applicable.

6. Pertinent motor starting characteristics and motor damage points.
 7. Pertinent generator short-circuit decrement curve and generator damage point.
 8. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center.
- F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

2.05 INCIDENT ENERGY STUDY

- A. An incident study shall be done in accordance with the IEEE 1584-2004A, "IEEE Guide for Performing Arc Flash Hazard Calculations" as referenced in NFPA 70, "Standard for Electrical Safety in the Workplace", 2008 Revision, in order to quantify the hazard for selection of Personal Protective Equipment (PPE). Simply using the table values from NFPA 70E and assuming fault current levels and clearing times for proper PPE selection is not acceptable. The manufacturer shall assist in selecting appropriate combinations of PPE prior to the final analysis and preparation of equipment labels.

2.06 REPORT SECTIONS

- A. Input Data:
1. Utility three-phase and line-to-ground available contribution with associated X/R ratios.
 2. Short-circuit reactance of rotating machines with associated X/R ratios.
 3. Cable type, construction, size, # per phase, length, impedance and conduit type.
 4. Bus duct type, size, length and impedance.
 5. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance and X/R ratio.
 6. Reactor inductance and continuous ampere rating.
 7. Aerial line type, construction, conductor spacing, size, # per phase, and length.
- B. Short-Circuit Data:
1. Source fault impedance and generator contributions.
 2. X to R ratios.
 3. Asymmetry factors.
 4. Motor contributions.
 5. Short circuit kVA.
 6. Symmetrical and asymmetrical fault currents.
- C. Recommended Protective Device Settings:

1. Phase and Ground Relays:
 - a. Current transformer ratio.
 - b. Current setting.
 - c. Time setting.
 - d. Instantaneous setting.
 - e. Specialty non-overcurrent device settings.
 - f. Recommendations on improved relaying systems, if applicable.
2. Circuit Breakers:
 - a. Adjustable pickups and time delays (long time, short time, ground).
 - b. Adjustable time-current characteristic.
 - c. Adjustable instantaneous pickup.
 - d. Recommendations on improved trip systems, if applicable.
3. Incident energy level (calories/cm²) for each equipment location and recommended PPE.

2.07 LABELS

- A. Based on the results of the incident energy study, the supplier shall produce and install danger labels for each piece of equipment as specified in Paragraphs 1., 2. and 3. of Section B above, in accordance with ANSI Z535.4-2002. The labels must be readable in both indoor and outdoor environments for at least 3 years and contain the following information as appropriate:
 1. Arc hazard boundary (inches).
 2. Working distance (inches).
 3. Arc flash incident energy at the working distance (calories/ cm²).
 4. PPE category and description including the glove rating.
 5. Voltage rating of the equipment.
 6. Limited approach distance (inches).
 7. Restricted approach distance (inches).
 8. Prohibited approach distance (inches).
 9. Equipment/bus name.
 10. Date prepared.
 11. Supplier name and address.

PART 3 – EXECUTION

3.01 FIELD ADJUSTMENT

- A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish conformance with short-circuit and protective device coordination studies.
- C. Notify Authority in writing of any required major equipment modifications.
- D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

3.02 SAFETY TRAINING

- A. The supplier shall provide one day of arc flash safety training that contains the requirements referenced in OSHA 1910.269, OSHA 1910 Subpart S and NFPA 70E. This shall include:
 - 1. Proper use of the system analysis data.
 - 2. Interpretation of hazard labels.
 - 3. Selection and utilization of personal protective equipment.
 - 4. Safe work practices and procedures.
- B. The supplier shall provide an outline of the one day training course including training materials at time of quotation. The owner, at its discretion, may require a needs assessment and/or additional training customized to its specific needs. The supplier shall be capable of developing and presenting customized training for approval as required.
- C. The supplier shall provide a training certificate to record satisfactory completion by owner's employees for continuing education credits and re-licensing requirements. Satisfactory completion is defined as the student obtaining a minimum of 70% on the post training examination and the ability to work safely if a hands on performance evaluation is provided.

END OF SECTION