

H:\CAD\24-610-2249\22490\_MpPumps\22490 - C05 - Pump Station - Details.dgn - Master Model 3/7/2022 2:52:29 PM Plotted by jhanks Plot Scale 50.000000 -7.1in Plot Driver: Volz15 PDF Plotter Pn: Table: Volz15 PDF.tbl

- ii. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
  - iii. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
  - iv. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
  - v. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
  - vi. IEEE 1584 -Guide for Performing Arc-Flash Hazard Calculations
  - b. American National Standards Institute (ANSI):
    - i. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
    - ii. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
    - iii. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
    - iv. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.
  - c. The National Fire Protection Association (NFPA)
    - i. NFPA 70 -National Electrical Code, latest edition
    - ii. NFPA 70E – Standard for Electrical Safety in the Workplace
- D. SUBMITTALS FOR REVIEW/APPROVAL**
- a. The studies shall be submitted to the responsible City representative for review and approval prior to final completion.
- E. FINAL SUBMITTALS**
- a. The results of the short-circuit protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. A minimum of five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Electronic PDF copies of the report shall also be provided.
  - b. The report shall include the following sections:
    - i. Executive Summary including Introduction, Scope of Work and Results/Recommendations
    - ii. Short-Circuit Methodology Analysis Results and Recommendations
    - iii. Short-Circuit Device Evaluation Table
    - iv. Protective Device Coordination Methodology Analysis Results and Recommendations
    - v. Protective Device Settings Table
    - vi. Time-Current Coordination Graphs and Recommendations
    - vii. Arc Flash Hazard Methodology Analysis Results and Recommendations including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy Levels and Personal Protection Equipment levels.

- viii. Arc Flash Labeling section showing types of labels to be provided. Section will contain descriptive information as well as typical label images.
  - ix. One-line system diagram that shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, device numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis. All drawing files must also be submitted electronically as a .dwg file format for future updating by City personnel.
- F. QUALIFICATIONS**
- a. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.
  - b. The Registered Professional Electrical Engineer shall be an employee of the approved contractor.
  - c. The Registered Professional Electrical Engineer shall have a minimum of five (5) years of experience in performing power system studies.
  - d. The approved contractor shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year.
  - e. The contractor shall have a minimum of ten (10) years of experience in performing power system studies.
- G. COMPUTER ANALYSIS SOFTWARE**
- a. The studies shall be performed using ETAP software or approved equal. The purpose of this requirement is to allow the City to obtain studies and reports that remain consistent and similar by design to studies that have already been provided to several of our locations.
- PART 2 PRODUCT**
- A. STUDIES**
- a. The Contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D. This study shall also include short-circuit and protective device coordination studies.
- B. DATA COLLECTION**
- a. Field data collection shall be performed by the Contractor's professional engineer and they must be a qualified person (as defined by NFPA 70E) to ensure accurate equipment modeling. The engineer shall have completed an instructor-led Electrical Safety Training Course. The course shall include NFPA 70E training which includes the selection and use of personal protective equipment.
- The Contractor will visually inspect to verify the equipment ratings, conductor ratings and overcurrent device data by removing panels, covers and

- doors where required to document the necessary data used in the analysis. These inspections can be performed with the equipment energized provided the incident energy values are less than 40cal/cm<sup>2</sup>, greater values or unusual site conditions will require an equipment shutdown so the equipment can be inspected de-energized.
  - b. The City shall provide qualified personnel to show the Contractor the equipment location and to open all equipment doors, locks, etc. necessary to collect nameplate data.
  - c. The Contractor will verify the Owner's one-line drawings (when available) and provide marked corrections where discrepancies are found.
  - d. Data collection shall begin downstream from the utility service and continue down through the Owner's electrical distribution system as defined under scope of work. The study shall not include any single phase AC circuits or DC distribution systems as these types of circuits and systems are excluded from IEEE 1584-2002 Arc Flash calculation guidelines. The study will not include equipment below 240 Volts, per Section 4.2 of IEEE 1584, unless it involves (1) 125KVA or larger low impedance transformer in its immediate power supply capable of supplying 10,000 AIC or greater.
  - e. The Contractor shall obtain from the utility the minimum, normal, and maximum operating service voltage levels, three-phase short circuit MVA and X/R ratio, as well as line-to-ground short circuit MVA and X/R ratio at the point of connection as shown on the drawings.
- C. SHORT-CIRCUIT ANALYSIS**
- a. Transformer design impedances shall be used when test impedances are not available.
  - b. Provide the following:
    - i. Calculation methods and assumptions
    - ii. Selected base per unit quantities
    - iii. One-line diagram of the system being evaluated that clearly identifies individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis. All drawing files must also be submitted electronically as a .dwg file format for future updating by City personnel.
    - iv. The study shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.
    - v. Tabulations of calculated quantities including short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings and notes regarding adequacy or inadequacy of the equipment rating.
    - vi. Results, conclusions, and recommendations. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system to include an engineer's cost estimate for recommended

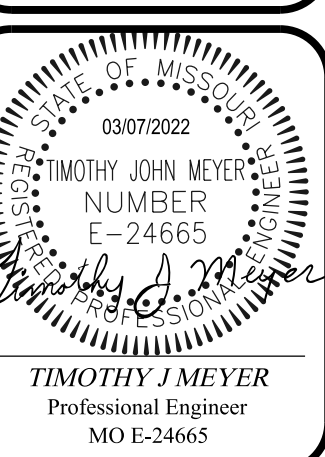
- improvements.
  - c. For solidly-grounded systems, provide a bolted line-to-ground fault current study for applicable buses as determined by the engineer performing the study.
  - d. Protective Device Evaluation:
    - i. Evaluate equipment and protective devices and compare to short circuit ratings
    - ii. Adequacy of switchgear, motor control centers, and panel board bus bars to withstand short-circuit stresses
    - iii. The Contractor shall notify the City in writing, of any circuit protective devices improperly rated for the calculated available fault current.
- D. PROTECTIVE DEVICE TIME-CURRENT COORDINATION ANALYSIS**
- a. Protective device coordination time-current curves (TCC) shall be displayed on loglog scale graphs.
  - b. Include on each TCC graph, a complete title with descriptive device names.
  - c. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
  - d. Identify the 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 TCC graphs, where applicable:
    - i. Electric utility's overcurrent protective device
    - ii. Medium voltage equipment overcurrent relays
    - iii. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
    - iv. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
    - v. Transformer full-load current, magnetizing inrush current, and ANSI throughfault protection curves
    - vi. Medium voltage conductor damage curves
    - vii. Ground fault protective devices, as applicable
    - viii. Pertinent motor starting characteristics and motor damage points, where applicable
    - ix. Pertinent generator short-circuit decrement curve and generator damage point
    - x. The largest feeder circuit breaker in each motor control center and applicable panel board.
  - f. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
  - g. Provide the following:
    - i. A One-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known. All drawing files must also be submitted electronically as a .dwg file format for future updating by City personnel.
    - ii. A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.

- iii. Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
  - iv. The study shall include a separate, tabular printout containing the recommended settings of all adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram
  - v. A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
  - vi. The Contractor shall notify the City in writing of any significant deficiencies in protection and/or coordination. Provide recommendations for improvements to include an engineer's cost estimate for the recommended improvements.
- E. ARC FLASH HAZARD ANALYSIS**
- a. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis (Section 7.7.C) and the protective device time-current coordination analysis (Section 7.7.D)
  - b. The flash protection boundary and the incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panel boards, busway and splitters) where work could be performed on energized parts.
  - c. Circuits less than 240 , where available bolted short circuit current is less than 10 kA, may be omitted from the computer model and will be assumed to have a hazard risk category 0 per NFPA 70E Table 130.7(C)(9)(a), including footnote 3.
  - d. Circuits less than 240 fed by transformers 112.5 kVA or less may be omitted from the computer model and will be assumed to have a hazard risk category 0 per IEEE 1584.
  - e. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.
  - f. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.
  - g. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by

- generator applications.
- The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
- b. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:
    - i. Fault contribution from induction motors should not be considered beyond 5 cycles.
  - i. For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides, or rear; and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arcing fault. For all other non ANSI rated equipment, only one calculation shall be required and it shall be based on a device located upstream of the equipment to clear the arcing fault.
  - j. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
  - k. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
  - l. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of 2 seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
  - m. Provide the following:
    - i. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels.
    - ii. The Arc-Flash Hazard Analysis shall report incident energy values based on recommended device settings for equipment within the scope of the study.
    - iii. The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety. If any new equipment recommendations or improvements are made by the contractor to reduce the incident energy levels, include an engineer's cost estimate for the recommended improvements.
- PART 3 EXECUTION**
- A. FIELD ADJUSTMENT**

- a. The Contractor shall adjust relay and protective device settings according to the recommended settings table provided by the coordination study.
  - b. The Contractor shall make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
  - c. The Contractor shall notify the City in writing of any required major equipment modifications.
- B. ARC FLASH LABELS**
- a. The Contractor shall provide a 4.0 in. x 4.0 in. thermal transfer type label of high adhesion polyester for each work location analyzed.
  - b. The labels shall be designed according to the following standards:
    - i. UL969 – Standard for Marking and Labeling Systems
    - ii. ANSI Z535.4 – Product Safety Signs and Labels
    - iii. NFPA 70 (National Electric Code) – Article 110.16
  - c. The label shall include the following information:
    - i. System Voltage
    - ii. Flash protection boundary
    - iii. Personal Protective Equipment category
    - iv. Arc Flash Incident energy value (cal/cm<sup>2</sup>)
    - v. Limited, restricted, and prohibited Approach Boundaries
    - vi. Study report number and issue date
  - d. Labels shall be printed by a thermal transfer type printer, with no field markings.
  - e. Arc flash labels shall be provided for equipment as identified in the study and the respective equipment access areas per the following:
    - i. Floor Standing Equipment - Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries shall be labeled as identified in the Arc Flash Analysis table.
    - ii. Wall Mounted Equipment – Labels shall be provided on the front cover or a nearby adjacent surface, depending upon equipment configuration.
    - iii. General Use Safety labels shall be installed on equipment in coordination with the Arc Flash labels. The General Use Safety labels shall warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.
  - f. Labels shall be field installed by the Contractor. The technician providing the installation shall have completed an 8-Hour instructor led Electrical Safety Training Course with includes NFPA 70E material including the selection of personal protective equipment.

- SECTION 8 - SCADA MONITORING & ALARM SYSTEM**
- 8.1 SYSTEM REQUIREMENTS
    - A. A 15" by 15" open space shall be provided in the control panel for installation of future SCADA equipment.
  - 8.2 SYSTEM INTEGRATOR SCOPE OF WORK
    - A. Refer to paragraph 7.1 of this specification for further description of the required Scope of Work for the System Integrator.



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INVERNESS

PUMP STATION - DETAILS

1575 BRYAN RD. Project # 22450

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PHASE 3