

## SECTION 34 21 75

### TRACTION POWER FACILITY FUNCTIONAL FACTORY TESTING

#### PART 1 – GENERAL

##### 1.01 SECTION INCLUDES

- A. Traction Power Facility Functional Factory Test Requirements.

##### 1.02 OVERVIEW

- A. General
  - 1. The Contractor's testing program shall verify, validate and document that the Traction Power Facilities have been designed, manufactured, constructed, assembled, installed, adjusted, calibrated and electrically connected to meet the approved design, operational, functional and performance requirements as specified in the Contract Documents and approved design and construction submittals.
  - 2. The testing program shall implement a methodical and structured approach that demonstrates all circuits function as intended and failsafe if subjected to abnormal operating conditions.
  - 3. The inspections and tests specified in this Section and elsewhere in the Contract represent the minimum requirements. Where additional inspection and/or testing requirements are recommended by the respective equipment manufacturers and/or industry standards, include these requirements in the test documentation and processes.
  - 4. Refer to Contract Specifications Section 01 45 24, Testing Program Requirements for test plan preparation, submittal, and reporting requirements. The Contractor shall have approved test plan and procedures before starting the factory tests described herein.
  - 5. Refer to Section 01 78 55, Safety and Security Certification for safety certification requirements associated with the testing program.

##### 1.03 ABBREVIATIONS/SYMBOLS

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|---------|--|
| 1. CPUC | California Public Utilities Commission |
| 2. EBP  | Emergency Backup Panel                 |
| 3. ETP  | Emergency Trip Panel                   |
| 4. ETS  | Emergency Trip Switch                  |
| 5. ETTC | Emergency Transfer Trip Cabinet        |

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|-----|------|--|
| 6.  | ETTS | Emergency Transfer Trip System           |
| 7.  | HMI  | Human Machine Interface                  |
| 8.  | ICS  | Integrated Control System                |
| 9.  | IPR  | Integrated Protection Relay              |
| 10. | MPR  | Multi Function Protection Relay          |
| 11. | PLC  | Programmable Logic Controller            |
| 12. | NGD  | Negative Grounding Device                |
| 13. | NYMS | New Yard Management System               |
| 14. | RTAC | Real Time Automation Controller          |
| 15. | SBBS | Sectionalization Breaker Blocking System |

#### **1.04 RELATED SECTIONS**

A. Refer to the following Sections for requirements relating to inspection and testing activities:

1. Section 01 45 00, Quality Control
2. Section 01 45 24, Testing Program Requirements
3. Section 34 21 33, Control, Monitoring and Display Panel
4. Section 34 21 35, Emergency and Transfer Trip System

#### **1.05 MEASUREMENT AND PAYMENT**

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with related items of Work in the Bid Schedule of the Bid Form, or incidental to the Work.

### **PART 2 – PRODUCTS**

Not Used

**PART 3 – EXECUTION****3.01 GENERAL**

- A. This Section includes the functional factory testing requirements for the fully assembled AC and DC house equipment included within traction power switching and sectionalizing stations, traction power substations, and gap breaker stations.
- B. Completion of the factory tests specified in the following Sections are prerequisites for the functional tests specified in this Section:
1. Section 34 21 05, Prefabricated AC and DC Equipment Houses
  2. Section 34 21 11, Multi-Function Protection Relay Equipment
  3. Section 34 21 17, AC Switchgear (SF 6 Gas Insulated Type)
  4. Section 34 21 18, AC Switchgear (Sealed Vacuum Type)
  5. Section 34 21 19, Separable Insulated Connectors
  6. Section 34 21 20, AC Busways
  7. Section 34 21 21, Transformer-Rectifier Units
  8. Section 34 21 25, DC Switchgear
  9. Section 34 21 27, Liquid Immersed Type Auxiliary Power Transformers
  10. Section 34 21 30, Negative Grounding Device
  11. Section 34 21 33, Traction Power Control, Monitoring and Display Panel
  12. Section 34 21 35, Emergency and Transfer Trip System
  13. Section 34 21 40, DC Control Power System
  14. Section 34 21 50, Common Materials and Methods for Traction Power
  15. Section 34 21 55, Manual DC Disconnect Switch
  16. Section 34 21 56, 34.5 kV Isolation Disconnect Switches
- C. All tests shall be carried out in accordance with detailed and pre-approved testing program plans, procedures and data sheets.
- D. Prior to commencement of factory acceptance testing to be witnessed by the Engineer ensure that:
1. AC and/or DC equipment houses and associated equipment, cabling, conduits, etc. are completely installed per the approved equipment vendor design.

2. All control and protective relay devices are programmed with correct operational parameters and in a condition ready for testing.
3. AC and/or DC equipment houses and associated equipment are cleaned.

The Engineer will attend factory testing as a witness only after receipt of certification that Items 1 through 3 above have been completed. The Contractor shall bear all costs associated with any cancellation, delay, and rescheduling of factory tests due to incompleteness of the equipment preparation for testing.

- E. FAT punchlists are actioned and FAT reports are approved by the District prior to shipping equipment to site for field installation.
- F. Where the test execution and associated test records deviates from the approved test procedures the Contractor and/or its sub-contractors shall demonstrate equivalency and/or conduct all the tasks within the approved test procedures at no additional cost to the District.

### **3.02 INSTALLATION VERIFICATION**

- A. Equipment Assembly Inspection: Verify the following:
  1. Enclosures and equipment are anchored correctly.
  2. Physical damage, cracked insulators, and tightness of connections, defective wiring, and general mechanical and electrical conditions are noted.
  3. Record all part numbers and serial numbers, and equipment nameplate data and main coil identification numbers.
- B. Verify presence of voltage shock hazard and arc-flash hazard warning safety labels (per NFPA 70E) and all other safety / warning labels / signage required by the equipment manufacturer, CalOSHA and/or as specified in Section 26 05 53, Identification Requirements, are visibly installed on the front side, and at other access points, of the equipment enclosures.
- C. Grounding Connections Inspection: Verify that all enclosure, equipment, and relay grounding connections inside of the ac and dc equipment houses, and rectifier transformer ground connections are in place, and properly made. Verify using approved drawings, which shall be marked as to completion.
- D. Verify all doors for correct gaskets, closing and latching, and padlock provisions.
- E. Mechanical Integrity Tests
  1. Perform mechanical checks on the physical integrity of all equipment. These tests shall include, but shall not be limited to, verifying the correct alignment of the racking mechanism of all circuit breakers by withdrawing and inserting the breaker module, verifying interlocks, contact gap spacing, correct bus connection torqueing and placing of torque marks, and checking up doors and access panels.

2. Interchangeability of like-rated ac and dc circuit breakers shall be confirmed. An AC and DC circuit breaker shall not be interchangeable with a switchgear cubicle designed for a circuit breaker with a different rating. Dc feeder circuit breakers shall not be interchangeable with dc cathode circuit breakers.
  3. Verify correct mechanical and key interlocking.
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not available, use those specified in UL 486 A&B.
  - G. Settings and Calibration: Verify the proper settings of all relays, and other protective and control systems and devices.
  - H. Conform by bench testing or by injection of signals into installed equipment that all protective relays function in accordance with the approved relay coordination study and settings.
  - I. Verify space heater operation.

### **3.03 TRACTION POWER FACILITY FUNCTIONAL TEST**

- A. General. The following system-level tests shall be carried out on each AC and DC equipment house, rectifier-transformer control modules, negative grounding devices, and remote Emergency and Transfer Trip System (ETTS) components. Tests shall be done after the houses are completely assembled and wired and all equipment has successfully passed the specified design and production tests. Equipment such as the CISCO Ethernet network switch in the C02 panel and the ETTS logic controller in the ETTC cabinet shall have passed the required equipment-specific system factory tests, and shall have been installed and wired in the DC equipment house.
- B. Circuit Continuity Tests. Perform tests to verify the continuity of all power and control circuits, combined with inspection checks to confirm that all wiring is correctly terminated in accordance with approved control schematics and wiring diagrams. The wiring shall be checked completely, including interconnections between associated AC and DC equipment houses equipment where applicable, and at shipping splits, if required.
- C. Dielectric Tests. Resistance tester (megger) with appropriate voltage output to confirm the insulation integrity of all power, control power, and hard-wired control and indication circuits and control power buses and confirm the isolation of the dc switchgear and rectifier enclosures from ground:
  1. Test insulation resistance at 6.8 kV dc for one minute on the 1,000 V dc power buses to ensure there is no insulation breakdown along the main power path.
  2. Test dc switchgear and rectifier enclosures (with Device 164 disconnected) and on insulated wall surfaces to confirm the integrity of the insulation from ground. The enclosures to ground insulation shall be tested with at least 6800 V dc applied for one minute.

3. Test high resistance floors at 2,500V dc for one minute using a six-inch square (minimum) weighted test plate with meter connected between the test plate and the DC house structure ground. Apply a high conductivity saline solution between test plate and floor surface to ensure good electrical contact. Test locations shall be 24 inches apart covering the entire floor surface. Perimeter locations shall be within six inches of the edge. Minimum isolation resistance shall be 1,000 megohms, minimum.
4. Test to verify the insulation integrity of control power buses and low voltage power and control cables and wiring with the end devices disconnected where appropriate at 1500 V AC for one minute or 1800 V ac for one second.

D. Fire Alarm System Tests:

1. After the fire alarm and smoke detection system is completely installed, it shall be tested for continuity and correct operation.
2. The fire alarm system for the entire facility shall be tested as a complete system. If elements of the AC and/or DC equipment house to be protected by the fire alarm system are absent from the factory test setup, system end devices (smoke detectors, pull stations, strobes) shall be provided as part of the test setup enabling test of the complete fire alarm system.
3. Check operational integrity of the detection chamber by applying smoke. Each ionization detector shall be operated to ensure that the indicating lamp at the annunciator panel is lit. After completion of the test, the ionization detectors shall be set for correct sensitivity.

E. System Level Production Test. Perform functional tests on all equipment, devices, and control circuits to verify that they function in accordance with the final approved control schematics, and meet the requirements of the Contract:

1. Verify that all ac and dc feeder breakers of like size and application are interchangeable.
2. Temperature Alarms and Devices. All high temperature alarms and devices shall be tested, their calibration and settings checked, and proper operation verified.
3. Undervoltage Relays. Tests to verify the pickup and dropout levels of the undervoltage relays shall be performed.
4. Door Interlocks. Tests to verify the proper functioning and operation of all door interlocks in the DC house such as those on the rectifier doors and the doors to the dc circuit breaker compartments shall be performed.
5. No load DC Negative Disconnect Switch Interlock: Test to verify proper functioning of the interlocking system between the no load DC negative disconnect switch and the main DC circuit breaker shall be performed.
6. Support Systems and Devices. Check the required settings of thermostats and humidistats for the space heaters, ventilation equipment, the facility air

temperature alarm, and confirm the proper functioning of all support systems and devices, including those of the 125 V dc control power system.

7. Control and indication functions shall be tested for all circuits including relays, annunciator panel, local and remote indications, local and remote control, and shutdown.
8. Control and indication functions shall be checked for proper operation by actuating each contact that initiates a control operation or alarm indication, and then following the control sequence or signal propagation through the various associated devices to ascertain that the correct results and indications are obtained for each condition. A complete set of the job schematics and connection diagrams shall be maintained by the test department during the testing. Upon completion of a circuit check, that circuit shall be high-lighted by the test technician to indicate circuit sequence verification.
9. Actuation of contacts, as required to initiate an operation and to set up the interlocking conditions, shall be performed in a manner that effectively simulates operating scenarios. Functional tests on controls of the 34.5 kV ac circuit breakers shall include comprehensive verification of all automatic transfer routines. Functional tests on controls of the 1000 V dc circuit breakers shall include verification of the load measuring, auto-reclosing, and non-reclosing sequences.
10. Reverse-Current Trip. The Contractor shall apply current in the reverse direction through each main dc circuit breaker to verify that the reverse-current trip device trips the associated circuit breakers at the minimum current setting, as required.
11. DC Equipment Enclosure Protective Scheme. The proper operation of the high-resistance frame grounding scheme in all modes shall be verified by tests involving application of high potential and ac and dc control voltages to the dc switchgear enclosure (enclosure 'hot'), as well as grounding of the dc switchgear enclosure (enclosure 'grounded').
12. System full voltage test shall be performed on the switchgear assemblies to verify voltage transducers and voltage multipliers/dividers primary input to secondary output.
13. Control Parameters. Verify the control parameters, configuration, and set points of all equipment with electronic (microprocessor-based) controls such as electronic relays, NGD and ETTS equipment.
14. Emergency and Transfer Trip System (ETTS). The emergency and transfer trip cabinet (ETTC) shall be installed and wired to connect with the dc switchgear and the C02 panel. Other ETTC cabinets and logic controllers that will operate at adjacent facilities in conjunction with the DC house ETTC shall be interconnected to simulate the complete system to be placed in service. The following ETTS tests shall be performed:
  - a. Actuate, one at a time, all system inputs that receive platform trip and emergency trip signals. Verify correct operation of the platform and

emergency trip circuits and logic by confirming correct response of circuit breakers to each signal, and that the dc circuit breakers tripped do NOT attempt to reclose. At adjacent facilities, verify that correct dc feeder breaker trip signals are received by the ETTS logic controller.

- b. At the DC equipment house under test, generate one at a time, transfer trip signals from the actuating device at each dc feeder breaker. Verify correct operation of the transfer trip circuits and logic by confirming correct response of circuit breakers to each signal, and that the dc circuit breakers tripped do successfully reclose. At adjacent facilities, verify that correct dc feeder breaker trip signals are received by the ETTS logic controller.
  - c. At equipment to be located at adjacent facilities, actuate one at a time, all system inputs that receive transfer trip request signals. Verify correct operation of the transfer trip circuits and logic by confirming correct response of circuit breakers to each signal, and that dc circuit breakers tripped do successfully reclose. At adjacent facilities, verify that correct dc feeder breaker trip signals are received by the ETTS logic controller.
  - d. Verify that the emergency trip panel (ETP) incoming Blue Light Station trip signal from the local traction power facility to the ETTS equipment is properly decoded by the ETTC Logic Controller and that appropriate ac and dc circuit breakers are trip and do NOT attempt to reclose.
  - e. For all cases observed in Items a-c above, verify that accurate alarm signals are received locally at the C02 PLC, and remotely at Integrated Computer System (ICS), Emergency Back-up Panels (EBP1, EBP2), and New Yard Management System (NYMS).
15. Control and Annunciator Panel (C02). BART will provide a test laptop that emulates remote controls and indications of the BART ICS, EBP1 and EBP2, and the NYMS for use during functional testing. These communicate through the BARTnet system using the communication protocol used by BART via the PLC in the C02 cabinet and the Ethernet switch in the C04 cabinet. The following functional tests shall be performed:
- a. AC and DC switchgear status shall be verified at the C02 annunciator panel, and confirmation shall be obtained that the correct status indications are sent to the ICS, EBP1, EBP2, and NYMS. Tests shall be done by operating the switchgear.
  - b. Alarm functions at the switchgear shall be simulated at each device, and the correct indication verified at the C02 annunciator panel and the ICS, EBP1, EBP2, and NYMS.
  - c. Tests shall demonstrate that the C02 software has been configured so that all required traction power facility equipment controls, indications, alarms, system and device status indications, and data downloads can be successfully passed between the traction power facility C02 panel and the appropriate remote terminals to the ICS, EBP1, EBP2, and NYMS.
  - d. Control circuit functional testing shall be performed by actuating control switches on the C02 annunciator panel, and observing the operation of the circuit breakers and associated status indications on the mimic panel.

- e. The correct operation of selector and lockout switches shall be verified between the C02 panel and the switchgear.
  - f. Access to RTAC PLC, IPR, MPR, and NGD data and settings through the secondary Ethernet Port shall be demonstrated.
16. Any wires which are not tested during the functional testing shall be tested by continuity test to confirm wiring accuracy to the approved schematic and

**END OF SECTION 32 21 75**