

SECTION 18600

SIGNAL SYSTEMS TESTING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Section includes requirements for tests and inspections to demonstrate that systems, subsystems, assemblies, subassemblies, and components supplied and installed under this Contract are in compliance with these Specifications and with all applicable regulatory requirements.

1.02 REFERENCE STANDARDS

- A. Code of Federal Regulations (CFR), Title 49, Transportation:
 - 1. Part 234 Grade Crossing Signal System Safety
 - 2. Part 236 Rules, Standards, and Instructions for Railroad Signal System
- B. American Railway Engineering and Maintenance of Way Association (AREMA):
 - 1. Communications and Signals Manual of Recommended Practices (C&S Manual). When following recommendations of the AREMA, substitute the word "should" with "shall".

1.03 TEST SYSTEM DESCRIPTION

- A. It shall be understood where this Section states "as authorized by the PCJPB Signal Manager or PCJPB Signal Engineer" or "submit to the PCJPB Signal Manager or PCJPB Signal Engineer" such authorization or submittal shall be through the Engineer.
- B. Tests and inspections shall be made both during the progress of this Contract and after completing installation of equipment, and shall consist of factory tests of Contractor Furnished equipment, circuit breakdown tests, wiring verification tests, continuity tests, resistance tests, voltage and current tests, applicable locking tests, operating tests, simulation tests, and other electrical and mechanical tests and inspections.
- C. The work shall include all tests required to ensure proper and safe operation of all systems and subsystems, and to prove the adequacy and acceptability of the total installation specified herein. Tests to be performed shall cause each system and subsystem to be sequenced through its required operations, including imposition of simulated conditions to prove that the installation complies with all specified fail-safe requirements.
- D. Each Contractor furnished component and unit of the wayside signal and highway grade crossing system shall have an inspection performed at its point of manufacture

and evidence of this inspection and acceptability shall be indicated on the item where practicable.

- E. Conduct an acceptance test on all Owner furnished equipment prior to loading at the warehouse. Provide certified acceptance reports with each unit at time of delivery.
- F. Work shall include costs of the Contractor's personnel and any special equipment and assistance required to conduct all tests with complete documentation.
- G. Test equipment of proper type, capacity, range, and accuracy shall be supplied by the Contractor to perform required tests and inspections.
- H. Test equipment used shall be in good working order and properly calibrated within 6 months of the date of the tests. This equipment shall display a sticker indicating its calibration date and the agency that performed the calibration.
 - 1. Calibration of each instrument shall be certified by a recognized testing facility. Instruments with out-of-date calibrations will be considered non-certified. Tests conducted with non-certified instruments will be rejected.
- I. In the event that the system does not meet requirements, necessary corrections and retesting shall be made by the Contractor. The Contractor shall successfully complete all tests and inspections possible prior to performing final in-service tests.
- J. Work shall include all necessary disconnecting and reconnecting in order to perform the specified tests.
- K. Signal systems test work specified elsewhere in these Specifications shall be construed as related to and inclusive with the testing described herein.
- L. Field tests shall be coordinated with the Engineer. As many tests and inspections as possible shall be completed prior to the final cutover to avoid train delay, inconvenience to the travel public, and cost to the Owner. The Contractor shall place systems in-service in phases where possible, thus reducing the actual cutover period.
- M. Tests shall ensure conformance with CFR 49, Parts 234 and 236, and shall be recorded on forms provided by the Engineer and signed by the Contractor's Signal Engineer directing each test and inspection.
- N. Tests and inspections shall conform to the PCJPB's Test and Maintenance Manual. Three copies of this Manual will be provided to the Contractor at the Pre-Construction meeting. Refer to Section 01200, Meetings. The Contractor shall request guidance from the Engineer where the test and inspection requirements written herein conflict with the PCJPB's Test and Maintenance Manual.
- O. Testing, including pre-testing, shall include operating all switch machines and lighting all signals. The use of lamp simulators in lieu of, or in parallel with signal lamps will not be allowed in pre-testing. An exception may be authorized by the PCJPB Signal Manager or PCJPB Signal Engineer where a signal or switch

machine is in service and will be reconfigured for final cutover, or cannot be installed or wired until final cutover.

- P. An appropriate meter shall be used when testing circuits. Visual observation of a relay is only valid when coil voltage or current or contact voltage, as applicable, is also measured.
- Q. Test and inspection procedures shall be subject to the PCJPB Signal Manager or PCJPB Signal Engineer's acceptance and shall comply with all regulatory requirements and the manufacturer's recommended test procedure.
- R. Notify the Engineer in writing at least 48 hours prior to each field test. No part of the signal system shall be placed in service without an authorized representative of the Engineer being present and witnessing the in-service tests.

1.04 SUBMITTALS

- A. Submit the following pre-test information to the Engineer for acceptance:
 - 1. Submit a Pre-testing authorization request 15 days in advance of proposed pre-testing. Such request shall include:
 - a. Names of Contractor's Signal Engineer in charge of pre-testing.
 - b. Other personnel assigned to the pre-test who will be performing the tests or assisting with the tests.
 - c. List the assigned location(s) of the Contractor's personnel and their designated duties during the pre-test.
 - d. An outline of the tests to be performed on each type of component, unit, or system, together with samples of the corresponding test records. The outline shall be arranged to indicate the proper sequence of each test to be performed on each component or unit. In addition, the date and time will be shown for each test.
 - e. Description of each test to be performed, including the operating parameter to be tested. Test equipment to be used for the test, including the model number, serial number, calibration period, last calibration date and a brief description of the purpose of the test equipment.
 - f. Description of equipment to be used for communication purposes.
 - 2. Schedule of pre-testing Contractor proposes to perform which includes beginning and ending dates, times, and locations in a time-line format.
 - 3. Identify any test or operation that may disrupt or disarrange the existing signal circuits or systems. Include description of proposed safety provisions and back-up contingency plans.

- B. Submit the following in-service testing information to the Engineer for acceptance:
1. Submit, 30 days in advance of any in-service testing, a detailed cutover and in-service test procedure. This procedure shall indicate the Contractor's personnel involved, their assigned location, and responsibility during the in-service testing. Include the following for Contractor-directed signal cutovers (the following does not apply to Owner-directed signal cutovers): The test procedure shall adequately reflect the test to be performed and the sequence in which the tests shall be performed. A signal aspect chart indicating the appropriate signal aspect to be displayed as train simulation tests are made shall be included. The signal aspect chart shall indicate the progressive down grading of signals and track codes and shall reflect the resulting signal aspect displayed as a result of a light-out condition.
 2. The test procedure shall include an outline of the tests to be performed on each type of component, unit, or system, together with corresponding samples of test record forms and cards. The outline shall be arranged to indicate the proper sequence of each test to be performed on each component or unit; the numbers of each type of component or unit to be tested to demonstrate adequacy of design and quality control; and a line diagram showing the grouping and sequencing of system and subsystem
- C. Contractor's testing procedures and cut-over plan must pass the PCJPB Signal Manager or PCJPB Signal Engineer's and the Operating Railroads review. Contractor shall allow 30 days for this approval process.
- D. Record the results of each test, as herein specified, and submit copies of the field test reports to the Engineer immediately at the completion of the cut-over testing. Prepare final type-written test reports as indicated herein and submit to the Engineer within five (5) days after the completion of each test. Final Type-written test reports shall include complete details of the test results and corrections or adjustments performed or which remain to be completed. The type-written test reports shall be signed and dated by the Contractor's responsible employee. Furnish certified test results for tests performed by any subcontractors, when such tests are required within these Specifications.
- E. Where required in this Section, submit test results on completed PCJPB test record forms.
- F. Submit test reports for any additional tests required by the Contractor to ensure the safe operation of the system to the Engineer.
- G. Upon completion of all tests, submit a letter certifying that all tests necessary to comply with all current regulatory requirements of these specifications have been performed.

1.05 QUALITY ASSURANCE

- A. The Work and testing shall comply with the following standards and regulatory requirements: AREMA Communications and Signals Manual, Part 2.4.1. and CFR, Title 49, Parts 234 and 236. When following the recommendations of the AREMA

C&S Manual substitute the word "shall" for the word "should" in the applicable Manual Part.

PART 2 – PRODUCTS

2.01 SITE TEST INSTRUMENTS AND EQUIPMENT

- A. Test instruments and equipment necessary to conduct the tests specified herein shall be available, ready for use not less than one week in advance of test need. "Ready for use" shall mean properly matched for test parameters, properly calibrated, sufficiently supplied with leads, probes, adapters, stands, and similar items necessary to conduct the particular test in a completely professional manner.

2.02 TEMPORARY TEST MATERIALS

- A. Temporary or interim test related materials, special tools, connections, jumpers, and similar items shall be furnished and available not less than one week in advance of the test need.

2.03 FACTORY TESTS AND INSPECTIONS

- A. All wiring and equipment shall be checked to verify conformance to the Contract Drawings and the Specifications.
- B. Each control point, intermediate signal, grade crossing warning system shelter or any other signal equipment shelter shall be tested to verify that it functions properly before it is shipped to the field for installation. These tests shall involve connecting all control systems (excluding signals, switches, and similar equipment) that make up a control point, intermediate signal, grade crossing warning system shelter, or any other signal equipment shelter; applying power; and then exercising each function of the system and verify proper result.
- C. Confirmation shall be provided by the Contractor that all required factory tests of Systems, sub-systems, assemblies, sub-assemblies and components supplied under this Contract have been performed. Each component and unit shall be inspected at its point of manufacture and evidence of this inspection and acceptability shall be indicated. Certified test reports shall be furnished.

PART 3 - EXECUTION

3.01 FIELD TEST PROCEDURES

- A. Perform as many pre-tests as possible in advance of in-service testing. Include, at a minimum, the adjustment of tunable joint couplers, microprocessor based coded track circuits, verify signal aspects against received and transmitted codes. Verify operation of, calibrate grade crossing prediction units, and adjust grade crossing signal control equipment as required to assure proper operation. In order to have a successful cut-over, it is essential that as much pre-testing and advance wiring be completed on the Main tracks before in-service testing begins.
 - 1. Condition precedent for in-service testing and cut-over will be the completion of pre-testing and the PCJPB Signal Manager or PCJPB Signal Engineer's

acceptance of the results. Complete pre-testing and submit the results to the Engineer not less than one (1) week prior to the proposed cut-over date.

- B. The field tests performed shall cause each installed system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions, to demonstrate that the installation complies with all specified fail-safe design requirements and operational functions.
- C. Demonstrate the quality of installation by field tests for continuity, insulation resistance, resistance of ground connections, circuit breakdown, visual inspection, and any other tests required by these Specifications. Perform these tests prior to any operational testing of systems or subsystems.
- D. The Contractor's test procedures shall consist of preprinted data sheets or inspection forms. Where applicable, results of test results shall be recorded on PCJPB forms. These forms will be provided by the Engineer. When completed by the field test personnel and checked for accuracy and completeness, submit the sheet as the test report.
- E. When tests require specific meter or test instrument readings, the preprinted data sheet shall show the allowable range of values, for each part of the test. The test report shall also contain a check off system for each action and a blank space adjacent to the expected value in which to record the test readings.
- F. All test reports shall be dated and signed by the responsible employee of the Contractor or subcontractor on the day the test is performed. Space also shall be provided for the signature of the witnessing inspector.
- G. The report shall show the specific test instruments used on each test, with instruments identified by name, type, serial number, calibration date, and calibration due date.
- H. Should an error be discovered during field testing due to field wiring and connections that do not agree with the accepted circuit plans, the Contractor may correct such errors without prior acceptance of the Engineer. The Contractor shall not, however, make any changes that deviate from the Contract Drawings without prior written acceptance of the Engineer.
- I. The Engineer will make all final determinations as to whether only a part, or the whole test, shall be rerun when any specific field test does not meet the requirements specified for the test.
- J. Any changes made after completion of test procedure shall be re-tested in accordance with the applicable test procedure and regulatory requirement.

3.02 GENERAL FIELD TESTS AND INSPECTION

- A. Perform general field tests including the tests listed herein.
- B. Ground verification test.
- C. Dielectric Breakdown test of all vital circuitry.

- D. Wiring verification of all non-vital circuitry.
- E. Vital function tests.
- F. Operating tests.
- G. All applicable tests prescribed by AREMA C&S Manual Part 2.4.1, where the AREMA inspections and tests do not conflict with the requirements of these Specifications
- H. All applicable tests as required to ensure systems comply with CFR 49, Parts 234 and 236.

3.03 SPECIFIC FIELD TESTS AND INSPECTION

- A. Perform specific field tests listed herein.
- B. Grounds:
 - 1. Ground resistance shall be tested and reported as described in Section 18450.
 - 2. All low voltage dc circuits shall be tested to verify that they are free of grounds.
 - 3. Contractor shall record test results on the appropriate PCJPB form and submit this completed form to the Engineer in order to obtain acceptance of this test requirement.
- C. Insulation Resistance:
 - 1. Insulation resistance tests shall be made between all conductors and ground, and between conductors in each cable in accordance with FRA rule 236.108. The insulation resistance of wires and cables installed by the Contractor shall provide an "infinite" reading when using a direct reading instrument (megger) having a self-contained source of direct current test voltage. The megger scale shall have a minimum range of zero to 20 megohms and be rated at 250 volts minimum and 650 volts maximum.
 - 2. All insulation tests shall be performed after the equipment and cables are installed in the field.
 - 3. Contractor shall record test results on the appropriate PCJPB form and submit this completed form to the Engineer in order to obtain acceptance of this test requirement.
- D. Vital Relays:
 - 1. All dc vital relays shall be tested for pick-up and drop-away values. These values shall be in accordance with field requirement values stated in Table I of AREMA C&S manual, Part 6.4.1.

2. Contractor shall perform all tests required to complete the appropriate PCJPB form.
 3. These tests shall be performed at the shelter locations after the shelter has been set.
 4. Contractor shall record test results on the appropriate PCJPB form and submit this completed form to the Engineer in order to obtain acceptance of this test requirement.
- E. Energy Distribution: Energy-Off Tests: With all power to the signal instrument shelter or wayside case off, the following checks and tests shall be performed. These tests shall include:
1. Removing all fuses.
 2. Verifying that circuit breaker size compares to that of Contract Drawings.
 3. Comparing wire gages with those called for on the Contract Drawings. All discrepancies in wire sizes shall be replaced with the proper size wire.
 4. During energy distribution breakdown, a wire count on each terminal, relay contact, etc. shall be taken to ensure that only the number of wires called for on the Contract Drawings is present at each terminal, relay contact, etc. Any discrepancies found shall be corrected and additional wires, if found, shall be removed.
 5. Verify proper system voltage for each power supply, ac and dc.
 6. Verify all power supplies for correct setting quantities.
 7. Verify that no cross, shorts, or grounds exist.
 8. Tags shall be verified for proper nomenclature and terminal location.
- F. Breakdown of Control Circuits:
1. All circuits shall be tested in their entirety for the correct operation of and response to each contact on each circuit element, such as relays and contactors. Where parallel paths exist, the tests shall validate each path, and circuits shall be opened when required to ensure the proper test.
 2. Each circuit shall be tested by simulating all operating conditions to verify that the circuit operates in accordance with the Specifications and accepted plans.
- G. Electric Switch and Lock Movements (when applicable):
1. Continuity checks of field wires to switch-and-lock movements to verify all nomenclature.

2. Adjust throw bar so that proper tension is placed on switch points in both directions.
 3. Manually operate switch machine normal and adjust lock rods and point detector rods to allow switch machine to lock up with no obstruction. Repeat above for switch machine in reverse position.
 4. Turn on switch machine power, call switch machine normal and observe in field that switch machine corresponds to position called, and observe in wayside instrument shelter that proper switch correspondence relay is energized.
 5. With switch machine called normal, check gaps on circuit controller contacts to see that they meet equipment specifications. Operate machine reverse and repeat.
 6. Break down each contact in switch circuit controller and observe that proper switch correspondence relay drops. Repeat this procedure for both positions of the switch.
 7. Place ammeter in series with motor control energy and adjust clutch such that it causes overload relay to pick up in less than ten seconds with 1/4-inch obstruction in switch point. Record current reading. Repeat for opposite position.
 8. Place switch and lock movement in "hand" operation and observe switch mechanism cannot be operated by power. Place back in "motor" and verify that switch mechanism can be powered.
 9. Operate switch, then shunt detector track circuit and observe that switch machine is stopped in middle of stroke and not allowed to complete movement. Remove shunt and verify switch completes movement.
 10. Contractor shall record test results on the appropriate PCJPB form and submit this completed form the Engineer in order to obtain acceptance of this test requirement.
- H. Signal Layouts: Tests shall be performed on all signal layouts. These tests shall include the following:
1. Continuity check of field wires and verification of all nomenclature.
 2. Apply energy to signal lighting circuits and adjust all lamp voltages to 10 percent less than the lamp rating.
 3. Sight signals for maximum visibility.
 4. Check that light-out feature, where used, complies with FRA Rule 236.23(f).
- I. Line Circuits: The purpose of this test procedure shall be to verify the integrity of line circuits between wayside instrument locations. These tests shall include the following:

1. All nomenclature shall be verified and line circuits tested for continuity.
 2. Each repeater relay shall be tested to determine that it follows all the proper track relays de-energized in the signal shelters.
- J. Control Office to Wayside Interface (when applicable): Upon completion of the wayside tests, a system test shall be performed to ensure continuity of operation of wayside equipment by the supervisory control system. This test shall consist of controlling all office wayside functions from the supervisory control console, and the transmission back to the control office of all indications from the field stations. The functions to be tested shall include the following:
1. Controls from Supervisory Control Console
 - a. Control of switch machines.
 - b. Lining of routes.
 2. Indications to Supervisory Control Console
 - a. Switch machine positions
 - b. Track circuit occupancy.
 - c. Signal indications.
 - d. Power-off and alarm indications.
 3. All design changes found necessary to obtain proper operation shall be submitted to the PCJPB Signal Manager or PCJPB Signal Engineer for acceptance.
- K. Local Panel Test (when applicable):
1. Verify proper operation of all controls and indications.
- L. Switch Circuit Controllers (when applicable):
1. Each switch circuit controller shall be tested to verify wiring, mechanical connectors, point obstruction, and point detection in accordance with AREMA C&S Manual, Part 12.5.1.
 2. Contractor shall record test results on the appropriate PCJPB form and submit this completed form to the Engineer in order to obtain acceptance of this test requirement.
- M. Track Circuits:
1. Each track circuit shall be tested for shunting sensitivity and polarity in accordance with the AREMA C&S Manual, Part 8.6.1.

- N. Insulated joints:
1. Each insulated joint installed by the Contractor shall be tested with S&C Model 324 Track Circuit Short Finder, or Engineer accepted equal, and shall measure no less than 100 ohms across the joint.
- O. Interlocking and Control Point Tests (when applicable):
1. A detailed list of the tests and complete test procedures shall be provided by the Engineer to establish safe and proper operation of interlockings. The Contractor shall provide the necessary personnel and equipment, along with support functions, as part of the Signal Test Crew. The test sequence shall be designed to test each function for correct performance, in accordance with these Specifications and the accepted plans. Furthermore, the test sequence shall include simulated unusual conditions to determine that the interlocking circuits will respond in a safe and desirable way.
 2. The functions to be tested shall include the following:
 - a. Time locking
 - b. Route locking
 - c. Verification of timing of time releases
 - d. Indication locking
 - e. Signal operation in accordance with route and aspect charts
 - f. Interconnection with existing block signal systems
 - g. Interconnection with existing interlockings. With an established direction of traffic, the controlled signal governing entrance to that particular route shall be put to stop. Traffic in the opposite direction shall not be established until a predetermined time has passed. This predetermined time shall be as indicated on the accepted plans. It shall be ascertained that time locking is effective for this test.
 3. Time tests shall be as follows:
 - a. Loss of shunt
 - b. Time locking
 - c. Flashing rate time
 4. Contractor shall record test results on the appropriate PCJPB forms. Submit these completed forms to the Engineer in order to obtain acceptance of these test requirements.

END OF SECTION