

SECTION 18000

GENERAL SIGNAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Section includes general procedures and requirements for the planning, manufacturing, installation, removal, relocation, modification, testing, placing in service, and documentation of as-built conditions of the various signal systems.

1.02 GENERAL

- A. Provisions of this Section apply to all Sections of Division 18, Signals.
- B. Modify existing equipment and material as shown on the Contract Drawings to interface with the existing and proposed signal system.

1.03 REFERENCE STANDARDS

- A. Electrical equipment, unless specifically excluded herein, shall conform to the standards of the National Electrical Manufacturers Association (NEMA), The Underwriters' Laboratories Inc., (UL), the Electrical Testing Laboratories (ETL), the National Electrical Testing Association, Inc. (NETA), or the Electronic Industries Association (EIA), wherever applicable. Unless specifically excluded herein, materials and workmanship shall conform to the requirements of the National Electrical Code; California Administrative Code, Title 8, Chapter 4, Subchapter 5, Electrical Safety Orders; Caltrain Signal Standards, and any applicable local ordinances.
- B. The following General Orders (G.O.) of the State of California Public Utilities Commission (CPUC) shall apply:
 - 1. G.O. 26 Clearances on Railroads and Street Railroads as to Side and Overhead Structures, Parallel Tracks, and Crossings
 - 2. G.O. 52 Construction and Operation of Power and Communication Lines for the Prevention or Mitigation of Inductive Interference
 - 3. G.O. 75D Protection of Crossing at Grade of Roads, Highways, and Streets with Railroads
 - 4. G.O. 88 Alteration of Existing Grade Crossing of Public Roads, Highways, and Streets with Railroads
 - 5. G.O. 118 Construction, Reconstruction, and Maintenance of Walkways and Control of Vegetation
 - 6. G.O. 128 Construction of Underground Electric Supply and Communication Systems

- C. The following parts of the Code of Federal Regulations, Title 49, Transportation, shall apply:
1. Part 212 State Safety Participation Regulations
 2. Part 214 Railroad Workplace Safety
 3. Part 219 Control of Alcohol and Drug Use
 4. Part 218 Railroad Operating Practices
 5. Part 220 Railroad Communications
 - Part 228 Hours of Service of Railroad Employees
 6. Part 234 Grade Crossing Signal System Safety
 7. Part 235 Instructions Governing Application for Approval of a Discontinuance or Material Modification of a Signal System or Relief From the Requirements of Part 236
 8. Part 236 Rules, Standards, and Instructions for Railroad Signal System

In addition, the Contractor shall be responsible for adherence to all of the above rules and reporting requirements, including those regulations which require pre-employment drug testing and random drug testing of employees engaged in the installation and testing of signal facilities, and the reporting and tracking of employees injured in the performance of work on a railroad.

- D. Manual on Uniform Traffic Control Devices (MUTCD), Part 8, Traffic Control Systems for Railroad and Light Rail Transit Grade Crossings, shall apply.
- E. In addition to the regulations and code requirements specified in this Section, materials and equipment for the signaling systems shall conform to the standards and recommendations of the Communications and Signals Manual of Recommended Practices of the American Railway Engineering and Maintenance of Way Association (AREMA), hereinafter referred to as the AREMA C&S Manual, except that where the Manual uses the word "should" the Contractor shall substitute the word "shall".

1.04 SYSTEM DESCRIPTION

- A. Owner-furnished materials for signal systems, if provided, along with delivery points or location of this material for pickup, are listed in the attachments to Section 01600, Materials. Refer to Section 01600, Materials, for Contractor responsibilities for receiving, accepting, and transporting Owner-furnished materials. Assemble and install this material as shown on the Contract Drawings.
- B. Provide all additional materials and installation services required for complete working signal systems, as described herein, and as shown on the Contract Drawings, including any equipment not designated as being relocated or designated as Owner-furnished.

- C. All materials and equipment for installation and for interconnection of the various signaling systems shall be fabricated, furnished, and installed as indicated on the Contract Drawings and specified herein.
- D. The Contract Drawings represent a final design utilizing systems, components, and materials that meet the Contract Specifications. Contractor may provide equivalent systems, components, and materials subject to the approval of the Engineer. If equivalent systems, components and materials are provided, the Contractor shall provide an alternate detailed final design as specified herein under Design Submittals.
- E. Provide systems that are compliant with applicable rules and regulations of 49CFR, parts 234, 235, and 236, and CPUC GO 75D. Refer to Design Submittals herein for Contractor's responsibility to indicate any corrections or modifications to the Contract Drawings final design that the Contractor may determine are required to conform to these rules and regulations.
- F. The Contractor shall be represented at all design meetings held with the Engineer by a signal engineer qualified in the design and application of the signaling equipment the Contractor proposes for use on this project.
- G. No circuit is considered to have met the requirement of these Specifications for function and safety until it has been properly tested and verified in the field. Any circuit changes made to meet the functional and safety requirements of these Specifications shall be considered as included as part of the Work.
- H. Provide continuous train control and highway grade crossing warning during all phases of rail construction. At no time shall the work of the Contractor cause delay to train operations, cause an unsafe signaling condition to exist, or reduce the effectiveness or quality of the existing or new grade crossing warning systems.
 - 1. Refer to Design Submittals herein for requirements for submittal of plans for providing wayside signaling and highway crossing warning systems protection during the Work and plans for point protection and fouling when crossovers are installed or removed. Alternate methods shall conform to CFR 49, Part 234, Part 236 and all local ordinances.
- I. Provide rail bonding for all new, temporary, and relocated turnouts as shown on the Contract Drawings or as required by the Engineer. Provide rail bonding, as necessary, to maintain existing systems during construction.
- J. Protect existing signal cabling and, where necessary, relocate existing cabling in order to prevent damage during track installation and surfacing.
- K. Refer to Section 01720, Contract Record Documents, and additional requirements specified herein. Record the final as-built conditions of the signal systems for each system.
- L. Perform and document all tests and inspections in accordance with CFR 49 regulations, the AREMA C&S Manual, the PCJPB Maintenance and Test Manual, and these Specifications.

- M. Refer to Section 01005, Contractor's Personnel and Equipment, and additional requirements specified herein. Provide at least one qualified signal person to accompany any on track equipment, and remove, relocate, or disconnect and reconnect any signal equipment that could be damaged by on track equipment.
- N. Coordinate installation, inspection, and testing of new Owner-furnished material with the Engineer. Notify the Engineer in writing 30 days prior to any installation, inspection, and testing as part of this coordination.
- O. Perform acceptance testing and commissioning of the signal system as a normal part of the Work.
- P. Contractor furnished software and components shall be new and manufacturer certified.
- Q. Remove, salvage, retire, relocate, furnish, and install project related devices as indicated in the Contract Documents and as required to complete the Work.
 - 1. To retire a grade crossing or a control point, first bulletin it as retired and then take temporary measures with the existing equipment, as required, before removing and salvaging it.
- R. Refer to Section 02300, Earthwork, for provisions for excavation and requirements for shoring of excavation as specified in Section 02200, Support of Excavation.
- S. Refer to Section 01047, Utilities and Systems Coordination, for requirements for locating and protecting existing utilities. Details of signal cable runs, conduit runs, and pullbox installations including number, size, and type of cable are shown in the signal drawings of the Contract Drawings. Information regarding new conduit runs and pullbox installations appear elsewhere in the Contract Drawings. Conduit runs and pullbox locations, as shown, are the preferred locations. In case of conflict between the signal drawings and other Contract Drawings, the signal drawings take precedence as to detail, and in the event of conflict as to placement of equipment, the Engineer will determine the correct placement.
 - 1. Make any minor deviations in location, minor meaning within 10 feet of the location as shown on the civil drawings of the Contract Drawings, as part of the Work. Deviations in excess of 10 feet may be subject to the changes provisions of General Provisions GP4, Scope of Work.
- T. All underground signal cables shall be in conduit or trough except for the final connection of the twisted two conductor number six track cable to the twisted flex to the rails.

1.05 FAIL-SAFE DESIGN REQUIREMENTS

- A. As used in these specifications, the fail-safe principle shall mean that whenever an equipment failure, human error or failure to act, or adverse environmental condition affects the specified operation of a system involved with the safety of life or property, that system shall revert to a state known to be safe.

- B. Failure of a circuit or equipment that results in an indication of a dangerous or restrictive condition, whether or not there is in fact actual danger, shall have met the fail-safe requirements. Conversely, a failure that results in an indication of safe or nonrestrictive condition when, in fact, a dangerous condition may exist shall not have met the fail-safe requirements.

- C. Vital applications, such as detector locking of switches, shall be based on the following principles that permit the attainment of fail-safe operation in all known or discovered failure modes:
 - 1. Closed Loops: Fail-safe circuits shall employ the closed loop principle and shall protect against open circuits, shorts, or any combination thereof.
 - 2. Vital Relays: Relays used in vital circuits
 - 3. Vital Circuits: All line circuits, which energize a vital relay, shall be two-wire, double-break circuits and shall be energized from an ungrounded direct current (dc) power supply line circuits are defined as any circuit that leaves the housing in which the relay or microprocessor input is controlled by that circuit from the relay or microprocessor input to the energy that controls that input.
 - 4. Grounds: Components or wires becoming grounded shall not cause an unsafe condition.
 - 5. Spurious Oscillations: Any amplifier, generator, or device element, active or passive, breaking into spurious oscillations shall not cause an unsafe condition.
 - 6. Filters: Filters used in fail-safe circuits shall be designed to prevent undesired signals from appearing at the filter output at levels which could cause an unsafe condition.

- D. Equipment failures and conditions which shall be considered in producing a fail-safe design shall include the following, at minimum:
 - 1. Relays (non-vital): Open coil, fused contacts, high contact resistance, shorted coil, armature sticking, contacts sticking, or broken spring
 - 2. Relay (vital as defined by the AREMA C&S Manual): Open coil, shorted coil, or high contact resistance
 - 3. Transformers: Open primary, open secondary, shorted turns, primary-to-secondary shorts, or combinations thereof
 - 4. Capacitors: Short, open, or leakage
 - 5. Resistors: Increase or decrease in resistance
 - 6. Transistors: Short, open, leakage, or loss of Beta
 - 7. Diodes: Short, open, or reverse leakage

8. Coils: Open or shorted turns
 9. Loss or degradation of power sources
 10. Appearance of abnormal signal levels, electrical noise levels, frequencies, and delays
 11. Effects of electrical interference
 12. Absent or abnormal input signals
 13. Opens or shorts in internal circuitry at inputs and at outputs
 14. Mechanical vibration or shock
 15. Drift or instability of amplifiers, receivers, transmitters, oscillators, switching circuits, and power supplies
 16. Deterioration of contacts, connectors, terminals, solder connections, printed circuits, circuit adjusting devices, and mechanical devices
- E. Fail-safe equipment proposed for vital signaling applications shall have been proven with a minimum of 5 years of successful rail service operation in the United States of America.

1.06 ENVIRONMENTAL PARAMETERS FOR EQUIPMENT

- A. Contractor provided material and equipment shall be fully operable with no impairment resulting from the effect of the environment throughout the range of worst values indicated below. The general operating environment shall be considered to be in salty atmosphere and in generally sunny weather.
- B. Ambient outdoor temperature range: From minus 40 degrees F (minus 40 degrees C) to plus 160 degrees F (70 degrees C).
- C. Relative humidity range: From zero to 100 percent.
- D. Maximum rainfall: 4 inches in 24 hours and 1.5 inches in 1 hour.
- E. Maximum wind velocity: 100 miles per hour.
- F. Seismic Zone Location of Work Site: Seismic Zone 4 as defined in the Uniform Building Code.
- G. Isokeraunic Level: Five per year.

1.07 DESIGN SUBMITTALS

- A. Undertake no work without the prior submittal to and approval by the Engineer of the relevant plans and procedures.
- B. Alternate Detailed Final Design: Submit proposed equivalent systems, components, and materials, if proposed, for Engineer's approval no later than 90 days after Notice to Proceed. Utilize, at a minimum, the symbols, nomenclature,

and CADD standards depicted on the Contract Drawings and PCJPB Communications/Signal Design Standards. The Contractor's alternate final design drawings shall be approved and stamped by a professional electrical engineer registered in California. The Engineer will render a decision concerning alternative design within 60 days of the Contractor submittal.

- C. Submit marked-up Contract Drawings for approval, indicating any corrections or modifications to the final design that the Contractor may determine are required to conform to rules and regulations. Submit these revised drawings for the Engineer's approval within 60 days after Notice to Proceed.
- D. Submit proposed plans, procedures, data sheets of proposed materials, application logic, installation details, shop drawings, mechanical drawings, proofs of compliance with applicable standards, and other pertinent data required to fully demonstrate the Contractor's proposed plan for the manufacture, installation, testing, and maintenance of the various signaling systems. Submit for Engineer's approval within 60 days after Notice to Proceed. Plans shall include:
 - 1. Proposed plan for providing alternate methods of wayside signaling and highway crossing warning systems protection when signal components are relocated, deactivated, altered, or modified in order to accommodate construction work.
 - 2. Plan for point protection and fouling when crossover or turnouts are installed or removed.
- E. Signal system shop drawings and design submittals shall include any CADD files in AutoCAD formats. Signal circuit drawings shall conform to the PCJPB CADD standards. Submit electronic files on CD-ROM.
- F. As part of the Site Specific Work Plan (SSWP) submission for review and approval by the Engineer, prepare and submit a detailed Signaling Construction Sequencing Plan for each location where a signal system is to be modified, installed, or removed. The Plan, as a minimum, shall contain a wire-by-wire for each wire to be disconnected and/or connected, and the following:
 - 1. A narrative description of the work to be undertaken at the designated location.
 - 2. A step-by-step sequence of work description which identifies those steps during which the existing system will be disabled, and a description of what steps will be taken to assure that the signal system will be tested and returned to full operation without causing a delay to any train movement.
 - 3. An estimate of time to complete the critical steps in the sequence specified in step-by-step sequence of work description.
- G. Submit circuit drawings indicating any required modifications to new systems or existing circuits where only a segment of the new work can be completed or the complete system must be placed in operation in phases. Submit these temporary interface drawings for the Engineer's approval a minimum of 30 days prior to the scheduled cutover.

1. Revisions to existing circuit plans shall use the "Xs" and "Os" convention to show changes. Encircling the change with "Xs" shall identify deletions. Encircling the change with "Os" shall identify additions. The Contractor may, with the prior approval of the Engineer, alternately use the "Red In"/"Yellow Out" convention if Contractor provides seven colored copies of the drawing.
- H. Request approval from the Engineer prior to making any deviation, modification, or changes to the approved design drawings. During the field testing/cut-over period, obtain the approval of the Engineer's representative on site for any deviations, changes, or modification to the design drawings.

1.08 SUBMITTALS

- A. Submit product information, references, shop drawings, and test data as detailed

1.09 DELIVERABLES

- A. Submit manufacturers' warranties, instruction sheets, and part lists supplied with materials to the Engineer prior to Final Acceptance.
- B. Operation and Maintenance Manuals: Refer to Section 01730, Operations and Maintenance Manuals. A minimum of 30 days prior to placing any system in-service, submit to the Engineer 10 sets of application, installation, operating, and maintenance manuals of all new equipment and systems utilized under this Contract which are provided by the Contractor. Include complete material ordering reference numbers for each type of product.

1.10 QUALIFICATIONS AND DUTIES OF SIGNALING PERSONNEL

- A. Refer to Section 01005, Contractor's Personnel and Equipment. Key employees of the Contractor engaged in the final adjustment and testing of the various signaling systems shall be qualified and have had experience on an operating railroad in the type and level of signal installation and testing work as required herein.
- B. Signal Engineer as used herein shall be understood to mean Contractor's railroad signal engineer or engineers approved by the Engineer. Signal Manager as used herein shall be understood to mean Contractor's railroad signal manager or managers approved by the Engineer.
- C. Signal construction and installation personnel shall work under the authority of the Signal Engineer. The Contractor's signaling construction forces shall work under the authority of a Signal Engineer.
 1. Signal Engineer shall plan, direct, and oversee the adjustment, installation, and testing of signal related work and shall coordinate signal work with related track construction work.
 2. Signal Engineer shall be responsible for all work under his charge and must have the authority to remove any personnel from the project who are not performing the work in a satisfactory manner.

3. Signal Engineer shall be on site whenever signal related work or track construction work is in progress in the vicinity of existing wayside signaling equipment, highway grade crossings, and/or cabling.
- D. The Signal Managers shall report to and work under the direct authority of the Signal Engineer and shall supervise and direct the work of all signal construction and installation personnel. The Signal Managers shall only perform some major and critical activities, such as cutovers under the direct supervision of the Signal Engineer.
- E. Signal Engineer shall direct and organize the performance of all tests on signaling equipment and systems, under direction of the Engineer, prior to releasing the systems for service. The Signal Engineer shall be responsible to ensure that all applicable test documentation other than that documentation provided by the Engineer, is completed prior to, or immediately after, in-service testing is completed.
- F. The proposed Signal Engineer shall demonstrate experience in the philosophy, application, and testing requirements of the various signaling systems. The proposed Signal Engineer shall have a minimum of 10 years signal supervisory or management related experience on a Class I railroad. The proposed Signal Engineer shall also demonstrate knowledge of the governing General Code of Operating Rules, including CPUC and FRA regulations and procedures. This demonstration shall be by interview of the proposed Signal Engineer by the Engineer prior to commencement of any work that may affect the signal system. The work of this project includes working within tight windows on a live railroad consisting of freight trains, inter-city passenger trains, and PCJPB commuter trains. Candidate shall have a similar level of working experience to Caltrain system. The Engineer's decision concerning the candidate's qualifications will be final. Begin no signaling related work prior to obtaining Engineer's approval of the Signal Engineer. In addition, obtain the Engineer approval of each Signal Engineer prior to beginning any work that may affect the signal system. Obtain approval of and provide additional Signal Engineers as required depending upon the level and type of work being performed. Propose alternate personnel if the original candidate is found unacceptable.
- G. The proposed Signal Managers shall demonstrate experience in the philosophy, application, and testing requirements of the various signaling systems. The proposed Signal Managers shall have a minimum of 3 years signal supervisory or management related experience on a Class I railroad. The proposed Signal Managers shall also demonstrate knowledge of the governing General Code of Operating Rules, including CPUC and FRA regulations and procedures. This demonstration shall be by interview of the proposed Railroad Signal Managers by the Engineer prior to commencement of any work that may affect the signal system. The work of this project includes working within tight windows on a live railroad consisting of freight trains, inter-city passenger trains, and PCJPB commuter trains. Candidates shall have a similar level of working experience to Caltrain system. The Engineer's decision concerning the candidate's qualifications will be final. Begin no signaling related work prior to obtaining the Engineer's approval Signal Managers. Obtain approval of and provide additional Signal Managers as required depending upon the level and type of work being performed.

- H. Propose alternate personnel if the original candidate is found unacceptable. Previous qualification as a Signal Engineer or Manager on other PCJPB projects does not constitute qualification as a Signal Engineer or Manager for this Contract.
- I. The Engineer reserves the right to disqualify any Signal Engineer or Signal Manager at any time during the course of the Work. This right is at the sole discretion of the Engineer and is not subject to protest or appeal.
- J. All Contractor field personnel shall receive safety training in accordance with Section 01005, Contractor's Personnel and Equipment, and 01545, Work Site Safety and Security.

1.11 AS-BUILT DOCUMENTATION

- A. Refer to Section 01720, Contract Record Documents, for requirements preparation and submittal of Record Documents.
- B. The following as-built documentation requirements augment requirements specified in Section 01720, Contract Record Documents. After a location is placed in service, submit as-built documentation as follows:
 - 1. Detailed circuit drawings within 3 working days.
 - 2. Submit four copies of as-built corrections to the Engineer within 3 working days.
 - 3. Civil Drawings which show the physical location of all signal apparatus and conduits, both along the tracks and perpendicular to it, and heights of all signal structures within 60 calendar days.
- C. Annotate the as-built drawing sets to show all approved circuiting and wiring changes made during installation and testing of the location prior to placing it in service, and any approved changes made after placement in service. Clearly identify all changes on the drawings using the "Red In"/"Yellow Out" convention. Changes shall be dated and initialed by the Contractor's responsible Signal Engineer. Identify the date that the location was tested and placed in service in the revision block of the drawings.
- D. In addition to the as-built drawings provided to the Engineer, one set shall be bound and shall be kept in the instrument enclosure at a location and manner approved by the Engineer. As-built drawings shall be clean and legible. The as-built drawings shall not be removed from the field location after the location is placed in service without the prior written approval of the Engineer.
- E. The final as-built drawings shall be 11 inches by 17 inches, unless authorized by the Engineer to substitute another size.
- F. Each circuit that continues on another drawing shall be annotated with drawing number and routing information for the continuation of the circuit.
- G. The circuit drawings shall show all individual circuits. Typical circuits will not be accepted.

- H. The location plans shall show all cable installed with the number of conductors, the size of conductors, the type of cable, termination points of conductors, and the circuit on each conductor. Separate cable plans shall be drawn if cable information cannot be shown in a neat and organized manner on the location plans.
- I. The shop drawings shall be detailed equipment drawings for each type of equipment installed.

1.12 TRACK AVAILABILITY REQUIREMENTS

- A. General: Refer to Sections 01011, Work Planning, and 01040, Work Hours and Track Access, for track access and related provisions. PCJPB Commute Service and any freight service may not be interrupted by the Work of this Contract, except as provided in the Contract Documents.
- B. Signal Cutovers may be required under traffic.
- C. Signal Cutovers under traffic will require coordination between the Contractor, PCJPB, other railroad, as applicable, and the Operator of Record to keep train delays to a minimum.

1.13 SCHEDULE OF VALUES

- A. Submit the Schedule of Values for signal bid items as required under General Provisions GP9.2, Schedule of Values, and in accordance with the following additional requirements:
 - 1. Schedule of Values for the signal bid items shall include all interface circuits and staging necessary to place the location in service at each stage, all acceptance testing and transportation of materials, all equipment rental, and all pretesting and removal of old equipment.
 - 2. Organize Schedule of Values for signal bid items to assign a value to each signal location. A location is defined as a grade crossing warning system, an intermediate signal location, or a Control Point.

1.14 WARRANTY

- A. Provide warranties for all equipment and material covering parts and labor for two years from the date equipment or material is "placed in service".

PART 2 – PRODUCTS

2.01 EQUIPMENT – GENERAL

- A. Signaling materials and equipment shall be the products of manufacturers regularly engaged in the production of such material and equipment and shall be the manufacturer's latest design. The materials and equipment shall have shown proven performance in the US or Canada for a minimum of 5 years. Materials and equipment shall be delivered to the job-site in unbroken packages, reels, or other forms of containers.

- B. All materials and equipment shall conform to the recommendations of AREMA C&S Manual, except as modified in the Specifications and Contract Drawings.
- C. Reference to specific equipment and manufacturers is intended to establish quality, overall design, and fit, subject to compliance with all criteria specifications. Equipment equal to or exceeding the specifications and requirements may be used subject to the Engineer's written approval. Should alternate equipment be accepted, the Contractor shall perform all necessary work to fit the alternate equipment to these specifications and to revise the Contract Drawings at no additional cost to the PCJPB.

2.02 ELECTRICAL AND ELECTRONIC COMPONENTS

- A. Design and construct fusing of all dc power supplies and circuitry according to the following requirements:
 - 1. Circuit breakers and fuses shall be the correct side-band rating for circuit current interruption and shall protect the electrical equipment and circuits from short-term and long-term overloads.
 - 2. Fuses shall be sized to protect the wire
 - 3. Fuses shall be in the positive leg of the power supply
 - 4. Fuses shall be of the nonrenewable indicating type
 - 5. All branch feeds for a circuit shall be from the same fuse to prevent fuse cascading due to branch fusing carrying loads for other circuits.
 - 6. Fuses shall be no smaller than 5 amperes unless otherwise shown on the Drawings.
 - 7. Loads shall be divided so that no normal operating current is more than 75 percent of the fuse rating.
 - 8. Fusing shall be functionally oriented to minimize the equipment affected by a blown fuse (i.e., per track, switch control circuits, etc.)
 - 9. Fuse clips shall be constructed to retain their resilience under all installation and service conditions and to ensure a positive contact between the clips and the fuse.
- B. Printed Circuit (PC) Cards and Connectors:
 - 1. The PC cards shall be mounted in 19-inch card files unless otherwise approved by the Engineer.
 - 2. The PC wiring shall be organized so that wires serving the same function shall be connected to the same terminal of PC cards. PC cards containing the same circuitry and programming, where applicable, shall be interchangeable between subsystems.

3. The design and construction of PC cards of the same subsystems shall be the same. Cards of different subsystems shall be of the same design and construction wherever practicable.
 4. PC cards shall be of glass epoxy construction. Card material shall meet the requirements of NEMA, Type FR-4. Cards shall have sufficient thickness to permit easy insertion and removal, and shall be physically keyed to protect against incorrect interchange. Circuits shall be formed by etching. Conductor material shall be copper and shall be protected from exposure to air.
 5. PC cards containing components that may be damaged if a plug connector or plug-in unit is removed while the equipment is energized shall be clearly identified in the equipment maintenance manual. PC cards shall be marked or labeled with a warning note on the individual board, be conspicuously located on the module, or by an alternate means as approved by the Engineer. A means shall be provided to remove power from the module or card file.
 6. Components mounted on the PC card, weighing more than 1/2 ounce or with a displacement of more than 1/2 cubic inch, shall have a mechanical supporting attachment to the card separate from all electrical connections.
 7. Do no stacking or piggybacking of PC sections in order to accomplish changes or modifications to wiring or components on printed circuit cards.
 8. Connectors shall have plating with a minimum thickness of 0.00005 inch.
- C. Printed Circuit Card Files:
1. There shall be not more than one type of card file for each size of PC card. The card file plug boards shall be registered to agree with the registry of the associated PC card. PC cards shall not project beyond the front of the equipment rack when mounted in the card file.
 2. Card files shall be installed in dust-proof cabinets and protected with dust covers.
 3. Insulated cable clamping devices shall be located on the back of the file in such a way that wires terminating in the files shall be installed in a neat and secure bundle, rigidly supported, and protected to prevent chafing of insulation. Cabling provision on the file shall permit wires to enter or leave the file from both the right and left sides. Such cabling shall not restrict access to the card file when the rear covers of the card files are removed.

2.03 SHOP FINISHES

- A. Factory finish signal equipment with the exception of signal system parts which are stipulated as field finished in AREMA C&S Manual, Part 1.5.10, and aluminum alloy and galvanized metal components. If manufacturer typically provides

factory painted finish for aluminum alloy and galvanized components, include such information in equipment submittals for Engineer's acceptance.

- B. Finishes shall comply with AREMA C&S Manual, Part 1.5.10, signal equipment manufacturer's standards, and provisions specified herein. It shall be understood that where AREMA C&S Manual, Part 1.5.10, uses the word "should" that the word "shall" shall be substituted except as accepted by the Engineer in writing.
 - 1. Finish terminal boards and interior of shelters with white gloss fire retardant paint.
 - 2. Factory finish signal equipment with aluminum paint except as otherwise specified herein and in AREMA C&S Manual.
 - 3. For signal system parts which AREMA C&S Manual stipulates as shop primed and field finish, shop prime in accordance with requirements specified in Section 05200, Structural Steel.
 - 4. For signal system parts which AREMA C&S Manual stipulates to receive shop prime and finish coats followed by field finish coat, coordinate shop finish coat with field finish specified in Section 09900, Paints and Coatings.

2.04 FIELD PAINT MATERIALS

- A. Field finish as specified in Section 09900, Paints and Coatings, and AREMA C&S Manual, Part 1.5.10. Exterior surfaces shall receive heavy duty finish system.
- B. Touch-up Paint for Signal Manufacturer Finishes: Touch-up paints recommended by signal manufacturer, including aluminum touch-up paint.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Contractor shall make all necessary modifications to the existing signal system, protect or relocate existing cabling, signals, switches, and signal shelters; and modify associated signal and highway grade crossing systems to ensure the existing signal system operates as intended during construction and installation of the new signal system. Protect operating signal and highway grade crossing systems to ensure train operations are not interrupted and safety is maintained.
- B. Contractor shall take no action which will violate any rule or regulation as specified by CFR 49, the General Code of Operating Rules, timetable instructions, general order, bulletin, or special instruction; which will reduce the integrity of the signal system; or endanger railroad personnel, the public, or employees.
- C. All equipment installation as described herein or as shown in the Contract Drawings shall be in accordance with the Caltrain Standards.
- D. Ensure that equipment within the instrument shelters and relay cases is securely anchored or otherwise fastened in enclosure upon completion of enclosure installation. Securing equipment shall not negate the requirements to maintain isolation between ground systems as otherwise called for in these Specifications.

- E. An updated, detailed set of the approved signal design drawings shall be kept at the each field location for equipment as it is placed in-service.

3.02 FIELD FINISHES AND TOUCH UP

- A. For signal system parts which AREMA C&S Manual, Part 1.5.10, stipulates as shop primed and field painted, field finish as specified in Section 09900, Paints and Coatings, and AREMA C&S Manual, Part 1.5.10, including requirement to apply one field coat prior to field assembly and one field coat following field assembly.
- B. Touch-up signal manufacturer's finishes after installation.

END OF SECTION