

GENERAL ORDER No. 176

**PUBLIC UTILITIES COMMISSION OF THE
STATE OF CALIFORNIA**

**RULES FOR OVERHEAD
25 kV AC RAILROAD ELECTRIFICATION SYSTEMS
FOR A HIGH-SPEED RAIL SYSTEM**

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1 GENERAL

1.1 PURPOSE

The purpose of these rules is to establish uniform safety requirements governing the design, construction, installation, operation and maintenance of 25 kV ac (alternating current) electrification systems ("25 kV Electrification Systems") constructed in the State of California, serving a high-speed rail passenger system capable of operating at speeds of 150 miles per hour or higher, located in dedicated rights-of-way with no public highway-rail at-grade crossings and in which freight operations do not occur (HSRS). These rules promote the safety and security of the general public and of persons engaged in the construction, maintenance, and operation of a 25 kV electrified HSRS.

These rules establish the base standards for the design, construction, installation, operation and maintenance of the 25 kV Electrification System for an HSRS. These rules require coordination and cooperation of the Agency and non-Agency facility owners so that the facilities of both parties are not prevented from performing as required or intended. Nothing in these rules will prevent the owner or operator of an HSRS from entering into agreements with non-Agency facility owners that establish stricter standards than and/or additional requirements to those specified in these rules.

1.2 APPLICATION

These rules apply to the design, construction, installation, operation and maintenance of the 25 kV Electrification System for an HSRS, which comprises:

- a. Overhead Contact System (OCS)
- b. Negative Feeders (where used)
- c. Traction Power Return System

These rules apply to all such installations that are planned, acquired or constructed on or after the effective date of this General Order.

With the exception of Rule 9.2, this General Order does not apply to Agency traction power supply facilities, which include Substations, Switching Stations, Paralleling Stations and electrical supply stations. The application of Rule 9.2 to such facilities shall not limit or expand the otherwise applicable authority of the Commission to regulate such facilities.

1.3 DESIGN, CONSTRUCTION AND MAINTENANCE

25 kV Electrification Systems shall be designed, constructed, installed, and maintained for their intended use, regard being given to the conditions under which they are to be operated to enable the furnishing of safe service, to secure the safety of workers, the public in general, and passengers, to prevent damage to the electrification system components, and to allow adjacent non-Agency facilities to perform as required and intended.

For all particulars not specified in this General Order, the Agency is in compliance with this rule if it designs, constructs and maintains a facility in accordance with industry accepted good practice for the intended use and known local conditions.

1.4 COOPERATION

The Agency designing, constructing, installing, or operating a 25 kV Electrification System adjacent to or in close proximity to other conductive facilities, such as rail, pipeline, cable, or electric transmission and distribution lines, shall confer with the other party or parties concerned to avoid or minimize adverse impacts. Prior to construction, installation, or operation, the party designing the 25 kV Electrification System shall include the use of modeling during design to determine potential adverse impacts and shall include the use of testing prior to operation to avoid any such adverse impacts. Other public utilities located adjacent to or near such system shall cooperate during such modeling, testing, and efforts to mitigate adverse impacts to either of the proximate facilities or systems. If it is impracticable to avoid the adverse impact, the adverse impact shall be minimized to the parties' mutual satisfaction. Where the Agency seeking to design, construct, install, or operate a 25 kV Electrification System has entered into an agreement establishing additional rights and obligations or stricter standards than these rules with respect to adverse impacts, such agreements shall govern such matters.

1.5 DISPUTE RESOLUTION

Parties to disputes arising under this General Order shall first attempt to resolve their dispute informally. Any party to such a dispute may utilize the Commission's Alternative Dispute Resolution processes for this purpose. If informal dispute resolution is unsuccessful, any party to a dispute arising under this General Order may seek appropriate relief from the CPUC.

1.6 ABBREVIATIONS

AREMA	American Railway Engineering and Maintenance-of-Way Association
AREMA Manual	AREMA Manual for Railway Engineering
CPUC	California Public Utilities Commission
EN	Euro Norm - European Standards
GO	General Order
HSRS	High-Speed Rail System

2 DEFINITIONS

2.1 25 kV ELECTRIFICATION SYSTEM

The Overhead Contact System, negative Feeders, and Traction Power Return System used to power electrified trains in a High-Speed Rail Right-of-Way. Traction power Substations, Switching Stations, Paralleling Stations and electrical supply stations are not included in this definition.

2.2 AGENCY

The entity that owns the HSRS, and its successors.

2.3 AUTHORIZED PERSON

A person, who has been authorized by the Agency to enter restricted areas of the High-Speed Rail Right-of-Way.

2.4 AUTOTRANSFORMER

Apparatus in an electrification system which helps boost the catenary voltage and reduce the Running Rail return current in the 2x25 kV Autotransformer Feed configuration. It uses a single winding having three terminals.

2.5 AUTOTRANSFORMER FEED SYSTEM

A traction power feeding system in which the main transformers and Autotransformers are fitted with a single secondary winding having three terminals. The intermediate terminal, located at the midpoint of the winding, is connected to the Running Rails/ground/Static Wire. The other two are connected to the catenary conductors and to the parallel negative Feeder(s) respectively, giving rise to the 2x25 kV designation for this feeding system.

2.6 BARRIER

Equipment preventing entry by an unauthorized person to a restricted area, structure or building, and providing physical protection against direct contact with Energized Parts under normal circumstances.

2.7 BOND

An electrical connection between conductive elements for the purpose of maintaining a common electrical potential.

2.8 CATENARY SYSTEM

That part of an Overhead Contact System that comprises a Messenger Wire supporting a Contact Wire by means of a number of hangers.

2.9 CATHODIC PROTECTION

A technique to reduce the corrosion rate of a metal surface by making it the cathode of an electrochemical cell.

2.10 COMMUNICATIONS LINES

A conductor or system of communications conductors located outside of buildings and through which an electric current flows or light is transmitted and is used for public or private communications service.

2.11 CONTACT WIRE

A solid grooved, bare aerial, overhead electrical conductor of an Overhead Contact System that is suspended above the rail vehicles and which supplies the electrically powered vehicles with electrical energy through roof-mounted current collection equipment (Pantograph) and with which the current collectors make direct electrical contact.

2.12 COUNTERPOISE

A buried wire or a configuration of wires constituting a low resistance grounding system or portion of a grounding system.

2.13 DIRECT FEED SYSTEM

A traction power feeding system, frequently referred to as a 1x25 kV feed configuration, in which the transformers are fitted with a single secondary winding having two terminals. One terminal is connected to the Running Rails/ground/Static Wire and the other to the catenary conductors over the tracks.

2.14 ELECTRICAL CLEARANCES

- a. Passing (Dynamic) Electrical Clearance is defined as the minimum permissible clearance distance between the live parts of either the vehicle or OCS and the Grounded vehicle, overhead structure, or other adjacent fixed structure under dynamic operating conditions.
- b. Static Electrical Clearance is defined as the minimum permissible clearance distance between live parts of either a vehicle Pantograph or the OCS, and Grounded parts of either a vehicle or adjacent fixed structure, while the vehicle is stationary.
- c. Safety Clearance is the distance in a straight line between a standing surface accessible to persons and Energized Parts that is necessary to prevent direct contact with Energized Parts, without the use of objects, as defined in EN 50122-1: 2011 Protective Provisions Relating to Electrical Safety and Earthing - Section 5.

2.15 ELECTRICAL SECTION

The section of the OCS which, during normal system operation, is powered from a Substation (SS) feeder circuit breaker. The SS feed section is demarcated by the Phase Breaks of the supplying SS and by the Phase Breaks at the adjacent Switching Station (SWS) or line end.

2.16 ENERGIZED

Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of the ground in the immediate vicinity.

2.17 ENERGIZED PART

A conductor or conductive part that is Energized under normal service conditions, but does not include the Running Rails or parts connected to them.

2.18 FAULT CONDITION

The presence of an unintended and undesirable conductive path in an electric power system.

2.19 FEEDER

A current-carrying electrical connection between the OCS and a traction power facility (Substation, Paralleling Station or Switching Station). Also, a conductor supported on the same structure as the OCS.

2.20 GROUNDED

Connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to limit the build-up of voltages which may result in undue hazard to persons or connected equipment.

2.21 GROUNDING CONDUCTOR

A conductor used to connect equipment or wiring systems to a ground electrode or ground grid.

2.22 HIGH-SPEED RAIL RIGHT-OF-WAY

A railroad right-of-way for an HSRS , including main tracks and all related station, siding, lead and yard tracks, dedicated solely to passenger use with no public highway-rail grade crossings, in which no freight operations occur at any time.

2.23 HIGH-SPEED RAIL SYSTEM (HSRS)

A high-speed rail passenger system capable of operating at speeds of 150 miles per hour or higher, located in dedicated rights-of-way with no public highway-rail at-grade crossings and in which freight operations do not occur.

2.24 HIGH VOLTAGE

A nominal voltage of 750 Volts or more.

2.25 IMPEDANCE BOND

An electrical device located between the rails consisting of a coil with a center tap used to bridge Insulated Rail Joints in order to prevent Track Circuit energy from bridging the insulated joint while allowing the traction return current to bypass the insulated joint. The center tap can also be used to provide a connection from the rails to the Static Wire and/or traction power facilities for the traction return current.

2.26 INSULATED RAIL JOINT

A joint in the Running Rail used to prevent Track Circuit energy on one side of the joint from leaking to the other side of the joint.

2.27 MESSENGER WIRE

A longitudinal bare stranded conductor that physically supports the Contact Wire and is electrically common with the Contact Wire.

2.28 OCS POLE

Vertical structural element supporting the Overhead Contact System equipment, which provides physical support, registration and/or termination of the OCS conductors including ancillary wires or cables.

2.29 OVERHEAD CONTACT SYSTEM (OCS)

The OCS comprises the aerial supply system that delivers 25 kV traction power from the Substations to the Pantographs of the electric trains, and includes the Catenary System Messenger and Contact Wires, auxiliary wires and hangers, associated Supports and structures (including poles, portals, headspans and their foundations), manual and/or

motor operated isolators, insulators, Phase Breaks, conductor terminations and tensioning devices, downguys, and other overhead line hardware and fittings.

2.30 PANTOGRAPH

Current collector apparatus consisting of spring-loaded hinged arms mounted on top of electrically powered rail vehicles that provides a sliding electrical contact and collects current from the Contact Wire of the Overhead Contact System.

2.31 PARALLELING STATION (PS)

An installation which helps boost the catenary voltage and reduce the Running Rail return current by means of the Autotransformer feed configuration. The negative Feeders and the catenary conductors are connected to the two outer terminals of the Autotransformer winding at this location with the central terminal connected to the rail return system. The OCS Electrical Sections can be connected in parallel at PS locations.

2.32 PHASE BREAK

An arrangement of insulators and Grounded or non-Energized wires or insulated overlaps, forming a neutral section, which is located between two sections of catenary that are fed from different phases or at different frequencies or voltages, under which a Pantograph may pass without shorting or bridging the phases, frequencies or voltages.

2.33 PRACTICABLE

Capable of being accomplished by reasonably available and economic means.

2.34 QUALIFIED PERSON

In regard to traction electrification system equipment, a person who has been trained in and has demonstrated adequate knowledge of the installation, construction, maintenance, and operation of the electrification system equipment and the hazards involved.

2.35 RETURN CABLE

A conductor that forms part of the electrification system return circuit, and which connects the rest of the return circuit to the Substation.

2.36 RUNNING RAILS

The steel rails on which the rail vehicles run and which, in an electrified system, form part of the traction return circuit.

2.37 SCREEN

A Barrier that prevents unintentional direct contact with Energized Parts but does not totally prevent direct contact by deliberate action.

2.38 STATIC WIRE

A wire, usually installed aerially adjacent to or above the catenary conductors and negative Feeders, that connects OCS Supports collectively to ground or to the Grounded Running Rails to protect people and installations in case of an electrical fault. In an ac electrification system, the Static Wire (sometimes termed aerial ground wire) forms part of the traction power return circuit and is connected, via Impedance Bonds, to the Running Rails at periodic intervals and to the traction power facility ground grids.

2.39 SUBSTATION (SS)

An installation that supplies electrical energy to the OCS and Parallel Negative Feeders (where used), where the incoming High Voltage utility supply is transformed to the electrification system voltage.

2.40 SUPPORTS

The structural elements that support the conductors and their associated line hardware and insulators in an OCS.

2.41 SWITCHING STATION (SWS)

An installation at which electrical energy can be supplied to an adjacent, but normally separated Electrical Section during contingency power supply conditions. It also acts as a Paralleling Station.

2.42 TOUCH POTENTIAL (VOLTAGE)

The potential difference between two points which can be contacted simultaneously by a person's hands or feet. The conductive path through the body is conventionally deemed to be from hand to both feet, from foot to foot or from hand to hand.

2.43 TRACK CIRCUIT

An electrical circuit which uses the track rails as the conductors between transmit and receive devices, the limits of which are often defined by the location of insulated joints. The primary purpose of the Track Circuit is to detect an occupancy or interruption. It may also be used to convey information.

2.44 TRACTION POWER RETURN SYSTEM

The combination of track structure Running Rails, jumpers, Impedance Bonds, static and/or ground wires, and cables, which form the path for the traction return current from the train wheels to the Substations.

2.45 TRACTION SYSTEM GROUND

The Traction System Ground consists of the Running Rails, the Static Wires and conductive parts connected thereto and which are connected to ground.

2.46 UPLIFT

The vertical distance by which the Overhead Contact System is raised during the passage of a Pantograph.

3 SYSTEM DESCRIPTION

3.1 OVERHEAD CONTACT SYSTEM

The Overhead Contact System (OCS) supplies power to the electrically powered rail vehicles at 25 kV, and includes the aerial conductors, insulators, line hardware, support brackets, and support structures and their associated foundations. 25 kV Electrification Systems typically utilize a catenary configuration, which comprises an Energized and current carrying Messenger Wire (MW) to support a Contact Wire (CW) by means of in-span wire hangers.

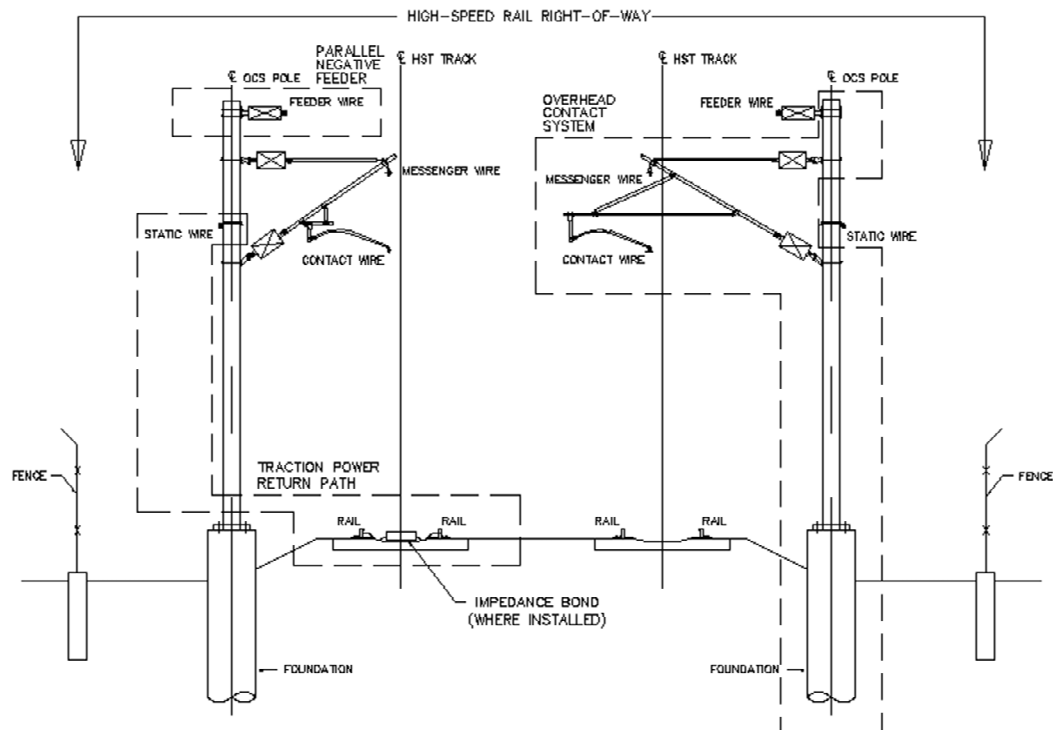


Figure 3-1 Typical 2x25 kV Electrification System

3.2 PARALLEL FEEDERS

In a 2x25 kV Autotransformer Feed System (shown above), a bare parallel Feeder (often termed the negative Feeder) will normally be mounted aerially on insulators on the OCS Poles, and will form a continuous electrical connection between Substation facilities. There is a 180 degree phase difference between the voltages of the parallel negative Feeder and the Catenary System, giving a 50 kV phase-to-phase voltage difference between these conductors.

In a 1x25 kV Direct Feed System, the Feeder (where used) will be a bare paralleling conductor that can be connected at frequent intervals to the OCS to provide localized electrical reinforcement of the circuit. There is no phase difference between the voltages of the parallel reinforcement Feeder and the Catenary System.

In some restricted clearance locations, insulated cables may have to be substituted for the bare conductors in either system.

3.3 TRACTION POWER RETURN SYSTEM

The Traction Power Return System comprises the Running Rails, Impedance Bonds, Return Cables, and static or ground wires. The principal return path is through the Running Rails and Static or ground wires. Due to the resistance of the rails, some residual current will flow through earth back to the Substation.

In a 2x25 kV Autotransformer Feed System, because of the configuration and electrical connectivity arrangement of the Autotransformers, the Negative Feeders also form part of the return system.

4 PERFORMANCE REQUIREMENTS

4.1 OPERATING VOLTAGE REQUIREMENTS

4.1.1 The operating voltages of the Electrification System, detailed below, establish the limits for which safety clearances and values at the 25 kV level shall apply:

a. Nominal Voltage	25 kV (line to ground),	50 kV (line to line)
b. Maximum Voltage	30 kV (line to ground)	[+ 20% of Nominal]
c. Minimum Voltage	17.5 kV (line to ground)	[- 30% of Nominal]

4.2 ENVIRONMENTAL PARAMETERS (CLIMATIC AND GEOGRAPHIC CONDITIONS)

4.2.1 The 25 kV Electrification System shall be designed to operate safely and satisfactorily within the anticipated environmental conditions. The required clearances shall be maintained at all times. The following factors shall be taken into consideration:

- a. Ambient temperature range
- b. Permissible conductor operating temperature range
- c. Permissible equipment operating temperature range
- d. Wind variations and wind loading effects
- e. Ice loading
- f. Seismic zone
- g. Humidity
- h. Atmospheric pollution
- i. Lightning (Isokeraunic levels)
- j. Elevation
- k. Soil conditions
- l. Soil resistivity

4.2.2 Wind and Ice Loading

The 25 kV Electrification System Supports, conductors, and appurtenances shall be designed in accordance with the wind and ice loading criteria detailed in GO 95 Rule 43 – Temperature and Loading.

4.2.3 Soil Conditions and Soil Resistivity

- a. OCS Pole footings, equipment foundations, and power facility ground grids shall be designed based on detailed geotechnical investigations derived on a project- and location-specific basis.

- b. Soil resistivity tests shall be performed during the geotechnical investigations to permit the development of safe pole grounding and ground mat designs that satisfy the Rules in Section 6 of this General Order.

5 CLEARANCES AND PROTECTION

5.1 OVERHEAD CONTACT SYSTEM ZONE AND PANTOGRAPH ZONE

Structures and equipment may accidentally come into contact with an Energized broken OCS wire(s), or with the Energized Parts of a broken or de-wired Pantograph. Figure 5-1 defines the zone inside which such contact is considered probable, but whose limits are unlikely to be exceeded by a broken Overhead Contact System conductor or damaged Energized Pantograph.

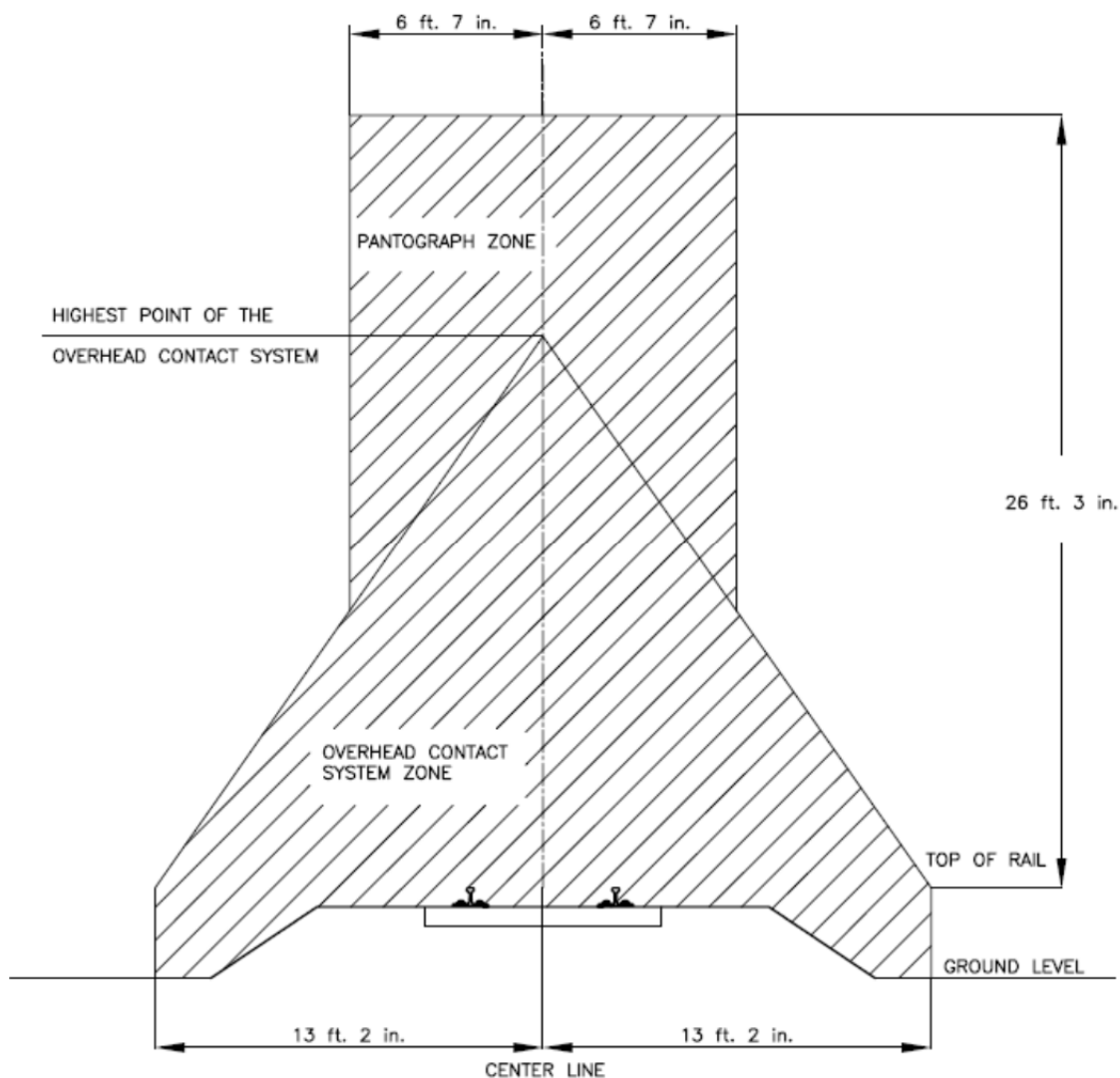


Figure 5-1 Overhead Contact System Zone and Pantograph Zone

- 5.1.1 The limits of the Overhead Contact System zone below the top of rail extend vertically down to the earth or structure surface on which the tracks are supported. In the case of out-of-running OCS conductors, the Overhead Contact System zone is extended accordingly.

5.2 SAFETY CLEARANCES – PUBLIC AND RESTRICTED AREAS

- 5.2.1 The minimum clearances from Energized Parts for areas with unconstrained access (no Barriers, Screens or other physical restrictions to movement) are shown in Figure 5-2 for (a) public areas, such as areas in passenger stations that are accessible to the general public and (b) restricted areas to which access is permitted only for Authorized Persons.

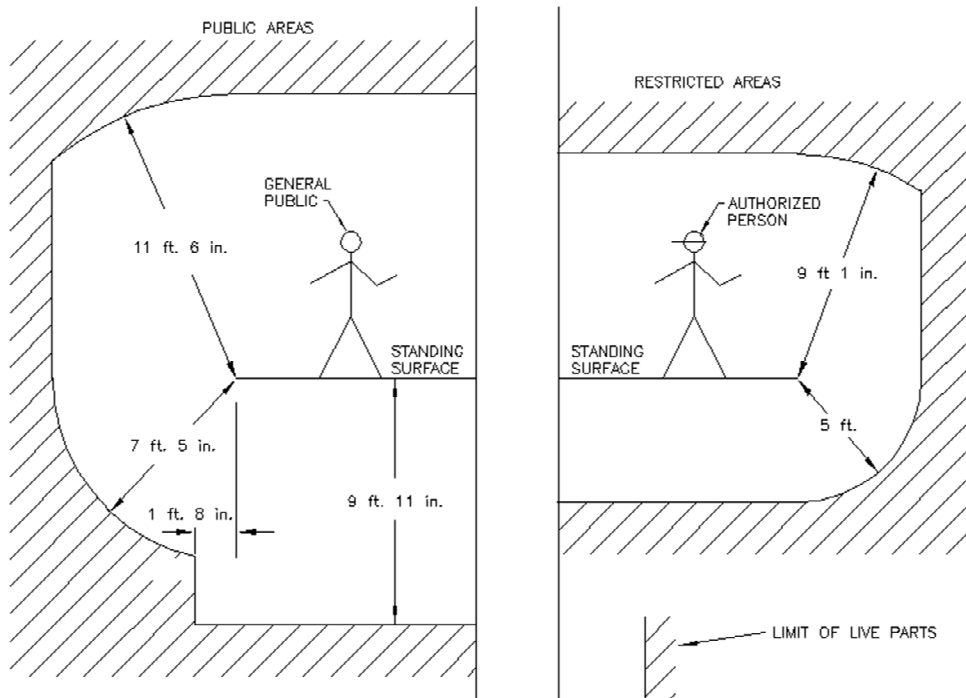


Figure 5-2 Minimum Required Safety Clearances – Unconstrained Access

Note 1: The clearances are based on the straight line reach without the use of tools or other objects. These requirements include clearances from standing surfaces to accessible Energized Parts on the outside of vehicles as well as to Energized Parts of the OCS.

Note 2: The standing surface indicated in Figure 5-2 does not itself provide protection against contact with exposed Energized Parts located below or to the side. However, dependent on its construction, this surface may meet the requirements detailed below regarding Barriers and Screens, in which case the lower clearance values appropriate to the type of Barrier may be used.

Note 3: Exposed Energized Parts of the OCS shall be limited to the electrified tracks and adjacent areas that are necessary for support, tensioning and positioning of the OCS. Placing OCS Energized Parts over safety walkways shall be avoided where Practicable.

Note 4: For safe working clearances and approach distances for qualified employees, see Rule 8.1.

5.3 GENERAL REQUIREMENTS FOR PROTECTIVE BARRIERS AND SCREENS

- 5.3.1 Protection Barriers or Screens shall be of sufficient strength and shall be supported rigidly and securely enough to prevent their being displaced or deflected by a person slipping or falling against them.
- 5.3.2 Barriers and Screens shall be permanently fixed, and shall be removable only with tools. Barriers in public areas shall be affixed with non-removable, captive fasteners.
- 5.3.3 Barriers shall be of solid construction and fabricated from either conductive or non-conductive materials.
 - a. Conductive Barriers shall be bonded and Grounded by inter-connection with the Traction System Ground, preferably at not less than two locations.
 - b. Non-conductive Barriers within 3 feet of live parts shall be supported by or attached to a Grounded frame and interconnected with the Traction System Ground, preferably at not less than two locations.
- 5.3.4 Screens shall be of conductive, open mesh materials and Grounded by inter-connection with the Traction System Ground, at not less than two locations.
 - a. Mesh Screen construction shall be such that required clearances to Energized Parts are maintained.
 - b. Conductive mesh Screens shall be constructed such that a cylinder, greater than 0.5 inches in diameter, cannot be pushed through the mesh.
 - c. Non-conductive mesh or plastic coated metal shall not be used.
- 5.3.5 The size of the Barrier or Screen shall be such that Energized Parts cannot be reached by persons on a standing surface.
- 5.3.6 The metallic part of the overhead bridge screening and Barriers shall be bonded to Static Wires. Other metallic items on the overhead bridge, within a lateral distance of 10 feet from any exposed Energized and uninsulated equipment passing below the structure, shall be bonded to Static Wire.
- 5.3.7 Protective Barriers and Screens shall be inspected and maintained for their intended use.

5.4 BARRIERS AND SCREENS – PUBLIC AREAS

- 5.4.1 Where clearances are less than specified in Figure 5-2, the protection shall be of solid Barrier construction for standing surfaces above exposed Energized Parts on the outside of vehicles or above Energized Parts of the 25 kV Electrification System. The clearance requirements where protective screening and Barriers for

standing surfaces in public areas are utilized for protection against direct contact with adjacent Energized Parts for nominal system voltages up to 25 kV ac to ground are depicted in Figure 5-3. For other situations, as depicted in Figure 5-3, Rules 5.4.2 and 5.4.3 shall be referenced.

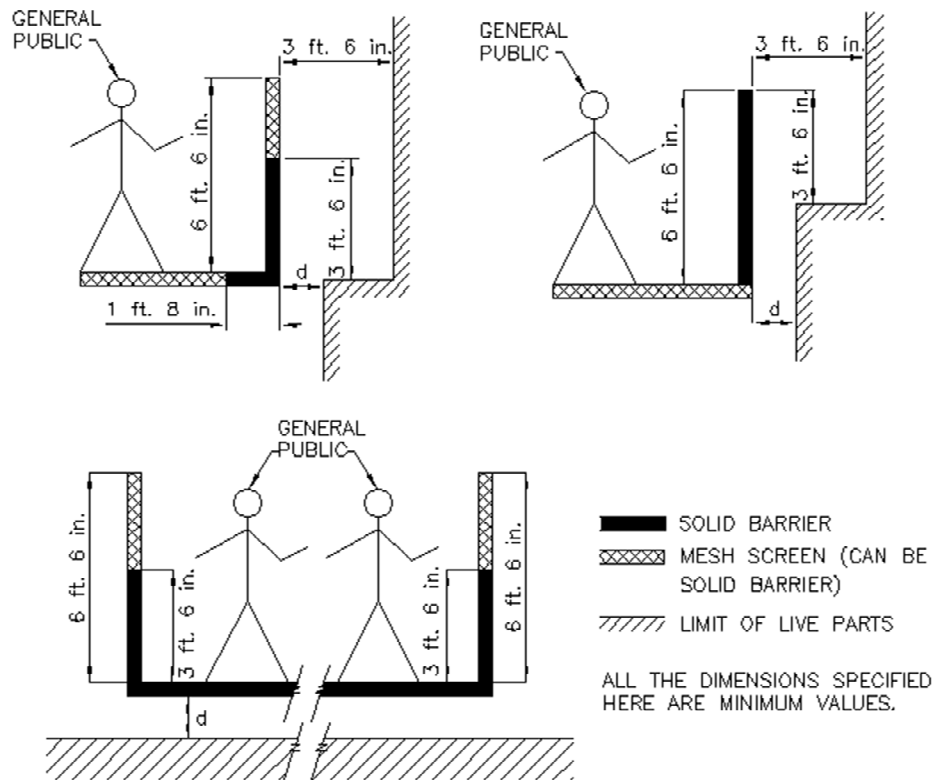


Figure 5-3 Clearance Requirements from Protective Screens and Barriers for Standing Surfaces in Public Areas

- 5.4.2 The minimum requirements for Barriers and Screens to exposed Energized Parts in public areas are 6 feet 6 inches for solid Barriers or a combination of solid Barrier and mesh Screen. The value for dimension “d” between the protective Screens & Barriers and exposed Energized Parts shown in Figure 5-3 shall be determined from Table 5-1.
- 5.4.3 The length of the protective Screen and/or Barrier on structures that cross over Energized Parts, and which protect publicly accessible standing surfaces, shall extend laterally beyond the exposed Energized Parts by not less than 10 feet on each side.

5.5 BARRIERS AND SCREENS – RESTRICTED AREAS

- 5.5.1 Where clearances are less than specified in Figure 5-2, the protection shall be of solid Barrier construction for standing surfaces above exposed Energized Parts on the outside of vehicles or above exposed Energized Parts of the 25 kV Electrification System. The requirements for clearances from protective Screens and Barriers for standing surfaces in restricted areas are shown in Figure 5-4.
- 5.5.2 The length of the solid Barrier, protecting the standing surface, shall correspond to the Pantograph zone and shall extend beyond the exposed Energized Parts by not less than 20 inches.
- 5.5.3 The minimum requirements for Barriers and Screens to exposed Energized Parts in restricted areas are 6 feet 6 inches for solid Barriers or a combination of solid Barrier and mesh Screen. The value for dimension “d” between the protective Screens & Barriers and exposed Energized Parts shown in Figure 5-3 shall be determined from Table 5-1.
- 5.5.4 Dimension “h” of the protective Screen and Barrier shall be such that a clearance of 5 feet to Energized Parts is maintained from the top of the protective Screen and Barrier (see Figure 5-4).

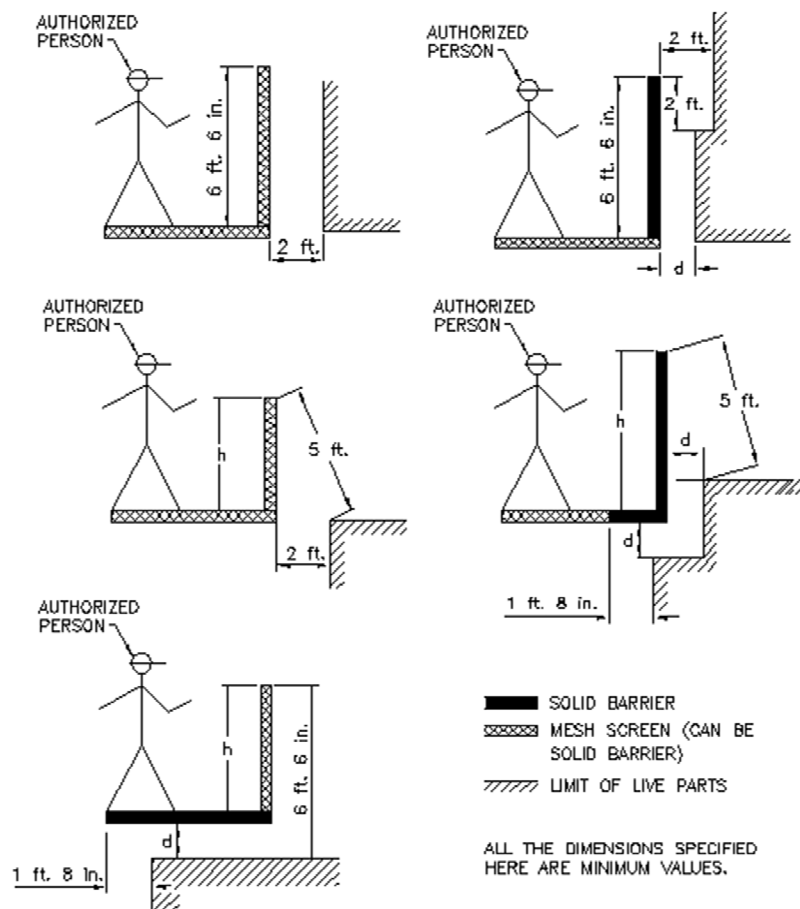


Figure 5-4 Clearance Requirements from Protective Screenings and Barriers for Standing Surfaces in Restricted Areas

5.5.5 The height of the side protective screenings and Barriers must correspond to the height of any necessary safety railing, but must have a minimum height of 3 feet 6 inches.

Exception: For safe working clearances for Qualified Persons, refer to Rule 8.

5.6 PROTECTION AGAINST CLIMBING

- 5.6.1 Where there is public access or where trespass has occurred, anti-climbing protection shall be provided at buildings and other structures supporting Energized Parts of the OCS. Signs or markings warning of the dangers of electric shock shall also be installed.
- 5.6.2 Access to fixed ladders, particularly at signal poles and signal gantries, and the means of access to any roof or other place, which could allow unauthorized persons to approach Energized Parts, shall be secured or otherwise protected.

5.7 CLEARANCES FOR NON-AGENCY OVERHEAD LINES

- 5.7.1 The minimum clearance for overhead electric lines and Communications Lines, which are not part of the 25 kV Electrification System, shall be in accordance with CPUC General Order No. 95 Rule 38 Table 2. Consideration shall be given to the operating voltages for the 25 kV Electrification System stated in Section 4, Rule 4.1.1.
- 5.7.2 Electrical supply lines of equal or higher voltage rating than the 25 kV Electrification System crossing the High-Speed Rail Right-of-Way shall meet the following requirements:
 - a. Grade 'A' construction strength for lines and structures.
 - b. Compliance with GO 95, Section XI.
 - c. Design and construction methods to prevent cascading failures from impacting the HSRS.
 - d. Dead-end construction for all crossing span lines and conductors.
 - e. No splices or taps on the span crossing the High-Speed Rail Right-of-Way.
 - f. Wooden poles are not permitted to support the span crossing the High-Speed Rail Right-of-Way.
 - g. Structures adjacent to the High-Speed Rail Right-of-Way guyed away from the Right-of-Way. Exceptions may be granted by the Agency for steel poles or towers which can support broken conductor loads.
 - h. Except in case of emergency and with the consent of the Agency, inspection and maintenance of such wires or lines, whether imposed by regulatory authorities or by the utility's requirements, shall be performed without entering the High-Speed Rail Right-of-Way.
- 5.7.3 Subject to the exceptions set forth in Rule 5.7.4, guy wires, span wires, support wires, Communications Lines and electrical supply lines of lower voltage rating than the 25 kV Electrification System shall not be permitted to cross over the HSRS, unless supported on or over a bridge structure, such as a roadway, pedestrian bridge, or an independent utility structure.

If an independent utility structure is used for crossing over the HSRS, the structure shall have a solid surface and meet the following requirements:

- a. It shall be built independent of the HSRS infrastructure for its intended use and maintained in accordance with recognized industry standards.
- b. The utility owner shall treat the independent utility structure as part of its system, and hence, include it in the owner's inspection and maintenance plan. The inspection and maintenance activities within the High-Speed Rail Right-of-Way shall be limited to the non-operating hours of the HSRS. It shall have a minimum clearance consistent with Figure 5-5 of this General Order.
- c. Communications and supply lines shall be installed in conduits on top of or within the independent utility structure with enough support to prevent them from falling off the independent utility structure.
- d. Arrangement of the facilities on the independent utility structure shall be in accordance with other applicable Commission rules not covered in this General Order.
- e. Warning signs shall be placed on the independent utility structure to warn the public against climbing or accessing any part of the independent utility structure.
- f. The independent utility structure shall be Grounded as defined in Rule 2.20 of this General Order.

5.7.4 The Agency may approve an application from the utility or communications provider for an exception to Rule 5.7.3 (which approval may not be unreasonably withheld) provided the applicant demonstrates the proposed alternative design meets or exceeds the requirements in Rule 5.7.2 and the following additional requirements:

- a. All conductors and cables must be self-supporting.
- b. Communications Lines shall not contain any conductive elements.
- c. Protective measures shall be adopted to electrically isolate the crossing span from its circuit, shunt the crossing span to ground, or otherwise similarly mitigate safety risks in order to protect the safety of the public in case normally energized conductors in the crossing span make contact with the 25 kV Electrification System.

5.8 NON-AGENCY UNDERGROUND PIPELINE, ELECTRIC AND COMMUNICATION FACILITIES

- 5.8.1 To the extent Practicable, longitudinal encroachment within the High-Speed Rail Right-of-Way shall be avoided.
- 5.8.2 Except as provided below for steel natural gas pipelines, pipes, electric and communication facilities crossing under the High-Speed Rail Right-of-Way shall be encased or installed in rigid conduit, and buried at sufficient depth in accordance with industry standards.

Steel natural gas pipeline facilities crossing under the High-Speed Rail Right-of-Way may be uncased provided that the natural gas utility submits plans to the

Agency demonstrating that such installation is in accordance with the AREMA Manual Chapter 5, Section 5.2, and buried at sufficient depth in accordance with industry standards.

Inspection and maintenance of natural gas pipelines crossing under the High-Speed Rail Right-of-Way will be performed by the natural gas utility without entering the Right-of-Way. Sectionalizing valves for natural gas pipelines crossing the High-Speed Rail Right-of-Way shall be installed and maintained in accordance with 49 CFR Part 192, and, in case of emergency, shall be activated to shut off the flow of gas across the High-Speed Rail Right-of-Way. If the cause of the emergency is due to the condition of the pipe crossing the High-Speed Rail Right-of-Way, a new pipe crossing shall be installed, and the old pipeline shall be filled with grout, abandoned and removed from natural gas service without impacting High-Speed Rail operations. Alternatively, the old pipeline may be used for purposes other than natural gas service by mutual agreement between the Agency and the owner.

- 5.8.3 Pipe, electric and communication facilities crossing under the High-Speed Rail Right-of-Way shall be perpendicular to the railroad alignment to the extent Practicable, and not less than 45 degrees from railroad longitudinal alignment.

5.9 NON-AGENCY ABOVE GROUND PIPELINE FACILITIES

- 5.9.1 To the extent Practicable, existing above ground pipeline facilities shall be relocated underground when crossing the High-Speed Rail Right-of-Way.
- 5.9.2 Pipe that cannot be relocated underground shall be located on an independent utility structure, encased in a larger pipe, and appropriately protected from the 25 kV Electrification System. Refer to Rule 5.7.3 for the requirements of an independent utility structure.

5.10 CLEARANCES TO RAIL VEHICLES AND STRUCTURES

- 5.10.1 Minimum Electrical Clearances, as specified in Table 5-1 and depicted in Figure 5-5, shall be maintained from exposed Energized Parts to Grounded parts of rail vehicles or structures.

Table 5-1 25 kV ac Electrical Clearances

Atmospheric Condition	Minimum Clearance	
	Static (C _A)	Passing/Dynamic (P _A)
Non-Polluted *	8 in.	6 in.
Polluted *	10 in.	8 in.

*: See AREMA Manual Chapter 33, Table 33-2-2 (2010)

Note 1: In a 2x25 kV ac Electrification System, there is a 180 degree phase difference between Energized Parts common to the negative Feeder and those of the OCS. The minimum clearance between these elements is 21.5 inches under static conditions or 12 inches under worst case dynamic conditions.

Note 2: Enhanced clearances or other protective measures may be required at locations where there is a high probability of incidents or vulnerable structures. Regardless, the maximum Practicable value of Electrical Clearance shall be provided.

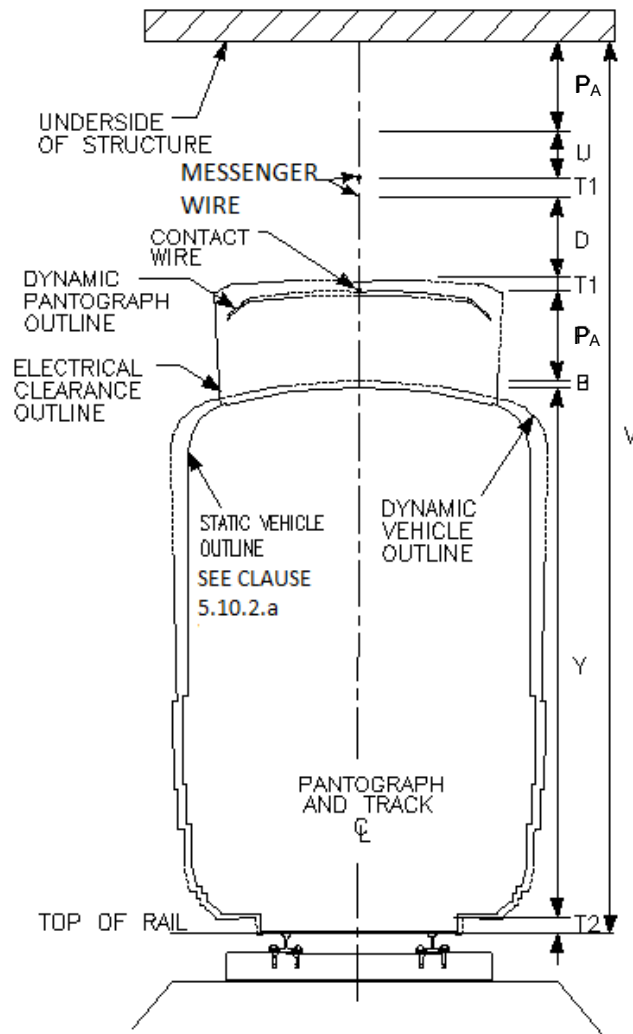
5.10.2 Structural Clearance Envelope

In determining the minimum vertical and lateral clearance envelope at fixed structures, including OCS support structures and signal bridges, the following factors shall be assessed (see Figure 5-5):

- a. The static vehicle outline shall be based on the size of the rail vehicles.
- b. The dynamic vehicle outline shall take into consideration the dynamic envelope, and track position, condition, and maintenance tolerances.
- c. The position of Energized Parts on the rail vehicles, including the dynamic Pantograph envelope, and vehicle construction and maintenance tolerances.
- d. The position and size of Energized Parts of the OCS allowing for installation and maintenance tolerances, and dynamic movements.

5.11 CLEARANCES TO VEGETATION

- a. Vegetation and Energized Parts of the 25 kV Electrification System shall have a minimum clearance of 8 feet and there shall be no overhanging vegetation. When the Agency has actual knowledge, obtained either through normal operating practices, including routine inspections, or notification to the Agency, that dead, rotten or diseased trees or the dead, rotten or diseased portions of otherwise healthy trees may fall into any parts of the 25 kV Electrification System, said trees or portions thereof shall be removed. This requirement does not apply where the Agency has made a good faith effort to obtain permission to trim or remove vegetation but permission was refused or unobtainable. A good faith effort shall consist of current documentation of a minimum of an attempted personal contact and a written communication, including documentation of mailing or delivery. However this does not preclude other action or actions from demonstrating good faith.
- b. In addition, the High-Speed Rail Right-of-Way shall be managed such that vegetation will not:
 - 1) Constitute a fire hazard or other threat to safety or operations.
 - 2) Obstruct a vehicle or train operator's visibility of signs, signals, or the track ahead.
 - 3) Interfere with personnel in performing normal trackside duties.
 - 4) Obstruct emergency walkways.



V - Total Vertical Clearance Required for Electrification
 P_A - Passing (Dynamic) Electrical Clearance – see Note below
 U - Catenary Uplift
 $T1$ - Catenary Construction Tolerances
 D - Catenary Depth
 B - Vehicle Bounce
 Y - Static Vehicle Load Height
 $T2$ - Track Maintenance Tolerance
 C_A - Static Electrical Clearance

Note 1: The diagram depicts the dynamic condition. For static situations, the Static Electrical Clearance (C_A) – refer to Table 5-1 - shall be not less than $P_A + U$ or $P_A + B$

Note 2: Based on AREMA Manual Chapter 33, Figure 33-2-3 and Figure 33-2-4

Figure 5-5 Vertical Structural Clearance Envelope

5.12 PAVED AREAS IN MAINTENANCE FACILITIES AND YARDS

- 5.12.1 The normal clearance of the lowest Energized Part of the 25 kV Electrification System above paved areas in maintenance facilities, yards and workshops, are specified in Table 5-2. Warning signs shall be provided, per Rule 5.13.2.
- 5.12.2 At pedestrian and vehicle crossings in maintenance facilities or yards where vehicles over 8 feet in height are prohibited, a restricted clearance is permitted, as specified in Table 5-2.

Table 5-2 Minimum Clearances above Track Crossings in Paved Areas of Maintenance Facilities, Yards and Workshops

Normal Clearance	20 ft. 4 in.
Restricted Clearance	18 ft. 4 in.

5.13 SIGNAGE

5.13.1 Where required, warning signs bearing the words “No Trespassing,” “Danger” and “High Voltage” in letters at least 3 inches in height shall be posted. The sign or signs may carry other information relative to the hazard present.

5.13.2 Permanent warning signs shall be posted:

- a. In conspicuous places at entrances to locations containing exposed Energized Parts.
- b. On enclosures that provide access to conductors, equipment, and apparatus Energized at High Voltage.
- c. At anti-climbing locations.
- d. At pedestrian and vehicle crossings in maintenance facilities and yards.
- e. At Barriers and Screens placed in areas accessible to the public during normal operation to guard against exposed Energized Parts.

5.13.3 The warning signs shall be posted at intervals of not more than 500 feet throughout the electrified route and be clearly visible to the public.

6 GROUNDING AND BONDING

6.1 GENERAL

- 6.1.1 Grounding and bonding shall be designed and installed throughout the electrified system to provide proper return circuits for the traction power currents and fault currents. Grounding and bonding conductors and systems shall have sufficient current carrying capacity such that Touch Potentials do not exceed the values in Table 6-1 of this General Order.
- 6.1.2 The principal elements of the traction return circuits for normal load or fault currents are the Running Rails and the Static Wire. Exposed normally non-current-carrying metallic parts within the shaded area in Figure 5-1, likely to become Energized under short circuit or Fault Conditions, shall be directly connected to the traction return circuits.

Exception: Where normally non-current-carrying metallic parts cannot be directly connected to the traction return circuits, an alternative method may be used.

- 6.1.3 The Running Rails and the Static Wires shall be the principal return circuits for normal load or fault currents. However, because some residual current will flow through the earth, the Agency shall take protective measures to mitigate the effect on current carrying elements and non-Agency facilities, such as pipes, electric supply and communications systems, or rails. Protective measures shall be coordinated with the facility owner(s), so that the facilities of both parties are not prevented from performing as required or intended.
- 6.1.4 **25 kV AC Electrification System Adjacent to a DC System**
Where a 25 kV ac Electrification System is located adjacent to a dc electrification system, a dc Cathodic Protection system or dc utility facilities, special protection measures may be necessary to avoid interaction of the two systems and to mitigate the effect of leakage currents on either system. Protective measures shall be coordinated with the facility owner(s), such that the facilities of both parties are not prevented from performing as required or intended. When the Agency has actual knowledge of leakage, or residual currents that may affect the safe operation of the dc electrification system or the Cathodic Protection system, the Agency shall coordinate with the facility owner(s) to implement mitigation measures to prevent unsafe operation of either system resulting from the leakage, or residual currents.
- 6.1.5 **Coordination with Train Control and Signal Systems**
Grounding measures shall be coordinated with the train control and signal systems design so that the integrity of the train control/signal system is not compromised.
- 6.1.6 **Non-Agency Grounding Systems**
Where non-Agency pre-existing grounding systems are encountered, coordination with the relevant non-Agency system owner shall occur.

6.2 RUNNING RAILS

- 6.2.1 Where Insulated Rail Joints are used to define the limits of Track Circuits in a signaling system, the insulated joints shall be by-passed by Impedance Bonds to provide a continuous return circuit for the traction power supply and short circuit or fault currents.
- 6.2.2 Suitable connections shall be made between the rails or Impedance Bonds and the adjacent aerial Static Wire, Counterpoise, or traction power facility ground grid. The location of the Impedance Bonds and connections to Grounding Conductors shall be coordinated with the signal system design.

6.3 OCS SUPPORT STRUCTURES AND METALLIC COMPONENTS

6.3.1 General Requirements

- a. Non-current carrying metallic components associated with the OCS shall be Grounded by a direct connection to an aerial Static Wire. OCS Poles, attachments and support structures shall be interconnected by an aerial Static Wire. Multi-track structures supporting more than one OCS shall be interconnected with two separate aerial Static Wires.
- b. Connections shall be made between each aerial Static Wire and the Running Rails, usually at an Impedance Bond as necessary. The spacing of such interconnections must be coordinated with the signaling system. Aerial Static Wires shall also be connected to the ground bus of traction power facilities providing power to the OCS.
- c. The maximum permissible potentials described in Rule 6.5 shall not be exceeded and, the resistance to ground shall not exceed 25 ohms.

6.3.2 Railroad Passenger Stations

- a. Metallic structures and miscellaneous metallic items, including overhead walkway structures and canopies, located on passenger station platforms, as well as any OCS Poles installed within 8 feet from the platform edge, shall be isolated from the Static Wire and Grounded by a direct connection to a Counterpoise.
- b. One end of the Counterpoise shall be connected to the Running Rails either directly or via an Impedance Bond outside the limits of the station platform. The connections shall avoid interference with broken rail detection and adhere to other requirements of the signaling system.
- c. The maximum permissible potentials described in Rule 6.5 shall not be exceeded.

6.4 WAYSIDE NORMALLY NON-CURRENT-CARRYING METALLIC PARTS

6.4.1 General Requirements

- a. At concrete or masonry overhead structures, where the structure above Energized OCS conductors or Feeders is within the Overhead Contact System Zone and Pantograph Zone (Figure 5-1), metallic flash plates shall be installed above the conductors.

- b. Flash plates and overhead bridge Barriers/Screens shall be Grounded by a direct connection to the aerial Static Wire.
- c. Facilities, such as pipelines or conduits, crossing over, or paralleling the 25 kV Electrification System, may require joint assessment and mitigation. Protective measures, such as shielding or bonding and grounding, shall be coordinated between the owner and the Agency.
- d. Wayside equipment enclosures, structures and fences shall be Grounded.
- e. The maximum permissible potentials as specified in Rule 6.5 and the resistance to ground shall not exceed 25 ohms.
- f. Signal equipment shall be separately Grounded and coordinated with the signal system design.

6.5 TOUCH POTENTIALS

6.5.1 Touch Potentials of Running Rails and normally non-current-carrying metallic parts shall be controlled within the High-Speed Rail Right-of-Way.

6.5.2 The requirements specified in Table 6-1 provide values for maximum permissible Touch Potentials for short term conditions of less than 0.5 seconds and also for long term conditions under all power supply feeding conditions.

These requirements also address permanent conditions for time intervals greater than 300 seconds. The maximum Touch Potentials shall not exceed 60 V RMS.

Table 6-1 Maximum Permissible Touch Potentials as a function of Time ¹

SHORT TERM		SHORT TERM		LONG TERM	
Time - seconds	Voltage – volts	Time - seconds	Voltage – volts	Time - seconds	Voltage – volts
0.02	865	0.3	480	0.7	90
0.05	835	0.4	295	0.8	85
0.1	785	0.5	220	0.9	80
0.2	645	0.6	180	1	75
		< 0.7	155	300	65
				>300 *	60 *

Exception: * The limit for maintenance shops is 25 V RMS

¹ derived from EN 50122-1: 2011 Clause 9.2.2

- 6.5.3 Whenever the Agency determines, through normal operating practice or notification by a non-Agency, that operation of the High-Speed Rail System is likely causing or contributing to Touch Potentials on normally non-current carrying metallic parts of non-Agency facilities outside the High-Speed Rail Right-of-Way, such that the facilities are prevented from performing as required or intended, the Agency shall cooperate with such facility owner and any other involved parties to determine the cause. The Agency shall only be responsible for the remedy in proportion to its share of the cause. The comprehensive remedy shall allow the affected facilities to perform as required or intended.

7 STRENGTH REQUIREMENTS FOR 25 KV ELECTRIFICATION SYSTEMS

7.1 LOADING

- 7.1.1 General Order 95 Rule 43 shall be used for determining the loading condition(s).

Exception: In calculating the strength of the OCS conductors, supporting structures, span wires, backbones, etc., there shall be no requirement to account for additional vertical loads on Supports or conductors imposed by a worker.

- 7.1.2 Foundations shall be designed on a location-specific basis in accordance with established engineering practices and shall be capable of meeting the structural and OCS loading requirements

7.2 MINIMUM SAFETY FACTORS

- 7.2.1 The safety factors specified in General Order 95, Table 4, Grade 'A' Construction shall apply at the time of construction. A one-third reduction in these values is allowed after initial construction.

Exception: Messenger and Contact Wires in auto-tensioned equipment are not subject to the standard variations in tension due to temperature changes.

8 SAFE WORKING PRACTICES

8.1 GENERAL

8.1.1 The Agency shall:

- a. Develop, maintain and follow formal safety rules, procedures and safe working practices pertaining to the operation and maintenance of the 25 kV Electrification System.
- b. Provide non-Agency personnel with appropriate levels of training in the application of the safety rules, emergency procedures and safe working practices for work within the High-Speed Rail Right-of-Way.
- c. When requested, provide non-Agency personnel working on or in adjacent worksites, using equipment or processes that may result in an intrusion into the High-Speed Rail Right-of-Way, with appropriate levels of training in the application of the safety rules, emergency procedures and safe working practices.
- d. If the Agency identifies non-Agency personnel working on or in adjacent worksites, using equipment or processes that may result in an intrusion into the High-Speed Rail Right-of-Way, such non-Agency personnel shall be provided with appropriate levels of training in the application of the safety rules, emergency procedures and safe working practices.
- e. Periodically inspect first aid equipment, personnel protective equipment and protective devices to ensure they are in safe working condition.

8.2 FAULT LOCATION AND ISOLATION

8.2.1 To provide for maintenance and operational needs, the OCS shall be sectionalized with locally and remotely operable motorized disconnect switches installed to facilitate de-energization of sections and alternate feeding arrangements. At some locations, particularly in the maintenance yards and shops, non-supervised, manually operated disconnect switches will be utilized.

8.2.2 To provide for rapid fault detection and isolation, a relay protection system shall be installed. Where the 25 kV Electrification System is remotely supervised, controlled and operated, communication with the appropriate electric service provider control centers shall be maintained.

8.2.3 The relay protection scheme shall:

- a. Protect the 25 kV Electrification System equipment against short-circuit faults, overloading and subcomponent failures
- b. Provide proper coordination and selectivity for rapid fault clearance to the affected area of the 25 kV Electrification System for the protection of people and facilities.

8.3 ACCESS TO ENERGIZED PARTS

- a. Energized Parts, other than rails or rail connected equipment installed or maintained as part of the 25 kV Electrification System, shall be located with sufficient clearance or enclosed so as to prevent accidental contact by persons or objects.

- b. OCS switches and enclosures shall be kept locked at all times to prevent unauthorized access or operation.
- c. Access to enclosures containing Energized Parts shall be limited to Qualified Persons, and to Authorized Persons under the supervision of a Qualified Person.
- d. Enclosures housing 25 kV Energized Parts and cables accessed by Qualified Persons shall have permanent labels, indicating operating voltage, to aid the personnel in performing maintenance tasks safely.

9 RECORD KEEPING, REPORTING AND INCIDENT INVESTIGATION

9.1 INSPECTIONS AND RECORDS

The Agency shall prepare and follow procedures for conducting inspections and maintenance for the 25 kV Electrification System for the purpose of ensuring that the system is in good condition and is conforming to these rules.

The Agency shall maintain records of inspection and maintenance activities. Commission staff shall be permitted to inspect records and procedures consistent with Public Utilities Code Section 314 (a).

9.2 INCIDENT REPORTING AND INVESTIGATION

9.2.1 In the event of an incident meeting the criteria described below, the Agency shall send an initial notification to the Commission and to the Governor's Office of Emergency Services per the following guidelines.

- a. If the incident occurs during its normal working hours, the report shall be made as soon as Practicable but no longer than 2 hours after the Agency is aware of the incident and its personnel are on the scene.
- b. If the incident occurs outside its normal working hours, the report shall be made as soon as Practicable but no longer than 4 hours after the Agency is aware of the incident and its personnel are on the scene.
- c. The notification shall identify the time and date of the incident, the time and date of notice to the Commission, the location of the incident, casualties that resulted from the incident, identification of casualties and property damage, and the name and telephone number of the Agency contact person. This notification may be by (a) using the Commission's Emergency Reporting Web Page, (b) calling an established CPUC Incident Reporting Telephone Number designated by the Commission's Safety and Enforcement Division (SED) or its successor or (c) sending a message to an electronic mail address designated by the Commission's SED or its successor. Telephone notices provided at times other than normal business hours shall be followed by a facsimile or email report by the end of the next working day.

9.2.2 Reportable incidents are classified as those which:

- a. Result in fatality or injury requiring overnight hospitalization and are attributable or allegedly attributable to the 25 kV Electrification System or Agency's traction power supply facilities (which include Substations, Switching Stations, Paralleling Stations and electrical supply stations).
- b. Are the subject of significant public attention or media coverage and are attributable or allegedly attributable to the 25 kV Electrification System or Agency's traction power supply facilities (which include Substations, Switching Stations, Paralleling Stations and electrical supply stations).
- c. Include damage to property of the Agency or others estimated to exceed \$50,000 that are attributable or allegedly attributable to the 25 kV Electrification System or Agency's traction power supply facilities (which include Substations, Switching Stations, Paralleling Stations and electrical supply stations).

- 9.2.3 Not later than 30 days from the end of the month in which the reportable incident occurred, the Agency shall submit to the CPUC a written account of the incident which includes a detailed description of the nature of the incident, its cause and estimated damage. The report shall include a description of the Agency's response to the incident and measures the Agency took to repair facilities and/or remedy any related problems on the 25 kV Electrification System or the Agency's traction power supply facilities (which include Substations, Switching Stations, Paralleling Stations and electrical supply stations) which may have contributed to the incident.
- 9.2.4 The Agency shall establish procedures for investigating reportable incidents for the purpose of determining the causes of the incident and minimizing the possibility of a recurrence.

9.3 ACCESS BY COMMISSION REPRESENTATIVES

Representatives of the Commission shall be allowed to enter upon the Agency's property for the purpose of determining compliance with Commission rules, conducting tests, and inspecting records. Commission representatives entering the property shall have appropriate training or be accompanied by appropriately qualified Agency personnel.