



IEEE Guide for Design of Direct Current Overhead Contact Systems for Transit Systems

IEEE Vehicular Technology Society

Developed by the
Overhead Contact Systems Standards Committee

IEEE Std 1833™-2023

STANDARDS

IEEE Guide for Design of Direct Current Overhead Contact Systems for Transit Systems

Developed by the

Overhead Contact Systems Standards Committee
of the
IEEE Vehicular Technology Society

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IEEE SA Standards Board

Abstract: The general parameters used in the design of direct current overhead contact systems used in transit systems are defined in this guide. The guidelines mentioned in this document are intended to be used for the design of either new or expanding transit systems where a legacy of design standards does not exist. These guidelines are not intended to replace or supersede existing design standards, but to formalize the design process.

Keywords: electric trolleybuses, IEEE 1833™, light rail system, OCS design, OCS styles, overhead contact system, streetcars, transit systems, trolley

*This standard is dedicated to the memory of our
friend and colleague Paul F. White*

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Introduction

This introduction is not part of IEEE Std 1833-2023, IEEE Guide for Design of Direct Current Overhead Contact Systems for Transit Systems.

The Overhead Contact Systems Subcommittee was formed in 2001 with the purpose of developing standards governing the design and construction of overhead contact systems for rail transit. The primary concern of the Overhead Contact Systems Subcommittee Design Guide Working Group P1833 was to unify practices and applications for the design and implementation of dc overhead contact systems for rail transit vehicles and electric trolleybuses (ETB). Most of the present operating dc electrified rail systems use overhead contact system (OCS) or third rail to supply power to the vehicles. This guide specifies the parameters solely used in the design of overhead contact systems. This guide does not cover the design parameters used for third rail systems, rail systems at different operating voltages than what is mentioned in this document, and any other subsystem used in the transit system in conjunction with the overhead contact system.

This guide is intended to apply to rail transit vehicles that are electrically powered, which are defined to include heavy rail vehicles (“subway or elevated” cars) and light rail vehicles (streetcars), including units that combine powered and unpowered trucks or axles. This guide does not apply to vehicles that include locomotives and railway electric multiple unit (EMU) cars. Fully automated, driverless implementations of rail transit vehicles are sometimes included in the mode of transit referred to as “automated guideway transit” (AGT), and to the extent that the vehicle does not have other unique requirements, this guide can be applied. This guide is not intended to be universally required for all AGT systems.

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IEEE Guide for Design of Direct Current Overhead Contact Systems for Transit Systems

1. Overview

1.1 General

The Overhead Contact System Subcommittee to the Rail Transportation Standards Committee was formed in 2001 with the purpose of developing standards governing the design and construction of overhead contact systems for rail transit. This guide unifies the general practices and applications used in the design process for the implementation of direct current (dc) overhead contact systems for rail transit and electric trolleybuses (ETBs). This guide applies to the design of an overhead contact system (OCS) used to power light rail vehicles (LRV), streetcars, and ETBs, where traction power is supplied from a direct-current, conventionally suspended OCS with a nominal voltage of 600 V dc to 3000 V dc.

1.2 Scope

This guide defines the general design parameters of OCS design for dc transit systems. The guidelines that follow are intended for new systems and for the expansion of systems where a legacy of design standards does not exist. This guide is not intended to replace or supersede existing design standards but to formalize the design process.

1.3 Purpose

The purpose of this guide is to develop the performance requirements and design guidelines for dc OCS. The guidelines within should be used to address potential safety hazards, improve the performance and reliability of the system, and reduce service life-cycle costs. These guidelines consider safety, system reliability, modes of operation, type of vehicle to be used, and maintenance factors.

1.4 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall equals is required to*).^{6, 7}

⁶The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁷The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 1791™-2019, IEEE Recommended Practice for Terminology Used for Direct Current Electric Transit Overhead Contact Systems.^{8,9}

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* and IEEE Std 1791™-2019 should be consulted for terms not defined in this clause.^{10, 11}

contingency operations: Operations that are not scheduled. If normal train operations are disrupted by accident or equipment failure, the situation is examined by power dispatch and train dispatch staff and a temporary operating plan is devised. The sectionalizing of the rail system is designed to enable the power dispatcher to disconnect power at the required location while maximizing the energized routes available to permit a near-to-normal rail service to be operated.

electrical section: The portion of the circuit divided into discrete power sections by means of overhead contact system (OCS) sectionalization and individually controlled by circuit breakers located within substations.

head-span suspension: An assembly of multiple cross-span wires between poles consisting of a head span, body span, and/or steady span.

heavy rail transit: A mode of rail rapid transit generally characterized by fully grade-separated construction, operation on exclusive rights of way, and station platforms at the floor level of the vehicles.

heavy rail vehicle: A vehicle operating on a heavy rail transit system. Typically, electrically propelled, bidirectional, capable of operating in multiple units, and designed for rapid, high-level boarding and discharging of passengers.

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light rail transit (LRT): A mode of rail transit characterized by its ability to operate on exclusive rights-of-way, street running, center reservation running, and grade crossings and to board and discharge passengers at track or vehicle floor level.

light rail vehicle (LRV): A vehicle that operates on a light rail transit system, capable of boarding and discharging passengers at track or vehicle floor level.

maintenance operations: A planned train operation in which individual electrical sections or subsections de-energized to allow maintenance to be performed locally, while the remainder of the electrical system remains available for electric traction.

mechanical tensioning equipment: Arrangement enabling the mechanical tension of the conductors to be adjusted.

normal/abnormal feeding: Normal feeding is the set of settings applied to switches and circuit breakers during normal, everyday train operations. These settings are shown on sectionalizing diagrams. Abnormal feeding is any other set of settings applied to switches and circuit breakers to permit train operations while allowing for an outage of some portion of the system.

operating authority: A geographical or political division created specifically for the single purpose of providing transportation service.

ply pole construction: A manufacturing process comprising compressing together two or more steel shells along the length of the pole to act as a single unit.

single failure policy: A policy applied during design of a sectionalizing scheme that requires that the designer need only consider one overhead contact system or substation failure at any one time in each portion of the route. Multiple simultaneous failures are not considered unless the route includes an unusual risk.

stray current: Portion of the return current that follows a path other than the designed return circuit (i.e., earth, pipes, and metallic structures).

subsection: A separately switchable portion of an electrical section.

system height: The vertical distance between messenger and contact wires at the support structure.

traction power substation (TPSS): An electrical substation primarily comprising one circuit breaker per section connected to a bus. Traction power is supplied to the bus by a rectifier transformer connected to a utility supply.

weathering steel: Alloys of steel that have a stable surface that reduces the need for painting or galvanizing.

3.2 Acronyms and abbreviations

ADC	agency design criteria
AGT	automated guideway transit
ATSC	auto-tensioned simple catenary (as known as “SCAT”)
ATSCW	auto-tensioned single contact wire
EMU	electric multiple unit
FAA	Federal Aviation Administration

FRA	Federal Railroad Administration
FRTTP	fiberglass reinforced thermoset plastic
FTSC	fixed terminated simple catenary
FTSCW	fixed terminated single contact wire
LP	low profile
LPATSC	low-profile ATSC
LPFTSC	low-profile FTSC
LRT	light rail transit
MPA	midpoint anchor
MSO	midspan offset
NOC	nonoperating condition
OCR	overhead conductor rail
OPC	operating condition
POS	point of switch
ROW	right-of-way
SC	simple catenary
SCAT	simple catenary auto-tensioned
SCE	structure clearance envelope
SCST	simple catenary spring tensioner
SCW	single contact wire
SCWAT	single contact wire auto-tensioned
SED	structure erection diagram
TOH	trolley overhead
TPFS	traction power feeder system
TPSS	traction power substation
VCE	vehicle clearance envelope
WF	wide flange steel column

4. Technical requirements

This guide is applicable to electric traction overhead lines for railways, tramways, and trolleybuses. These guidelines are based on typical North American OCS design practices based on federal, state, and local codes and standards. European standards will be referenced in this document where applicable. Consequently, all dimensioning will be represented in metric (imperial) units, when applicable. This guide has been prepared for use on light rail transit (LRT) systems where no agency design criteria (ADC) has been developed and published. It is recommended that these provisions be applied to electric traction overhead lines of new construction or when complete transformation of existing lines takes place.

The following factors should be considered during the design process:

- a) Design parameters where the ADC is silent.
- b) Transit subsystems interfaces such as traction power, track, civil, structures, rolling stock/vehicles, stations, operations, communications, and signal systems.
- c) Sectionalization schemes that facilitate safe operation of the system, while allowing for ease of maintenance.
- d) Other features that may impact the OCS design, such as traffic signals, streetlights, overhead structures, overhead utilities, airport runways, hospitals, laboratories with special low magnetic field requirements, low vibration tolerance, and low noise disturbance zones.
- e) Design for uniformity and standardization of OCS installations and design documentation. This uniformity facilitates the supply and availability of components and conductors and maintainability during revenue operations. Maintenance crews generally have limited resources of equipment and labor; therefore, these factors should be considered within the design process.
- f) For new transit systems, once the appropriate studies have been conducted, it is recommended that the choice of conductor types and sizes, OCS styles, configurations and system parameters be standardized to align with common industry practice for new transit line projects.

5. General design requirements for overhead contact systems

5.1 General provisions

5.1.1 Traction electrification system (TES)

The TES provides power to electrically propelled vehicles by the means of the traction power system (TPS) and the OCS. The TPS consists of the traction power substation (TPSS) and the traction power feeder system (TPFS). The TPFS includes both the positive and the negative feeder or return cables and their respective conduits from the substation to the tracks. The OCS, while primarily describing the power distribution system for pantographs operations, also includes trolley overhead systems (TOH) for trolleybuses and rail vehicles with trolley collector poles.

5.1.2 Selection of design parameters

The ADC will typically provide the basis of design for all disciplines involved on the project and list applicable codes and standards. The OCS section is usually combined with traction power under traction electrification. Other sections of the ADC of special interest to the OCS include the following:

- a) Environmental parameters (including wind, ice, and temperature range)
- b) Conductor selection
- c) Sectionalization schemes for either mainline or yard operation
- d) Lateral structure clearances to centerline of tracks
- e) Structures (including pole grounding on flyovers, clearances at overpasses, and OCS attachments to soffits)
- f) Vehicles (including envelope/motion characteristics)
- g) Vehicle pantograph width, height range, dynamic motion, and electrical/mechanical clearances

Design parameters are those design criteria values that have been selected from a range of possible values. Examples include nominal contact wire height, normal conductor tensions, preferred sizes of wide-flange poles, and preferred foundation diameter(s).

Although many design parameters may already be stipulated in the ADC, others may not be. These may include structure spacings on tangent and curves, maximum and minimum conductor tensions, maximum OCS tension section length, maximum staggers at various heights, and acceptance criteria for contact wire position at midspan (midspan offset). For these parameters, design analyses will be required.

5.1.3 Design analyses

When designing for extensions to existing transit systems, much of the analysis needed to create basic design parameters will have been done for the equipment already installed.

When basic design drawings are available from previous agency projects, new design analyses may only be needed to validate the former parameters. It is recommended that existing parameters be retained wherever practical for uniformity of design and maintenance.

On new starter lines, the following analyses may be required:

- a) Maximum tension length and stagger change
- b) Pantograph security, maximum staggers, and midspan offset
- c) Maximum span and structure spacing on curves
- d) Conductor tension, maximum sags, and use of temperature stops
- e) Hanger length tables
- f) Vertical, wind, and radial load tables
- g) Pantograph clearance envelope
- h) Structure clearance envelopes for various track curves
- i) Pole deflection and pole capacity

Vehicle parameters used in developing span length criteria, per the pantograph security analysis study, and in producing pantograph clearance envelopes are listed in detail in [Clause 7](#).

5.1.4 Current collection

Light rail vehicles (LRV) collect current from the overhead line contact wire by means of pantographs or collector poles and return the current to the substations via the running rails.

5.1.5 Line voltages

Transit systems are characteristically differentiated from commuter rail systems by the classification of the operating voltage, the type of vehicle, and the maximum operating speed. Standard nominal line voltages for modern transit systems are specified in [Table 1](#).

Table 1—Typical nominal voltages for OCS¹²

System type	Nominal voltage (V dc)	Application	Recommendations
OCS for pantograph operations	600 750 1500 3000	LRVs and some streetcars	It is recommended that for new systems, the OCS nominal supply voltage be 750 V dc or 1500 V dc.
NOTE 1—Existing OCS line voltages may differ from values mentioned within this table.			
NOTE 2—Refer to Clause 11 and Clause 12 for TOH and ETB line voltages.			

5.1.6 Overhead contact system styles for pantograph operation

Overhead conductor wires can be configured in several ways. Each configuration is called an “OCS style,” which refers to the general configuration of the conductor wires and the manner of tensioning the wires. One or more bare overhead conductors exists in an OCS. Each OCS style will have its own discrete parameters, many of which may not be shared with other styles. Tensioning of conductors is defined as either AT or FT.

The most common OCS styles for modern installations are as follows:

- a) Auto-tensioned simple catenary (ATSC)
- b) Fixed terminated simple catenary (FTSC)
- c) Low profile ATSC (LPATSC)
- d) Low profile FTSC (LPFTSC)
- e) Auto-tensioned single contact wire (ATSCW)
- f) Fixed terminated single contact wire (FTSCW)
- g) Overhead conductor rail (OCR)

Selection of the OCS style(s) depends on power demand and application along the route or in storage yards. Refer to [Table 2](#) for the recommended application of the OCS styles.

Also, the overhead conductor rail is an alternative to conductor wires for use where close-spaced supports under 12.2 m (40 ft) are feasible, such as in tunnels and in maintenance shops.

5.1.6.1 Single contact wire (SCW)

A single wire system consists of an SCW usually requiring one or more aerially installed or underground parallel feeder cables for electrical reinforcement of the system.

5.1.6.2 Simple catenary (SC)

An SC system consists of a contact wire suspended by hangers from a messenger wire. Typically, SC has a normal system height of 1219 mm (48 in), but may fall into the range of 610 mm to 1520 mm (24 in to 60 in) and a maximum span of 73 m (240 ft), depending on the system height and the tensioning method. SC has a variant called “low profile (LP) simple catenary,” which has a reduced system height of 381 mm to 610 mm (15 in to 24 in) with a span length of 49 m (160 ft). LP catenary reduced system height and simplified support system is considered more aesthetically pleasing for historic and downtown areas, but typically requires additional support columns along the system.

¹²Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

5.1.6.3 Auto-tensioned (AT)

In an AT system, the tensions in the conductors are terminated to a tensioning device such as balance weight assembly or spring tensioners. These tensioning devices keep the tension in the conductor constant by taking up or letting out elongation or contraction of the conductors caused by environmental change and power supply affecting the conductor temperature and tension. The use of AT style OCS generally allows for longer span lengths since conductor tensions stay constant over a greater temperature range.

5.1.6.4 Fixed terminated (FT)

In a FT system, the conductors are dead-ended to a pole, anchor portal, or wall and conductor tension varies with temperature. At high temperatures, the reduced tension and the resulting increase in sag of the contact wire should be considered in the design to mitigate degradation of pantograph performance. At low temperatures, the contraction of the conductors can result in considerably higher tensions that should be considered in the design of the poles and cantilevers.

Table 2—Application of OCS styles

Application	OCS styles	Recommendations
Main line dedicated ROW	ATSC	Auto-tensioned system using center or side poles.
Main line crossovers	ATSC	Auto-tensioned system using side poles.
Aesthetically sensitive streets	FTSCW with parallel underground feeders (if required)	Fixed terminated system using center or side poles.
City streets or downtowns	LPATSC	Fixed terminated system using center or side poles.
Suburban street medians	ATSC	Auto-tensioned system using center or side poles.
Tunnels [less than 1220 m (4000 ft)]	SCWAT with parallel feeders (if required), LPATSC, or OCR	Auto-tensioned or conductor rail system.
Tunnels [longer than 1220 m (4000 ft)]	SCWAT or LPATSC	Auto-tensioned or fixed terminated system.
Yard tracks	FTSCW, no parallel feeders	Fixed terminated system with poles located between storage tracks.
Yard leads	ATSC	Auto-tensioned system with side poles.
Maintenance shops	FTSCW or conductor rail	Low-tensioned fixed terminated system or conductor rail system.

5.2 Environmental factors

In addition to satisfying the performance needs of the LRVs, the OCS should be designed to withstand service conditions within the operating environment and provide safeguards to enhance reliability.

5.2.1 Service conditions

Service conditions dictate some of the parameters used when designing the OCS, such as conductor tensions, span lengths, minimum contact wire height, and structure loadings. Typically, service conditions are specified within the ADC as operating conditions (OPC) that define the normal parameters used for revenue service or as non-operating conditions (NOC) that define the parameters used for nonrevenue service. Service conditions, as defined within the ADC, should consider the following factors:

- Temperature
- Wind

- Ice
- Elevation (above sea level)
- Special inclement weather conditions

5.2.1.1 Temperature

Temperature ranges, as defined within the ADC for recorded historic low and high temperatures, affect the OCS in numerous ways. The following temperature parameters should be considered within the OCS design:

- a) Average ambient temperature is used to determine the normal or mean setting position for various OCS equipment.
- b) Maximum and minimum ambient temperatures define the temperature range that the OCS equipment will operate during revenue service. Special design considerations should be accounted for when designing fixed terminated systems due to the imposing expansion and contraction of the OCS conductors.

5.2.1.2 Wind

As defined within the ADC under wind loading conditions, wind speed parameters are used to design conductor blow-off values, pantograph security, structural supporting columns, OCS supports, and numerous other design elements depending on the OCS style selected. Wind parameters are normally combined with other loading factors when performing OCS calculations.

5.2.1.3 Ice

Ice accumulation on the OCS increases the loading on the equipment and supports, therefore, increasing tensions and sag of the OCS wires. Tension and sag are compensated for in auto-tensioned systems; however, this system has its limitations and capabilities outside the working range of the tensioning equipment. Dependent on the geographical area of the system, typical ice loading conditions are defined by either light, medium, or heavy categories in accordance with the National Electrical Safety Code® (NESC®), section 250 A and section B [B1].¹³

5.2.2 Safeguards

The following factors must be safeguarded by design wherever practical:

- a) Icicles and ice prevention
- b) Ground topography and elevation
- c) Geophysical conditions
- d) Surge protection
- e) Atmospheric pollution
- f) Vermin and human vandalism
- g) Other adverse conditions pertinent to the geographical area

5.2.2.1 Icicles and ice prevention

Icicles typically form from the dripping of water under freezing conditions. Ice buildup on linings at the mouths of tunnels can be prevented by the application of thermal insulation set marginally away from the lining for

¹³The numbers in brackets correspond to those of the bibliography in Annex A.

the distance into the tunnel along which ice has been observed. The core temperature of rock, normally 8 °C (46 °F), prevents the water from freezing so that it can drain away naturally.

Ice buildup on conductors can be minimized or prevented using several methods, including physical screening or electrical heating.

Passive ice mitigation systems are often used on transit systems, which include ice scrapers fitted to the pantograph head, plastic covers, and anti-icing compounds.

5.2.2.2 Ground topography and elevation

Ground topography and elevations should be considered when designing the OCS. Gradient changes will limit the overall performance of the OCS while impacting the propulsion and braking system of the LRT vehicle. Typical maximum track gradients for a light rail vehicle are 6% to 7% (TRB TCRP Report 155 [B8]). Gradient changes for the contact wire are mentioned within Chapter 33 of *AREMA's Manual of Railway Engineering* [B2].

5.2.2.3 Geophysical conditions

The following geophysical conditions should be considered, and a mitigation plan should be set in place when designing the OCS:

- a) In geographical areas subject to seismic events, the OCS design should follow local building and state codes.
- b) The soil resistivity values along the right-of-way will affect the design of the grounding systems. In general, a soil resistivity measurement of 25 Ω or less should be used for general grounding of OCS structures and 5 Ω or less for surge arrestor ground connections (IEEE Std 81™ [B5]).
- c) Any corrosive soil conditions along the right-of-way will lead to deterioration of concrete foundations and should be addressed by the appropriate party.
- d) Contaminated soils along the right-of-way and environmental impacts.
- e) Subsidence and slipping embankments may require foundations remedial adjustments.
- f) Soil bearing capacity and presence of rock will affect the OCS foundations depths.

5.2.2.4 Surge protection

Lightning strikes on the OCS and other electrical surges can cause insulator failure, disconnect switch failure, and breakdown of insulated feeder cables. The effects of surges can be mitigated by the installation of surge (lightning) arresters on OCS poles, disconnect switches, feeder cable risers, and bridge supports. The amount and intensity of lightning is characterized by the keraunic level for the area. An insulation coordination study is necessary to establish the design parameters for the protection of along-track equipment, overpasses, track crests, disconnect switches, and end of the line.

5.2.2.5 Atmospheric pollution

Atmospheric pollution can decrease the effectiveness of insulators, cause corrosive conditions, and decrease the life of the OCS. Sources of air pollution include diesel locomotives and exhaust stacks from coal plants and manufacturing industries. If pollution sources are present, special consideration should be given to areas where the pollutant may be able to concentrate, especially near tunnels.

Mitigating the effects of airborne particulates that can adhere to insulators in the proximity of highways where de-icing agents are used should also be addressed within the ADC or specifications.

Depending on the operating voltage of the system, increases in electrical clearances are often required for systems installed over 915 m (3000 ft) above mean sea level due to the reduction of dielectric strength with elevation (NESC [B1]).

5.2.2.6 Vermin and human vandalism

Indigenous animals, typically birds, squirrels, and mice, can come into contact with the electrification system and either bridging electrical sections or bridging to ground. Provisions should be included to protect against vermin intrusion at susceptible locations within OCS. Items of particular concern are low clearance bridges where birds tend to bridge across to the bridge damaging the adjacent infrastructure. When possible, precautions should be taken to address human vandalism.

5.2.2.7 Other adverse conditions pertinent to the geographical area

Other adverse conditions that should be considered are salt (oceanic, roadway, etc.), solar radiation, and utility power reliability.

5.3 Safe working zones for transit maintenance employees

Safe working zones are created by use of double insulation in the OCS support system and the use of insulating screens around the OCS to prevent maintenance staff from accidentally contacting grounded equipment.

5.3.1 Double insulation

Double insulation is the provision of two discrete insulation points, for each connection to grounded supporting infrastructure. Each level of insulation should be at the full rating for the selected voltage.

Spacing of the double insulation should be designed to prevent a maintainer's hands from bridging between live equipment and conductive grounded equipment, which may be fatal. Refer to the ADC for separation distance between double insulation.

Also, requirements for double insulation may be met by providing a single 2.13 m (7 ft) long insulator or by using synthetic nonconductive fiber rope.

All OCS support insulators should be carefully located to achieve a safe working zone for maintainers.

5.3.2 Insulating screens

Safe working conditions for maintaining energized OCS can also be achieved by screening around all grounded equipment within reach of the energized OCS by using insulated sheeting. Insulated sheeting, such as FRTP, is installed between the energized equipment and conductive grounded equipment, such as the deck or beams of a steel bridge. This insulated sheeting should be suitably dimensioned so that it cannot be reached around by a maintainer with one hand touching energized equipment. This screen should be clear of the pantograph clearance envelope and designed to withstand the local climatic conditions and anticipated loads, such as ice buildup, and any likely impact like a maintainer falling against the screen or equipment impacting it.

5.3.3 Precautions at overhead bridges and tunnels

For bridges with steel beams, if the clearance between the underside of the beams and the OCS is less than 1.2 m (4 ft), a screen of insulated sheeting may be provided extending at least 1.2 m (4 ft) each side of the OCS. This screen should be designed to withstand the effects of ice buildup.

Bridge decks made of concrete or other nonconductive materials, and conductive decks more than 1.2 m (4 ft) above energized equipment, do not require screening unless specified by the transit agency.

Tunnels should be handled similarly to overhead bridges, with the additional consideration of other installations such as cabling, pipes, and lights, mounted on the soffit, parts, all of which are typically grounded.

5.4 Public safety

5.4.1 Precautions at bridges over the right-of-way

Where bridges with pedestrian access pass over OCS, solid screening should be erected if the parapet walls or fences are less than 1.8 m (6 ft) high. Consider similar precautions in retained cut or “boat” sections with vertical or nearly vertical sides. These depressed sections of track between retaining walls may have public walkways along the outside and safety screens may be required if energized equipment is within 3 m (10 ft) of where people can stand. Preference should always be given to locating the OCS supports on the track side away from the wall and walkway.

6. Sectionalizing

6.1 General

Sectionalizing is implemented to divide the power network into discrete power sections individually controlled by circuit breakers. A fault tripping the breakers, nuisance trips, emergency power de-energization, or planned maintenance outages can be undertaken without affecting other sections of the network with sectionalizing. It can be implemented by mechanical devices known as “section insulators” or by arrangement of the conductors into an insulated overlap or airbreak.

Three basic types of section breaks occur: bridging, nonbridging, and diode. Bridging allows the current collector to momentarily physically bridge between two power sections, whereas nonbridging prevents the current collector from bridging the two power sections either physically or with the arc from the momentary interruption of power. Diode section insulators are nonbridging while providing constant current to the vehicle. This type of device allows the vehicle to always have power as with a bridging section insulator but does not allow bridging of the two power sections due to the blocking action of the diodes.

Section insulators can be so configured that they allow both trolley pole and pantograph operation. They can be designed to have a center runner, gliders, arcing horns, or other features.

Suspension of section insulators can be accomplished with a messenger wire, span wires, cantilever/bracket arm pipe, or no suspension at all. In the case of the latter, the unit sits in the contact wire with no support, and in this case, the section insulator should be near a support to prevent rolling over and be of such design that its center of gravity is low on the unit to limit rolling.

Choice of section breaktype is governed by multiple factors, including speed, bridging safety, location along the line, and type of OCS style. The type must be appropriate for the service it will be subjected to, and the agency or designer will make that choice based on the ADC, if available. If safety is of primary concern to prevent bridging into a dead or grounded power section, then a nonbridging or a diode section insulator should be used. If this is not of concern, then bridging or nonbridging can be used. If safety dictates that power sections cannot be bridged and the vehicle cannot have an interruption to power, then the diode section insulator should be used. Installation methods and instructions for installing section insulators into contact wire or messenger wire are typically provided by the manufacturer of the insulators.

The location of section insulators must consider OPCs and be determined based on the judgment of the designer or on the requirements of the operator that dictates location. General installation location considerations to be followed are as follows:

- Supported near an OCS cantilever.