

Design guidelines

Railway Energy: Part 2 Overhead Contact Line System

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1. Standards and recommendations

Applicable standards and recommendations are:

Standard number	Designation
ISO9223	Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation
EN15273-2	Railway applications – Gauges – Part 2: Rolling stock gauges
EN15273-3	Railway applications - gauges - Part 3: Structure gauges
EN1990	Eurocode – Basis of structural design
EN1991-1-1	Eurocode 1: Actions on structures – Part 1-1: General actions – densities, self-weight, imposed loads for buildings
N1991-1-4	Eurocode 1: Actions on structures- Part 1-4: general actions – Wind actions
EN1992-1-1	Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings
EN1993-1-1	National annex to Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings
EN1993-1-11	Eurocode 3: Design of steel structures – Part 1-8: Design of joints
EN1993-1-9	Eurocode 3: Design of steel structures – Part 1-9: Fatigue
EN1997-1	Eurocode 7: Geotechnical design – Part 1: General rules
EN1997-2	Eurocode 7: Geotechnical design – Part2: Ground investigation and testing
EN206	Concrete – Specification, performance, production and conformity
EN 50119	Railway applications – Fixed installations – Contact overhead lines for electric traction.
EN 50122-1	Railway applications – Fixed installations – Protection measures related to electrical safety and earth wiring.
EN 50122-3	Railway applications – Fixed installations – Electrical safety, earthing and the return circuit. Mutual Interaction of a.c. and d.c. traction systems (see Note 1)
EN 50124-1	Railway applications – Insulation coordination - Part 1: Fundamental instructions – Insulation clearances and creepage of any electrical and electronic equipment.
EN 50124-2	Railway applications – Insulation coordination - Part 2: Overvoltage and related protection.
EN 50149	Railway applications - Fixed installations - Electric traction – copper and copper alloy grooved wire for overhead lines.
EN 50152-1	Railway applications – Fixed installations – Particular requirements for alternating current switchgear – Part 1: Circuit Breakers with nominal voltage above 1 kV
EN 50152-2	Railway applications – Fixed installations – Particular requirements for alternating current switchgear – Part 2: Disconnectors, earthing switches and switches with nominal voltage above 1 kV

Standard number	Designation
EN 50152-3-1	Railway applications – Fixed installations – Particular requirements for alternating current switchgear – Part 3-1: Measurement, control and protection devices for specific use in AC traction system – Application guide
EN 50152-3-2	Railway applications – Fixed installations – Particular requirements for alternating current switchgear – Part 3-2: Measurement, control and protection devices for specific use in AC traction system – Single-phase current transformers
EN 50152-3-3	Railway applications – Fixed installations – Particular requirements for alternating current switchgear – Part 3-2: Measurement, control and protection devices for specific use in AC traction system – Single-phase inductive voltage transformers
EN 50163	Railway applications – Supply voltages of tractions systems
EN 50182	Overhead lines conductors. Circular strand conductors, cables in concentric layers.
EN 50317	Railway application – Current collection system – Requirements for and validation of measurements for the dynamic interaction between pantograph and overhead contact line.
EN 50318	Railway applications. Current collection systems. Validation of the dynamic inter-action simulations between the pantograph and the catenary.
EN50388	Railway applications – Power supply and rolling stock – Technical criteria for coordination between power supply (substation) and rolling stock to achieve interoperability
EN60439-1	Low-voltage switchgear and control gear assemblies – Part 1: Type-tested and partially type-tested assemblies
EN60529	Degrees of protection provided by enclosures (IP Code)
UIC799	Characteristics of A.C. overhead contact systems for high-speed lines worked at speeds of over 200km/h

Note 1: This standard shall be fulfilled when the Rail Baltica line lies in parallel with existing DC electrified railway in operation (cities approach for instance – chainages to be checked by the designer)

2. General requirements

2.1. System interoperability

The necessary requirements to ensure the interoperability of the railway system are specified in the ENE TSI.

All catenary systems for the main tracks shall be covered by a TSI certification.

The certification of Interoperability Constituent shall be achieved before ENE subsystem certification.

2.2. Interaction between pantograph and catenary

The catenary shall satisfy the requirements of the ENE TSI concerning the dynamic behaviour and the quality of the current collection.

The pantograph catenary and the quality of the current collection shall be validated by simulation before starting the design studies.

The simulation tool shall be validated in accordance with standard EN 50318.

2.3. Design speed

The catenary system shall be design for maximum speed of 249km/h in the main tracks.

The catenary nominal speed shall be:

- Catenary nominal design speed on the main track (freight and passengers line): $v=249\text{km/h}$;
- Catenary nominal design speed on passengers and light freight portions with alignment design speed inferior to 160km/h: $v=160\text{km/h}$;
- Catenary nominal design speed on the depot areas, yards and secondary lines: $v=40\text{km/h}$.

2.4. Catenary system

The catenary system shall be designed for a 25kV 50Hz AC system as defined in EN 50163.

The catenary system shall be composed of:

- Foundations;
- Supports and anchors;
- Cantilevers, including isolators, registration arm, steady arms, top tube, and all attachments to the support;
- Catenary cables messenger wire, contact wire, droppers, electrical connections;
- Negative feeder and suspension set.
- Tensioning devises and all attachments;
- Return current circuit, composed of a return circuit cable;
- Earthing system, with an aerial earth conductor connecting all the catenary supports;
- Section isolators and disconnectors.

2.5. Catenary system exploitation

The catenary system for each track shall be mechanically and electrically independent from the catenary system on adjacent tracks.

It shall be ensured that the cantilevers that equip tracks that are electrically independent are not installed on the same support. In case of twin track cantilever or portal, cantilevers that are used to equip electrically independent tracks have to be installed on different drop tube or support.

In stations depot areas, maintenance bases, multimodal terminals, with no interface with the main tracks, tracks could be grouped in a common electrical section, providing approval from operations.

2.6. Catenary system supports

The conductors shall be supported by means of single track cantilevers placed at the side of the tracks but outside of the track way. In heavily built up areas where space limitations prevent the use of single track cantilevers, portal structures supporting the cantilevers shall be used.

3. Functional requirements

3.1. The railway network

The catenary system shall allow bi-directional operation at the catenary system nominal design speed.

3.2. Tensioning system

The mechanical tension of the catenary wire and the contact wire shall be uniform over the entire length of the section.

The tension in each wire shall be automatically maintained over the temperature range. The operating amplitude of the tensioning devices is 80°C minimum.

On depot areas, maintenance bases, multimodal terminals, with no interference with the main tracks, the catenary system could be replaced by a simple overhead contact line solution of tensioned or non-tensioned contact wire(s). The number of contact wires shall be adequate to the power supply needs. The transition between tensioned catenary and non-tensioned overhead contact line shall be done inside the tracks to be equipped with such system (not on the main line).

3.3. Tension lengths/Mid-point

The tension lengths shall be limited between auto-tensioned anchors or between an auto-tensioning device and a fixed point.

The tensioning devices at each end of a tension length shall divide the catenary system tension length into two half tension lengths, with a fixed point, called mid-point, in the middle of the tension length.

3.4. Catenary system supporting structures/ foundations

The materials and equipment to be used shall be adequate for the loading requirements at each structure location.

3.5. Feeding and sectioning

The catenary system shall be divided into separate electrical sections. Further electrical sub-sectioning shall be designed to facilitate operational, safety and maintenance of the sections.

- On main tracks sections with circulation of raised pantographs at speed superior to 160 km/h, sectioning shall be carried out as air sectioning;
- On main track sections with circulation of raised pantographs at speed inferior or equal to 160 km/h, sectioning shall be carried out using air sectioning as the primary solution. Section insulators may on exception be permitted if there are signalling and track layout conflicts that make it impossible the use of the primary solution.
- On depot areas, maintenance bases, multimodal terminals, sectioning shall be carried out using section insulators.

The catenary system shall be equipped with voltage indication devices that shall provide the state of the catenary elementary sections (energized or not) to the existing remote-control system.

3.5.1. Phase separation sections

Phase Separation Sections shall be installed to separate two successive catenary sections fed by different traction substations/feeder stations which can be of different phases.

Phase separation sections shall be design in accordance with ENE TSI - chapter 4.2.15.3.

The neutral sections of the phase separation section shall provide electrical separation between catenary sections fed by different phases of the traction power supply system.

The design of phase separation sections shall ensure that TSI compliant trains can move from one catenary section to an adjacent one without bridging the two phases.

The design of phase separation sections shall adopt solutions as described in EN 50367:2012, Attachment A.

Adequate means shall be provided to allow a train that is stopped within the phase separation section to be restarted. The neutral section of the phase separation section shall be connectable to the adjacent catenary sections by remotely controlled disconnectors.

The phase separation sections shall function at maximum catenary system design speed during the transition through the phase separation section.

The phase separation section shall allow for bi-directional operation at catenary system design speed.

Guidance: The connection area of the power supply systems may consist of three insulated neutral inserts with the total length of minimum 402 m. The connection areas along both main tracks must be arranged opposite each other. Their positioning is greatly dependent on other considerations (track gradients, track alignment, signalling, overpasses...).

A separation section includes a neutral catenary section (not powered). It must therefore be designed so that the trains cannot remain stationary in it.

It must therefore be possible to accelerate enough after the upstream signalling to cross the neutral zone (headway travel).

For a connection where the implantation of a separation section can be difficult for the railway operation, check the possible interest of having a resupply system.

The control of the installations will be carried out from the sub-station centre.

3.5.2. System separation sections

The traction changeover systems shall ensure mechanical separation and electrical isolation between Rail Baltica 25kV AC 50Hz traction power and other electrical traction systems.

The system separation section shall be traversing with pantograph raised and touching the contact wire, in accordance with ENE TSI - chapter 4.2.16.

The system separation section shall be positioned such that the longest train under normal operation conditions can come to a safe stop facing a departure and arrival with the rear of the train clear of the system separation section. The system separation section shall support automatic and manual operation.

The system separation section shall function at maximum catenary system design speed during the transition through the system separation section.

The system separation section shall allow for bi-directional operation at catenary system design speed.

3.5.3. Disconnectors

All disconnectors shall be of mast mounting type.

They shall allow disconnection. Disconnectors located in depot areas, cargo charging / discharging areas, and inspection areas for rolling stock roof equipment shall be equipped with earth functions.

All the disconnectors shall be remote controlled and locally manually operated, with the exception of disconnectors located inside depot areas that may be operated only manually.

4. Design criteria

The design of the catenary system shall comply with standard EN50119.

4.1. Environmental conditions

The catenary system shall be designed to cope with environmental conditions defined in standard EN50125-2.

The environmental conditions are described in document RBDG-MAN-012 general requirements.

4.2. Safety coefficient

In every case, the most rigorous rules of standard EN50119 and Eurocodes with national annexes shall be respected.

4.3. Catenary system dynamic behaviour

4.3.1. Pantograph type

The catenary system shall be able to operate without fault or failure with two types of pantographs, 1600mm and 1950mm, with the head geometry specified in the LOC & PAS TSI points 4.2.8.2.9.2.1 (1 600 mm) or 4.2.8.2.9.2.2 (1 950 mm).

A conformity assessment shall be carried out in accordance with standard EN50317.

4.3.2. Pantograph spacing for overhead contact line design

The pantograph spacing for overhead contact line design shall be for an ac. system, $160 < v < 250$ km/h, according to ENE TSI - chapter 4.2.13.

- A=200
- B=85
- C=35

4.3.3. Maximum lateral deviation under action of the wind

The maximum lateral deviation shall be in accordance with ENE TSI - chapter 4.2.9.2. The value shall be in relation to the pantograph that imposes more important restrictions to the use:

- Pantograph length 1600mm -> Max. lateral deviation 400mm

4.3.4. Pantograph gauge

The pantograph gauge shall be design in accordance with ENE TSI - chapter 4.2.10.

4.3.5. Mean contact force

The criteria to prescribe the current collection performance shall be the mean contact force (F_m) according to standard EN50367.

4.3.6. Uplift/vertical movement

According to the ENE TSI, space for steady arm uplift shall be double the size of calculated, simulated or measured uplift of the contact wire at a steady arm (S_o), generated in normal operating conditions, with one or more Pantographs, with an upper limit of F_m at maximum Section speed. When the uplift of the steady arm is physically limited due to the catenary system design, it is permissible for the necessary space to be reduced to 1,5 S_o . The catenary system shall be designed for a static contact force range of 60 to 90N according to standard EN50367. If the contact wire is accidentally pulled up vertically higher than the maximal lifting used in the design, it shall not lead to abnormal wear of the contact wire.

4.4. Electrical clearances

The minimum electrical clearances between the live parts of the catenary system and earth parts shall be at least as defined in EN50119 - chapter 5.1.3 for an AC. System

4.5. Gauges

All the Sections shall be designed to comply with the gauge described in RBDG-MAN-012.

4.6. Tension length

4.6.1. Tensioning devices

The operating amplitude of the tensioning devices shall be at least 80°C.
The tensioning system shall be designed with respect to the tension length. All expected friction forces and temperature variations shall be considered.
The efficiency of the tensioning device shall be equal or superior to 0.97.
The tensioning device shall be fitted with stops to prevent run out of the weight elements in the event of broken catenary wire/contact wire.

4.6.2. Mid-point anchoring

The devices for tensioning divide the catenary into tension lengths, with a fixed cantilever with anti-creep device in the middle of the tension length. The mid-point shall be a fixed cantilever.

4.6.3. Half tension length

The catenary wire and the contact wire can be anchored with a tensioning device at each extremity of the tension length. However, for the tension lengths with a length smaller than the maximum half tension length, one extremity can be equipped with tensioning device whereas the other extremity can be a fixed anchor.

4.7. Overlaps

Overlaps in the catenary system shall be designed to provide a smooth transition between tension lengths and shall be optimized in respect of the current collection criteria.

Overlaps shall be positioned clear of cross-overs and complex track layouts as far as practical.

The contact forces in the overlaps shall not differ from those expected in the regular spans.

The insulated overlaps shall maintain the minimal dynamic insulating distance between parallel wires, whatever the climatic conditions are. Also, the static insulating distance in the air has to be ensured.

The non-insulated overlap shall have no insulation except at terminations of conductors. The adjacent catenary tension lengths shall be connected by electrical connections to provide the required electrical continuity.

4.8. Turnouts

Turnouts in the catenary system shall be designed to provide a smooth transition between catenary of the main track and deviated catenary (and vice-versa) and shall be optimized in respect of the current collection criteria. To ensure the interoperability of the system, and in addition to the ENE TSI, the attack angle of the deviated contact wire on the pantograph shall always be carried out on a vertical plane to the carbon stripe.

4.9. Supporting structures

4.9.1. Design

Double tracks shall be equipped with independent supports for each track.

Catenary system supporting structures shall in particular:

- Support the catenary cables and wires;
- Not prevent the longitudinal movements of the regularized conductors;
- Electrically insulate the catenary with regards to the support by an insulator;
- Resist environmental conditions.

Rigid portals can be installed where the parallel tracks do not allow the installation of independent supports for each track for areas where number of tracks is superior to 2 or in stations.

All catenary system supporting structures shall be designed considering a potential 0.05m lowering and 0.1m lifting of the cantilever.

Catenary system supporting structures made of steel shall be designed and built according to Eurocodes (EN1993)

4.9.2. Installation / location

Locating catenary supporting structures in front of station buildings shall be avoided.

The location of catenary supporting structures in station areas shall not restrict any work and Passenger flow.

The location of catenary supporting structures close to buildings shall not restrict the buildings/surroundings usage and maintenance.

The location of supports in bridges and viaducts shall be avoided. When supports are to be installed in bridges and viaducts, the span length shall take into consideration an overexposure to the wind and shall be limited at a maximum value of 54m.

The installation shall be equipped with devices intended to ensure the Safety of personnel working at height (anchorage point...).

The installation shall be compliant with the safety clearance from public and railway personnel as defined in the Standard EN50122-1.

4.10. Foundations

The design of the supporting structures shall be in accordance with EN50119 - chapter 6.

The choice of the foundation type shall depend on the structure design, the load, the subsoil condition and the possible design of the foundation.

Foundations made of concrete shall be designed and realized according to Eurocodes (EN1992 and EN1997).

The following points shall be taken into account in the design of the foundations:

- design loads and method,
- configuration of the foundation,
- limit values of movements,
- geotechnical design parameters taking into account the level of underground water,
- design parameters for the structural materials,
- support/foundation interconnections,
- construction of the foundation and installation,
- special loads.
- the foundation shall be maintenance free all its lifetime.

Foundation design shall be subjected to ground investigation and structure load assessment.

At detailed design stage, all foundation positions shall be confirmed after undertaking site surveys

Foundations shall be sited to avoid underground utilities such as power cables, piping systems, IT and telecommunication systems and railway related installations where reasonably practicable.

4.11. Catenary system components

4.11.1. Isolators

The shape and orientation of the wings shall not constitute a rain water retention point.

Insulators shall not require Preventive maintenance or cleaning during their life time.

Insulators shall be designed, manufactured and tested in accordance with Standard EN50119 and other applicable EN and IEC Standards.

The minimum creepage distance of the insulator shall be 1100mm. The minimum creepage distance of the insulator is defined in Standard EN50124-1.

4.11.2. Section isolators

Section Insulators shall be capable of operating at maximum catenary system design speed with an adequate dynamic and electrical behaviour.

The section insulators in the catenaries shall be placed in such a position so as not to infringe on clearances to the pantograph head.

4.11.3. Cantilever

The cantilever shall be designed considering a potential sideways movement of the tracks of ± 0.1 m.

The steady arm shape shall be designed to release the kinematic envelope of the pantographs.

4.11.4. Conductors

Permissible materials for contact wires are copper and copper-alloy. The contact wire shall comply with the requirements of standard EN50149.

The contact wire height is the distance from the top of the rail to the lower face of the contact wire, measured perpendicular to the track. The wire-height measurements shall be taken perpendicular between the contact wire or catenary wire and the top of the rail.

The contact wire height shall be in accordance with ENE TSI - chapter 4.2.9.1

For Mixed Traffic Line sections (Refer to RBDG-MAN-013):

- Minimum and Nominal contact wire height: 5.30m – shall be implemented as constant contact wire height;
- Maximum design contact wire height: 6.20m in service tracks, in depot, in freight terminal or in case of gauge crossings 1435/1520.

For Passengers only and light freight traffic sections (Refer to RBDG-MAN-013):

- Nominal contact wire height: 5.30m;
- Minimal contact wire height: 5,00m - In accordance with EN 50119:2009, clause 5.10.5 taking into account the height of the loading gauge GC;
- Maximum design contact wire height: 6.20m;
- The maximum contact wire gradient shall be 1‰ and the maximum change of gradient shall be 0,5‰ in the main tracks.

Potential track uplift of 50mm shall be considered to define the minimum contact wire height in case of existing infrastructure installation

Guidance : As defined in standard EN50119, the minimum contact wire height should always be greater than the swept envelope (kinematic gauge GC + track tolerance installation of 50mm under a bridge or 100mm in rest of the section in case of new infrastructure installation), also taking into consideration the electrical clearance in air (dynamic recommended clearance) and a potential track uplift of 50mm (in case of existing infrastructure installation), to avoid arcing between the contact wire and the earthed parts of vehicles.

The maximum contact wire gradient shall be 1‰ and the maximum change of gradient shall be 0,5‰ in the main tracks.

The contractor shall validate, by simulation, that the maximum overheating in the conductors caused by the current does not result in temperatures liable to deteriorate their mechanical properties.

The contact wire shall incorporate stagger either side of the track centreline to provide even wear to the pantograph on rolling stock.

The contact wire shall be staggered so that the wear of the shortest pantograph contact strip shall be evenly distributed over at least 80% of the area.

4.11.5. Negative feeder

The positioning of the negative feeder shall be subject to assessment during the detailed design and the following parameters shall be considered:

- Minimum wire/cable height;
- Minimum separation between catenary system and negative feeder;
- Conductor sag due to temperature variation;
- Electrical clearances;
- Proximity to the catenary system and operational constraints;
- Failure mode and consequences.

Where reasonably practical the negative feeder shall not be routed over signalling locations or other working platforms.

4.11.6. Marking and numbering

In accordance with Standard EN50119, each insulator shall have an identification number or other indelible system, making traceability of the insulator possible.

An individual numbering plate shall be installed in each catenary support.

Guidance:

Main track supports

The numbering system is composed of two numbers:

- *the first indicates the kilometer in which the support is;*
- *the second number indicates the place it occupies in the kilometer.*

This last number starts with 1 every kilometre, increased in the direction of the mileage of the line, in the natural order of integer numbers. The odd-side track supports have an odd number and those located on the even side track have an even sequence number.

Siding track supports

The numbering for siding tracks supports will follow the same methodology as for main track supports. The second number will be followed by the letter K.

Normally in parallel track sections the siding track supports are in the same cross section as those from the main track. In this case their number will be the next integer that the one from the main track support, followed by the letter K. In case of multiple siding tracks having separate supports, the letter K is replaced by the letter N, M, O, P or Q according to the track.

Regardless of the position of the siding track in relation to the main track, the support number must always have the parity of the way this pole addresses.

Portals and semi-portals

The numbering of portals and semi-portal will follow the same methodology as for main track supports. The second number will be followed by the letter A.

Feeding portals

This type of portal is often composed of several supports.

The various supports constituting it are designated by the same serial number locating the portal in the kilometre; this number is followed by a letter A, B, C, etc.

The letter A is given to the support closest to the origin of the line and the succession of letters takes place in the direction increasing kilometres.

The serial number preserves the parity of the track to which the support or supports are addressed.

Supports in tunnels and overbridges

The numbering of supports in tunnels and overbridges will follow the same methodology as for main track supports.

Supports between two main track centre lines

Supports located between two main track centre lines, whether simple or part of a portal have their serial number followed by the letter U; as principle the odd number is predominant.

Secondary / depots track supports

Secondary / depots tracks supports are numbered with a four-digit number from, starting at 1000 at each zone / depot.

The first digit on the left represents the order number of the support in a portal: the last three digits recall the order number of the support or portal in the direction of increasing kilometres of the main tracks.

The even numbers are assigned to the numbering of the tracks located on the even side of the main tracks; the odd numbers are assigned to the numbering of tracks on the odd side of the main tracks.

A simple support is considered to be the first support of a portal; their first digit of his number order is always 1.

4.12. Sectioning devices / Disconnectors

The disconnectors shall be operated by means of remotely controlled and manual mechanism.

The disconnectors with manual and remote-control operation shall be applied for:

- the connection or separation of individual catenary sections;
- Feeding purposes;
- Cross and longitudinal coupling of catenary sections;

either in a standard or emergency situation or to facilitate maintenance.

The motor drive unit shall be in a box that is corrosion, pollution, water and dust resistant (at least IP55 according to EN60529).

4.13. Protection screens

Protection screens shall be installed at any location where minimum clearances to accessible live parts according to standard EN50122-1 are not respected.

The protection screens should be effective at all times throughout the stage works.

The protection screens shall be designed in accordance with standard EN50122-1.

4.14. Overpasses and tunnels

Two types of equipment can be installed under overpasses. In order of preference these are:

- in free passage;
- with intermediary suspensions under the overpass structure.

In any case (except the usage of the rigid catenary), for overpasses and tunnels, the system height of the overhead contact system is adapted according to the vertical clearance of the overpass and tunnel and the minimum clearance distances shall be respected.

The messenger wire cable shall be of the protected type and the protection shall outrun the outside of the structure.

If feeders are used, the bare feeders are replaced by insulated ones, if insulation distances cannot be respected. On either side of the structure, the insulators and the catenary wire shall resist malicious acts.

Where they are freely accessible to the public, the structures shall be equipped with protection screens, regardless of the height of the structure.

The protection screens shall be bonded to the earthing and bonding system.

4.15. Protection against corrosion

All the equipment shall be protected against corrosion, naturally or with an adapted device, in order to guarantee a coherent durability of the maintainability and regeneration policy.

All the equipment shall present no signs of corrosion during its life time.

The principles implemented shall not cause a risk of galvanic coupling.

4.16. De-icing system

The de-icing circuits shall make it possible to eliminate the ice that might accumulate on the contact wire, under certain climatic conditions.

The installation of this equipment shall be carried out for the whole Rail Baltica line.

These installations shall be carried out at each sub-station.

Guidance:

Ice usually causes detachments of pantographs during circulation or at the starting movement of rolling stock engines, and, as a result, it causes a located warm-up of the contact wire and / or the pantograph of the rolling stock.

This warm up, can provoke the annealing of the catenary, rupture of the contact wire (s) and possibly lead to degradation of the rolling stock collecting system. Ice is also responsible for important capture defects.

Ice imposes a charge in the catenary conductors, which will lead to a more important sag in mid-span. This will increase the minimum contact wire height.

The de-icing system may consist of a closed circuit between the two tracks to produce a short-circuit monitored, during a limited time. The length of the closed circuit covers about 20km from each side of substation.

The heat in the conductors will cause the meltdown of the ice.

The switch on of the de-icing depend on climatic conditions and will be connected when temperature its bellow or equal to 0° and humidity higher than 95%.

*Advantages: Fast and simultaneous de-icing of long catenary section;
 No special rolling stock with a steel pantograph travelling on the track to remove physically the ice from the contact wire;
 Prevents capture defects and potential ruptures of catenary wire (see above);
 Ice loads on conductors could not be taken into account for minimum contact wire height calculus (considering that there is no ice on the catenary when track is in exploitation).*

Disadvantages: All the traction installations, from the sub-station to the catenary must be design and dimensioned to take the de-icing system into account.

4.17 Earthing & Bonding

All supports for OCS and related equipment shall be integrated into the general earthing & bonding requirements.

The local earthing and bonding system associated to OCS poles will be simple, with their reinforced concrete foundation. If the soil resistivity in the area is high, additional measures may be necessary to achieve a low earth resistance along the line such as a supplementary buried earth conductor and buried earth rod connected to each pole earth terminal.

The metallic structures of tunnels, bridges, viaducts and other metallic structures shall be connected to return circuit according to EN 50122-1.

The following figures demonstrate the principles. The green colored connections shall be in responsibility of System designer. Whereas red and blue coloured connections shall be in responsibility of civil structure designer.

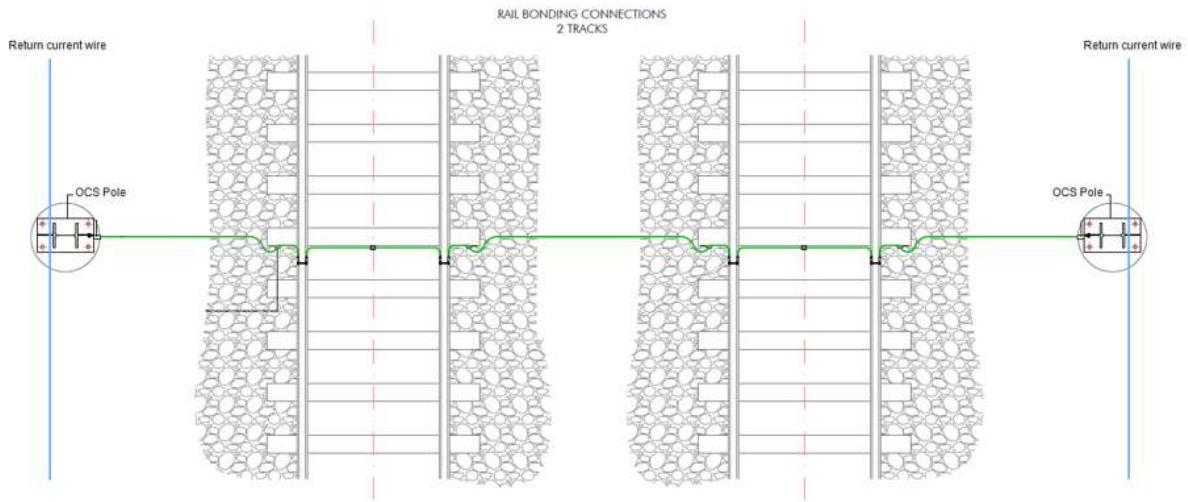


Figure 1. Earthing&Bonding in open track areas

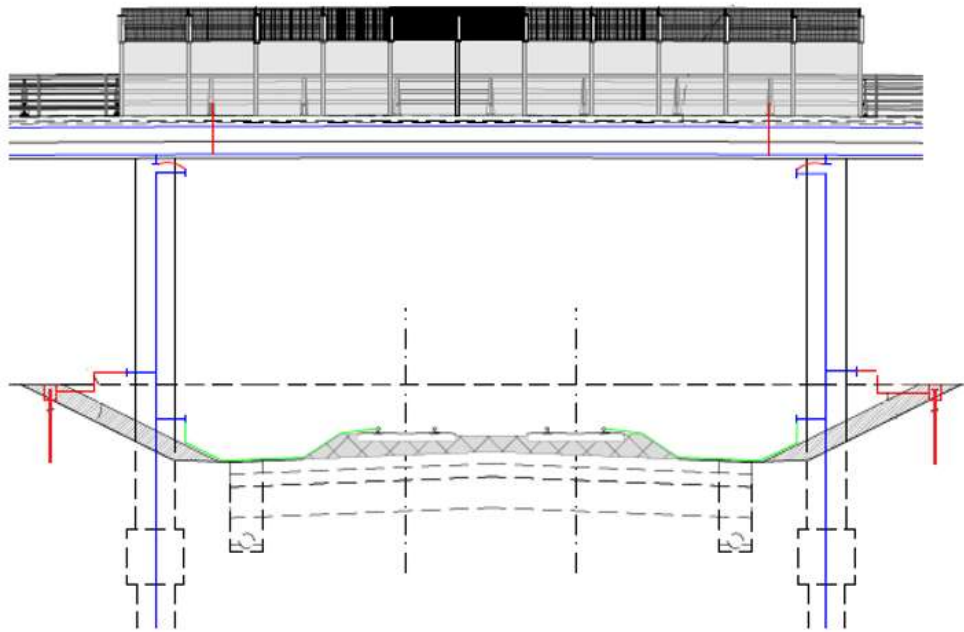


Figure 2. Earthing&Bonding in overbridges

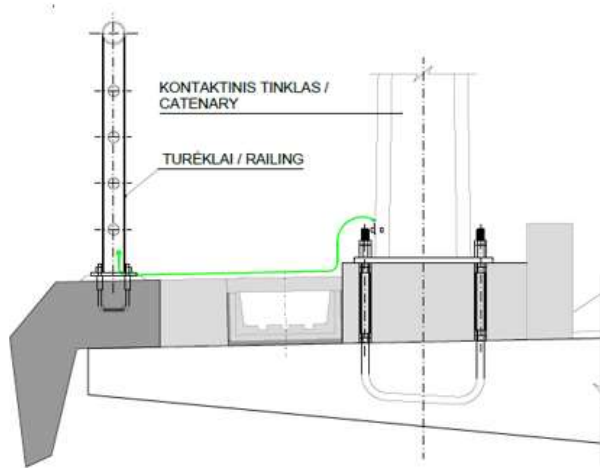
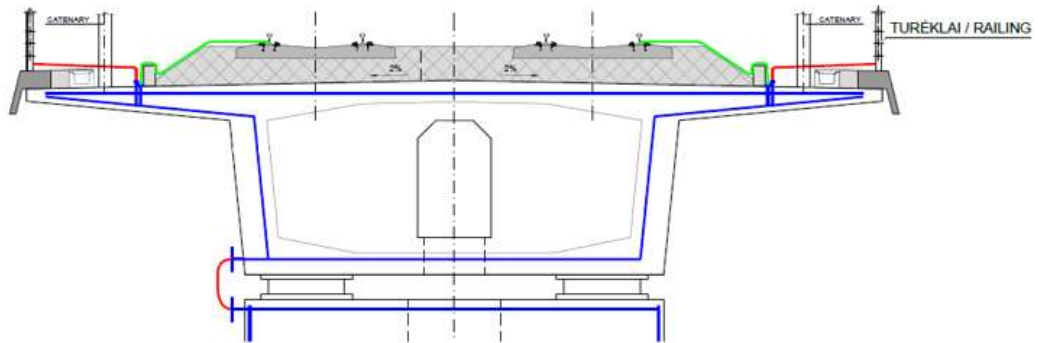


Figure 3. Earthing&Bonding on bridges and viaducts

5. Protective provisions against electric shock

Electrical safety of the overhead contact line system and protection against electric shock shall be achieved by compliance with EN50122-1:2011

EN 50122-1, defines the zones OCLZ (Overhead Contact Line Zone) and CCZ (Current Collector Zone) as the zones not exceeded by a broken overhead contact line or energized dewired or broken current collector, as shown in the Figure 4.

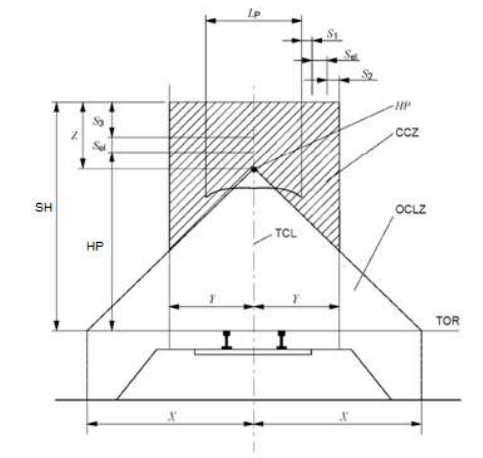


Figure 4. OCLZ&OCZ Zones

TOR Top of rail

HP Highest point of the overhead contact line

OCLZ Overhead contact line zone

CCZ Current Collector zone

TCL Track center line

X Width of the overhead contact line zone: 3.2 m

Y Width of the pantograph zone from the center of the track: 2 m

Z SH – HP: 2 m

S1 Width of lateral movement of the pantograph

S2 Lateral safety distance for the broken or dewired pantograph (design-dependent)

S3 Vertical safety distance for the broken pantograph (design-dependent)

Sel Electrical clearance (270 mm)

6. Life time of the overhead contact line system

The catenary system shall comply with the requirements for lifetime defined in RBDG-MAN-012 general requirements.

Note: The life of the catenary system depends on a periodic maintenance cycle.