Contact line: Design. Contact line systems

1 Purpose and scope

The purpose of these provisions is to ensure that the selection of an overhead contact line system is evaluated and determined on the basis of the NNRA's overall strategy, choice of technology, compatibility and requirements of the respective railway undertakings.

The overhead contact line system must be constructed from standard components and uniform solutions in order to:

- Minimise stock holding.
- Improve the volume of framework agreements relating to procurement.
- Simplify enquiries in respect of the design and construction of overhead contact line systems.
- Simplify the maintenance strategy.
- Increase the efficiency of training for personnel engaged in the field of overhead contact lines.
- Simplify fault analysis.

The chapter also contains the additional requirements that must be complied with when constructing an overhead contact line system designed to be compatible with the Euro-pantograph.

kapittel 9 (Autotransformatorsystem med seksjonert kontaktledning) contains requirements for the design of an autotransformer system with a segmented overhead contact line to be used when designing such systems. The requirement for taking into account AT systems when refurbishing overhead contact lines on sections of line where AT systems may be required at some later date should also be noted.

2 Requirements for overhead contact line systems

The requirements apply to all overhead contact line systems designed for use in installations covered by these regulations. The systems must constitute a systematised whole and comprise design and technical solutions offering an acceptable level of reliability, which are cost-effective in terms of procurement and operation. Refer also to Kontaktledning/Prosjektering/Generelle tekniske krav.

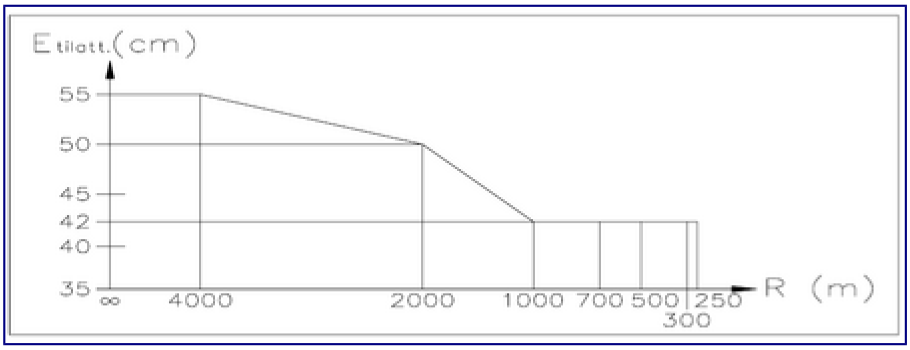
2.1 Wind deflection

This item stipulates requirements regarding the permissible level of wind deflection to be used in relation to current collector width, design speed and track radius.

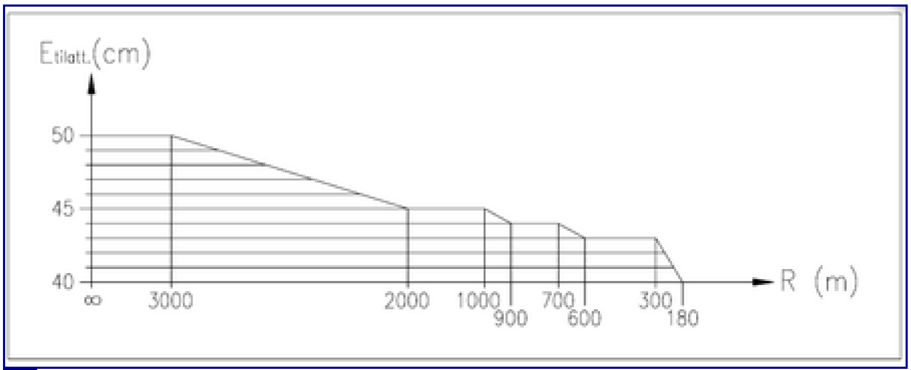
The contact wire's wind deflection, $E_{permitted}$, specifies a maximum distance from the contact wire to a target axis, which is perpendicular to the track plane in the centre of the track, as a function of the track radius. $E_{permitted}$ must be complied with in the event of a wind load resulting from the design wind speed, perpendicular to the relevant span length.

The requirement applies to all span lengths on which the contact wire comes into contact, or could come into contact, with the current collector during normal operation.

Figur 1 and Figur 2 applies to current collectors with a width of 1,800 mm and 1,950 mm.



Figur 1: Wind deflection curve for an overhead contact line system with a design speed of up to 200 km/h.



Figur 2: Wind deflection curve for an overhead contact line system with a design speed of over 200 km/h."

2.2 Current collectors

Overhead contact line systems must be designed for current collectors equivalent to WBL 85 or WBL 88 with a head width of 1,800 mm. The clearance envelope for current collectors is shown in Figur 3.

When calculating and/or simulating an overhead contact line system's performance, the static force between the contact wire and the current collector must be set at 55N.

The current collector must be aerodynamically balanced with a maximum force of 120 N between the contact wire and the messenger wire at a speed equivalent to the relevant rolling stock's maximum speed, plus 10 km/h.

Additional requirements for overhead contact line systems designed for use by the Euro-pantograph are specified in a separate item in this chapter.

2.3 System height

'System height' refers to the vertical distance between the centre of the contact wire and the centre of the messenger wire at the point of suspension.

For overhead contact line systems with a design speed of between 160 and 200 km/h the system height would normally be:

> 1.60 metres on an open line.
> Between 1.60 and 1.30 metres beneath portal structures and other structures.
> At least 0.70 metres in tunnels.
> Changes in system height from one mast to the next within this speed range must not exceed 0.30 metres.

For overhead contact line systems with a design speed of over 200 km/h the system height would normally be:

> 1.80 metres on an open line.
> Between 1.60 and 1.80 metres beneath portal structures and other structures.
> At least 1.10 metres in tunnels.
> Changes in system height from one mast to the next within this speed range must not exceed 0.15 metres.

When overhead contact line systems are constructed in existing tunnels, bridges, snow sheds, etc., it is permissible, following a technical evaluation, to use a lower system height than is stipulated in this document. In respect of system heights of less than 0.70 metres, an evaluation of the system's speed potential must be conducted. Refer also to Hengetråder for minimum length of droppers.

2.4 Span lengths

The maximum length of a single span must not exceed 65 metres.

For overhead contact line systems with a design speed of up to 160 km/h, the difference in length between two consecutive spans must not exceed 30% of the length of the longest span. For overhead contact line systems with a design speed of over 160 km/h, the difference in length between two consecutive spans must not exceed 20 % of the length of the longest span. At stations and shunting areas where the maximum running speed of trains is less than 100 km/h, the difference in length between two consecutive spans may be up to 50% of the length of the longest span.

The maximum span length for a specific track radius must be a function of the tensile force of the contact wire/messenger wire, design wind speed (wind load), maximum permitted wind deflection and stagger.

When calculating the numeric value of the maximum span length, the suspension points must be viewed without displacement and/or tolerances.

2.5 Stitch wire

For overhead contact line systems with a design speed of between 160 km/h and 200 km/h, a stitch wire should be used for all track radii greater than 800 metres. For overhead contact line systems with a design speed of over 200 km/h, a stitch wire must be used for all track radii greater than 1,200 metres.

2.6 Stagger

For overhead contact line systems with a design speed of up to 200 km/h, stagger values that do not exceed 400 mm must be used for running cantilevers, measured from a target axis that is perpendicular to the track plane in the centre of the track.

For overhead contact line systems with a design speed of over 200 km/h, stagger values that do not exceed 300 mm must be used for running cantilevers, measured from a target axis that is perpendicular to the track plane in the centre of the track.

For passing loops and double-track lines, the overhead contact line's stagger must be run in parallel in order to achieve the greatest possible distance between cantilevers installed on opposing tracks.

2.7 Sag

For overhead contact line systems with a design speed of up to 200 km/h, a sag of $\frac{1}{1000}$ of the span may be used if adjacent spans have stitch wires and $\frac{1}{2000}$ of the span if adjacent spans do not have stitch wires. For overhead contact line systems with a design speed of over 200 km/h, a sag must not be used.

2.8 Droppers

For overhead contact line systems with a design speed of between 160 km/h and 200 km/h, the shortest dropper, including terminals, must have a minimum length of 500 mm, and the distance between two consecutive droppers, for running spans, must not exceed 11 metres.

For overhead contact line systems with a design speed of over 200 km/h, the shortest dropper, including terminals, must have a minimum length of 600 mm, and the distance between two consecutive droppers, for running span lengths, must not exceed 10 metres.

When overhead contact line systems are constructed in existing tunnels, bridges, snow sheds, etc., it is permissible, for speeds up to 160 km/h, and following a technical evaluation, to use a shorter dropper than is stipulated in this document.

When using droppers shorter than 500 mm, an evaluation of the system's speed potential must be conducted.

In respect of requirements in this item, the dropper length for a specific location may be regarded as the specific distance between the centre of the contact wire and the centre of the messenger wire.

Droppers must be insulated. Insulated droppers are not required if they are attached to stitch wires or to the last span before tensioning. Droppers must be constructed from approved 10 mm^2 multiwire flexible wire.

2.9 Anchor arms

Anchor arms must be used on all running cantilevers. Anchor arms must also be used on section cantilevers for contact wire that has been raised by up to 15 cm in relation to the running contact wire.

The maximum angle of an anchor arm at rest must not exceed 20° (36.40%), in relation to the track plane. It must be possible to raise the contact wire by at least 150 mm before the anchor arm's upward movement encounters any obstruction. The absolute value of the horizontal force of the anchor arm must always be at least 80 N. The horizontal force of the anchor arm for main tracks should not exceed 1,000 N. For other lines, the force should not exceed 1,500 N. Anchor arms must always be tension-loaded as long as they have not been designed to absorb compressive forces.

2.10 Length of a section of overhead line

For overhead contact line systems with a design speed of up to 200 km/h, the total length of a section of overhead line, measured from tensioning point to tensioning point, must not exceed 1,500 metres. A half section of overhead line, measured from tensioning point to midpoint anchor, must not exceed 750 m.

For overhead contact line systems with a design speed of over 200 km/h, the total length of a full section of overhead line, measured from tensioning point to tensioning point, must not exceed 1,200 metres. A half section of overhead line, measured from tensioning point to midpoint anchor, must not exceed 600 m.

The maximum length of a section of overhead line should be used where this is possible and appropriate.

2.11 Contact wire temperature

The neutral temperature of the contact wire must not exceed 80 °C based on an outdoor temperature of 40 °C and a 1 m/s wind load. For temperature ranges in respect of overhead contact line systems reference is made to Kontaktledning/Prosjektering/Generelle tekniske krav.

2.12 Number of flexible cantilevers, loss of tensile force

Overhead contact line systems with a design speed of up to 160 km/h must not have more than 15 flexible cantilevers between automatic tensioning and fixed termination point.

Overhead contact line systems with a design speed of up to 160 km/h must not have more than 11 flexible cantilevers between automatic tensioning and fixed termination point. This number may be increased based on further calculations. In such calculations, the total loss of tensile force up to the fixed termination point, through the system's entire temperature range must not exceed 10% of the system's theoretical tensile force value. Loss of tensile force in automatic tensioning in this respect must be set to 2.5% of the system's theoretical tensile force value.

3 Choice of overhead contact line system

The most important criteria for choice of system relates to the speed profile, current collector configuration for trains, traffic density and superstructure class. When choosing an overhead contact line system, a technical evaluation must be conducted in respect of future train speeds and current collector configurations. The time aspect of such an evaluation must be set to at least the minimum expected service life of the overhead contact line system, which is 50 years.

A distinction must be made between main tracks and other tracks.

'Main tracks' in this context refers to:

- tracks on an open line
- running lines at stations
- other heavily used tracks

'Other tracks' in this context refers to:

- all other tracks

In principle, there are three overhead contact line systems to choose from for newly electrified or refurbished lines, which are divided into three classes in accordance with system designations:

- System 35 and 35 MS, which must only be used for other tracks
- System 20, all standards, or System 25 which must be used for the refurbishment of existing

lines and for newly constructed main lines

System 35 MS is the lowest speed class.

To be used in shunting yards, narrow tunnels and/or bridges. For low flyovers, etc., the NNRA has approved a number of specially adapted systems and components. Examples of this could be various types of tunnel cantilevers, overhead contact line systems without messenger wires for shunting yards, double contact wires for narrow tunnels and conductor rails. These systems and components may be used where appropriate, if it is not possible for normal systems and components (i.e. all versions of System 35, System 20 and System 25) to be used or if they can only be used with extreme difficulty. Every specially adapted system or component being used must be approved by the NNRA. A list of the approved systems and components that may be used at any given time may be obtained from Jernbaneverket.

The choice of overhead contact line system must be made at the master plan level and approved in conjunction with the general master plan.

The performance of individual systems is outlined in Tabell 1.

Tabell 1: Performance of overhead contact line systems.

System description (Speed class)	Train speed in km/h for one current collector and a > 200 m	Train speed in km/h for two current collectors with a reciprocal distance of 73 < a ≤ 200 m	Train speed in km/h for two current collectors with a reciprocal distance of 25 < a ≤ 73 m	Current -carrying capacity
System 35 MS	140	120	100	600A
System 35	150	130	110	600A
System 20, Standard B and C2	160	130	110	600A
System 20, Standard A and C1	200	160	130	600A
System 25	250	200	160	800A

A current collector distance of less than 25 metres is not permitted.

For overhead contact line systems with a design speed of over 160 km/h, cables that cross each other must have the same tension.

In the event that parts of a section of overhead line cover tracks with a radius of less than 800 metres (does not apply to points), it is permitted to construct System 20 with a tensile force in the contact wire and messenger wire that is equivalent to System 35. Where the greatest part of a section of overhead line runs along a straight track, an evaluation must be made regarding the tensile force in relation to the maximum running speed of trains.

When switching between two overhead contact line systems, the difference between these two systems must not exceed one speed class.

The design must include one overhead contact line system capable of servicing two current collectors, with a current collector distance greater than 73 metres in the same train set, for the maximum running speed for the section of line. An application for exemption must be submitted for any potential deviation from the above speed requirement. This will require simulations, and possibly also measurements from equivalent systems, showing that the requirements for contact force and uplift have been complied with. In such cases, the simulated values must be documented with measurements.

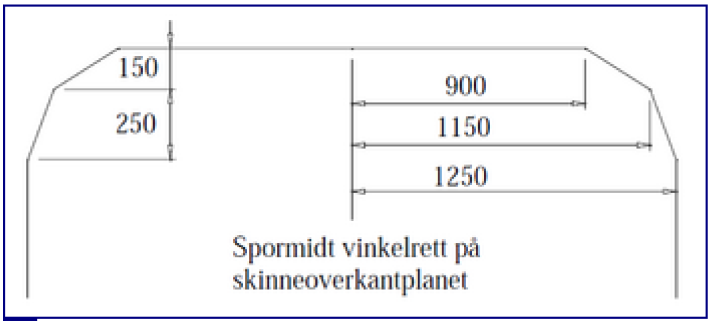
3.1 Safety factor

Cables tensioned by counterweight that form part of the overhead contact line system must not be subject, without any additional load, to more than 40% of the breaking load, refer also to the requirements specified in § 8-2 [FEF].

For cables with fixed termination, the requirements of § 6-2 [FEF] apply.

4 Overhead contact line system profiles

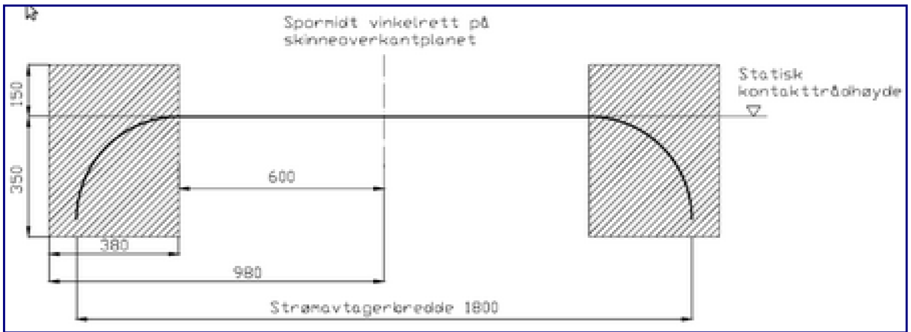
4.1 Clearance envelope for current collectors



Figur 3: Clearance envelope for current collectors, all measurements in mm.

There must be no permanently mounted objects within the boundaries of the clearance envelope for current collectors. The envelope is dynamic and applies regardless of the force between the contact wire and the current collector. The clearance envelope for current collectors and apertures beneath structures and in tunnels is described in Underbygning/Prosjektering og bygging/Profiler og minste tverrsnitt. No numeric value for any ballast reserve for the track been incorporated into the tables. This requirement must be imposed on a regional level based on local considerations.

4.2 Terminal-free space



Figur 4: Terminal-free space (hatched), all measurements in mm.

The terminal-free space extends from 600 mm to 980 mm from each side of the middle current collector. The height of the terminal-free space is 150 mm measured upwards and 350 mm measured downwards. There must be no contact wire terminals, press connectors, screw connectors or cross-suspension terminals in the terminal-free space. Where required, it is permitted for terminals for normal droppers to be located in the terminal-free space. The terminal-free space must be maintained at a force of 55 N between the current collector and the contact wire.

5 Euro-pantograph, additional requirements

This item provides the additional requirements that must be complied with when constructing an overhead contact line system designed to be compatible with the Euro-pantograph. For areas where this item does not impose specific requirements, the other requirements in the Technical Regulations apply.

Normally, the Euro-pantograph cannot be used in overhead contact line systems that have been designed for an 1,800 mm or 1,950 mm wide current collector.

The profile of the Euro-pantograph is shown in Figure A.6, Annex A, [EN 50367:2006].

Overhead contact line systems that are compatible with the Euro-pantograph must also be compatible with an 1,800 mm wide current collector. The clearance envelope for current collectors must be in accordance with Figur 3 in this chapter.

The terminal-free space must be in accordance with Figur 4 but with the following change: For the Euro-pantographs, the terminal-free space must start at a distance of 400 mm from the centre of the track, perpendicular to the top of the rail plane.

Maximum wind deflection, $E_{permitted}$, for the Euro-pantograph = the lowest value of 0.40 m or 1.4 m – L_2. L_2 is specified in A.3, Annex A, [EN 50367:2006] and is a function of the contact wire height, cant and track radius.

In comparison with an overhead contact line system designed for use by an 1,800 mm wide current collector, an overhead contact line system designed for the Euro-pantograph will have the following differences:

- Shorter maximum span lengths (more masts per km)
- More insulated overlap sections/overlap sections of more than three span lengths (less effective length of a section of overhead line)
- Less tolerances at wiring above points (imposes greater requirements upon technical solution and mast location)

6 Appendices

Vedlegg a System 35
Vedlegg b Tabeller
Vedlegg a System 25