Contact line: Design. General technical requirements

1 Purpose and scope

This document is intended to ensure that the NNRA's technical requirements are complied with. The requirements in this document must be observed when new overhead contact line systems are designed and when extensions and modifications are designed for existing systems. In areas for which no general technical design requirements have been stipulated in these regulations, [FEF] applies.

An overview of relevant norms/standards, in addition to those specified in Felles bestemmelser/Generelle bestemmelser, may be found in vedlegg a (Relevante normer/standarder).

Qualification requirements are stipulated in Kontaktledning/Vedlikehold/Generelle tekniske krav vedlegg i (Kompetansekrav vedlikehold kontaktledningsanlegg).

2 Documentation of planning and design

Overhead contact line systems must be designed in accordance with [FEF], the NNRA's regulations and tender documents.

The planning and design of overhead contact line systems will normally be covered by the preparation of the following technical documentation: General plans, circuit diagrams, return wiring diagrams, station plans, section plans, earthing plans, foundation plans, portal structure sketches, system drawings, parts lists, specifications and bills of quantity.

An evaluation of the following factors must also be conducted:

- EMC issues (outward and return currents running as close as possible to each other)
- Contact voltage, also refer to Felles elektro/Prosjektering og bygging/Generelle tekniske krav.
- Electrical properties of the soil
- Possible need to adopt a method of boosting the power supply, including the use of a reinforcing feeder, feeder line or an autotransformer system.
- Operation and maintenance
- Interdisciplinary interfaces

2.1 Calculating cantilevers and droppers

The calculation of cantilevers and droppers for the overhead contact line system must be conducted using calculation programmes and/or tables currently approved by the NNRA. Before the design of an overhead contact line system can be regarded as complete, all of the overhead contact line's cantilevers and droppers must be calculated using computer software and/or tables. The calculations must be conducted on the basis of design values and the results of the calculations must be reviewed in order to verify that all relevant system requirements have been fulfilled.

2.2 Wiring above points

Before the design of an overhead contact line system can be regarded as complete, the wiring above all affected points must be documented. The documentation should contain a drawing of each set of points and must include the following information as a minimum:

- Mast placement with reference to the point's stock rail joint.
- Wiring, stagger and terminal-free space for the main and diverging track.
- The height of the contact wires through the points.

In respect of the design of wiring above points, reference is made to Kontaktledning/Prosjektering/Kontaktledningssystemer vedlegg c System 20/25.

2.2.1 Requirements for design inspection

To ensure an optimum and uniform implementation of the NNRA's overhead contact line system, the requirements specified in the directives FEF 2006 and standards NEK EN 50119:2009 have been tightened through the introduction of overhead contact line design inspections via certified overhead contact line design inspectors.

a) **Overhead contact line design inspection:** On all overhead contact line systems that comprise one whole section of contact line or more, an overhead contact line design inspection must be conducted by a certified overhead contact line design inspector.

1. Implementation: The person responsible for ordering the assignment is also responsible for ordering this inspection from the overhead contact line design inspection co-ordinator. An overhead contact line design inspection may be ordered by using the following address:lenke

> 'Overhead contact line design inspection' plus indication of locality must be entered in the e-mail's **Subject** field. For example, **"Order for overhead contact line design inspection: Kongsvinger st."**

> The requirement is being introduced in order to ensure that the design of overhead contact line systems is conducted both in accordance with NNRA regulations and also in a uniform manner in order to avoid the possibility of any misunderstandings arising.

3 Technical solutions

The technical and functional service life of all components associated with an overhead contact line system must be set at a minimum of 50 years. Material selection and design must take into account this service life. Overhead contact line systems must possess the necessary electrical and dynamic qualities and be of sound technical construction in accordance with prevailing drawings and instructions.

The following overhead contact line systems have been approved: System 35, System 20 (versions 20A, 20B, 20C1, 20C2 and 20C3) and System 25. For selection of overhead contact line systems, reference is made to Kontaktledning/Prosjektering/Kontaktledningssystemer. Any other system solution that departs from approved overhead contact line systems must be documented in the same way and submitted for evaluation by Jernbaneverket. New overhead contact line systems must, as a minimum, be in accordance with the relevant requirements stipulated in these regulations, including the special requirements specified in Chapter 4 and Kontaktledning/Prosjektering/Kontaktledningssystemer. Also refer to Kontaktledning/Prosjektering/Mate-, forsterknings- og forbigangsledning.

All new overhead contact line systems must be constructed with an autotransformer system comprising a segmented overhead contact line. This applies to both single-track and double-track sections of line. If an overhead contact line system is being replaced, an autotransformer system must be built or planned for.

If there is insufficient reference material and specifications available for a preferred design, such design must be clarified so that it may be submitted for approval to Jernbaneverket.

For system specific descriptions in respect of the construction and design of overhead contact line

systems, reference is made to Kontaktledning/Prosjektering/Kontaktledningssystemer vedlegg a (System 35), Kontaktledning/Prosjektering/Kontaktledningssystemer vedlegg b (Tabeller) and Kontaktledning/Prosjektering/Kontaktledningssystemer vedlegg c (System 20/25). In some of these descriptions, the reference material is presented in such a way that there is a natural overlap between design, calculation and construction.

3.1 Electrical requirements

When designing an overhead contact line system, a technical evaluation must be conducted to ensure that the system has no electrical limitations in relation to the load that train operation is expected to place on the system. Refer to the requirements specified in Banestrømforsyning/Prosjektering/Energiforsyning.

When calculating the current-carrying capacity of an overhead contact line system, 20% wear to the contact wire must be taken into account.

The overhead contact line system must, in principle, be designed for maximum levels of short-circuiting as specified in Felles elektro/Prosjektering og bygging/Jording. However, the thermal short-circuit capacity of the overhead contact line system is specific, given the fact that the overhead contact line system is made up of several relatively thin cables (messenger wire and contact wire) with a high catenary tension. Thus, there is no guarantee that in every situation the overhead contact line system will be capable of withstanding the short circuit currents that may occur. Efforts must therefore be directed towards minimising the risk of excessive temperature and burnout, through the selection of rapid protection devices and switches.

In respect of double-track lines, the overhead contact line system must be constructed in such a way that, by means of electrical segmentation, it will be possible to work on one track without unduly obstructing traffic on the other track.

When extending or replacing existing overhead contact line systems, there must be a coordination between the power supply and the design of the overhead contact line system. Safer transfer of energy, improved utilisation of converters, stronger and more stable grid interconnection, as well as simplification of maintenance for both the overhead contact line system and for converters, can be achieved through the use of feeder lines, current supply lines, reinforcing feeders or an autotransformer system. During the same planning phase, an interface to supporting technical fields must be evaluated in respect of essential upgrading, or whether it may be permissible to use alternative technology. Of particular note here are the requirements for harmonisation and compatibility of earthing principles for electrotechnical installations.

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===Mechanical requirements===
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Supporting structures must be designed to withstand all relevant loads. An assessment must be made as to whether supporting structures must be designed with a future autotransformer system in mind.

3.1.1 Temperature range for the overhead contact line system

The overhead contact line system must be designed for a temperature of at least 70K. The normal temperature of an overhead contact line system must be suitable for the local conditions. System documentation is usually compiled for a normal temperature of 5 °C.

3.1.2 Wind speed in respect of permanent structural deformations

All structures associated with the overhead contact line system must be tested, in accidental limit state, to ensure that they are capable of withstanding a minimum wind load of 50 m/s before permanent structural deformations occur.

3.1.3 Design wind speed for the overhead contact line system

The overhead contact line system must be designed for two wind load scenarios: Mechanical and dynamic design.

Mechanical design (strength calculation of overhead contact line masts)
The mechanical design must ensure that supporting structures are capable of withstanding the anticipated wind load. The overhead contact line system must be designed for wind loads in accordance with Euro code NS-EN 1991-1-4:2005. The calculations are based on the reference wind speed for all municipalities and counties in Norway. The reference wind speed, as specified in the national annex, is the characteristic 10 minute average wind speed 10 m above terrain level, regardless of the time of year and wind direction. In addition to the reference wind speed, terrain roughness, terrain shape, basic wind speed and height above sea level, as specified in the standard, must also be taken into account. Information regarding the standard and the wind speed must be entered in the comments field of the section plan (e.g. NS-EN 1991-1-4:2005. Eidsvoll, 22 m/s).

Dynamic design (wind deflection of contact wire)
The dynamic design must ensure the running capability of the overhead contact line. The overhead contact line system must be designed for a wind speed of 30 m/s. At wind-exposed locations (high mountain sections, coastal sections and other wind-exposed sections), the overhead contact line system must be designed for a wind speed of 37 m/s. The overhead contact line system must be runnable at such wind speeds. At locations that experience extremely high winds, an evaluation must be made as to whether the above limits should be further increased. The design wind speed must be regarded as a constant load perpendicular to the span section (the track). Information regarding the selected wind speed for the overhead contact line system must be entered in the comments field of the section plan (e.g. Dynamic wind speed 30 m/s).

For permissible wind deflection for overhead contact line systems, reference is made to Kontaktledning/Prosjektering/Kontaktledningssystemer.

3.1.4 Displacement of suspension structures for overhead contact line systems

Static load-induced horizontal displacement of the contact wire on a suspension structure for overhead contact line systems must not exceed 37 mm. Displacement resulting from static loads must be adjusted during installation of the overhead contact line system.

Environmental load-induced horizontal displacement of the suspension structure for overhead contact line systems must not exceed 63 mm.

The displacement relates to a contact wire at a height of 5.60 m above the top of the rail plane. When calculating maximum displacement, the relevant design wind speed must be used and anything attached to the relevant suspension structure must be taken into account. For specific limit values applicable to masts and foundations, as well as a description of calculation tools, reference is made to Kontaktledning/Prosjektering/Konstruksjoner.

3.1.5 Contact wire height and changes to contact wire height

The contact wire height is the distance from the top of the rail plane to the bottom of the contact wire measured at the suspension point on a installation not under load.

3.1.5.1 Normal contact wire height

For overhead contact line systems with a design speed of up to 200 km/h, the contact wire height is normally 5.6 metres. The section on which the contact wire height has been reduced must be kept as short as possible.

For overhead contact line systems with a design speed of more than 200 km/h, the contact wire

height must be 5.30 metres. At platforms, the permissible contact wire height may be increased to a maximum of 5.50 metres in order to maintain the necessary electrical gaps. In such cases, the sections on which the contact wire height has been increased must be kept as short as possible and the maximum permitted speed must not exceed 200 km/h.

3.1.5.2 Minimum contact wire height

The minimum contact wire height for overhead contact line systems with a design speed of up to 200 km/h is 5.05 m.

For construction/replacement of overhead contact line systems with a design speed of up to 200 km/h in existing tunnels, bridges, snow sheds, etc., the Infrastructure department may, in each individual case, give dispensation for a contact wire height as low as 4.80 m.

The minimum contact wire height is measured at the contact wire's lowest point.

3.1.6 Changes to contact wire height

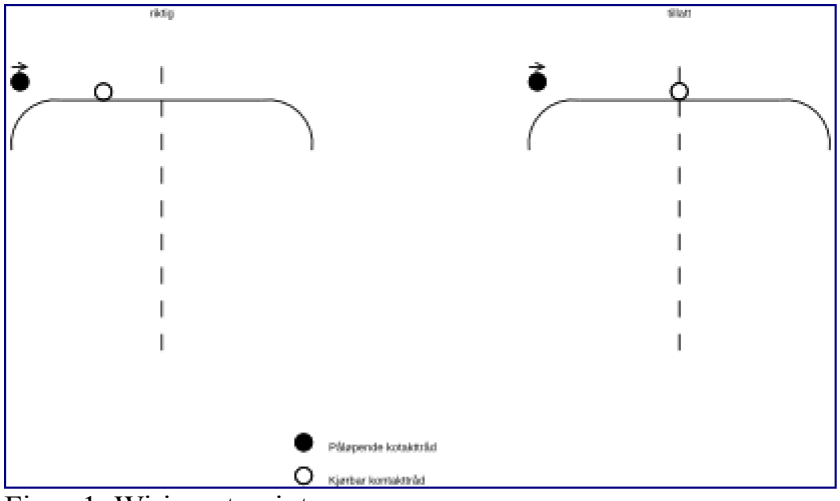
Where the line rises or falls, the contact wire must conform to a ramp function. At the point of transition from one contact wire height to another, the ramp function must have a gradient of up to $\frac{1}{10 - v}$ in the first and last span section and up to $\frac{1}{5 - v}$ in intervening span sections. v = maximum line speed for the relevant section of line.

Immediately before and after a height-restricting structure, the contact wire must remain constant for a minimum of one span section before the change in height commences or after the change in height is finished.

For overhead contact line systems with a design speed of up to 200 km/h, the contact wire height between 2 consecutive height restrictions should remain constant if it is above 5.05 metres and the distance between the height restrictions is less than 800 metres.

3.2 Wiring above points

At points, the contact wire run-off/run-up must enter, or exit, the current collector on the half of the current collector where the running contact wire is located, refer to Figur 1.



Figur 1: Wiring at points.

Section cantilevers located beside points should be designed in such a way that only one of the cantilevers has a running contact wire.

3.2.1 Lines and cables with fixed termination

The mounting dimensions for fastening lines and cables with fixed termination must be selected in a way that satisfies the relevant requirements for minimum gaps. Of particular importance are insulation gaps, distances between cables oscillating as a result of wind load, height above ground, height at level crossings, height at platforms and height in loading areas. Refer to Nærføringer og kryssinger.

Normally, the mounting dimensions for lines and cables with fixed termination are selected so that, at the highest temperature, they are not lower than the contact wire height. The sag for different types of lines and cables is shown in Tables 73 and 74, Kontaktledning/Prosjektering/Kontaktledningssystemer vedlegg b (Tabeller). During the design phase, the tables 'with droop' must be used. Droop is the line's expansion over an undefined period of time as a result of tensioning and dead weight, as well as the structural composition of the line or cable.

During the design phase, it must be verified that the maximum tension at the minimum temperature does not exceed the line's tensile strength and the mast bending moment.

3.3 Traceability of components/systems

The components listed in Kontaktledning/Vedlikehold/Generelle tekniske krav vedlegg b (Sporbarhet for komponenter/systemer) must be marked and registered in accordance with Felles bestemmelser/Generelle bestemmelser.

3.4 Signage

Signage that does not concern the cable installation must not be erected on overhead contact line masts.

4 Systems in proximity, crossings

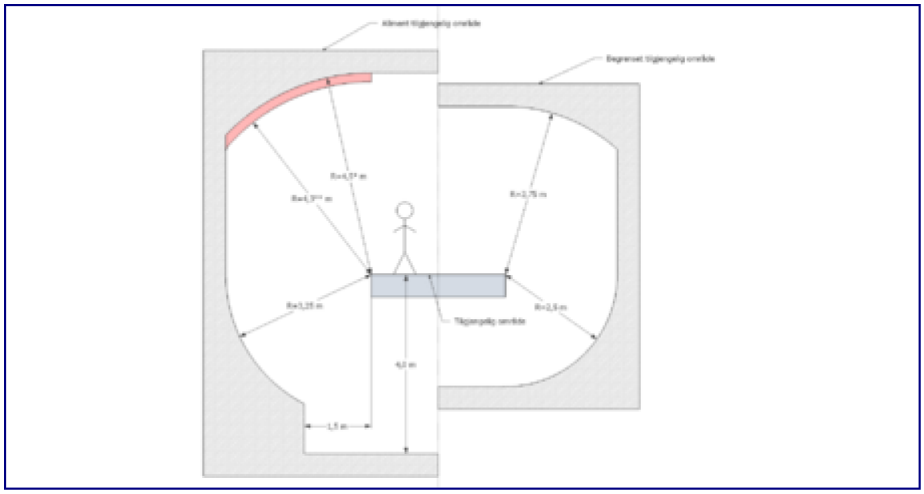
Direktoratet for sikkerhet og samfunnssikkerhet issues several laws and regulations that apply to electrical installations. These apply at all times, regardless of whether or not they are referred to in the Technical Regulations. Statens jernbanetilsyn issues several laws and regulations for the national rail network; the regulations are known as TSIs. In respect of systems in proximity, as well as crossings, a Norwegian electrotechnical norm NEK EN 50122-1 has also been issued. The norm stipulates how the regulations for electrical supply installations must be satisfied and gives guidelines for the safety level required by regulatory bodies in Norway. Particular reference should be made to § 4-5, kap. 6, kap. 7 (for returledning) and kap. 8., refer also to NEK EN 50122-1:2011 and TSI-ENERGI-HS. The following also applies:

a) **Minimum contact wire height (kth):** Minimum contact wire height, refer to separate chapter minimum kontakttrådhøyde
b) **Platforms in proximity:** In respect of platforms in proximity, in areas accessible to the public, the minimum distance from the platform to the nearest live component must be 4.5 m (refer to Figur 2)
c) **Restricted areas in proximity:** In respect of restricted areas in proximity, the distance from the accessible location to the nearest live component must be 3.75 m (refer to Figur 2)

d) **Terrain in proximity:** In respect of terrain in proximity, the distance to the nearest live component must be 5.0 m (refer to § 8-4 [FEF] fig. 8-2)
e) **Parallel overhead contact lines:** Parallel overhead contact lines intended for inspection and repair independently of each other must be erected in such a way that the live components of the various groups have a reciprocal distance of at least 2.0 m
f) **Single track suspended mast:** Suspended masts that carry the overhead contact line for a single track on two parallel tracks must have a protective screen if the distance from the middle of the suspended mast to the middle of the other track is less than or equal to 2 m
g) **Double track suspended mast:** Suspended masts that carry the overhead contact line for parallel tracks that may have different voltage must always have a protective screen
h) **Horizontal distance:** The horizontal distance from the nearest point on a road, car park, turning place, etc., to a live component must be at least 4.0 m
i) **Level crossings:** On level crossings associated with loading areas, industrial estates, etc., that experience a significant volume of high vehicles, height restriction barriers in the form of bars or chains, should be installed

1. Implementation: If height restriction barriers in the form of bars or chains are used these must be established at least 0.3 m below the contact wire's lowest point.

j) **Crossing:** Low voltage lines must cross a railway line via an underground cable installation or in accordance with the requirements specified in § 6-4 [FEF]
k) **Minimum distances:** If minimum distances cannot be complied with, protection must be established in accordance with the requirements specified in § 8-4 [FEF]
A reduction in the distance from the platform to the nearest live component down to 4.3 m (Figur 2) or the distance from terrain down to 4.5 m in accordance with § 8-4 [FEF], Figure 8-2, must be individually approved by the NNRA, use lenken. An application for exemption from the Technical Regulations may be submitted on the main page.



Figur 2: Minimum distances from accessible locations to the nearest live component.
*) In respect of the distance to an insulator (earthed side) the distance may be reduced to 4.3 m.
**) During modification work in which existing structures such as tunnels, bridges and snow sheds, etc., obstruct full height, it is acceptable for R to be reduced to 4.3 m. It is assumed that this will be in areas in which there is little snow or where snow clearance is undertaken

5 Interfaces

5.1 Interfaces to other technical fields

During the planning and design of overhead contact line systems, all interfaces to other affected technical fields and/or installations must be accommodated in order to ensure problem-free operation.

5.2 Interfaces to overhead contact line systems owned by other parties

All interfaces between the NNRA and privately owned overhead contact line systems must be accommodated. A physical interface must be established in the form of a disconnector at the interface between the NNRA's and private parties' overhead contact line systems.

6 Connection to the track

All connections to the track must be implemented with approved screw-on connectors.

7 Electrical compatibility

In consideration of surrounding systems and installations, during the planning and construction of overhead contact line systems, interference resulting from electromagnetic fields must be taken into account.

For general requirements reference is made to [prEN 50121]

In areas where buildings are situated in close proximity to electrified railway lines, an evaluation must be undertaken as to whether special measures are necessary in order to prevent undesirable interference.

Where return wires and/or bridging feeders are being used, these must be laid or installed in a way that ensures minimal distance between forward and return current circuits, as well as being sited at

the greatest possible distance from surrounding buildings and/or installations. The location of cables, draining transformers, section insulators, switches, etc., in the overhead contact line system, must be weighed against the traffic situation for the stations or area so that in normal traffic situations as little interference as possible occurs. In certain situations it may be necessary to use an earth cable to ensure that forward and return currents are run as closely together as possible.

Additionally, when reconnection and maintenance work is taking place on the system, the extent to which the connection situation in the area affects the total field situation must be taken into account.

8 Approval of technical systems and components

In respect of systems and components for which the NNRA has issued technical specifications, such specifications must be complied with in all public rail network procurement. For a list of approved technical specifications for overhead contact line systems, reference is made to vedlegg c (Tekniske spesifikasjoner for kontaktledningsanlegg).

Systems and components that may affect the safety of and accessibility to the infrastructure must be approved by the NNRA. For overhead contact line systems, the following systems and components must be approved by Jernbaneverket:

- Mast foundations, masts and portal structures[1]
- Masts and portal structures
- High voltage cables and return cables/cables
- Lines and wires
- Draining transformers and filter impedances
- Insulators
- Overhead contact line switches and motor drive mechanisms
- All overhead contact line system related components that can be attached to or suspended from a mast/portal structure
- All components that can be connected to the rails
- Overvoltage protection
- Anchoring wires/struts

For a list of approved systems and components, reference is made to vedlegg e.

9 Declaration of Conformity

In accordance with § 3-1 [FEF] the designing unit must issue a Declaration of Conformity confirming that the installation has been designed in accordance with prevailing requirements and conditions. In respect of the issuance of a Declaration of Conformity vedlegg b (Samsvarserkæring for prosjektering), may be used.

10 Footnotes

1. ↑ Approval of mast foundations, masts and portal structures requires completed and verified stability calculations, and also that requirements for contact wire displacement have been fulfilled.

11 Appendices

Vedlegg a Relevante normer/standarder
Vedlegg b Samsvarserkæring for prosjektering (.odt)(.doc)

Vedlegg c Tekniske spesifikasjoner for kontaktledningsanlegg
Vedlegg d Regler for prosjektering

Vedlegg e: Godkjente systemer og komponenter