Electrical engineering in general: Design and construction. General requirements

1 Purpose and scope

The general requirements in this document shall be the minimum set of requirements to obtain safety, polite operation and electromagnetic compatibility within the infrastructure of Jernbaneverket.

2 Environment, safety and vulnerability

a) All electronic equipment shall comply with [FEU], and at the same time all facilities shall work polite and in accordance with the functional requirements at all relevant environmental condition exposed to the facilities.

2.1 Electromagnetic environment

2.1.1 Equipment and products

a) The following requirements applies for EMC:

1. For electromagnetic immunity the equipment shall operate and be tested in accordance with [EN 61000-6-2]
2. For electrical emission the equipment shall operate and be tested in accordance with [EN 61000-6-3].

b) For aspects covered by product standards these product standards shall apply.

1. For railway installations the requirements for EMC depicted in [EN 50121] shall apply.

c) The necessary tests applicable for the standards shall be confirmed by an accredited third party if the supplier is not in position to check the conformability.

2.1.2 Persons with permanent stay close by railway tracks – within or outside buildings

For persons with permanent stay close to railway tracks – within or outside buildings – the requirements in ICNIRP (International Commission on Non-Ionizing Radiation Protection) and “Statens strålevern/NVE-veiledning” dated 1.10 2007 – as result of “Stortingsprop. Nr 66 (2005-06)” – shall be evaluated. a) In accordance to requirements laid down by “Statens strålevern/NVE-veiledning” dated 1.10.2007 – as a result of “Stortingsprop. Nr 66 (2005-06)”, Jernbaneverket shall build up assumptions related to magnetic fields and health.

2.1.2.1 Short time exposition

The recommended limits for expositions in accordance with ICNIRP are frequency dependent. Tabell 1 and Tabell 2 show recommended limits for short expositions of electric and magnetic fields for frequencies of 16,7 Hz and 50 Hz for the public and for the workers.

Tabell 1: ICNIRP's recommended limits for electric and magnetic fields for frequencies of 16,7 Hz and 50 Hz,
maximum values for the public

Frequency (Hz)	E-field (V/m)	H-field (A/m)	B-field (µT)
16,7	**10 000**	**240**	**300**
50	5 000	80	100

Tabell 2: ICNIRP's recommended limits for electric and magnetic fields for frequencies of 16,7 Hz and 50 Hz,
maximum values for the workers

Frequency (Hz)	E-field (V/m)	H-field (A/m)	B-field (µT)
16,7	**20 000**	**1 200**	**1 500**
50	10 000	400	500

2.1.2.2 Typical aspects for magnetic field in the vicinity of railway tracks

With a current consumption of 100 A in the contact line and in the return circuit in the railway tracks the momentary values of the magnetic flux are depicted in Tabell 3:

Tabell 3: Distance from the railway tracks and the magnetic flux

Height above rails	Distance from the middle of the track	Magnetic flux (µT)
2 m	0 m	14
2 m	5 m	3,5
2 m	10 m	1,0
2 m	20 m	0,275

There are different ways to construct the contact line system, and the magnetic flux will deviate accordingly. The highest exposition will arise from a simple contact line system. With a separate return conductor in addition to the rails the exposition will decrease, and with an autotransformer system (AT system) the exposition will be at a minimum, see Tabell 4:

Tabell 4: Different layouts for the contact line system

Contact line system	Exposition close to feeder stations (normalized)	Expositions half way between feeder stations (normalized)
BTRR3	1,00	0,50
BTRC3	0,62	0,33
ATKL6c	0,31	0,18

2.1.2.3 Prolonged exposure, requirements for surveys

According to requirements laid down by the “Statens strålevern/NVE-veiledning” dated 1.10 2007 – as result of “Stortingsprop. Nr 66 (2005-06)”, Jernbaneverket shall perform evaluations with respect to magnetic field and health.

1. For new and refurbished high voltage facilities (contact line system, cables, feeder stations etc.) Jernbaneverket shall depict the mean value of the magnetic field for buildings one year in advance and one year after the change.
2. In the vicinity of the railway infrastructure the actual number of buildings exposed to a mean magnetic field during the year of minimum 0,4 microtesla. The relevant buildings are living houses, schools and kindergarten.

3. Possible countermeasures shall be depicted for buildings exposed to a mean value of minimum 0,4 microtesla during a year. Costs, advantages and disadvantages of these shall be evaluated and justified, and relevant actions shall be proposed.

Please refer to [EN 50500] for measurements and calculation of magnetic fields.

2.2 Safety of persons

a) People shall be protected against danger which can arise by direct touch of live parts and equipment or by direct touch of exposed (conducting) parts which can become live by a fault (indirect contact).

b) Electric facilities shall be in accordance with national rules, such as [FEL] and [FEF]

1. In addition to FEF the annex 4d applies.

This annex high-lights national rules and recommendations in FEF with additional comments from Jernbaneverket. The comments are normative as long as they obey the rules of the words “shall” (skal), or “should” (bør) as fixed by Jernbaneverket, refer to [501]. With other words the comments are informative.

c) Facilities connected to the traction system supply and the contact line system and all facilities that may be influenced by traction system supply and the contact line system and all fixed installations that are necessary for maintaining the electrical safety in traction system supply shall be in accordance with [EN 50122-1].

d) High voltage facilities shall be marked with high voltage sign (“HØYSPENNING LIVSFARE”).

1. Facilities for shore supply where the secondary side of the transformer has a line voltage of 1730 V (1000 V phase-to-neutral) shall have such sign for the relevant parts of the facility where there is a risk to simultaneously touch two phases (within 2,5 m) – for instance when connecting/disconnecting fuses.

2.3 Vulnerability

Damage to cables – in particular telecommunication cables, but also signal cables and cables for energy supply – may result in interruption in the train traffic far away from the place of damage and in other vital functions of the community. Good work practices may well result in less vulnerability. A minor fire attack in a culvert for cables in the main railway station in Oslo blocked all train traffic and also set out parts of the public telecommunication network (November 2007).

A fire in a wooden snow shelter at Hallingskeid represented a big risk for cables, however, the cables was installed in concrete ducts with concrete lids installed. There was strong heath dissipation during the fire, but the cables sustained for days and could be replaced before the communication was interrupted (October 2008).

Vulnerable cables and infrastructure must be planned to avoid interruptions in vital functions. Possible actions are separation, extra protection, alternative or redundant pathways.

Damage may be limited by re-establishing fire barriers immediately after installation or removal of cables. It is as well important that cable ducts along the track is well positioned and closed by lids. Vulnerable cables shall not be laid unprotected along the track.

a) Telecommunications cables shall be kept away from power cables and contact line system parts.

b) Telecommunication cables should – if possible – be kept away from signal cables.

c) Where there is a vertical separation between different cables, the telecommunication and signal cables shall not be position above power cables, cables related to the contact line system, return conductors or similar.

d) Vital telecommunication cables may need to be routed into buildings by different routes. There may also be a need for independent pathway routes inside or outside buildings.

”Soneteorien” (electromagnetic topology, EMC matters) is not relevant for non-metallic fibre optical cables, and it is not relevant electrical consequence whether these cables are routed in co-located or diversity routes with other cables.

e) Choose cable types that are suitable for the actual application and the particular environment:

- telecommunication cables (twisted pair cables) and metallic armouring has good EMC performance,
- cables installed in outdoor environment (in soil, in duct or suspended) should be filled with Vaseline (cables without Vaseline (grease) are more vulnerable for damage and intrusion of water),
- cables in ducts or on ground should have a sheath/shield to avoid attack from rodents (steel band or aluminium treads makes the cables safe from rodents).

3 Electromagnetic environment within or close to railway tracks

a) All electrical facilities should be designed in accordance with “Soneteorien” (electromagnetic topology, EMC related) and used as a tool to administrate the facilities and each component to obtain electromagnetic compatibility for all facilities making up the installation/system.

The methods used regarding “Soneteorien” which should be used to obtain good EMC practice, is based on practical grounding, shielding and bonding.

3.1 Application of “Soneteorien” (electromagnetic topology)

By using “Soneteorien” the system/facility shall be defined with diverse zones following the rules below:

For more information of “Soneteorien” refer to annex 4e about electromagnetic topology.

a) A ***zone*** shall be a physical or a virtual area that defines an electromagnetic environment (level of isolation, level of electrical noise, grade of shielding etc.). Two principles shall be fulfilled within a zone:

- the equipment in the zone shall not disturb the environment within the zone above defined levels (e.g. level of isolation, nominal values for primary protection, level of radiation, grade of immunity etc.)
- the equipment in the zone shall tolerate the exposure that is declared as typical for the zone.

b) The zone shall be considered to be a ***shield***. The shield may consist of walls, enclosures, cabinets etc.. If zones are separated only by free distance in air it is assumed to be a ***virtual shield***. Be aware that walls in a wooden house (e.g. a room or outer walls) do not necessarily fulfil the criteria associated with a shield and hence does not represent a shield. The shield shall at least have two functions:

- avoid emission from the electrical circuits within the zone to the external environment
- protect the zone against external electromagnetic radiation

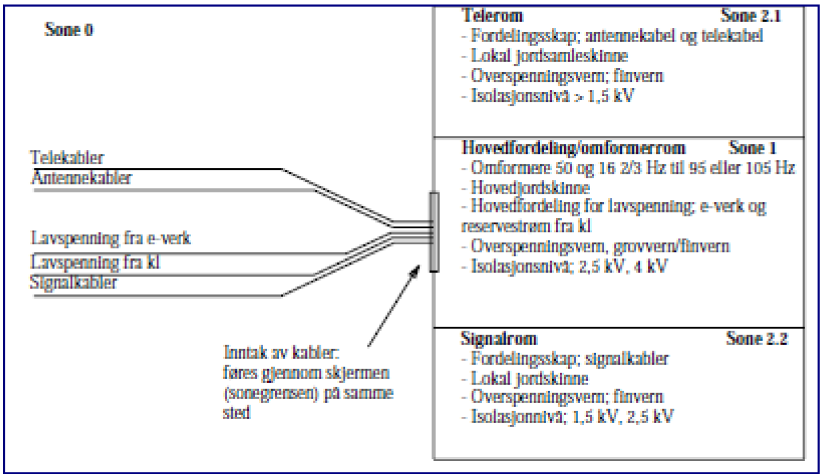
c) the external environment shall be denoted as zone “0”. The zones shall then be numbered as zone “1”, “2”, “3” etc.. Two physical separated zones with the same grade of shielding may be denoted as zone “1.1”, “1.2”, … “2.1”, “.2.2” etc..

d) All equipment within a zone shall be earthed at the inner perimeter of the zone, which in turn result that no earth connection shall cross the border (the shield) of the zone.

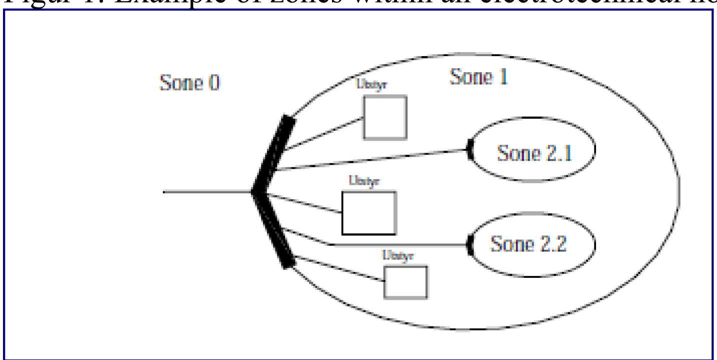
e) The pathway of cables between the zones should be enforced by additional shielding, e.g. a metallic plate, a bar or similar. All cabling shall be fed through the shield at one place only. Noise signals to be attenuated shall be deflected to the shield.

f) There should not be any punctuation to the shield other than the feed-through of cables. This is not necessarily possible in all cases (at windows, doors etc.) and this will then limit the performance close to such openings compared to the rest of the zone. Sensitive equipment should then be positioned as far away from the cable inlet – or other punctuations – as possible.

Figur 1 and Figur 2 depict examples to the definitions of zones in electrotechnical houses with an indication of level of isolation and shielding.



Figur 1: Example of zones within an electrotechnical house



Figur 2: Example of earthing between equipment in one zone and between different zones

Non-metallic fibre optic cables have no influence on the EMC design with zones and earthing. Other aspects of vulnerability are relevant whether to fibre optic cables should enter the electrotechnical house in one or more entries. Other aspects of vulnerability is given in clause 2.3.

4 Approval of technical systems and components

Systems and components that can impact the reliability, availability, maintainability and safety of the railway infrastructure shall be approved by Jernbaneverket Teknologi. For systems and components where Jernbaneverket has published technical specifications, these shall apply for all procurements to the public railway infrastructure.

Jernbaneverket/Teknologi has its own database for approved systems and components on “Banenettet”. Teknisk regelverk for Kontaktledning and Banestrømforsyning provides an overview for approved systems and components.

Energy meters for low voltage installed in the infrastructures of Jernbaneverket and used for legal sale to a third party shall be in accordance with national codes (Forskrift om krav til elektrisitetsmålere (www.lovdata.no: FOR-2007-12-28-1753)).

5 Design set for short-circuit currents and delays in the 15 kV facility

a) Maximum short-circuit currents in the contact line system:

Oslo S switching station	I_k = 31,5 kA
Within Oslo area	I_k = 25,0 kA
Ofotbanen (Narvik)	I_k = 20,0 kA
Other places	I_k = 12,5 kA

The values are the most close approximation to values in [IEC 60059]. From these vales the dimensioning of short-circuit currents is due to thermal and mechanical dimensions of earthing conductors and bonds, refer to requirement in b), c) and d) below. The values results from recommendations given in the report EB.800049-000.

I_k denotes the rms-value of the sub-transient short-circuit current (I_{kjord}).

Oslo S switching station is limited by bars, outgoing cables and the parts of all tracks that is end-feed from Oslo S switching station.

Oslo area is defined as all railway tracks within the following places:

North-west, north and north-east: Nittedal railway station, Jessheim substation and Fetsund railway station

South-west and south-east: Drammen switching station and Ski switching station

b) The thermal short-circuit current is calculated to $I_{th0,3}$ = 0,744× I_{kjord}. Hence the following short-circuit currents shall be used for thermal calculation of short-circuit currents:

Oslo S switching station	$I_{th0,3}$ = 23,4 kA
Within Oslo area	$I_{th0,3}$ = 18,6 kA
Ofotbanen (Narvik)	$I_{th0,3}$ = 14,9 kA
Other places	$I_{th0,3}$ = 9,3 kA

c) Shock currents for mechanical design is: $I_p = \boldsymbol{\kappa}\ \textit{\textbf{sqrt(2)}}\ I_k$, where the factor for non-symmetry, $\boldsymbol{\kappa}$, to be used for Jernbaneverket, is: $\boldsymbol{\kappa} = 1{,}55$. Hence the following shock currents shall be used for the mechanical design:

Oslo S switching station	$I_p = 69{,}0$ kA
Within Oslo area	$I_p = 69{,}0$ kA
Ofotbanen (Narvik)	$I_p = 43{,}8$ kA
Other places	$I_p = 27{,}4$ kA

d) Short-circuit currents for design of earth conductors and bonding conductors are calculated to $I_{rms0,3} = 0{,}64\times I_{kjord}$. Hence the following short-circuit currents shall be used for the design of earth conductors and bonding conductors:

Oslo S switching station	$I_{rms0,3} = 20{,}2$ kA
Within Oslo area	$I_{rms0,3} = 16{,}0$ kA
Ofotbanen (Narvik)	$I_{rms0,3} = 12{,}8$ kA
Other places	$I_{rms0,3} = 8{,}0$ kA

The design of earth conductors and bonding conductors is limited by the relation between cross section area of conductors and the maximum length of conductors to avoid too high electrical potentials or touch potentials. See [510], Jording.

e) The short-circuit duration shall be designed for different components in the following way:

Earth conductors and bonding conductors	0,3 s
Transformers	2,0 s
Earthing apparatus	0,5 s
Other components and constructions	1,0 s

If the time for disconnection is specified in the technical specification for a particular component, this technical specification shall apply.

If a short-circuit should happen far away from the feeding station the disconnecting time could be longer than 0,3 seconds due to the design wishes for selectivity. The short-circuit current will then be significant less than the design value.

6 Constructing license and obligation to notify

Jernbaneverket are set free from “konsesjon” (områdekonsesjon (license))” for all facilities on own premises if the facilities are used for the operation of railway only, and the facilities are limited to 22 kV. Requirements to apply for operation of facilities are depicted in the following. Se also letter from NVE dated 4.10 2007, reference 200400243-10.

Jernbaneverket shall in the future apply for constructing license for the following facilities:

1. New high voltage facilities with a nominal voltage of more than 22 kV [1)]. New high voltage cable facilities with a nominal voltage of more than 132 kV [1)].
2. Refurbishment of existing transformers or feeder stations with a nominal voltage of more than 132 kV [1)].

3. High voltage facilities [2)] applied for other utilization than that of the core business of Jernbaneverket, such as power distribution to cottages or external business customers in the area of railway stations (applies for new facilities, including refurbishment or extension of existing high voltage facilities). With this respect the activities of train companies related to rolling stock (for instance freight handling) is considered as a part of Jernbaneverket's core business.
4. High voltage facilities [2)] situated at other places than Jernbaneverket's premises (applies for new facilities, including refurbishment or extension of existing high voltage facilities)

[1)] The voltage applies for facilities with a phase-to-phase voltage in systems with three phases, for the voltage of a single phase system with two conductors or for a two phase system with three conductors (phase-to-earth (or neutral) voltage) of a system with auto-transformers
[2)] Facilities with a nominal voltage higher than DC 1500 V or AC 1000 V according to the definition in bullet 1) above.

b) Facilities that Jernbaneverket has applied to be free from "konsesjon" (områdekonsesjon (license))" do not need to be reported to DSB (Direktorat for sikkerhet og beredskap) in advance of installation and reconstruction. The facilities that needs constructing license shall be reported to DSB in advance of installation and reconstruction.

c) If the infrastructure is changed a message shall be directed to Statens jernbanetilsyn in advance of the changes.

7 Annexes

Vedlegg a (.pdf) Samsvarserklæring for prosjektering

Vedlegg a (.odt) Samsvarserklæring for prosjektering

Vedlegg a (.doc) Samsvarserklæring for prosjektering

Vedlegg b (.pdf) Samsvarserklæring, utførende (bygging)

Vedlegg b (.odt) Samsvarserklæring, utførende (bygging)

Vedlegg b (.doc) Samsvarserklæring, utførende (bygging)

Vedlegg c Normgivende referanser

Vedlegg d Jernbaneverkets kommentarer til FEF

Vedlegg e (.pdf) Elektromagnetisk topologi