Electrical engineering in general: Design and construction. Low voltage power supply

1 Purpose and scope

This clause shall provide low voltage power supply to technical facilities along the railway track build to provide safe and secure auxiliary power supply for any installations.

The clause relates to primary, auxiliary and emergency power supply for signalling and telecommunications and any installation in true need of auxiliary and emergency supply.

For power supply for other electronic installations see relevant clauses in Teknisk regelverk for low voltage facilities, [543] and [544].

2 Power supply systems

Definitions

Emergency power supply is defined as a system that is designed to maintain power supply that is important for the security of persons.

Auxiliary power supply is defined as a system that is designed to maintain the function of an installation or part of it under ordinary interruption of the primary power supply for other installations than those important for the security of persons.

Primary power supply includes:

- Power supply directly from local energy utilities (50 Hz)
- Power supply via a possible parallel high voltage supply (50 Hz)

Auxiliary power supply includes:

- Auxiliary power supply from the contact line system (230 V, 16⅔ Hz)
- Uninterruptable power supply (UPS) (50 Hz)
- Auxiliary generator (50 Hz)

Emergency power supply includes:

- Emergency aggregates
- Batteries.

2.1 Distribution system

a) The selection of distribution system (e.g. IT, TN and TN [FEL] shall depend on the required availability of the system for the actual faults and operation conditions that may be present.

b) Special care shall be applied to the selectivity for different protection devices in order to keep important parts of the facilities in operation while other parts are faulty.

1. When residual current disconnectors or relays have to be applied, only the actual faulty circuit shall be disconnected.
2. Residual current disconnectors shall not be used where the disconnection of circuit will

imply major disruption of the movements of trains.

2.2 Monitoring

a) Monitoring of the insulation should be performed in all facilities. For facilities supplied from a separate transformer insulation monitoring shall be performed (a common residual circuit disconnector from the transformer will not operate in such installations).

At the secondary side of a transformer with more circuit, or where there are much cabling installed (capacitive couplings), residual circuit disconnectors on separate circuits may, however, detect an earth fault.

b) All critical facilities shall be designed with monitoring of the power supply (e.g. fuses/protection devices will alarm circuit, voltage measurement, insulation monitoring or similar).

1. Fault and alarm indications shall be monitored for remote readout.
2. Procedures shall be developed to facilitate repair of insulation or earth faults as soon as possible.

2.3 Quality of voltage

a) The power supply from the different systems shall at minimum meet the requirements for quality of voltage at the entrance point in accordance with [EN 50160]. See Tabell 1.

b) Voltage drop from between the entrance point and the load should be less than 4 %. In general all equipment shall be supplied with the recommended voltage.

Tabell 1: Requirements to power supply system for facilities in the infrastructure

Distribution system	Voltage [V]	Deviation [%]	Frequency [Hz]	Deviation [%]
Primary power supply	230	± 10	50	± 0,2
Auxiliary power supply from contact line system	1-phase 230	-20/+15 [1)]	16⅔	± 0,2
UPS	230	± 10	50	± 0,5
Aggregate	230	± 10	50	± 2,0

[1)] Based on transformers with voltage ratio of 15/0,23 kV and a variation of the voltage on the contact line system in the range of 12 to 17,25 kV, see chapter 5.

3 Primary power supply

a) The primary power supply shall all the time be connected to provide continuous operation in all facilities connected to the supply.

3.1 Supply from the local energy provider

a) The power supply system for railway facilities at railway stations and along the track derived from the local energy provider shall not have any earth connection in common with the contact line return circuit. Earthing systems for the local energy supplier shall be separate from earthing system of the railway infrastructure.

1. This requirement is also valid for 1000 V shore supply for rolling stock.

Equipment associated with the contact line zone is equipment within or partly within the contact line or current collector zone or facilities connected by cable to parts within the contact line or

current collector zone, see [510], jording.

b) The power supply system shall be installed to avoid influence from or influencing the signalling systems, see [550], chapter 5, or be harshly affected by the traction return current. This implies a distribution system with isolated neutral (IT system). See also [EN 50122-1] and [510], jording.

c) The use of 230/400 V TN system shall fulfil the follow requirements:

1. there must be a dedicated area for the transformer supplying the railway installation where the primary and secondary side have galvanic isolation.
2. The neutral of the TN system (N conductor) and the earth system of the railway (parallel earth wire) shall only be connected in one point.
3. There must be a continuous parallel earth wire for the section that shall be served by the TN system.
4. The use of continuous parallel earth wire shall be compatible with the track circuits. See also [510], jording.

3.2 Supply from parallel high voltage system

a) If a high voltage supply is utilized by the track, all railway facilities (both within or outside the overhead contact line zone/current collector zone) and other possible facilities within the overhead contact line zone/current collector zone should be served.

1. The high voltage supply should have multiple primary sources (transformers) to have a secure energy supply and to avoid other auxiliary supplies than UPS for critical facilities.

b) Substations should be located in dedicated kiosk on ground. The kiosk should be located outside the overhead contact line zone.

1. The position and distances between substations shall be accommodated to serve all equipment within the voltage range specified for the equipment.

4 Auxiliary power supply

4.1 Need for auxiliary power supply

Requirements for availability are dimensioning for the type of auxiliary power supply to be selected. Some possible examples for dimensioning are depicted below:

Grade of availability	Diesel aggregate	Moveable aggregate	UPS (230/400 V) (operative time)	KL + operative time
Extreme	1-2	Ready, not connected	12 hours	Yes [a]
Very high	1	Ready, not connected	4 hours	Yes [a]
High	1	Ready, not connected (?)	1 hour	Yes [a]
Pretty high	—	Ready, not connected	8 hours	Yes [a]
Normal	—	Yes [b]	8 hours	—
Normal	—	Yes [b]	—	8 hours
Limited	—	Yes [b]	4 hours, eller ...	... 4 hours

No redundancy	—	—	—	—

The content of this table is for information only.

[a] May be designed as a supplement where the contact line system is available,

[b] May be stored on another location, but can be transported in due time.

a) For signalling, telecommunication and remote control facilities (and all other facilities related to the traction of trains) the auxiliary power supply shall ensure the operation of the facilities when ever the primary power supply should fail.

1. A risk analyse of the availability and reliability of the primary power supply shall be performed to evaluate the need and complexity of the auxiliary power supply.

b) The change-over to auxiliary power supply shall not influence the operation of the facilities and should be accommodated to the requirements from the facilities/equipment.

1. For signalling facilities the specific requirements implies that objects along the track shall not change condition due to the change-over of power supply.

c) Auxiliary power supply should be dimensioned for operation of the facilities for at least 8 hours.

d) Uncritical load should not have access to the auxiliary power supply.

e) Under normal maintenance work the contact line system may be without power feeding for hours (even days).

f) Under emergency condition with portioned delivery of primary energy an UPS facility may get short of stored energy. When such conditions arise, other countermeasures should be evaluated.

4.2 Auxiliary power supply from the contact line system

a) The auxiliary power supply from the contact line system is normally limited to a load of 10–15 kVA.

1. If the transformer supplies facilities external to the installation of Jernbaneverket, this shall be supplied on a dedicated circuit that is not serving any of the railway installations.

b) ”Jernbaneverkets standardvilkår for avregning av 16⅔ Hz energi”, (see at least clause 3.3) depicts how all facilities using energy with 16⅔ Hz shall be reported, registered and build.

1. All facilities with a stipulated yearly consumption of more than 15 000 kWh shall have separate energy metering.

c) Insulation monitoring should be implemented for the following installations

d) For the supply of facilities that is critical for the traction of trains, no residual current disconnectors shall be used.

e) For the supply of facilities that do not influence the traction of trains automatic disconnection in fault condition shall be installed according to [NEK 400] or in other ways.

f) Auxiliary power transformer shall in normal cases have galvanic isolation between the high voltage circuit and the low voltage circuit. (See also possible measures in 4.2h).) g) Installation of the auxiliary power transformer depends on the earthing concept and track circuits and shall be performed in accordance to figures in annex 8.a.

1. Where parallel earth wire is installed the protection earth shall be bonded to it, see figures 8a1 and 8a2.
2. Where parallel earth wire is not installed the protection earth shall be bonded to the rails, either to the continuous earthed rail (single isolated track circuit), or via an impedance bond

(double isolated track circuit), see figures 8a3 and 8a4.

3. The fuse on “A” side (primary) shall be installed with separate brackets to facilitate fuse replacement without disruption of power feeding in the contact line system.
4. Disconnector at the “A” side shall only be operated if it shows difficult to power down.
5. At the “A” side an over-voltage protection shall be installed (metal oxide arrester). Requirements for installation is contained in [510], chapter 7. Requirements for earth electrodes is contained in [510], jording.
6. The “B” side is connected to the track, either directly or via an impedance bond.

“ The neutral connection of the low voltage windings (“b”) shall be supplied with a voltage protection for the neutral voltage, refer to [FEF, §5-4]).

1. The voltage-protecting device shall be such that it makes a permanent earth connection when it fires due to over-voltages. It shall sustain the current without any danger for the environment. In the connection from “b” to earth no melting fuses or circuit breakers shall be installed, however, some means shall be arranged to short the voltage-limiting device for safe replacement of any defect voltage-limiting device.

h) If the cable from “a” and “b” to the installation is less than 30 m, the capacitance in the cable will be small, and high voltages with respect to earth may arise. In such cases “b” shall have a permanent connection to earth close to the auxiliary power transformer.

1. If the auxiliary power transformer is positioned within the overhead contact line zone, refer to [510], jording, the terminating point “b” shall be connected to “B”, which result in lack of galvanic isolation.
2. If the auxiliary transformer is positioned in a dedicated mast or kiosk free of the overhead contact line zone, then “b” shall be connected to an earth electrode that have no connection to the track return circuit, refer to thee clause about earth electrodes in [510], jording.

> When “b” is connected to “B” the voltage-limiting device from “b” to “earth” is short-circuited. The voltage-limiting device shall not be removed, but be ready in case the connection between “b” and “B” is removed.

i) For double tracks an auxiliary power transformer is installed for each track serving the respective track.

> Be aware that the traction of trains on one track shall be independent of the contact line system of the other track! This should also be the case for switching point heaters fed by the contact line system.

j) The power auxiliary transformer shall be permanent connected to the contact line system and shall be designed to sustain the electrical and mechanical stress that may arise.

k) The transformer should be installed in a dedicated kiosk on ground, but can also be installed in a mast for the contact line system. The kiosk on ground should preferably be situation outside the contact line zone. l) Cables and protection conductors shall be dimensioned in accordance with requirements in [540], Seksjonering and requirements in [FEL] and [FEF].

m) The operative status for the auxiliary power transformer shall be monitored to detect broken fuses or other faults prior to the need for power from the auxiliary power transformer.

4.3 Uninterruptable power supply, UPS

a) Uninterruptable power supply, UPS, shall ensure delivery of energy to facilities that can not afford interruption in the supply. The UPS facility shall serve energy deliverance until other energy

supply is connected (from contact line system, other source or aggregate).

In many cases the battery capacity for full load in 10 minutes may be sufficient.

b) UPS should not be the only backup source, but for some minor facilities with high availability for the primary power supply backup with UPS only may be accepted. The battery capacity shall in these circumstances be dimensioned for full load in 8 hours.

c) The performance of the UPS-facility shall be dimensioned and matched to the size and type of load. Special care should be paid for loads with high in-rush current, reactive load or non-linear load. d) Major facilities may have the UPS dimensioned for degraded operation of the total facility. In this case the total facility shall be evaluated to give priority and service to selected objects and no supply for the rest. The selection of priority shall be accepted by Jernbaneverket.

e) UPS may also be used where ever the voltage quality is to poor for specific and sensitive equipment to be supplied directly from the primary source.

f) The use of maintenance free batteries with continuous stand-by charging is preferred. Any use of the battery capacity shall be followed by charging. A totally dis-charged battery should be fully charged in 10-12 hours.

g) When designing a facility procedures for monitoring the facility shall be established. This is also valid for the elaboration of procedures for maintenance and service in cooperation with the supplier.

h) UPS facilities shall be monitored with remote supervision. The following shall at least be monitored:

- Status for the power supply (primary supply, other source or UPS operation from battery).
- Voltage and current on the input, the output and in intermediate circuits.
- Charging current and voltage on the battery.

4.4 Aggregate

a) The aggregate shall be dimensioned to fully supply all connected installations. The aggregate shall sustain all normal load variations (disconnection, in-rush current), and shall have sufficient performance to maintain normal operation in all installations.

b) Permanent installed aggregate shall have automatic start and change-over of the supply to the priority loads when the primary supply fails. A time delay should be implemented to avoid start for minor interruptions of the primary supply. The aggregate should be fully operating within five minutes.

Procedures for the operation and maintenance of the aggregate should be elaborated to facilitate periodic control of the facility, periodic operation and maintenance of the aggregate.

For periodic operation the aggregate should be operated for at least 15-30 minutes.

d) Permanent installed aggregate with automatic start shall have remote supervision. The following should at least be monitored:

- Operation status of the aggregate.
- Voltage, current, power and frequency under operation.
- The level of fuel.
- Battery voltage and charging current for the start battery.

e) Mobile aggregate shall be monitored locally by the staff for the parameters listed in d) above. Remote monitoring may be prepared for operational status, voltages, currents, power and frequency in operation.

5 Emergency power supply

5.1 Need for emergency power supply

a) For facilities where failure in the primary power source can result in danger for persons, the emergency power supply shall ensure automatic operation of the respective facilities in a sufficient long period to avoid dangerous situations.

b) Emergency power supply shall not be based on systems that disconnects by the first failure.

c) See also requirements in [FEL] and in [NEK 400].

6 Annexes

Vedlegg - Skisser for oppkobling av reservestrømstransformator