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INTERNATIONAL STANDARD

Railway applications – Fixed installations – Particular requirements for AC switchgear –
Part 3-1: Measurement, control and protection devices for specific use in AC traction systems – Devices

IEC 62505-3-1:2020-03(en)

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FOREWORD

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International Standard IEC 62505-3-1 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This second edition cancels and replaces the first edition published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– distinguish between requirements, Clauses 4 and 5, and application guides, annexes;
– include requirements on devices for example control and protection relays not included before;
– remove parts already included in other standards, for example EN 50633 for protection principles, which is intended to become an IEC standard.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
9/2563/FDIS	9/2575/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62505 series, published under the general title *Railway applications – Fixed installations – Particular requirements for AC switchgear*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

IEC 62505-3-1 is intended for measurement, control and protection devices for specific use in AC traction systems other than current and voltage transformers. These are covered by IEC 62505-3-2 and IEC 62505-3-3 respectively.

This standard covers a large variety of different kinds of equipment used in railway fixed installations which do not have railway specific product standards. It provides clarification on how to select ratings and test values relevant for operation in fixed installations. This standard should be read in conjunction with the relevant product standard of the equipment concerned.

Annex A and Annex B are application guides. Annex A deals with railway specific measurement principles and Annex B provides guidance on the design of control systems for AC traction. These application guides identify characteristics of and parameters for procedures and functions used. Guidance on protection principles is given in EN 50633.

The clause numbering of this part is different to that used in all other parts of the IEC 62505 series. Clause numbering in the other parts is the same as in the specific referenced product standard.

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – PARTICULAR REQUIREMENTS FOR AC SWITCHGEAR –

Part 3-1: Measurement, control and protection devices for specific use in AC traction systems – Devices

1 Scope

This part of IEC 62505 is applicable to new low voltage devices for measurement, control and protection which are:

– for indoor or outdoor fixed installations in traction systems, and

– operated in conjunction with high voltage equipment with an AC line voltage and frequency as specified in IEC 60850.

NOTE 1 IEC 60850 specifies the AC traction systems:
15 kV 16,7 Hz,
12 kV 25 Hz,
12,5 kV, 20 kV also 25 kV with 50 Hz and
12,5 kV, 20 kV, 25 kV also 50 kV with 60 Hz.

This document does not provide specific requirements for AC traction systems supplied with a frequency of 25 Hz or with a nominal voltage of 12,5 kV or 50 kV. Nevertheless, requirements set out in this document can also be used as a guidance for these systems.

This document also applies to measurement, control and protective devices other than low voltage devices and not covered by a specific railway product standard as far as reasonably possible. Requirements of this document prevail.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60255-1, *Measuring relays and protection equipment – Part 1: Common requirements*

IEC 60850:2014, *Railway applications – Supply voltages of traction systems*

IEC 61243-5, *Live working – Voltage detectors – Part 5: Voltage detecting systems (VDS)*

IEC 61869 (all parts), *Instrument transformers*

IEC 61869-1:2007, *Instrument transformers – Part 1: General requirements*

IEC 62236-5:2018, *Railway applications – Electromagnetic compatibility – Part 5: Emission and immunity of fixed power supply installations and apparatus*

IEC 62497-1, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*

IEC 62505 (all parts), *Railway applications – Fixed installations – Particular requirements for AC switchgear*

IEC 62505-2:2016, *Railway applications – Fixed installations – Particular requirements for AC switchgear – Part 2: Disconnectors, earthing switches and switches with nominal voltage above 1 kV*

IEC 62505-3-3:—[1], *Railway applications – Fixed installations – Particular requirements for AC switchgear – Part 3-3: Measurement, control and protection devices for specific use in AC traction systems – Voltage transformers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62505 (all parts) and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
under-voltage
voltage the value of which is lower than a specified limiting value

[SOURCE: IEC 60050-151:2001, 151-15-29]

3.2
under-voltage off
control function which permits a mechanical switching device to open, with or without time-delay, when the voltage of the circuit, the mechanical switching device is connected to, falls below a predetermined value

Note 1 to entry: This term is used when a loss of primary voltage is considered.

Note 2 to entry: This function will in most cases require some kind of shunt release.

3.3
under-voltage release
shunt release which permits a mechanical switching device to open or close, with or without time-delay, when the voltage across the terminals of the release falls below a predetermined value

Note 1 to entry: This term is used when a loss of an auxiliary voltage is considered.

[SOURCE: IEC 60050-441:2000, 441-16-42, modified – Note 1 to entry has been added.]

3.4
under-voltage trip
protection function which permits a mechanical switching device to open, with or without time-delay, when the voltage of the circuit, the mechanical switching device is connected to, falls below a predetermined value

Note 1 to entry: This term is used when a loss of primary voltage is considered.

Note 2 to entry: This function will in most cases require some kind of shunt release.

[1] Second edition under preparation. Stage at the time of publication IEC CFDIS 62505-3-3:2019.

4 Specific requirements from the traction system

Traction systems due to for example their load, voltage and earthing conditions require thorough analysis when defining operational principles and requirements for equipment.

The design of measurement, control and protection circuits, their devices and algorithms shall consider any effect arising from:

– fast fluctuation of traction power demand;
– moving tractions units, providing scenarios with traction currents higher than failure currents;
– the return current system, especially the track, which typically is effectively connected to earth;
– fast fluctuation of operating voltages between U_{min2} and U_{max2}, with U_{min2} and U_{max2} as specified in IEC 60850;
– high number of switching operations for example caused by a high number of short circuits in the contact line systems;
– in 16,7 Hz traction systems the duration of a period of 60 ms in respect to magnetization, saturation and switching times;
– in auto-transformer systems, a phase shift of 180° resulting in an maximum operating voltage of 2 × U_{max2} but only between phases.

NOTE 1 Typically the return circuit in AC traction systems is effectively earthed. Unlike utility networks a displacement of the star point during earth faults resulting in an increase of phase voltages by factor √3 cannot happen.

NOTE 2 Equipment in a 25 kV traction system is subject to a maximum permanent operating voltage phase to earth of 27,5 kV = U_{max1}. Equipment in a 3 phase utility network with a highest system voltage U_m = 36 kV has an average continuous voltage phase to earth during 99 % of its life of 33/√3 kV = 19,1 kV.

If the above values are compared, it becomes clear that the dielectric stress of equipment in traction power supply is significantly higher and therefore the test voltages e.g. during partial discharge testing have assigned higher values in this document.

5 Requirements on measurement, control and protection devices

5.1 General

Measurement, control and protection devices shall be designed, manufactured and tested to their specific product standards. Requirements of railway standards prevail and shall be applied as far as reasonably possible. This especially concerns IEC 62497-1 for insulation coordination and IEC 62236-5 for electromagnetic compatibility.

Annex A and Annex B provide guidance on specific measurement and control principles for AC traction systems. They identify characteristics of and parameters for procedures and functions used.

5.2 Voltage detection systems

Capacitive voltage detection systems shall comply with IEC 61243-5 except for the following requirements:

– voltage absence indication shall be below 50 % of U_{min2},
– voltage presence indication shall be above 90 % of U_{min2} and
– the capacitive voltage detection system shall properly work also up to U_{max2}.

NOTE 1 The thresholds for voltage absence and presence indication are adapted considering the fact that voltages are between contact line and running rail on ground potential and also considering the tolerances of supply voltages of traction systems.

When selecting voltage detectors manufactured according to IEC 61243-1 it may be preferential to use thresholds for voltage absence and presence indication as specified before.

NOTE 2 This portable equipment is only temporarily connected to a supply voltage of the traction system.

NOTE 3 There are national standards available in some countries specifying thresholds for voltage absence and presence indication.

5.3 Devices at supply voltage of a traction system

Devices not covered by a railway specific product standard and being connected to a circuit at supply voltage of a traction system shall comply with the test voltages including partial discharge level as specified in IEC 62505-3-3 for this supply voltage. If these devices are connected to provide isolation of feeding systems the test voltages shall be taken for "across the isolating distance" from IEC 62505-2:2016, Table 1, for example when connected parallel to a disconnector.

Other requirements of IEC 62505-3-2 or IEC 62505-3-3 or for sensors as given in IEC 61869 (all parts) shall apply as far as reasonably possible and shall be agreed upon between supplier and infrastructure manager.

Devices containing electronic parts shall be subject to a function test in the intended operational circuit and under worst case conditions, for example in its installation position next to a circuit breaker during a short circuit breaking test.

Dielectric type tests shall be applied as specified in IEC 61869-1:2007, 7.2.3 with test values as specified in IEC 62505-3-3:—, 7.1. Dielectric routine tests shall be applied as specified in IEC 61869-1:2007, 7.3.1 to 7.3.4 with test values as specified in IEC 62505-3-3:—, 7.1 and 7.3. Other tests and their test requirements shall be agreed upon between purchaser and supplier prior to the order.

5.4 Protection devices

Protection devices used in railway applications shall comply with the relevant product standards, particularly IEC 60255-1. They shall also comply with the electromagnetic compatibility requirements given in IEC 62236-5.

Any protection device shall be specified based on a consideration of the specific requirements from the traction system as given in Clause 4.

Protection devices for contact line protection shall include the following protection functions:

– distance protection with a minimum of two stages and the possibility to use directional settings;
– di/dt or du/dt protection, when specified, for example by the system designer or infrastructure manager;
– de-icing protection, when specified, for example by the system designer or infrastructure manager.

They shall also include the possibility of blocking or delaying between the functions. In particular, when specified, protection functions shall be blocked for a short time when a high 2nd harmonic content is detected, for example to avoid unintended tripping due to transformers inrush currents.

NOTE 1 This kind of protection device will typically use specially adapted algorithms and will therefore be different to devices intended for utility use.

NOTE 2 EN 50633 provides an application guide on protections systems including back scenarios.

Protection devices for 16,7 Hz contact line protection shall include the following protection functions in addition:

– instantaneous overcurrent protection;

– fast acting trip output.

NOTE 3 Instantaneous overcurrent protection in combination with the fast acting trip output are intended to support fault clearance in the first half of the period. 16,7 Hz circuit breakers are typically equipped with a fast tripping device and total time until opening of the breaker is in the range of 20 ms to 25 ms.

NOTE 4 Algorithms for 16,7 Hz contact line protection devices are in many cases different to those of 50 Hz and 60 Hz devices. This is due to the aim to achieve similar response times out of a shorter fraction of the period. Hardware modifications are also likely to be necessary.

Annex A
(informative)

Application guide – Measurement principles, particularly related to the line testing methods

A.1 Overview

This application guide provides guidance in measurement principles typical to traction systems particularly in relation to the line testing methods.

NOTE Many other principles are well known from public power supply systems and are not repeated in this annex.

Line testing has been classified as a measurement principle. Nevertheless it normally only provides a comparison to a threshold and not a measurement value.

A.2 Line testing

A.2.1 General

Overhead contact lines are exposed to a significantly higher number of short circuits compared to other overhead lines. This is due to the reduced height of installation above ground and operation together with fast moving pantographs.

Any short circuit provides extra stress to the contact line which is sensitive to over-temperatures. This sensitivity is influenced by many parameters including cross-sections and tensile force. Based on this data and under consideration of traction load, short-circuit current level and protection scheme, the withstand-ability of the contact line against, for example repeated short circuits, may be determined.

NOTE 1 A typical value derived from operational experience is 1 short circuit for each km of contact line per annum.

NOTE 2 Most sensitive to loss of tensile strength are droppers between messenger and contact wire.

The recommendation is to consider measures reducing the number of short circuits for a contact line. One possibility is to close line circuit breakers only after the ‘short circuit free’ condition of the contact line has been verified. Experience has shown that line testing provides a substantial benefit with short circuit current levels from 20 kA and higher.

NOTE 3 16,7 Hz railways with short circuit current levels of up to 40 kA typically use line testing whereas 50 Hz and 60 Hz railways with short-circuit current levels of up to 16 kA typically do not.

NOTE 4 Saturation of current transformers sometimes leads to a delay in tripping of the circuit breaker after switching on to a short circuit. Thermal stress to the contact line is unnecessarily increased in these cases. The current transformer can be designed to prevent this effect.

All line test principles have in common that the contact line is energized with a voltage in the range of the supply voltage for a predetermined time. The testing source provides a short circuit impedance limiting the failure current in case of a short circuit to a few percent of the rated current. Detection method and related parameters are fixed by the system designers/infrastructure managers for the system.

A.2.2 Line testing methods

A.2.2.1 Line testing based on voltage criterion

This method uses a test resistor limiting the fault current to values below 10 A. The resistor is connected to the feeder cable of the contact line under test and switched on to the feeding system, for example by a switch-disconnector. The voltage at the contact line is measured and provides the criterion for switching on.

NOTE 1 Typical resistance values are 3,3 kΩ to 5 kΩ leading to maximum test currents of 5,4 A to 3,6 A in 16,7 Hz railways. These resistors are typically indoor mounted, thus the room temperture is influenced by losses dissipated during testing.

A value in the range of 50 % of the nominal supply voltage is typically considered as short circuit free. A voltage transformer on the contact line side is required for this measurement. The result of the voltage measurement is increased by parallel overhead and overhead contact lines already energized and decreased by loads not automatically switched off, for example points heating transformers or train heating.

NOTE 2 It is normal practice in some countries to leave the train heating energized also when parked in depot or yard.

If this method is used the following should be specified:

– resistance of the test resistor;
– voltage value for short circuit free detection;
– test cycle, including individual on and idle times;
– number of cycles with negative result prior to a lock-out;

Temperature monitoring may be used to utilize the thermal capacity of the test resistor.

A.2.2.2 Line testing based on current criterion

A.2.2.2.1 By means of resistors

As in A.2.2.1 this method uses a resistor to limit the short circuit current. The testing current is measured either by a separate current transformer in the testing circuit or by the current transformer of the line feeder circuit. Possible saturation needs to be considered when the current transformer of the line feeder circuit is used.

NOTE Typical resistance values are 400 Ω to 550 Ω leading to maximum test currents of 45 A to 33 A in 16,7 Hz railways. These resistors are typically outdoor mounted due to the big losses during testing.

A value in the range of 20 A to 30 A is typically considered as short circuit free. This method is more robust to loads not automatically switched off due to the lower resistance value used compared to line testing based on voltage criterion.

If this method is used the following should be specified:

– resistance of the test resistor;
– current value for short circuit free detection;
– test cycle, including individual on and idle times;
– number of cycles with negative result prior to a lock-out.

Temperature monitoring may be used to utilize the thermal capacity of the test resistor.

A.2.2.2.2 By means of electronic devices

Modern high voltage power electronic devices are combined into a larger unit including internal control and auxiliary power supply. These units can be operated directly at traction line voltage in the same way as line testing utilizing resistors. The current is limited by internal control. Due to their limited thermal capacity these units are operating with single pulses only. The line test results may be achieved by evaluation of the current over time integral, also the voltage across the open testing device may be considered. The results are typically sent to the control system via a fibre optic cable.

NOTE These devices are typically used in conjunction with feeder related line testing procedures due to the compact design.

A.2.2.3 Other line testing methods

Line testing methods using test resistors to limit the test current produces high losses during line fault conditions. Other line testing methods may therefore also be applied provided they support reliable operation and allow an acceptable level of discrimination between normal and short-circuit conditions.

NOTE Various methods using inductances, capacitances or special transformers have already been investigated as an alternative. None of these alternative methods did show reliable test results for all different operational conditions mainly due to resonance phenomenon.

A.2.3 Line testing procedures

A.2.3.1 General

Line test procedures are one element in the traction power supply system and therefore they need to be coordinated. Especially timing of the test routine in correlation to switching off and re-energization of other constituents, for example traction units needs thorough consideration. This is important to prevent falsification of the test results.

The requirement of IEC 62313:2009, 11.3 should be included.

The main equipment of a resistor-based line testing consists of the test resistor, the instrument transformer and the load switching device, protective devices such as fuses may also be included.

A.2.3.2 Feeder related line testing

Feeder related line test procedures require the full test equipment for each line feeder circuit, an example is given in Figure A.1. Consequently line testing of each feeder circuit is independent from the other circuits and may be performed in parallel. This procedure enables the shortest possible time to restore traction power supply when a number of line feeders has tripped in about the same time.

If this procedure is used the following should be specified:

– Line test method and related parameters as detailed in A.2.2.

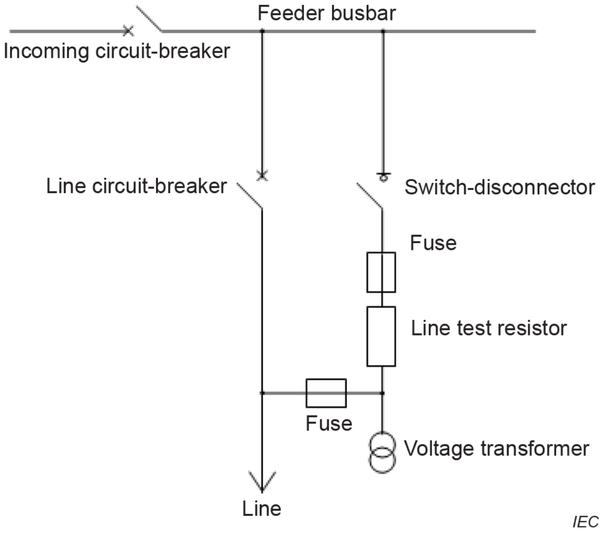

Figure A.1 – Example of a feeder related line testing based on voltage criterion

A.2.3.3 Centralized line testing

Centralized line test procedures require only one set of the main test equipment for each switchgear. The connection to each line feeder is established by a switching device providing isolation, for example a disconnector. Line testing can only be performed on a single line feeder circuit at a time. Any failure in the line testing circuit disables line testing for the full switchgear.

If this procedure is used the following should be specified:

– line test method and related parameters as detailed in A.2.2;
– number of line feeder circuits;
– total number of cycles on any line feeder with negative result prior to a lock-out;
– sequence to be followed if more than one line feeder requests line testing at a time.

Annex B
(informative)

Application guide – Control principles

B.1 Overview

This application guide provides guidance on selecting control principles typical to traction systems to establish a reliable power supply to the contact line or to ensure a defined switching condition.

NOTE Many other principles are well known from public power supply systems and are in many cases not repeated in this annex.

The application of the features described hereafter depends on the control philosophy applied by the system designer or infrastructure manager.

B.2 Closing control

B.2.1 General

Closing control systems are typically used in conjunction with the electrical closing of a switching device and are related to a single switching device. Their effect is to permit or inhibit a closure depending on the status of the system (and plant) and the compliance with specified requirements.

B.2.2 Close inhibit

B.2.2.1 General

Close inhibit is applied to switchgear in addition to interlocking conditions which purely rely on the position of other switchgear.

Close inhibit provides a more comprehensive possibility to prevent switching devices closing under potentially unsafe operating conditions by evaluating electric parameters from the traction system. It is applied especially to circuit breakers.

B.2.2.2 Lock-out

Lock-out may be used in control and protection systems.

It prevents switching on, for example after:

– an operation of a major protection function or
– a pre-set number of unsuccessful trials of a control or protection function.

A major protection function can be the frame-leakage protection which may require visual inspection. By this it deems adequate to immediately lock-out and to only allow local reset. A thermal protection of the contact line which requires time for cooling down may immediately lock-out but may be reset automatically by time either fixed or according to a thermal image.

Reset of the lock-out may be automatically after a set time, by a remote control signal or locally. The means of reset may vary with the initiating function.

If lock-out is used the following should be specified:

– the functions that trigger a lock-out and

– the conditions to reset.

B.2.2.3 Synchronism-check

Synchronism-check prevents switching on while voltage conditions across the open switching device are outside pre-set limits. It may be triggered by a difference in voltage, phase angle or frequency or any combination of them.

Synchronism-check is well known in 50 Hz, 60 Hz and 16,7 Hz traction systems. Main use in 50 Hz and 60 Hz systems is to prevent connecting sections fed with a phase shift of 120 electrical degrees, for example being derived from different phase pairs of the public power network. This situation may also apply to 16,7 Hz traction systems with fixed frequency. Synchronism-check in 16,7 Hz traction systems with varying frequency may be required to reconnect sections of the grid.

If synchronism-check is used the switching on conditions should be specified:

– minimum and maximum voltage;
– maximum difference in voltage amplitude;
– maximum difference in phase angle;
– maximum difference in frequency;
– maximum duration of the synchronism-check.

There may be more than one set of conditions specified for a switching device. Any set of conditions needs to consider the time between detection of a permissible condition and closing of the circuit to prevent impermissible changes of the conditions during the time in between.

B.2.2.4 Under-voltage close inhibit

Under-voltage close inhibit prevents switching on of de-energized circuits which ought to be energized first. It may be used when information provided by the interlocking is not sufficient. Different to synchronism-check voltage conditions are evaluated from one side of the switching device only. The presence of significant voltage, for example induced by parallel lines needs to be considered and discriminated from low supply voltages.

Under-voltage close inhibit may be applied to prevent energization from downstream, for example:

– to incoming circuit breakers to prevent energization of traction transformers, as well as
– to line circuit breakers to prevent energization of the bus bar.

Under-voltage close inhibit may be used in addition to an under-voltage protection which opens a circuit in case of loss of supply voltage.

If under-voltage close inhibit is used the following should be specified:

– minimum pick-up voltage.

There may be more than one set of conditions specified for a switching device.

B.2.3 On-command

On-command can be performed with or without line testing and may be prevented by one or more of the close-inhibit functions as described before.

B.2.4 Auto-reclose

Auto-reclose is mainly applied to line circuit-breakers and its purpose is to automatically restore the traction system when there is a temporary loss of supply. Only a small number of circuit breaker trips is caused by permanent short circuits and an auto-reclose system can enhance the availability of the system.

Auto-reclose may be triggered by a current induced protection function and may or may not include line testing. In combination with line testing the auto-reclose procedure including final lock-out is typically performed by the control system. In the other case it is typically performed by the protection system.

NOTE 1 Without line testing an auto-reclose can produce repeated short circuits. This can result in damage to the contact line system or other infrastructure involved.

Auto-reclose may also be triggered by an under-voltage protection or a control function similar to that. This auto-reclose procedure is typically performed by the control system. The final lock-out needs careful consideration regarding the number of trials and the time delay between loss and reinstitution of the contact line voltage. This is to distinguish between a temporary failure and a shut-down. Nevertheless an auto-reclose after a shut-down may also be intended.

NOTE 2 Auto-reclose triggered by an under-voltage protection is typically used in line feeders of autotransformer stations to reconnect the autotransformer to the system. In most cases auto-transformer stations can automatically be disconnected from the contact line to support isolation of faults.

The procedures for an on-command and auto-reclose may be different, for example line testing is only carried out in combination with auto-reclosing.

NOTE 3 Based on experience and philosophy system designers/infrastructure managers might aim for speeding up energization and therefore assume a traction line to be healthy when performing an on-command.

If auto-reclose is used the following should be specified:

– the functions that trigger auto-reclose and
– the pre-set number of unsuccessful trials ending auto-reclose.

There may be more than one set of conditions specified for a switching device.

B.3 Opening control

B.3.1 General

Opening control is only used in conjunction with the electrical opening of switching devices. It is applied to achieve defined circuit conditions and by this to reduce endangering operating conditions or to increase system availability, for example by speeding up fault finding in the traction power supply system.

Opening control may operate independently and concurrently switching devices at several installations of the traction power supply system. This needs to be coordinated during the design stage.

There is no typical open control sequence in railways, nevertheless de-energization from down-stream may be considered.

B.3.2 Auto-off sequences

B.3.2.1 General

Auto-off sequences are initiated by certain conditions of the supply system and not by a command from an operator in a control room. Aspects of human, plant and operational safety need to be considered when selecting auto-off sequences.

B.3.2.2 Under-voltage off

Under-voltage off is initiated by the loss of supply voltage.

It can be used to:

– speed up fault finding in the contact line system by opening feeding sections to provide predetermined scenarios which can be evaluated by an impedance protection or line testing scheme;

– limit inrush-currents, for example by disconnecting points heating and autotransformers prior to the re-energization of the contact line;

– prevent automatic re-energization of low voltage circuits fed from the traction system.

Different to the under-voltage trip which is intended to respond to failure conditions and may be used as back-up to another protection function, the under-voltage off is used to provide predetermined scenarios.

Under-voltage off may be used for:

– auto-transformer stations;

– points heating and train preheating installations;

– stations with renewable energy directly supplied to the contact line.

If under-voltage off is used the following should be specified:

– drop-off voltage;

– delay time, before operating the switching device;

– response time, for finalizing the sequence.

NOTE 1 The delay time is intended to prevent the function to react to short voltage dips. The response time is intended to coordinate with the re-energization from another location.

Under-voltage off corresponds to the under-voltage close inhibit of the closing control.

It may be combined with an auto-reclosing. Safety aspects to be considered shall also include all possible changes which might occur in between the time of opening and reclosing.

NOTE 2 This time can be very long and changes in the network can provide unintended conditions e.g. applied portable earthing devices.

B.3.2.3 Off due to loss of auxiliary supplies

Auto-off caused by loss of auxiliary supplies can be used when the availability of the circuit potentially switched off is less important than having control of it.

For this function the switching device needs to be operated by a under-voltage release. The under-voltage release keeps the latch when energized and releases the latch when the auxiliary voltage drops. The threshold is determined by the coil's holding voltage.