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Evaluation of incidents on the railway energy system

Evaluation des incidents affectant le système ferroviaire d'alimentation en énergie

Bewertung von Störungen im elektrischen Bahnenergieversorgungssystem



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Summary

This document was prepared by the UIC Energy and Electrical Traction Experts Group of the Rail System Forum to provide all railways with guidelines for the evaluation of energy system incidents based on uniform criteria and common objectives.

The energy system has been divided into its main sub-parts in order to clarify the different incident causes and provide feedback on maintenance activities.

At the same time the classification, statistics and relevant databases regarding main failures have been identified, along with the data to be examined to facilitate the management of energy system incidents, which will in turn allow all the relevant railway sectors/companies to focus their attention and improve their organisational strategies.

1 - General

1.1 - Scope

This leaflet was drawn up to provide all railways with standard guidelines to evaluate the causes of an incident involving the electrification systems and thus identify the relevant responsibilities.

Until now, when an incident occurred, the search for the attribution of responsibilities was confined to the departments of a single company (infrastructure, rolling stock, driving staff). The new railway organisation, based on different operators, and their relevant respective roles mean that an innovative approach is required to manage incidents involving both infrastructure and rolling stock.

Thus the leaflet focuses on the problems caused by failures within the energy system (substations, overhead contact line, pantographs, etc.), and classifies the responsibilities shared by the railway sectors/companies.

The matter is also developed in conformity with the "Technical Specifications for Interoperability" (TSI), with the aim of defining the requirements to be fulfilled by IIM and RU (see [List of abbreviations - page 45](#)) to achieve the interoperability of rolling stock in different European countries, firstly for the high speed network and then for conventional lines.

As a consequence, the document deals with the recording and analysis of failures affecting the OCL, both directly involving the contact line and produced by lack of energy in substations or power installations, under the direct or indirect responsibility of the IM.

Special attention is required for the investigation of events involving rolling stock and the relevant RU, with a particular focus on OCL/pantograph incidents.

To continue to pursue the objectives expected, the IMs have first to optimise the databases regarding the energy installations (localisation, performances, characteristics, maintenance done, previous failures, etc.) to input the investigation into all the subsequent analyses and considerations.

If other companies are involved, such as RUs, IMs must accept their honest contribution to help clarify causes and responsibilities, on the basis of procedures and guidelines agreed.

After defining causes and responsibilities for the incidents which have occurred, suitable statistics have to be input and updated to allow the different sectors/companies involved improve their organisational strategies and take effective countermeasures.

This leaflet is strictly linked with others prepared by the same UIC expert group and published by UIC on maintenance guidelines, diagnosis aspects and workers' safety, including:

- *UIC Leaflet 791-1*, (see [Bibliography - page 46](#)) which defines the main parameters to be checked and observed and the maintenance activities to be carried out in order to ensure the expected OCL performance;
- *UIC Leaflet 791-2*, (see [Bibliography - page 46](#)) which gives information on the diagnostic systems in order to characterise the behaviour of the OCL in static or dynamic conditions;
- *UIC Leaflet 791-3*, (see [Bibliography - page 46](#)) which provides guidelines for improving the safety of the personnel working on or in the vicinity of OCLs.

1.2 - Field of application

The leaflet can be applied to all energy systems operating at the following voltages (according to *EN 50163*, see Bibliography - [page 46](#)):

- 1.5 kV and 3 kV DC,
- 15 kV and 2 x 15 kV- 16 2/3 Hz,
- 25 kV and 2 x 25 kV - 50 Hz.

2 - Definitions and abbreviations

The main definitions required in this leaflet are all those referring to OCL as reported in *point 2 and the following of UIC Leaflet 791-1* which refer to energy system and general aspects concerned.

2.1 - General definitions

Energy system

All the electrical installations needed to supply an electric traction network including sub-stations, contact lines, return circuit and pantographs, as set out in the Technical Specifications for Interoperability (energy sub-parts).

Electric traction lines

Electric lines equipped to transmit electric power from substations to trains.

Electro dispatching

A central site equipped for remote command and control of electric traction installations from where shift operators control the energised state of installations and authorise their switching off at the request of the OCL personnel.

Substation (ESS)

Installation, the main function of which is to supply a contact line system, at which the voltage of a primary supply system, and in certain cases the frequency, is converted to the voltage and frequency of the contact line.

Overhead line

Electric line consisting of conductors supported above ground by means of insulators and appropriate supports.

Contact line

Conductor system to supply electrical energy to vehicles through current collection equipment.

Overhead Contact Line (OCL)

Contact line placed above the upper limit of the vehicle gauge and supplying vehicles with electrical energy through pantographs.

Item

Any part, component, device, sub-system, functional unit, equipment or system (consisting of hardware, software or both) that can be considered individually.

Incident

Any unexpected or unwanted event. This term includes accidents (as defined in "*European Safety Directive 49/2004*", see Bibliography - [page 46](#)) and failures.

Failure

The termination of the ability of an item to perform a required function. After failure, the item has a fault. "Failure" is an event, as distinguished from "fault" which is a state.

Fault

The state of an item characterised by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external energy supply.

Transient fault

A fault of an item which persists for a limited time duration following which the item recovers the ability to perform a required function without being subjected to any corrective maintenance action.

Permanent fault

A fault of an item that persists until a corrective maintenance action is performed.

Presumed fault

A hypothetical fault, supposed or communicated in some way, which has not really occurred.

Manufacturing failure (manufacturing fault)

A failure (fault) due to non-conformity during manufacture of the design of an item or to specified manufacturing processes.

Design failure (design fault)

A failure (fault) due to inadequate design of an item.

Maintenance

Combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform a required function.

Maintenance interventions

Combination of all technical actions (excluding administrative and supervision actions) intended to retain an item in, or restore it to, a state in which it can perform a required function.

Inspections

Activities intended to monitor the state of the overhead line and to evaluate the extent of maintenance work required, such as foot inspections, test car runs, observation of pantograph reaction, etc. The inspections are usually undertaken with the overhead line switched on.

Measurements

Activities carried out to measure the main parameters (geometrical, mechanical and electrical), which characterise the condition and the reliability state of the OCL system. Measurements may require track possession or for the electrical line to be switched off.

Measurements runs

Activities intended to provide evidence of the static as well as dynamic behaviour of the OCL system. The dynamic behaviour is generally determinate at the maximum permissible line speed. Measurement runs are usually made with the overhead line live.

Supervision (monitoring)

Activity performed either manually or automatically, intended to observe the state of an item.

Examinations

Activities undertaken to check those parts of the installations which can only be thoroughly inspected with the overhead line switched off and earthed. They are arranged for specific areas, when required, as a result of inspections, measurement runs, short circuits and disruptions. Generally there is no prescribed frequency. Examinations may also be made on a spot check basis.

Preventive maintenance

Maintenance activities carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item.

Scheduled maintenance (hard time maintenance)

Preventive maintenance carried out in accordance with an established time schedule.

Unscheduled maintenance (on condition maintenance)

Maintenance activities carried out, not in accordance with an established time schedule, but after receipt of an indication regarding the state of an item (inspections, measurements, etc).

Corrective maintenance

Maintenance activities carried out after fault recognition and intended to put an item into a state in which it can perform a required function.

Fault diagnosis

Actions taken for fault recognition, fault localisation and cause identification.

Fault recognition

The event of a fault being recognised.

Fault localisation

Actions taken to identify the fault sub-item or sub-items at the appropriate indenture level.

Fault correcting

Actions taken after fault localisation to restore the ability of the faulty item to perform a required function.

Fault repair

The part of corrective maintenance in which manual actions are performed on the item (manual activity to repair faults).

Fault correction time

That part of active corrective maintenance time during which fault correction is performed.

Fault localisation time

That part of active corrective maintenance time during which fault localisation is performed.

Repair time

That part of active corrective maintenance time during which repair actions are performed on an item.

Deferred maintenance

Corrective maintenance which is not immediately initiated after fault recognition but is delayed in accordance with given maintenance rules.

Extraordinary maintenance

Interventions planned to re-establish the reliability of installations, recovering long periods of poor or non-existent routine maintenance.

Renewals

Interventions planned to improve the performance of operating installations through large-scale works, such as renewal of components, adjustments of particular functional aspects and/or improvements of operating characteristics.

Maintainability

The ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources.

Reliability

The ability of an item to perform a required function under given conditions for a given time interval.

Availability

The ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided.

Track possession

Availability of the track for works.

Track possession duration

Length of time of the track possession.

Timetable for maintenance

Suspension of traffic on the tracks for maintenance.

2.2 - Main abbreviations

The main abbreviations normally used in this leaflet are in the List of abbreviations - [page 45](#).

3 - Identification of the item failed

The incidents to be defined or investigated are generally triggered by the breaking or improper operation of a component of the energy system belonging to the OCL or to the ESS, taking into account that the causes of the incident could be triggered by many different reasons, internal or external to the IM's field of activity.

In order to examine these incidents, it may be opportune to start with the items (parts, apparatus, components or devices) whose failure causes them or amplifies their consequences.

The main parts or devices to be taken into account for ESS and power supply installations are indicated in [point 3.1](#) below, while for the OCL parts and components the items used for maintenance aspects (see *UIC Leaflet 791-1*) are referred to and summarised in [point 3.2 - page 9](#).

3.1 - ESS parts and elements

When incidents are due to a lack of energy supply to trains, they are classified as belonging to the ESS installation, and relate to the failure or improper operation of an item in one of the following groups.

3.1.1 - Equipment and machinery

This group includes all the machinery and apparatus installed in the ESS or power centres, in HV and MV ([see List of abbreviations - page 45](#)) namely:

- high voltage supply,
- high voltage and medium voltage measurements apparatus,
- high voltage circuit breakers and sectioning devices,
- transformers,
- converters,
- filters,
- AC or DC medium voltage supply,
- AC or DC medium voltage circuit breakers and sectioning devices,
- surge arresters,
- earthing system.

3.1.2 - Protection and control-command devices

This group includes systems and devices, hardware and software, subsidiary and essential for the correct operation of the machinery and apparatus installed in the ESS or power centres, namely:

- measuring devices,
- control systems,
- protection systems,
- auxiliary systems,
- electro dispatching.

3.2 - OCL parts and elements

When the incidents occur along the OCL, it is necessary to identify in which part of the OCL they were generated, with reference to the following groups of elements.

3.2.1 - Supports and suspensions

This group includes all types of earthed structures supporting overhead contact lines, namely:

- masts and portals,
- head span suspensions,
- cantilevers and suffix posts for tunnel cantilevers,
- stays,
- foundations,
- other earthed parts connected to the support (excluding return and earth circuits).

Suspensions include all the parts installed between supports and conductors (including insulators), namely:

- supporting and registering elements,
- suspension clamps,
- hinged cantilevers,
- insulated cantilevers,
- tie bars,
- pull-offs,
- registration arms,
- suspension insulators.

3.2.2 - Spans

Spans include conductors and other live elements between two subsequent supports, namely:

- catenaries,
- contact wires,
- contact wire splices,
- connectors,
- stitch wires,
- links between catenaries and wires,
- droppers and other elements,
- feeders,
- clearances (mechanical and electrical),
- gauge (obstacles).

Special spans require more attention than ordinary spans. These include spans formed by several conductors in parallel or crossing over each other, spans approaching tensioning points, and spans over level crossings, among others:

- overlap spans,
- overhead crossings,
- neutral sections,
- overhead line over level crossings,
- section insulators,
- sectioning points.

3.2.3 - Anchors and tensioning devices

This group includes all the elements normally used to maintain the OCL conductors in mechanical tension, namely:

- terminal fittings,
- automatic tensioning devices,
- mid-point anchors,
- spring tensioners,
- balance weight tensioners.

3.2.4 - Sectioning and feeding points

This group includes all equipment mounted on supports to switch or protect the OCL or on the OCL for detection purposes, namely:

- disconnectors, switches and other apparatus,
- autotransformers,
- voltage measurement apparatus,
- automatic/handler devices,
- electrical connections between disconnectors and conductors.

3.2.5 - Return, earthing and protection circuits

This group is composed of the elements forming the intended path for the traction return current, namely:

- connections between ground and return circuit,
- elements of electrical continuity for the rails,
- links to the impedance bond for return current,
- return conductors.

The earthing and protection circuits contain the conductors and the connected elements and devices adopted to protect people from accidentally energising structures, namely:

- ground wires,
- connections between supports and ground or rail,
- voltage limiters, diodes,
- lightning arresters,
- grounding rods.

3.2.6 - Others

This group encompasses all the remaining parts, components and elements of the OCL or auxiliary required for safe operation, namely:

- transformers (auxiliary - measurement),
- warning signals,
- signs,
- shields.

4 - Information to be obtained from energy system archives

After having identified the items that have failed, it is necessary to collect all relevant information which may help to carry out the investigation in the best way possible.

For this reason, the items of the traction system installations (seen in [point 3 - page 8](#)), which need to be taken into account for failure investigations, must be easily obtained from the archives and databases with which IMs manage their installations and related activities.

Depending on the case, the information to be acquired may include some or more of the following points:

- location and/or reference numbering,
- main performances by project,
- main technical, geometrical and electrical characteristics, type and size and so on,
- setting values,
- date of first installation or last replacement,
- parameter measurements checked during observation, fault diagnosis runs, etc.,
- condition verified by inspections and observations,
- date and type of interventions,
- data of failure occurrences with relevant notes.

4.1 - Location references

The information must contain the minimum indications needed to localise the objects along railway lines. In particular it is important to know where exactly each object is located, for instance:

- to which asset or track it belongs,
- whether it is in a station or on a stretch of line,
- whether it is inside a substation or in other electrical locations,
- its mileage or distance from a known location,
- references of the support, the span and the tensioning length to which it belongs,
- the extension of the span and of the tensioning length to which it belongs,
- its number or code,
- electrical distances from ESS or switching and protection cabins.