Electrification and Power Supply

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RAILWAY POWER SUPPLY

- Electrification systems in Europe
- Electrification design criteria – Standard of Interoperability
- Italian High Speed line example
- Power supply for signalling
Railway power supply: an integrated system to feed the train

HV POWER LINES

SUBSTATIONS

CONTACT LINE

TRAIN

REMOTE COMMAND AND CONTROL SYSTEM TO GUARANTEE A GOOD OPERATION
Main advantages: electrical versus diesel traction

- greater power/locomotive weight ratio;
- less pollution; electricity may also be obtained from renewable sources;
- lower locomotive maintenance, personnel and energy costs;
- greater acceleration and therefore faster commercial speed with the same maximum speed.
European electrification systems for conventional lines
European electrification systems for high speed lines

- 25kV ac 50 Hz started in France and developed in Belgium, Spain and Italy supplied directly from the high voltage national provider network at industrial loads frequency;

- 15kV 16 2/3 Hz developed in Germany and supplied from dedicated high voltage network at “railway frequency”

Both of these systems are referred to the Technical Specification of Interoperability (TSI) for Energy Systems issued by the European Union.
Electrification design criteria

TSI of the energy subsystem defines the main features of the electric traction system in order to be certified as interoperable.

The main aspects to be evaluated in the electrical design should be:

- Quality of the power collection and voltage to the train during operation
- Quality of mechanical interaction between contact line and train pantograph at rated speed
- Reliability, availability during operation
- Maintainability and management of the electrical installations
Quality of the power collection

The quality of the power collection during operation should be evaluated with the voltage values calculated by integrated simulation programs based on the train circulation.

Power absorbed by Train

Voltage Calculation

\[ U_{\text{mean useful}} = \frac{\sum_{i=1}^{n} \frac{1}{T_i} \int_0^{T_i} |U| |P| \, dt}{\sum_{i=1}^{n} \frac{1}{T_i} \int_0^{T_i} |P| \, dt} \]

Voltage Limits

<table>
<thead>
<tr>
<th>Power supply system</th>
<th>HS TSI lines</th>
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<tbody>
<tr>
<td>a.c. 25 000 V 50 Hz</td>
<td>Zone and Train</td>
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<tr>
<td>a.c. 15 000 V 16.7 Hz</td>
<td>22 600</td>
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<td>14 200</td>
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Quality of mechanical interaction

The quality of mechanical behaviour of the contact line with the train runs at maximum rated speed should be simulated and measured before operation.
Reliability, Availability during operation

The Reliability and Availability of the system have to guarantee normal operation in case of substation or a part of the supply system fault.

Redundancy of the power supply system architecture in case of one substation out of service.

Redundancy of the substation plant in case one component is out of service.
Maintainability and management of electrical installation

Command and Control of all the electrical installations in the “Remote Control Room” in order to have:

- Control of the electrical system according to the circulation of the trains and reconfiguration in case of fault or maintenance
- Diagnostic data collection to prevent faults in the equipment, the out of service of plants and organize the maintenance interventions
The 2x25 kV Electric Traction System: example of the Italian supply system

Rated railway traffic to be supplied:

- Train Type: ETR500
- Rated Power: 12 MW
- Speed: 187.5 mph (300 km/h)
- Total mass: 771.6 ton (700 t)
- Frequency: 5 min.

Advantages of the 2x25 kV Electrical System:

- Possibility to supply power to high-traffic trains with a great distance between ESS
- Low voltage drops
  - Less number of ESS
  - Less environmental impact
- Smaller inductive effect on the conductors in parallel with the line and on the people
Main Characteristics of the 2x25 kV Italian Power Supply System

Supply system:
- Substation with 150/25/-25 kV transformer
  - Average distance 31 mi (50 km)
  - P=2 x 60 MVA
- PP with +25/0/-25 kV autotransformers
  - Average distance 7,4 mi (12 km)
  - P=2 x 15 MVA
- Contact line:
  - Messanger wire = 0,186 in² (120mm²)
  - Contact wire = 0,232 in² (150mm²)
  - Contact wire height = 17,38 ft (5,3 m)
Power Supply of ERTMS

- Every shelter has a double energy source.
- 1kV lines are supplied by a NO-BREAK source in technological building.
- Electrical system has 3 phase with earthed neutral wire.
- Shelters contain electronic equipment for GSM radio block center.
Thank you for your attention.