11.1 General

The electric energy supply on a railway line needs two conductors on a single phase[1] or direct current. (sect. 9.6) On of them is constituted by the rails; the second, isolated from rails can be :
- « aerial », above the vehicle ;
- ground fixed, lateral or on track center (not shown).

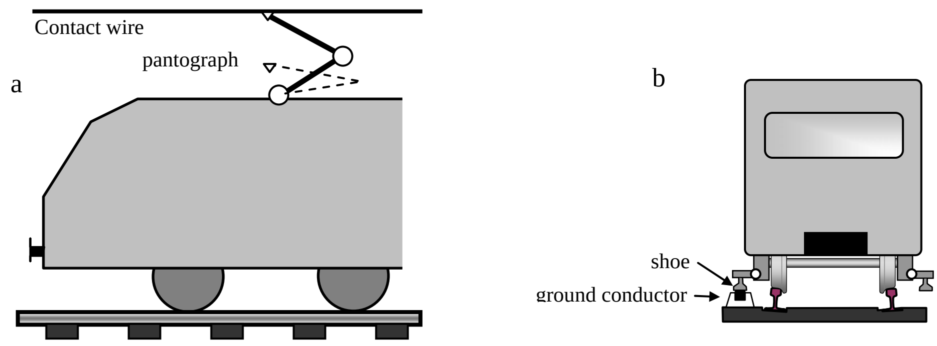


Fig. 11.1 Aerial and lateral current catch.

11.2 Dynamics

The aerial line is formed by a copper-wire, strained between isolators carried by masts.

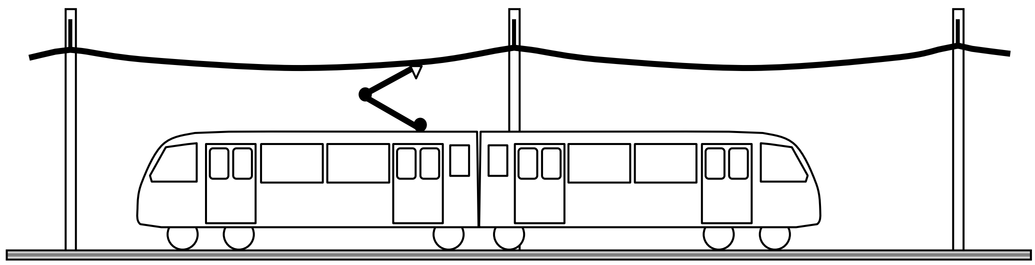


Fig. 11.3 Aerial contact line

At more than a certain speed, 60 km/h approximately, the capture quality needs a wire height above rail as regular as possible. This goes to eliminate the natural arrow of chain. Three solutions are possible:
- multiply the number of supports in order that the wire strength permit to neglect the arrow between supports. Solution incompatible from economical sight, and also the aesthetical one.
- increase the wire section until the wire strength permit to neglect the arrow between supports. In some cases – tunnels as example – this solution is used and called « rigid wire ».
- introduce intermediate supports, called « pendulum », between the contact wire and a carrier cable fixed on mast by isolators. This association is largely used and is called « catenary suspension » shown on fig 12.4.

[1] Three conductors are necessary for a three-phase power supply, as in Italy until sixties.

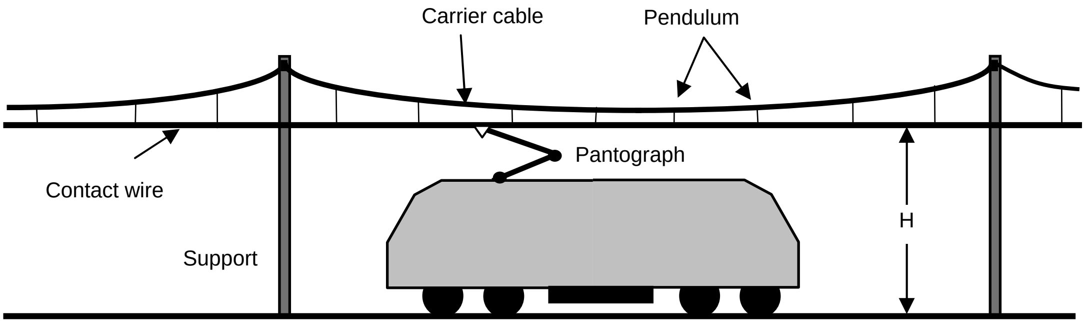


Fig. 11.4 Principle schema of a contact line with catenary suspension.

11.3 Pair: contact line – pantograph

From the good adequacy between dynamics properties of pantograph and contact wire depend the good current capture and the life cycle of the contact wire and contact shoe. The pantograph has to press with sufficient force to get a permanent contact to the wire, without cause a too big rising, with the risk to lose contact after the next fixation point.

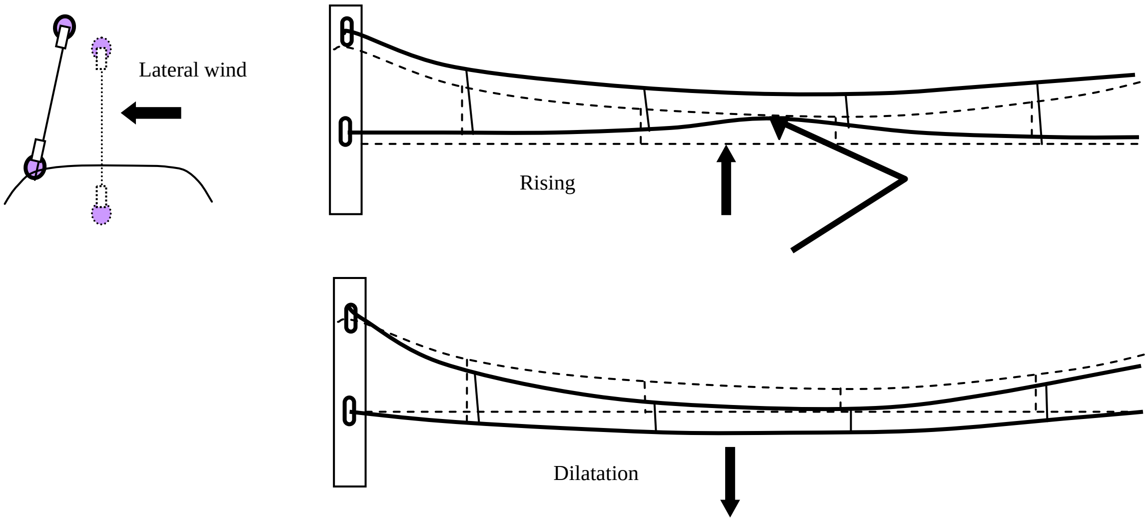


Fig. 11.5 Factors influencing the dynamic behavior of the contact line.

11.4 Technology

The circular section of the contact wire has two grooves for suspension claws (fig 11.9). From the voltage supply and the requested power, the wire section varies between 107 mm² and 150 mm². Section can be cylindrical or receive a flat at its bottom to increase the contact surface between it and the shoe.

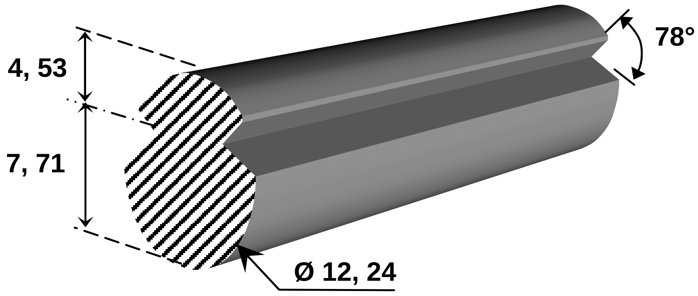


Fig. 11.9 Example of contact wire

The carrier cable has to hold the mechanical strain, it is fixed at supports by isolators. To reduce the electric resistance of the line, the contact wire and the carrier cable are connected in parallel, regularly by copper shunts, or by each pendulum, called *connecting pendulum*. The catenary is specified by its « equivalent copper » section noted in mm². The different electrification systems use specific construction modes, depending from the transported current intensity.

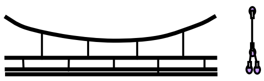
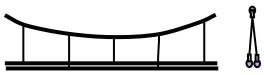
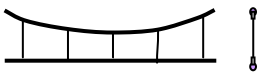
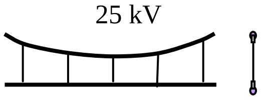
Contact line	Carrier	Contact wire	Equivalent copper section	Weight on linear meter
« tramway » 		Hard copper 107 mm²	107 mm²	1,52 kg
1500 V compound 	Principal : bronze - Sn 116 mm² Auxiliaire : 143 mm²	Hard copper 2 × 150 mm²	480 mm²	5,309 kg
3000 V simple 	Copper 120 mm²	Hard copper 2 × 100 mm²	320 mm²	2,85 kg
15 kV 	Steel-copper 92 mm²	Copper 1 × 107 mm²	189 mm²	1,85 kg
25 kV 	Al + steel 36 mm²	copper – Mg (or Sn) 1 × 150 mm²	147 mm²	1,334 kg

Tableau 11.12 – Main characteristics of some catenary types.

In plan view, the contact line installation needs a zig-zag from the center of track, to vary during the time the contact point on the contact shoe. A constant point would lead the sawing of the shoe.

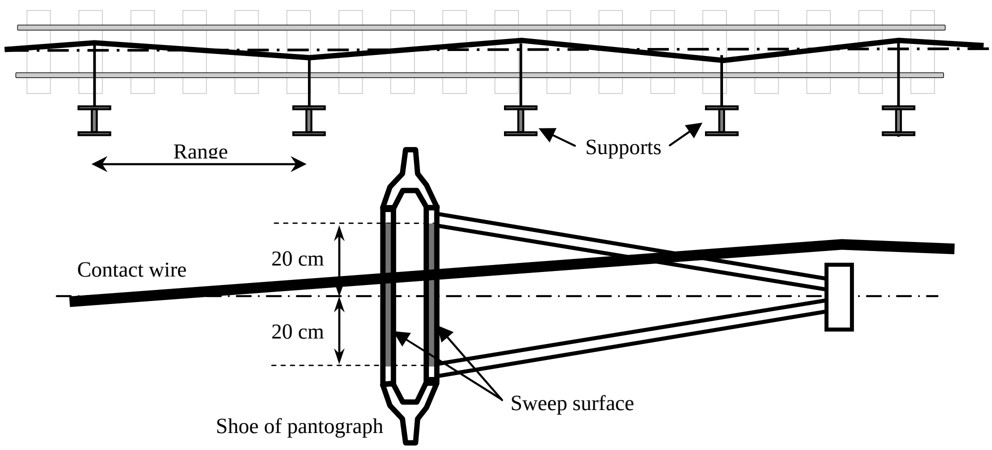
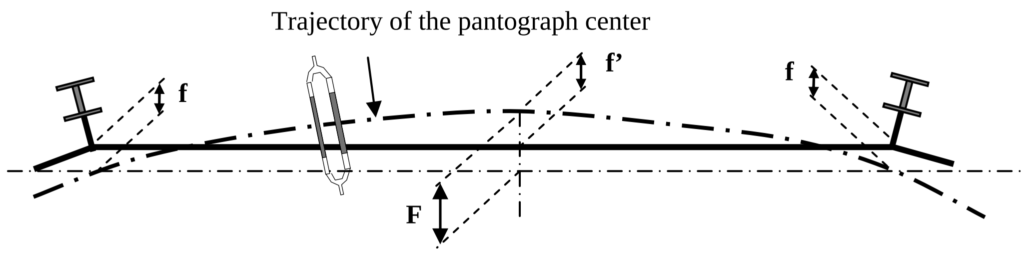


Fig. 11.14 Periodical misalignement on a right line.

In curves, the supports spacing must be compatible with the shoe width, including the possible transversal movements.



F : curve arrow in the middle of range = $a^2/8R$
f : misalignment at support
f' : misalignment in the middle of range

Fig.11.15 Curve misalignment

11.5 Current catching devices

Today, the current catching is done by « lights » pantographs.

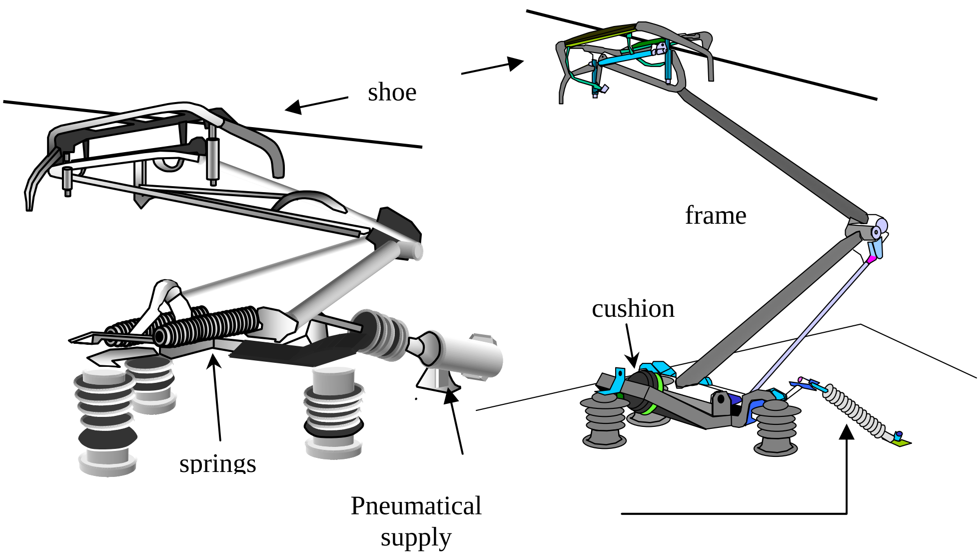


Fig. 11.28 – Two examples of pantographs