Some basic principles of railway braking

Railway braking relies on some basic principles that shall be known and understood to then better address the ins and outs of the design of brake systems for railway trains.

Three basic principles exist:

- The brake shall be automatic.
- The brake shall be continuous.
- The brake shall be inexhaustible.

The brake shall be automatic

Automaticity is certainly the most important design principle for a railway brake system. Indeed, a railway train is composed of vehicles or trainsets linked together by means of couplers (standard screw coupler, permanent bar or automatic coupler). However such devices have mechanical limits which can, in certain circumstances, be overpassed following high longitudinal forces consecutive to traction or brake forces variations. This can lead to a breakage of couplers, thus to a split of the train in two or several portions. If the train is on an up-hill gradient, the rear part – where no driver took place – shall have to be stopped than kept at standstill: thus braking shall be required, if possible automatically.

A brake system is considered as automatic if, when the control line that is goes all along the train is broken at any point in the train, braking is automatically initiated on both portions of the train.

It shall be noted that except breakage of a coupler (evidently leading to breakage of the control line by pull-out of the pneumatic or(and) electric links between vehicles), automaticity of the brake system makes it possible, in case of accidental breakage of the control line, to initiate braking on the whole train, forcing the driver to stop and remedy the problem or ask for rescue: this will avoid the train to be insufficiently braked afterwards when it will be necessary to slow down or stop.

This is how the pneumatic controlled brake is automatic: when the Brake Pipe is broken (in particular after pull-out of flexibles hoses following breakage of a coupler), it is vented on both portions of the train on each side of the breakage, leading *de facto* to the initiation of braking on all vehicles by means of the distributor valves and their local reserves of energy (Brake Auxiliary Reservoirs). For more details on the operation of the pneumatic brake, see the corresponding pages.

The brake shall be continuous

Those who had the courage to read the railway braking history could have understood, through the different systems developed since the beginning of railways, what continuity of brake system means.

A brake system is considered as continuous if each vehicle in the train is equipped with a device that ensures braking of this vehicle. Braking control can be ensured locally by an agent present on each vehicle or at regular intervals (and then controlling braking on several vehicles), or centrally by the driver from the front vehicle, by mean of a control line that extends all the length of the train.

As we have seen, most of the first developed brake systems were not continuous, as only some of the vehicles in the train were braked. But it quickly appeared that continuity was absolutely necessary, in particular to take into consideration the regular increase of trains weights and speeds compared to the braking capacities of the vehicles, which were necessarily limited.

Today, only a local isolation of brake equipment following a failure on a vehicle can impede this continuity principle, but this does not endanger safety as long as this isolation remains… an isolated case!

It shall be noted that we speak also about continuity of the control line (in particular of the Brake Pipe of the pneumatic brake: see page on this topic) to indicate that this control line is effectively active on the whole length of the train, and not only on a portion of the latter.

The brake shall be inexhaustible

In some configurations, i particular on long downhill gradients (e.g. Maurienne or Saint Gothard), the brake system can be frequently solicited to manage the train speed. During these repeated solicitations, the brake system shall keep the same efficiency at each application: it shall be inexhaustible.

The inexhaustibility only concerns the control portion, and not the components that dissipate energy (brake shoes, brake discs and pads). For the latter, the dissipation capacity is necessarily limited and cannot be easily regenerated, and only driving use or procedures can make it possible to use them in a way that they permanently keep their optimal efficiency: the problem is exactly the same when you drive down the mountain with your automobile…

Thus the brake shall be designed in such a way that every time brake release is required, brake equipment shall be ready for a new application with nominal performances. This concerns more particularly the recovery of the local reserve of energy that is necessary for braking.

In the case of brakes with pneumatic actuation, brake equipment shall be designed to guarantee, at every brake release, the filling of the Auxiliary Reservoir up to a pressure that is sufficiently high to guarantee that the maximum brake pressure required in the brake cylinders can be reached during the next brake application.

A complementary notion

Provided that railway trains are designed to transport passengers or goods, the latter shall have some regards (comfort for the first and integrity for the second). This is the reason why the brake system shall guarantee their safety while ensuring a regular and not “traumatizing” brake application, at least for service braking… It is then considered that the brake shall be quite.

Here comes the notion of jerk, which characterizes the change in the deceleration in relation to the time (for mathletes: it is the first derivation of the deceleration in relation to the time, or the second derivation of the speed in relation to the time). Indeed, more than the deceleration level by itself the deceleration change is damaging. Thus brake equipment include provisions that ensure limitation of this jerk, by introducing ramps that limit increase or decrease of brake force (thus of deceleration).

Those who regularly use or have used tramcars or some metros (in particular rubber tires metros) will mind that they already lived quite unpleasant emergency braking experiences that crammed all passengers on a very small surface at front end of the vehicle. To those, it shall be answered that jerk limitation always exists, but that in some configurations it is set to high values, considering the necessity to be quickly in braking at maximum deceleration as potential obstacles (pedestrians of cars in the case of a tramcar) only let few space to react.