Brake system architecture and main technical aspects

The brake system of a railway train, which can be a freight train, a TGV as well as a tramcar, is always architectured in the same way, the architecture resulting of the principles mentioned previously.

This architecture is divided in two main portions:

- Train braking control: this corresponds to all devices which aim is to generate and transfer the brake demands issued by the driver, the latter being a human being, an automatic train control device or a safety equipment (e.g. “dead man’s device”).
- The braking control locally to each vehicle, bogie or axle (brake actuation).

Train braking control

The train braking control uses two technologies:

- Pneumatic control ➔ This technology is commonly used on “main lines” rolling stock as well as on freight trains, regional trains and some suburban trains.
- Electric control ➔ This technology is used on urban rolling stock (tramcars, metros) and most of the suburban trains (RER or suburban EMUs), as well as on a growing number of regional rolling stocks.

Local braking control (brake actuation)

Braking control at local level is characterized by the type of energy used to ensure the brake actuation (in brake cylinders or calipers):

- Pneumatic energy ➔ Brake actuation is performed by means of a compressed air pressure.
- Hydraulic energy ➔ Brake actuation is performed by means of a hydraulic pressure.
- Electromechanical energy ➔ Brake actuation is performed by means of a spring which force is modulated by means of a step by step electric motor.

Brake system architecture

The brake system architecture then uses a combination of a train braking control type and of one of the energy types mentioned above. All combinations are *a priori* possible, but only some of them are effectively in use. The combinations in use in the railway field are the following:

- Pneumatic brake ➔ Train braking control is of the pneumatic type and the energy used for brake actuation is also pneumatic.
- Electropneumatic brake ➔ Train braking control is of the electric type and the energy used for brake actuation is pneumatic.

- Electrohydraulic brake ➔ Train braking control is of the electric type and the energy used for brake actuation is hydraulic.
- Electromechanical brake ➔ Train braking control is of the electric type and the energy used for brake actuation is mechanic.

Particular constraints

Selection among above mentioned combinations refers to several criteria. Main are the following:

- Compatibility with the existing rolling stock ➔ Necessity to enable coupling in normal operation or(and) for on-line rescue operations can deeply influence the choice for the train braking control type (pneumatic or electric). This criterion explains why most of the “main lines” rolling stocks (TGV, locomotives and coaches) and freight rolling stocks (locomotives and wagons) are equipped with the pneumatic control, in order to enable interoperability between vehicles on a Network, and exchanges of vehicles between Networks.
- Response time ➔ Most of the urban rolling stocks, in particular those operated with a fully or partially automatic control system, require very short response times in order to ensure a high accuracy in vehicle’s position regulation, as well as a high reactivity when needed (e.g. tramcars). This is the reason why these rolling stocks use only the electric braking control which ensures a quasi-immediate response time, where the pneumatic control depends on the propagation times of pneumatic demands (see further). In addition, the selection of actuation energy that will be used can depend on the required response times: pneumatic energy provides indeed notably longer response times than those provided by hydraulic energy, this being due to the nature of the fluid that is used (compressibility of air vs incompressibility of hydraulic fluids).
- Maintenance costs ➔ Pneumatic energy used for brake actuation is cheaper and more tolerant to small failures (leakages) than the hydraulic one. Moreover, the used fluid (compressed air) is freely available and cheap to produce. This is the reason why it is the far most commonly used.
- Available space ➔ Hydraulic energy makes it possible to generate very high brake forces with actuators (calipers) that are very compact, thanks to implemented very high pressure.
- Weather conditions ➔ Pneumatic energy presents a limit for low temperature which is around -25°C, when the hydraulic energy enables operation almost nominally down to around -40°C. Indeed, more than the fluid by itself, the components that are used are less resistant to low temperature (increase of leakage rates in particular).

You’ll find in the other pages some more details on the operating principles of each type of brake.