# Vacuum Braking System-Review Paper

**Shoban Babu.M [1], Nandha Kumar.C [2] and Arul Kumar.K [3]**

[1, 2] *Department Of Mechanical Engineering (2nd Year), Government College Of Engineering-Chettigharai, Dharmapuri-636 704, Tamil Nadu, India*

[3] *Assistant Professor-Department Of Mechanical Engineering, Government College Of Engineering-Chettigharai,Dharmapuri-636 704,Tamil Nadu, India*

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**Abstract -** *The vacuum brake was, for many years, used in place of the air brake as the standard, fail-safe, train brake used by railways. Pneumatic braking systems use compressed air as the force used to push blocks on to wheels. The vacuum brake system is controlled through a brake pipe connecting a brake valve in the driver's cab with braking equipment on every vehicle. A vacuum is created in the pipe by and ejector or exhauster. The ejector removes atmospheric pressure from the brake pipe to create the vacuum using steam on a steam locomotive, or an exhauster using electric power on other types of train. With no vacuum the brake is fully applied. The vacuum in the brake pipe is created and maintained by a motor-driven exhauster. The exhauster has two speeds, high speed and low speed. The high speed is switched in to create a vacuum and thus release the brakes. Slow speed is used to keep the vacuum at the required level to maintain brake release. Vacuum against small leaks in the brake pipe is maintained by it.*

***Key Words***: Vacuum brake; pneumatic brake; exhauster; atmospheric pressure; steam locomotive

## 1. INTRODUCTION

A moving train contains energy, known as kinetic energy, which needs to be removed from the train in order to cause it to stop. The simplest way of doing this is to convert the energy into heat. The conversion is usually done by applying a contact material to the rotating wheels or to discs attached to the axles. The material creates friction and converts the kinetic energy into heat. The wheels slow down and eventually the train stops. The material used for braking is normally in the form of a block or pad.

The vast majority of the world's trains are equipped with braking systems which use compressed air as the force used to push blocks on to wheels or pads on to discs. These systems are known as "air brakes" or "pneumatic brakes". The compressed air is transmitted along the train through a "brake pipe". Changing the level of air pressure in the pipe causes a change in the state of the brake on each vehicle. It can apply the brake, release it or hold it "on" after a partial application. The system is in widespread use throughout the world

An alternative to the air brake, known as the vacuum brake, was introduced around the early 1870s, the same time as the air brake. Like the air brake, the vacuum brake system is controlled through a brake pipe connecting a brake valve in the driver's cab with braking equipment on every vehicle. The operation of the brake equipment on each vehicle depends on the condition of a vacuum created in the pipe by an ejector or exhauster. The ejector, using steam on a steam locomotive, or an exhauster, using electric power on other types of train, removes atmospheric pressure from the brake pipe to create the vacuum. With a full vacuum, the brake is released. With no vacuum, i.e. normal atmospheric pressure in the brake pipe, the brake is fully applied.

The pressure in the atmosphere is defined as 1 bar or about 14.5 lbs. per square inch. Reducing atmospheric pressure to 0 lbs. per square inch, creates a near perfect vacuum which is measured as 30 inches of mercury, written as 30 Hg. Each 2 inches of vacuum therefore represents about 1 lbs. per square inch of atmospheric pressure.

The vacuum in the brake pipe is created and maintained by a motor-driven exhauster. The exhauster has two speeds, high speed and low speed. The high speed is switched in to create a vacuum and thus release the brakes. The slow speed is used to keep the vacuum at the required level to maintain brake release. It maintains the vacuum against small leaks in the brake pipe. The vacuum in the brake pipe is prevented from exceeding its nominated level (normally 21 Hg) by a relief valve, which opens at the setting and let air into the brake pipe to prevent further increase.

## 2. EVOLUTION OF BRAKING SYSTEM IN RAILWAYS

In the earliest days of railways, trains were slowed or stopped by the application of manually applied brakes on the locomotive and in brake vehicles through the train, and later by steam power brakes on locomotives. This was clearly unsatisfactory, but the existing technology did not offer an improvement. A chain braking system was developed, requiring a chain to be coupled throughout the along the train, but it was impossible to arrange equal braking effort entire train.

A major advance was the adoption of a vacuum braking system, in which flexible pipes were connected between all the vehicles of the train, and brakes on each vehicle could be controlled from the locomotive. The earliest scheme was a simple vacuum brake, in which vacuum was created by operation of a valve on the locomotive; the vacuum actuated brake pistons on each vehicle, and the degree of braking could be increased or decreased by the driver. Vacuum, rather than compressed air, was preferred because steam locomotives can be fitted with ejectors devices that create vacuum without moving parts.

The simple vacuum system had the major defect that in the event of one of the hoses connecting the vehicles becoming displaced (by the train accidentally dividing, or by careless coupling of the hoses, or otherwise) the vacuum brake on the entire train was useless.

## 3. PRINCIPLE PARTS OF THE VACUUM BRAKING SYSTEM

### 3.1 Driver's Brake Valve

The means by which the driver controls the brake. The brake valve will have the following positions: "Release", "Running", "Lap" and "Brake On". There may also be a "Neutral" or "Shut Down" position, which locks the valve out of use. The "Release" position connects the exhauster to the brake pipe and switches the exhauster to full speed. This raises the vacuum in the brake pipe as quickly as possible to get a release.

In the "Running" position, the exhauster keeps running but at its slow speed. This ensures that the vacuum is maintained against any small leaks or losses in the brake pipe, connections and hoses.

"Lap" is used to shut off the connection between the exhauster and the brake pipe to close off the connection to atmosphere after a brake application has been made. It can be used to provide a partial release as well as a partial application, something not possible with the original forms of air brake.

"Brake On" closes off the connection to the exhauster and opens the brake pipe to atmosphere. The vacuum is reduced and air rushes in.

Some brake valves were fitted with an "Emergency" position. Its operation was the same as the "Brake On" position, except that the opening to atmosphere was larger to give a quicker application.

### 3.2 Exhauster

A two-speed rotary machine fitted to a train to evacuate the atmospheric pressure from the brake pipe, reservoirs and brake cylinders to effect a brake release. It is usually controlled from the driver's brake valve, being switched in at full speed to get a brake release or at slow speed to maintain the vacuum at its release level while the train is running. Exhausters are normally driven off an electric motor but they can be run directly from a diesel engine.

### 3.3 Brake Pipe

The vacuum-carrying pipe running throughout the length of the train, which transmits the variations in pressure required to control the brake. It is connected between vehicles by flexible hoses, which can be uncoupled to allow vehicles to be separated. The use of the vacuum system makes the brake "fail safe", i.e. the loss of vacuum in the brake pipe will cause the brake to apply.

### 3.4 Dummy Coupling

At the ends of each vehicle, a dummy coupling point is provided to allow the ends of the brake pipe hoses to be sealed when the vehicle is uncoupled. The sealed dummy couplings prevent the vacuum being lost from the brake pipe.

### 3.5 Coupled Hoses

The brake pipe is carried between adjacent vehicles through flexible hoses. The hoses can be sealed at the outer ends of the train by connecting them to dummy couplings.

### 3.6 Brake Cylinder

Each vehicle has at least one brake cylinder. Sometimes two or more are provided. The movement of the piston contained inside the cylinder operates the brakes through links called "rigging". The rigging applies the blocks to the wheels. The piston inside the brake cylinder moves in accordance with the change in vacuum pressure in the brake pipe. Loss of vacuum applies the brakes, restoration of the vacuum releases the brakes.

### 3.7 Vacuum Reservoir

The operation of the vacuum brake relies on the difference in pressure between one side of the brake cylinder piston and the other. In order to ensure there is always a source of vacuum available to operate the brake, a vacuum reservoir is provided on, or connected to the upper side of the piston. In the simplest version of the brake cylinder is integral with the vacuum reservoir. Some versions of the brake have a separate reservoir and a piped connection to the upper side of the piston.

### 3.8 Brake Block

This is the friction material which is pressed against the surface of the wheel thread by the upward movement of the brake cylinder piston. Often made of cast iron or some composition material, brake blocks are the main source of wear in the brake system and require regular inspection to see that they are chan3ged when required.

### 3.9 Brake Rigging

This is the system by which the movement of the brake cylinder piston transmits pressure to the brake blocks on each wheel. Rigging can often be complex, especially under a passenger car with two blocks to each wheel, making a total of sixteen. Rigging requires careful adjustment to ensure all the blocks operated from one cylinder provide an even rate of application to each wheel. If you change one block, you have to check and adjust all the blocks on that axle.

### 3.10 Ball Valve

The ball valve is needed to ensure that the vacuum in the vacuum reservoir is maintained at the required level, i.e. the same as the brake pipe, during brake release but that the connection to the brake pipe is closed during a brake application. It is necessary to close the connection as soon as the brake pipe vacuum is reduced so that a difference in pressure is created between the upper and lower sides of the brake cylinder piston.

## 4. OPERATION ON EACH VEHICLE

### 4.1 Brake Release

The piston is at the bottom of the brake cylinder. The brake cylinder is open at the top so that it is in direct connection with the vacuum reservoir.

A vacuum has been created in the brake pipe, the vacuum reservoir and underneath the piston in the brake cylinder. The removal of atmospheric pressure from the system has caused the ball valve to open the connection between the vacuum reservoir and the brake pipe. The fall of the piston to the bottom of the brake cylinder causes the brake blocks to be released from the wheels.

### 4.2 Brake Application

The vacuum has been reduced by the admission of atmospheric pressure into the brake pipe. This has forced the piston upwards in the brake cylinder. By way of the connection to the brake rigging, the upward movement of the piston has caused the brake blocks to be applied to the wheels.

The movement of the piston in the brake cylinder relies on the fact that there is a pressure difference between the lower side of the piston and the upper side. During the brake application, the vacuum in the brake pipe is reduced by admitting air from the atmosphere. As the air enters the ball valve, it forces the ball upward to close the connection to the vacuum reservoir. This ensures that the vacuum in the reservoir will not be reduced. At the same time, the air entering the lower side of the brake cylinder creates an imbalance in the pressure compared with the pressure above the piston. This forces the piston to move upwards to apply the brakes.

## 5. TWO PIPE SYSTEM

Another version of the vacuum brake used two train pipes. The usual brake pipe operated in the conventional way but the second pipe was provided to give an additional supply to speed up the brake release.

The two-pipe system was introduced on diesel railcars where the exhauster was driven directly off the diesel engine. Since the engine was only idling if the train was stationary, the exhauster would only be running at slow speed. This meant that the restoration of the vacuum in the brake pipe and cylinders along the train would be very slow. To get a rapid brake release when it was needed to start the train therefore, a "high vacuum" reservoir was provided on each car, the reservoirs being supplied from a second train pipe called the Reservoir Pipe. These additional reservoirs were characterized by their operating vacuum of 28 Hg, as opposed to the 21 Hg used in the brake pipe and brake cylinders.

While the train is moving and the driver's brake valve is in the "Running" position, the exhauster is connected to the reservoir pipe and through the driver's brake valve to the brake pipe. An automatic feed valve is fitted between the reservoir pipe and the driver's brake valve limits the maximum vacuum passing to the driver's brake valve at 21 Hg. This means that the vacuum in the brake pipe and brake cylinders will be limited to 21 Hg. However, the vacuum created by the exhauster in the reservoir and high vacuum reservoirs will reach 28 Hg.

To apply the brake, "Brake On" is selected by the driver and the brake pipe is opened to atmosphere at his brake valve. The exhauster will continue to run and maintain the 28 Hg reservoir level. The connection to the feed valve is closed by the driver's brake valve when it is in the "Brake On" position. A partial application can be made by moving the handle to "Lap".

To get a release, the brake valve is moved to the "Running" position. There is no "Release" position. As soon as "Running" is selected, the connection to atmosphere is closed and the connection to the feed valve and exhauster opens to start restoring the vacuum. As there is a store of "high" vacuum available in the reservoir pipe and reservoirs, the process is speeded up to give a rapid release.

Each reservoir has an automatic isolating valve between itself and the brake pipe. This valve is set to 19 Hg and closes if the vacuum in the reservoir falls below this level. This has the effect of preventing the reservoir from being emptied. The volume of the reservoir is such that it can restore the vacuum for several applications and releases before it drops below 19 Hg.

## 6. ADVANTAGES

A .Simple in design.
B. Ability to get partial release without any additional equipment.

C. Greater amount of safety because the vacuum loss age results in the braking of the vehicle.

D. Highly reliable in case of rail wagons.

E. Permit the automatic application of brakes down the entire length of the train from the simple control in the driver's hand.

## 7. DISAVANTAGE

On none ejector fitted locos a vacuum pump is required. Low pressure means relatively large brake cyclinder are required which may be awkward to site. Leaks can be difficult to find.

## 8. CONCLUSION

The vacuum brake was not widely popular outside the UK railways, but it has the advantage of being simple in design and of having the ability to get a partial release, something the air brake could not do without additional equipment. The vacuum brake was not as effective as the air brake, it taking longer to apply and requiring large cylinders to provide the same brake effort as the air brake. It was also slow to release and requires additional equipment to speed up its operation.

## REFERENCES

[1] Google (Online).

[2] Wikipedia (Online) Available: http://en.m.wikipedia.org/wiki/vacuum_brake

[3] Railway Website available http://www.railway-technical.com/vacuum .shtml