EXXOTEST EDUCATION

Vehicle training equipment

User's guide for DTP-ABS1000
TRAINING MODEL:
Wheel antilock braking system

CONTENT

1. INSTRUCTION MANUAL

Installation and start-up of the DTP-ABS1000 model.

Connect the model to the 230V mains supply (check that the power switch behind the DTP-ABS1000 model is set to **0**).
After plugging in the power cable, set the power switch on the DTP-ABS1000 model to **1**.

Operational environment

The model must be installed in a clean, dry location, free of dust, water vapour and combustion fumes. The model requires a lighting level of approx. 400 to 500 Lux. The model can be installed in a Practical Workshop classroom. Operating noise will not exceed 70 dBA. The model is protected against any errors by future users.

Calibration and servicing of the DTP-ABS1000 model.

Calibration: Factory settings.
Servicing interval: N/A
Cleaning: Use a soft, clean cloth with a window cleaning product.

Number of workstations.

The DTP-ABS1000 model is considered as one single workstation.
The DTP ABS1000 training console stands on a work surface, the user remains seated during use.

Method for removal from service

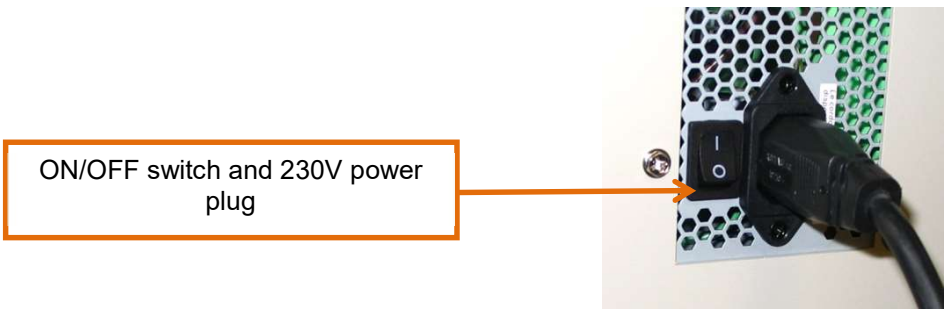
Set the switch to **0**.
Remove the 230V connection.
Then store the DTP-ABS1000 model in a closed room with a front panel marked 'Equipment Removed from Service'.

Only qualified and authorised members of personnel may access the interior of the model!!!

Transporting the DTP-ABS1000 model.

The model must be turned off and removed from service before transport (see "removal from service"). Important: never leave anything on the tablet. At least two people are required for transport purposes. Use the carry handles fitted for this purpose.

230V supply:



2. RESOURCES

2.1. Purpose of the ABS system

The improvements made on the braking systems allow us to meet the requirements in terms of driving performance, reliability and safety. However, the driver is not always under satisfactory circumstances to slow down and can be compelled to brake suddenly in front of an obstacle or in an unexpected situation.

His or her immediate reaction is to slam on the brakes which will generate excessive braking power, thus locking the wheels and making the vehicle uncontrollable (skid and loss of steering control). If the road is slippery owing to the weather conditions, if the state of the pavement and the road's configuration are unfavorable, the situation can be disastrous.

Very few drivers can evaluate all the physical information correctly and react accordingly in order to obtain optimum braking performance. In fact, a well trained driver can carry out a braking cycle in around two seconds while an ABS system can perform four to ten cycles in one second.

In a standard braking system the braking forces applied to the wheels of a same axle are identical. However, these forces do not take into account such parameters as each wheel's actual adhesion conditions or the distribution of longitudinal and transverse loads, when decelerating, accelerating and cornering. The latter continually vary the braking conditions of each wheel.

The ABS system prevents the wheels from locking when braking, even if each wheel's adhesion is weak or unbalanced. Therefore, it guarantees the vehicle's steering-ability and road-holding stability under very difficult circumstances.

2.2. Brief historical review

1920 : The first patent on a wheel anti-locking system was filed.

1950 : Use of the first wheel anti-locking systems in the aviation industry.

From 1964 to 1970 : Many car manufacturers were studying wheel anti-lock braking systems for passenger cars.

1973 : Bendix tuned up a system on a Citroën SM and Bosch introduced the ABS.

1978 : Bosch introduced the ABS 2 controlled electronically, and Honda launched the ABL.

1983 : Improvement of the Bosch system.

1984 : Mass production of the Anti-skid "MK2" by ATE in the USA.

1988 : Bosch presents the ABS 2E.

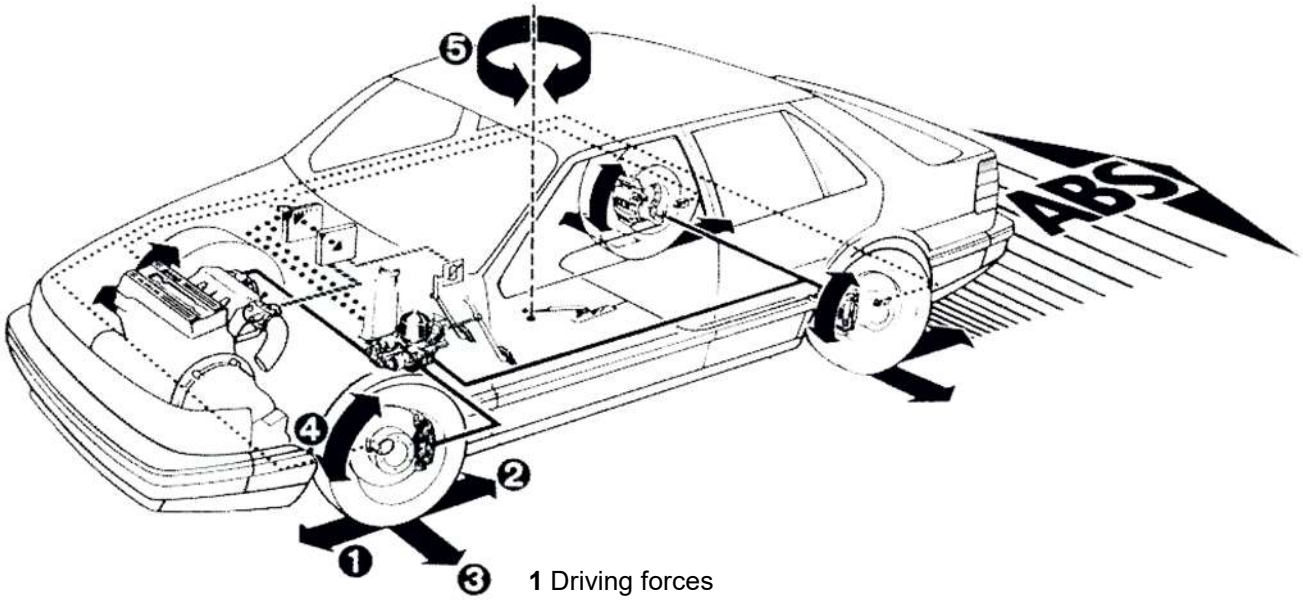
1995 : Launch of the ABS 5.

2000 : An ABS braking system is fitted on virtually every lightweight vehicle as standard equipment.

3. SURVEY ON THE VEHICLE'S DYNAMICS

5.1. Stability of the vehicle

Studying the main phenomena which can have an effect on the vehicle's stability :



1 Driving forces
2 Braking forces
3 Guiding force
4 Momentum of inertia of the wheels
5 Yawing moment

All these forces apply to the center of gravity.
Their amplitude varies according to the wheels' adherence to the ground (adhesion coefficient).

5.2. Adhesion coefficient

The adhesion coefficient varies according to a series of factors :

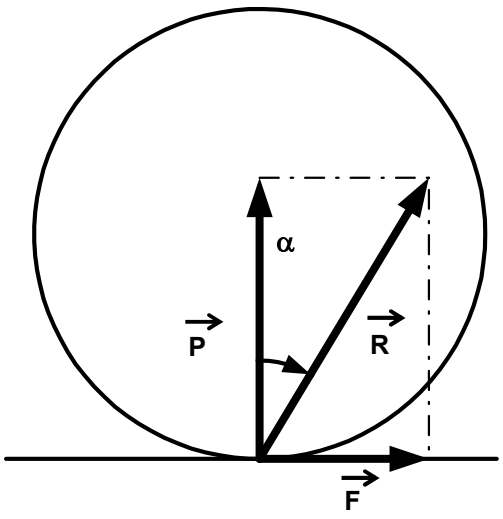
- The state of the road.
- The tire's structure and tread design.
- The tire pressure.
- The quality of the rubber.
- The tire deforming load.
- Slippage.

Simplified study of the transverse forces on a wheel:

$\vec{P}$ **P:** Resultant weight on the wheel

$\vec{F}$ **F:** Braking force

$\vec{R}$ **R:** Resultant force



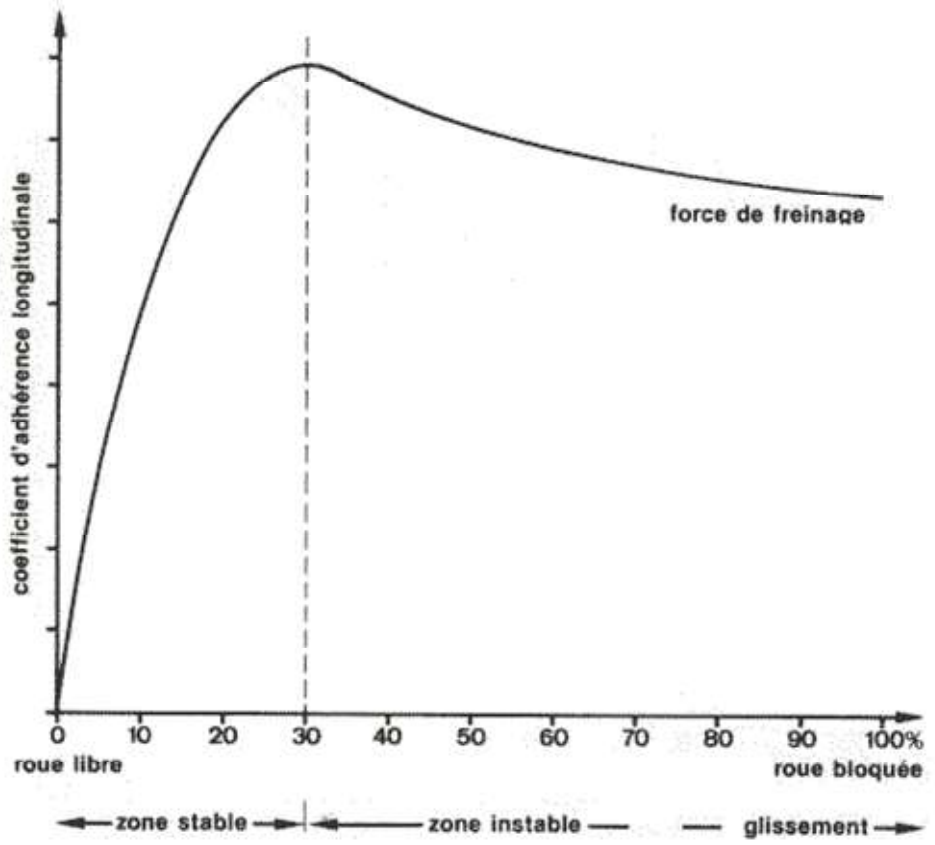
The adhesion coefficient is calculated according to angle α : the bigger this angle, the stronger the adhesion.

$$Tan\ \alpha = F / P$$

This adhesion coefficient ranges from 0 to 1 according to the state of the road and to the slippage of the wheel relevant to the ground.
Slippage is expressed in percentage, and is calculated as follows:

$$G=((Vehicle\ speed - wheel\ speed) / Vehicle\ speed)x100$$

Adhesion coefficient according to slippage



Starting from a slippage with zero braking effect, the adhesion coefficient increases quickly and reaches its maximum value approximately between 20 and 40% of slippage, then drops again.

The upward portion of the curve corresponds to the stable zone (partial braking zone); the downward portion corresponds to the unstable zone (towards total skid).

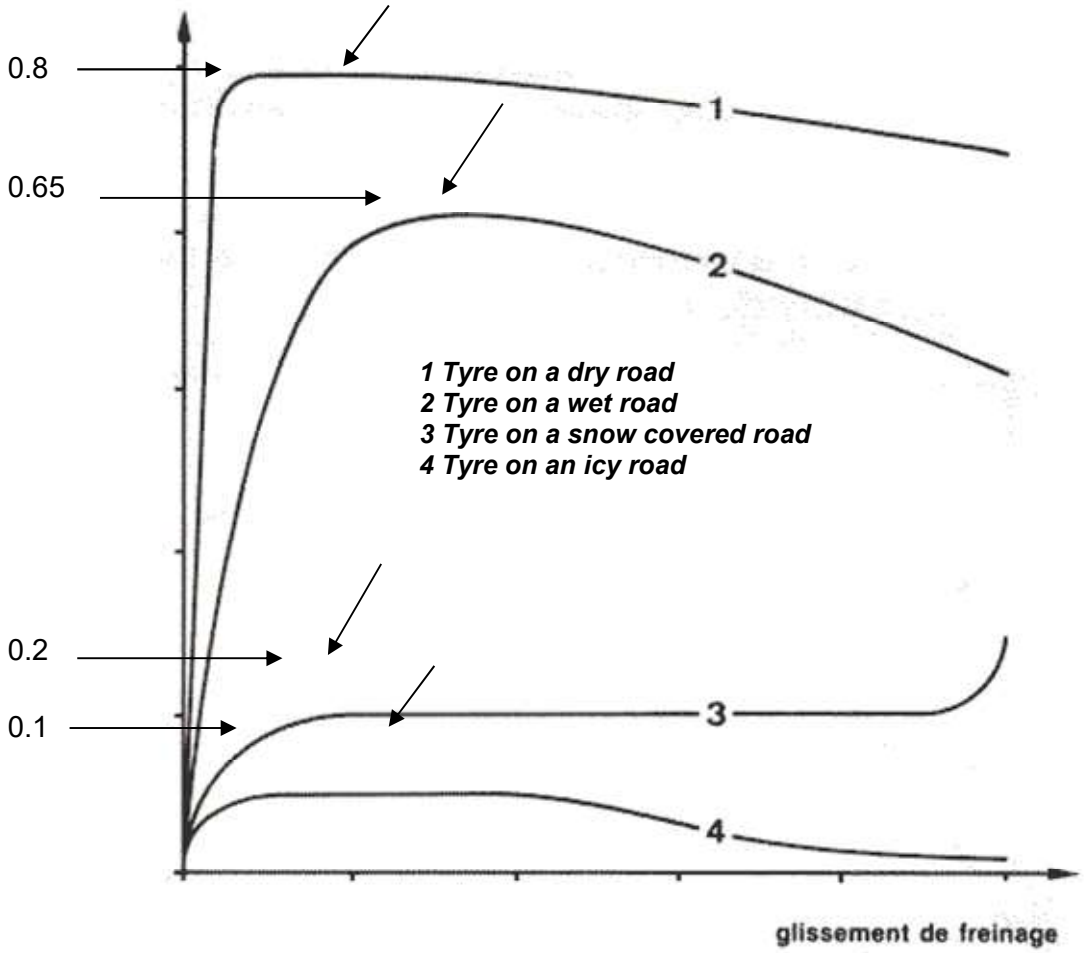
The ABS system prevents the vehicle from entering into this unstable braking zone.

We call skidding the frictional slippage of the tire on the road.

In the stable portion of the braking effect, slippage by deformation is the phenomenon which occurs the most.

In the unstable portion, frictional slippage becomes predominant, until the deformation effects disappear completely when the wheel is locked.

Adhesion coefficient according to slippage and to the state of the road



We can notice that braking is at maximum when the slippage value is measured exactly when the tire is about to skid (zones indicated by an arrow), it's the operating zone of the ABS system.

The upward portion of curve n°3 comes from the additional braking effect due to the amount of snow packed in front of the wheel, thus increasing the vehicle's deceleration. Under these circumstances, the ABS system increases the stopping distance considerably.

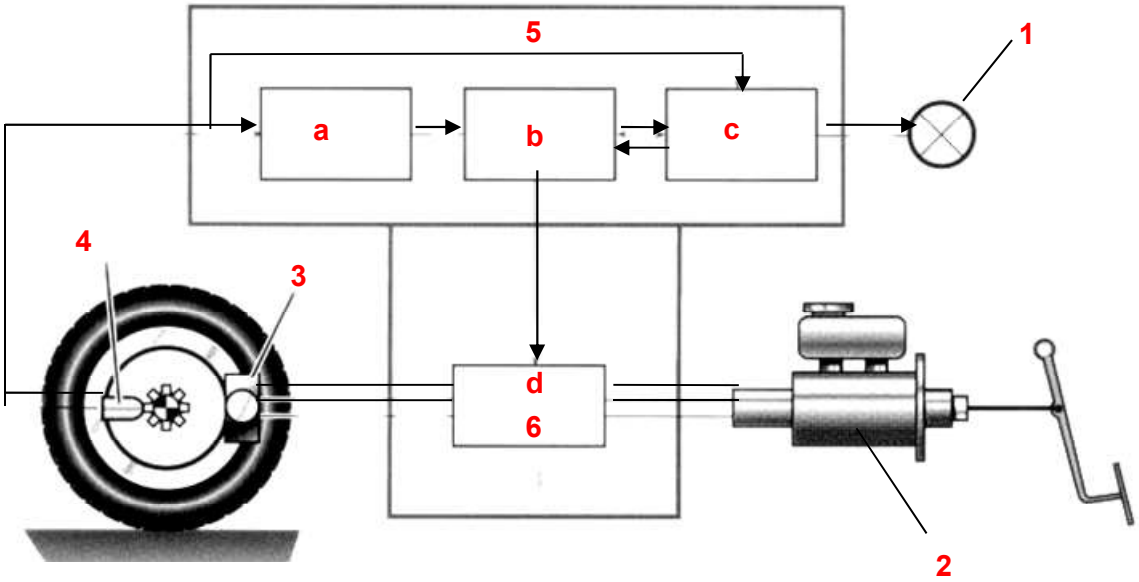
4. ABS SYSTEM DESCRIPTION

4.1. Principle of the braking control

The general principle is to avoid wheel lock-up. When driving, the ABS electronic control unit continually analyses the signals of the four wheel sensors by comparing them to its reference speed. The calculation of the reference speed allows you to determine the slippage threshold.

When braking, if the speed of one or several wheels becomes lower than the reference speed, the electronic control unit shuts the corresponding inlet solenoid valves (pressure holding phase). If the speed becomes lower than the slippage threshold, the exhaust solenoid valves and the re-injection pump are controlled to release the braking effort (power reduction phase).

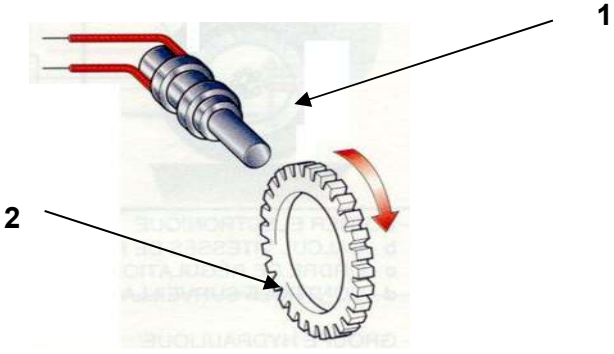
In case of an abnormal condition, the electronic control unit warns the driver by means of a tell-tale lamp. The wheel antilock system is then disabled. Braking is carried out by the standard system.



1- ABS test lamp
2- Dual master cylinder
3- Brake caliper
4- Wheel sensor
5- Electronic control unit : a) Calculation of the wheel speeds ;
b) Command of regulation ;
c) Check, surveillance, warning ;
6- Hydraulic control unit : d) Modulation of the braking pressure ;

4.2. Wheel speed sensors

The sensor is made of a permanent magnet and a coil. It is an induction-type sensor. Its purpose is to provide the electronic control unit with information on the wheel's speed.
A toothed wheel spins in front of the sensor. The magnetic flux varies and induces in the coil an alternating voltage whose frequency and amplitude are proportional to the toothed wheel's rotational speed.



1. Inductive sensor (ABR)
2. toothed wheel (29 teeth)

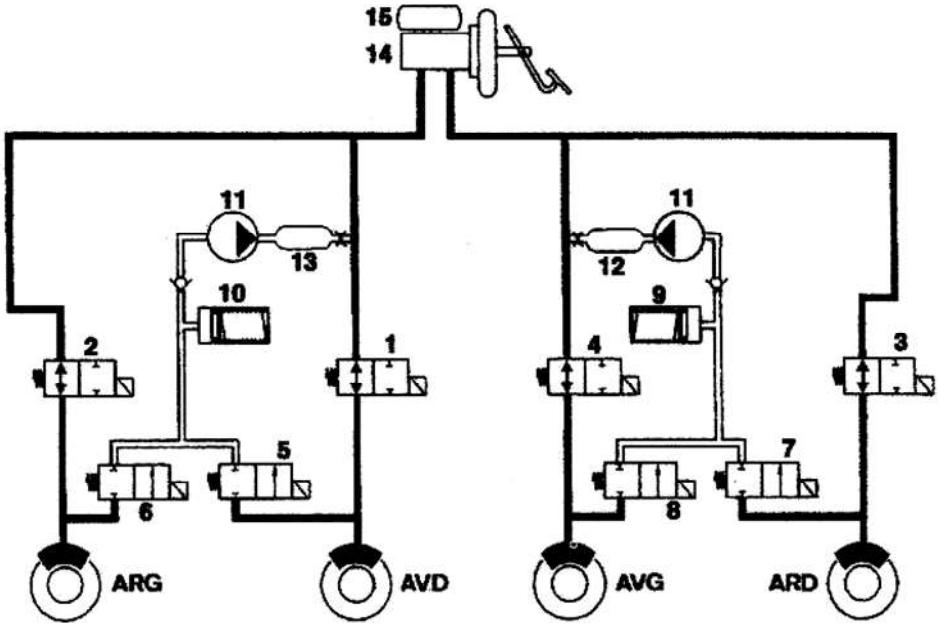
The minimum threshold of the detected speed is 2.75 km/h. These sensors' gap is not adjustable.

1) Hydraulic module

The hydraulic module regulates the braking pressure in the calipers in order to avoid wheel lock-up regardless of the driver's action on the brake pedal. It consists of:

- a hydraulic pump driven by an electric motor and which returns the caliper brake fluid to the master cylinder during the « pressure drop » phase.
- 8 two-way / two-position (open and shut) solenoid valves which are controlled in voltage: 0 or 12 volts. (1 inlet solenoid valve and 1 exhaust solenoid valve for each wheel)
- accumulators

System diagram of the ABS 5



1. Front RH inlet solenoid valve
2. Rear LH inlet solenoid valve
3. Rear RH inlet solenoid valve
4. Front LH inlet solenoid valve
5. Front RH exhaust solenoid valve
6. Rear LH exhaust solenoid valve
7. Rear RH exhaust solenoid valve
8. Front LH exhaust solenoid valve

9 and 10 Accumulators

11. Feed pump

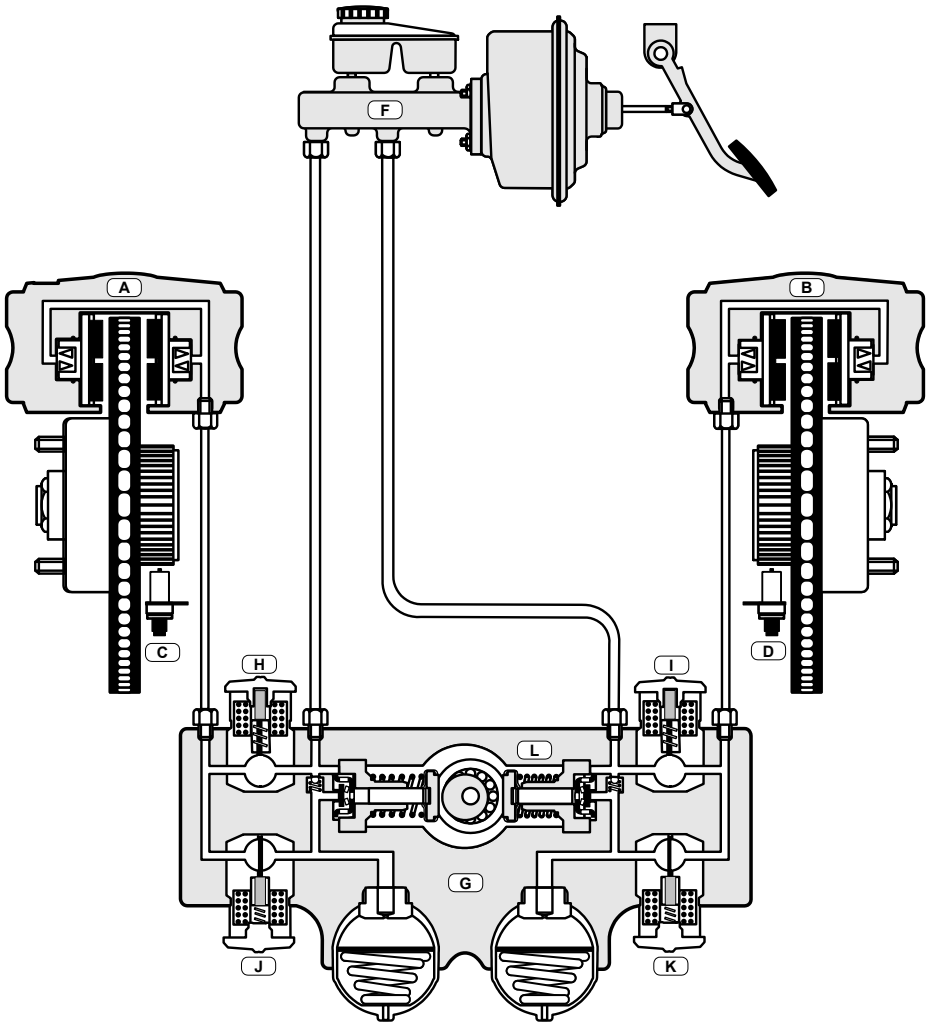
12 and 13 damping or silent chambers

14. Dual master cylinder
15. Brake fluid reservoir

5. Operation

5.1. Braking system inoperative position

In the inoperative position, the inlet solenoid valves (H et I) are open, while the exhaust solenoid valves (J and K) are closed.



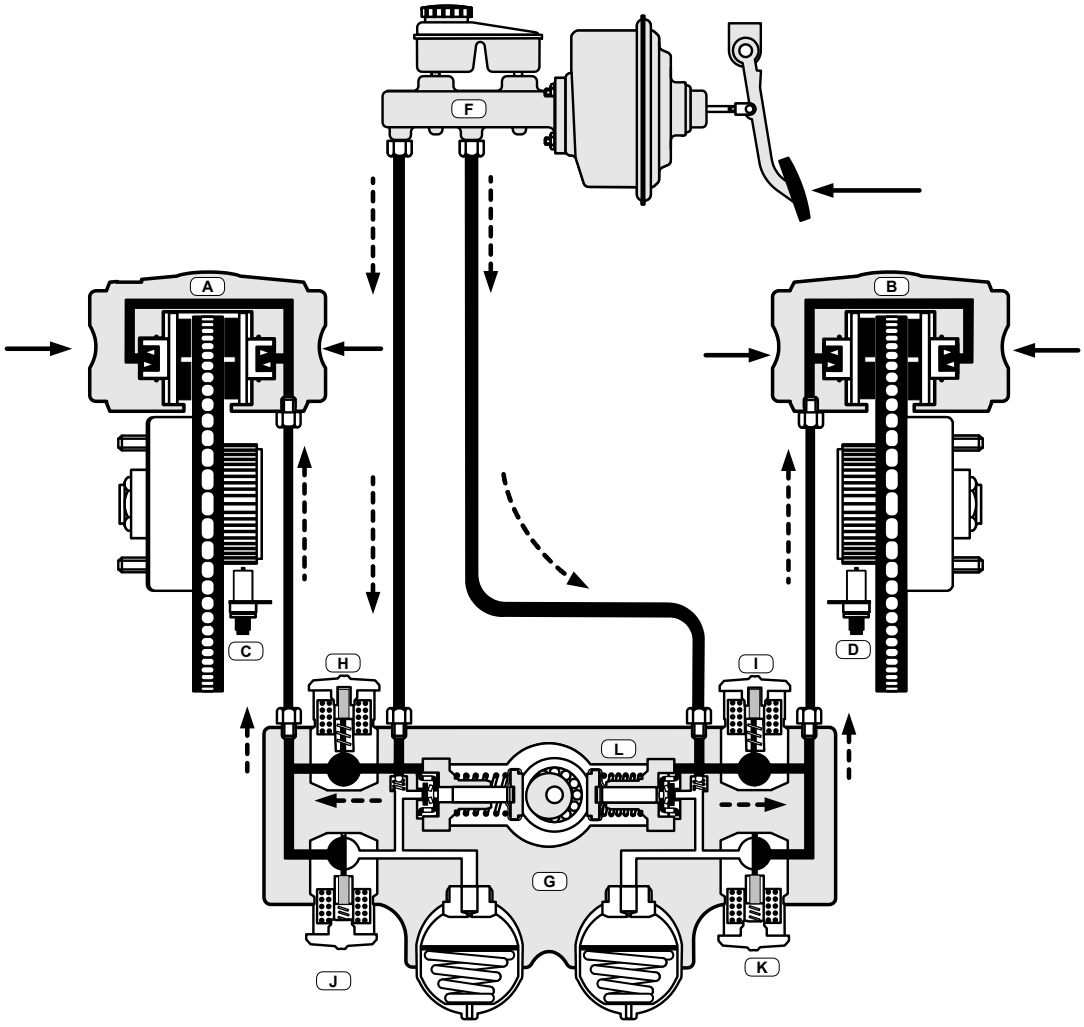
A. Front LH brake caliper
B. Front RH brake caliper
C. Front LH wheel speed sensor
D. Front RH wheel speed sensor
F. Master cylinder of a standard brake
G. ABS hydraulic module (pump, solenoid valves, Accumulators, valves)
H. Front LH inlet solenoid valves
I. Front RH inlet solenoid valves
J. Front LH exhaust solenoid valves
K. Front RH exhaust solenoid valves
L. Feed pump

5.2. Braking phase with no regulation

This operating mode is found in two situations:

- The electronic control unit detects a fault (for instance, a missing sensor signal).
- The wheel speed is higher than or equal to the reference speed.

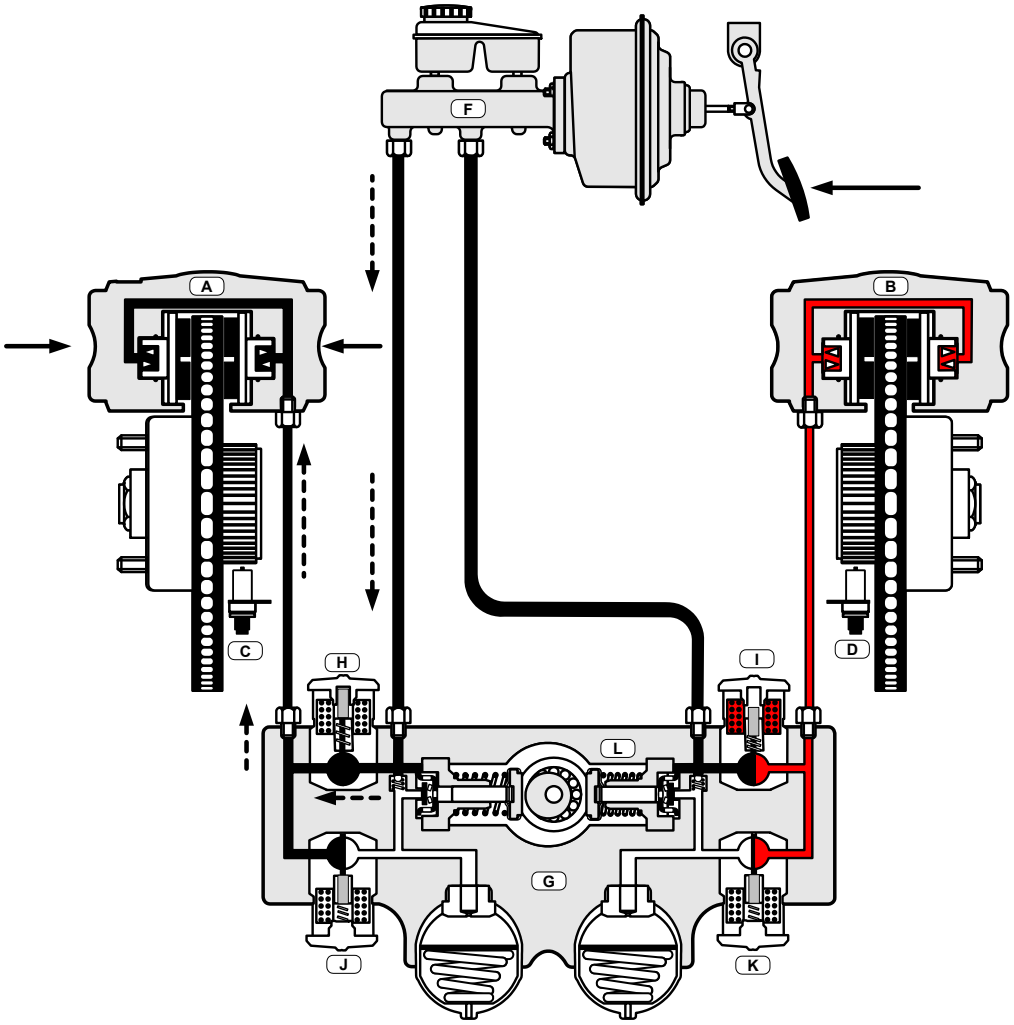
The effort on the brake pedal is directly applied to the wheels through the inlet solenoid valves (H et I). The hydraulic module (G) remained in the inoperative position, and the regulation does not occur. Everything carries on as if there were no ABS system.



Circulation of the brake fluid
Braking effort
Braking pressure

5.3. Pressure holding phase

When a wheel's speed gets lower than the reference speed, the electronic control unit controls the corresponding inlet solenoid valve (I) which closes, in order to cut off the caliper (B) from the master cylinder (F). The pressure in the caliper (B) is held, but it can no longer increase even if the effort on the brake pedal becomes greater.

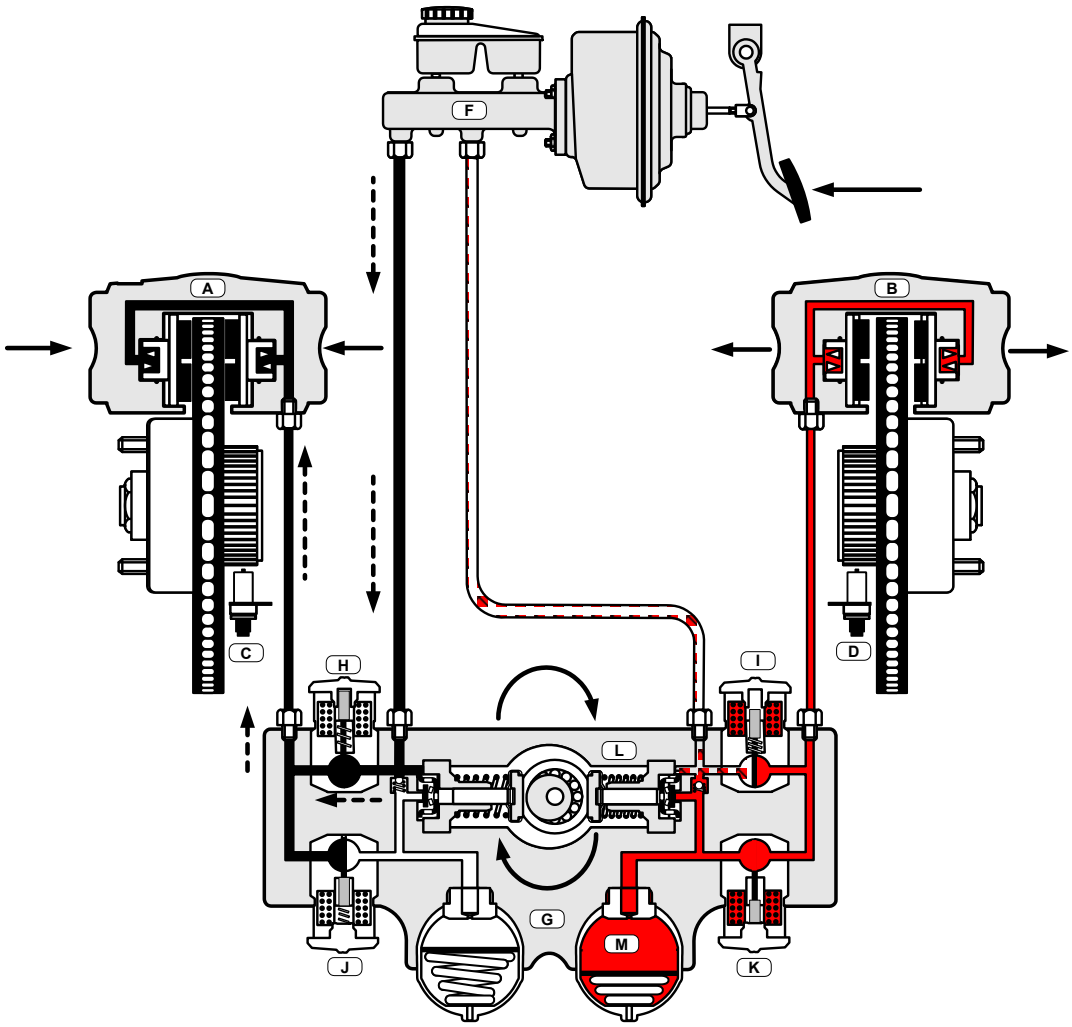


Circulation of the brake fluid
Braking effort
Braking pressure
Holding pressure

On this diagram the pressure is held for the front RH wheel.

5.4. Pressure drop phase

If the slippage threshold is exceeded on a wheel, the electronic control unit opens the exhaust solenoid valve (K) which links the caliper (B) to the accumulator (M). The diaphragm moves and compresses the spring which generates a pressure drop in the circuit and allows the wheel to pick up speed. At the same time the electronic control unit controls the re-injection pump (L) which returns to the master cylinder (F) the liquid stored in the accumulator (M).



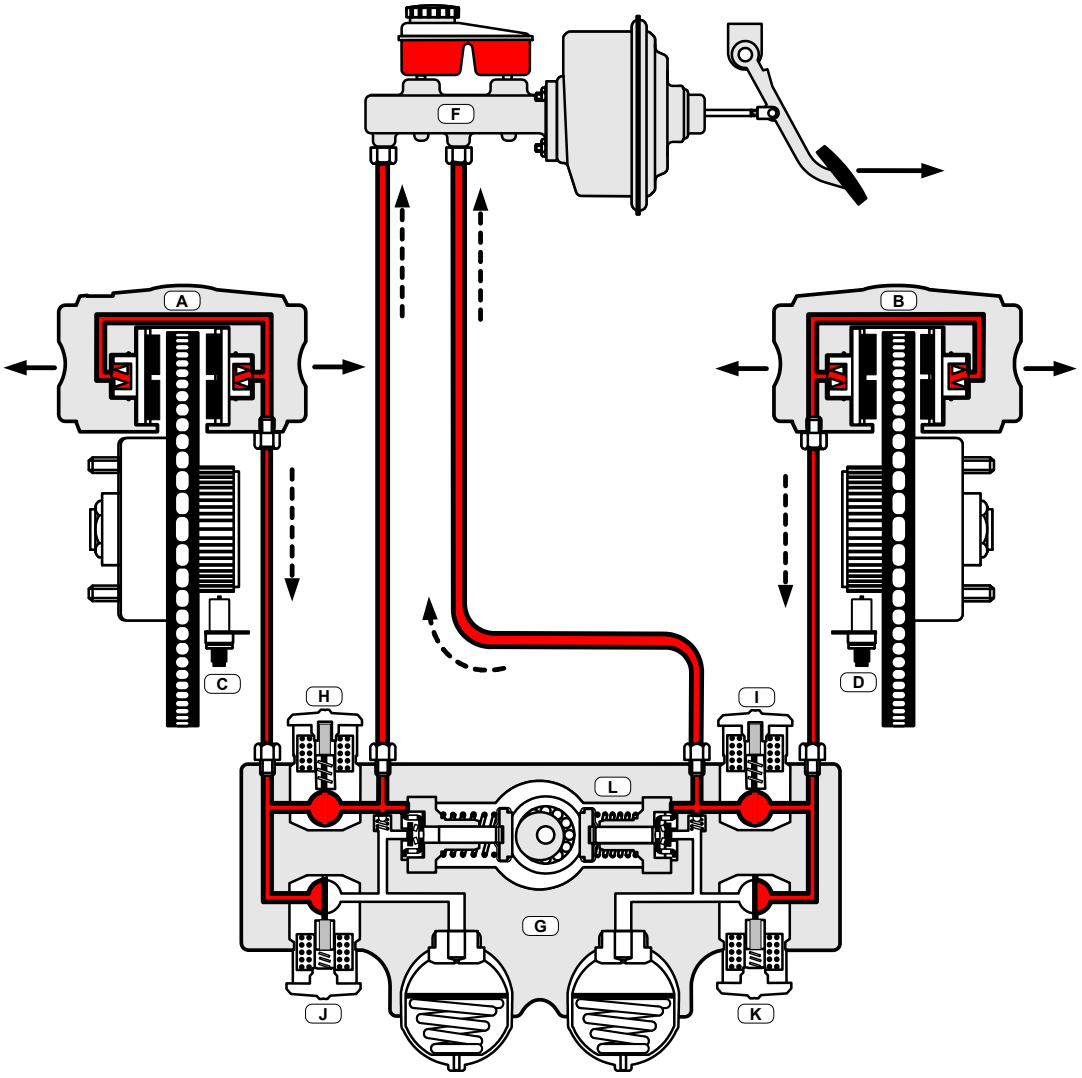
Circulation of the brake fluid
Braking effort
Braking pressure
Pressure drop
Zone in which the braking pressure and the pressure of the feed pump are in conflict (this is what generates the shaky brake pedal phenomenon)

On this diagram the pressure is held for the front RH wheel.

5.5. De-braking phase

The effort on the brake pedal disappears. The master cylinder (F) links the calipers (A and B) and the reservoir, the pressure drops and releases the wheels.
The regulation does not occur in this phase of operation, the solenoid valves are not powered:

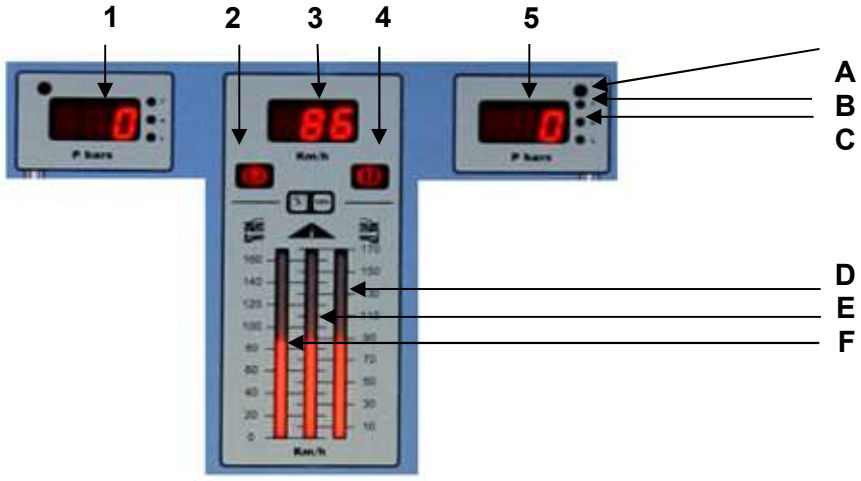
- The inlet solenoid valves (H et I) are open.
- The exhaust solenoid valves (J et K) are closed.



Circulation of the brake fluid
De-braking effort
Pressure drop

6. TRAINING MODEL DESCRIPTION

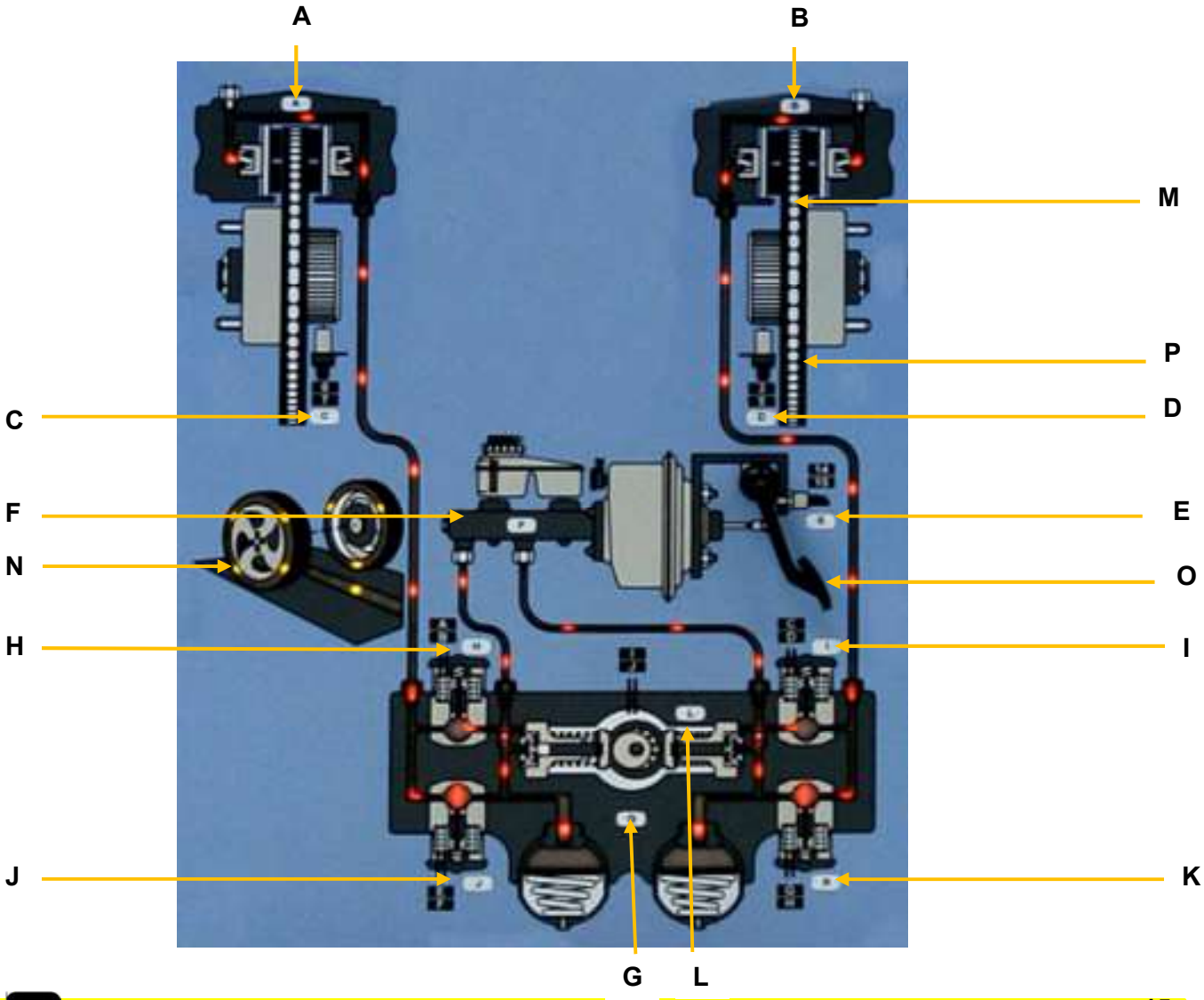
6.1. The front board: viewing the ABS system



1. Display the pressure in the LH caliper
2. ABS test tell-tale lamp
3. Display the reference speed
4. Brake fluid level tell-tale lamp
5. Display the pressure in the RH caliper

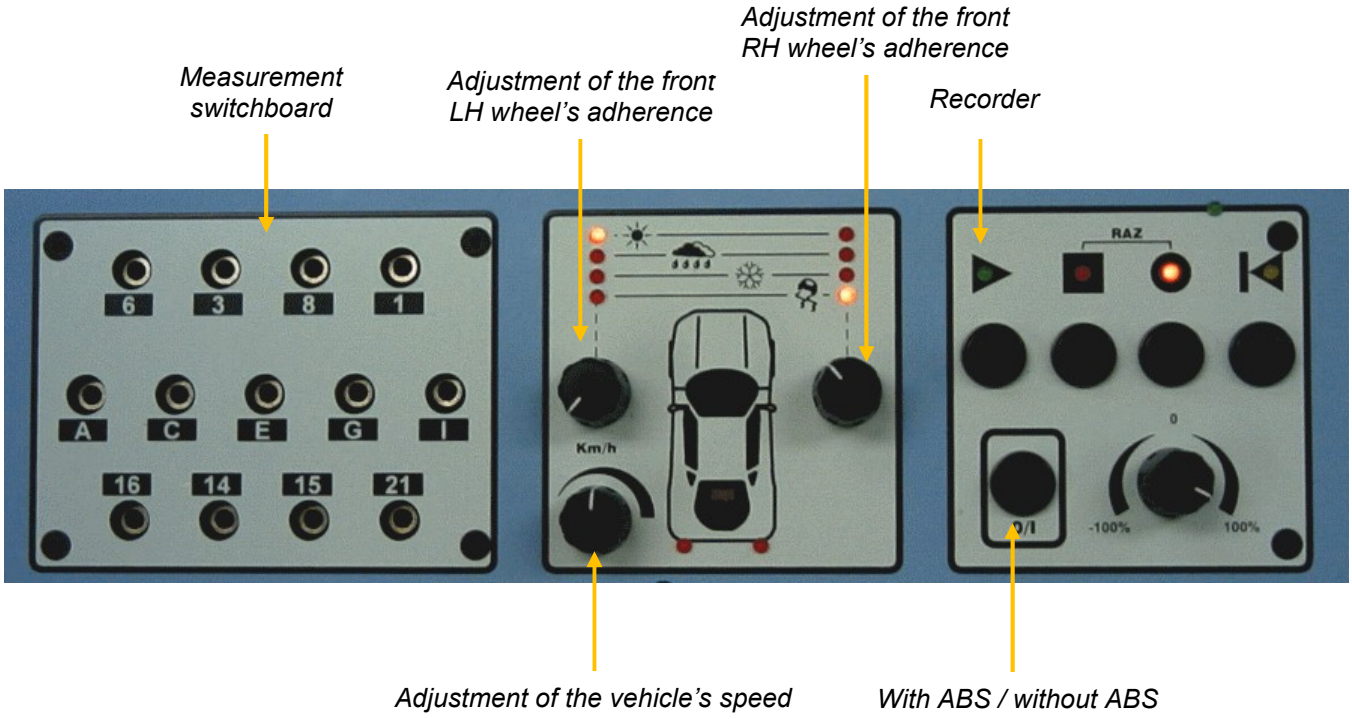
A. Led indicate the increase of braking pressure (inlet phase)
B. Led indicate a stabilized pressure (holding phase)
C. Led indicate the decrease of braking pressure (exhaust phase)
D. Bar graph of the RH wheel's speed.
E. Bar graph of the reference sped.
F. Bar graph of the LH wheel's speed.

Block diagram of the ABS system



A. Caliper of the front LH brake
B. Caliper of the front RH brake
C. Speed sensor of the front LH wheel
D. Speed sensor of the front RH wheel
E. Stop light contact switch
F. Master cylinder of a standard brake
G. ABS Anti-lock hydraulic module (Pump, Solenoid valves, Accumulators, Valves)
H. Front LH inlet solenoid valve
I. Front RH inlet solenoid valve
J. Front LH exhaust solenoid valve
K. Front RH exhaust solenoid valve
L. Feed pump
M. Front brake disks
N. Front wheels with display representing the speed
O. Brake pedal, simulation of the driver's action
P. Display indicating the direction the fluid flows

Control and measuring board

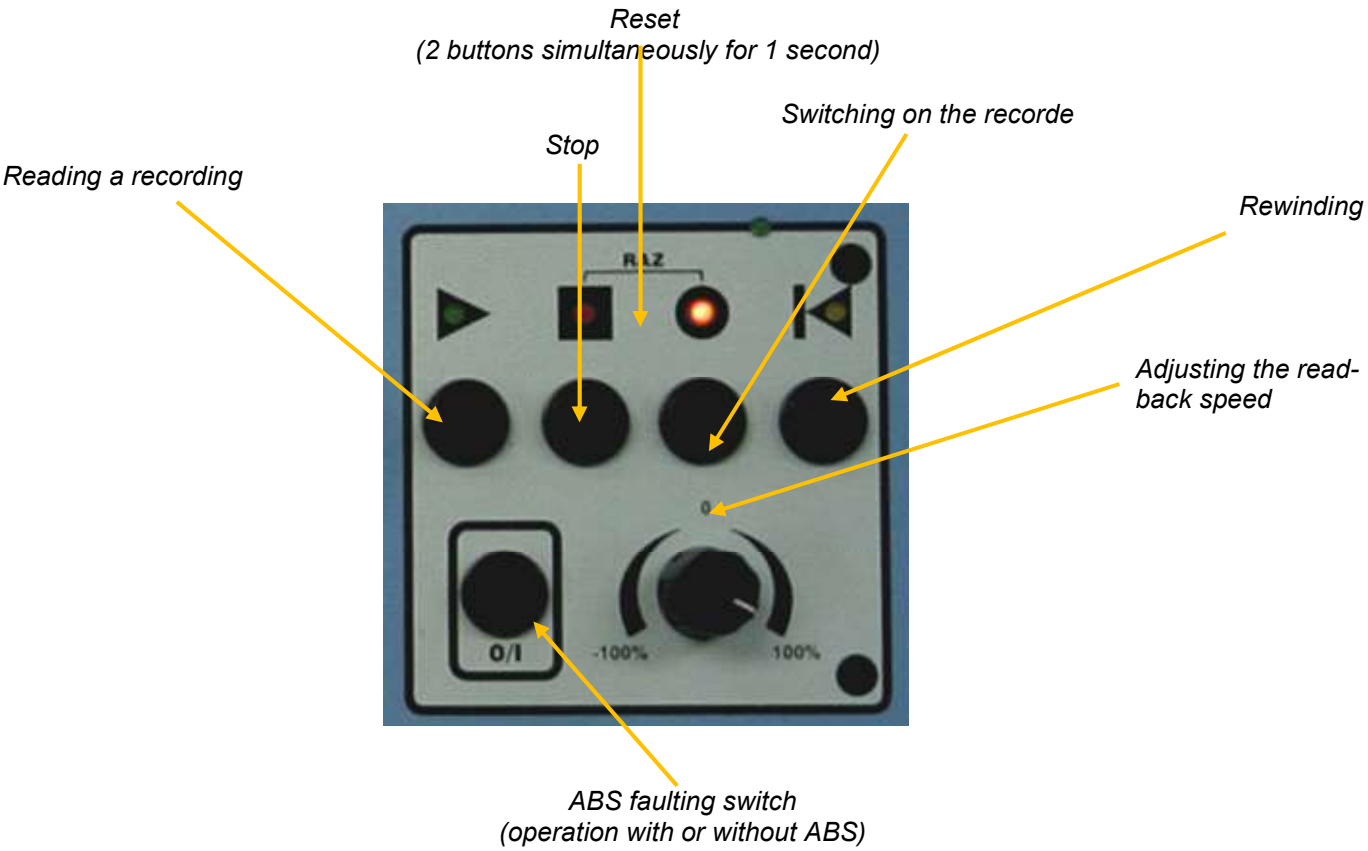


Measurement switchboard :

6. Front LH wheel sensor signal.
3. Front RH wheel sensor signal.
8. Rear LH wheel sensor signal.
1. Rear RH wheel sensor signal.
A. Front LH inlet solenoid valve control.
C. Front RH inlet solenoid valve control.
E. Front LH exhaust solenoid valve control.
G. Front RH exhaust solenoid valve control.
I. Pump motor control.
16. Earth.
14. Stop light switch.
15. + APC.(with the ignition on)
21. ABS test lamp.

Note : The solenoid valves are controlled when they are connected to the earth (presence of a voltage U = 12 Volts at the solenoid valve's terminal when it is not controlled)

Sequence recorder :



6.2. The rear side

On the rear side of the console, there is the main switch and the socket for the 200V power supply cord (provided when delivered). Access to inside of the console is strictly for EXXOTEST personnel. In case the console does not operate, you can check the state of the fuses which can be reached through the access lid around the main switch (the lid can be opened only when the console is unplugged).

All the serial ports which make up the EXXOBus allow you to connect the console to a computer's serial port (com1 and com2) so as to retrieve the data using the ABSCom software (software and cord are supplied). Updates can be carried out by means of this connector.

6.3. Values used by the ABS1000 console

The chart and the graph below show the maximum theoretical deceleration values possible.

These calculations do not take into account the tire's deformation on the ground and the changes in the road adhesion coefficient.

The wheels are supposed to keep their shape.

The brake fluid pressure is calculated by using the dimensions of the braking system of a medium-size sedan, such as a Peugeot 406:

- Wheel diameter : 507.75 mm
- Average disk radius : 232.5 mm
- Diameter of the front brake pistons : 45 mm
- Pad / disk adhesion coefficient : 0.6

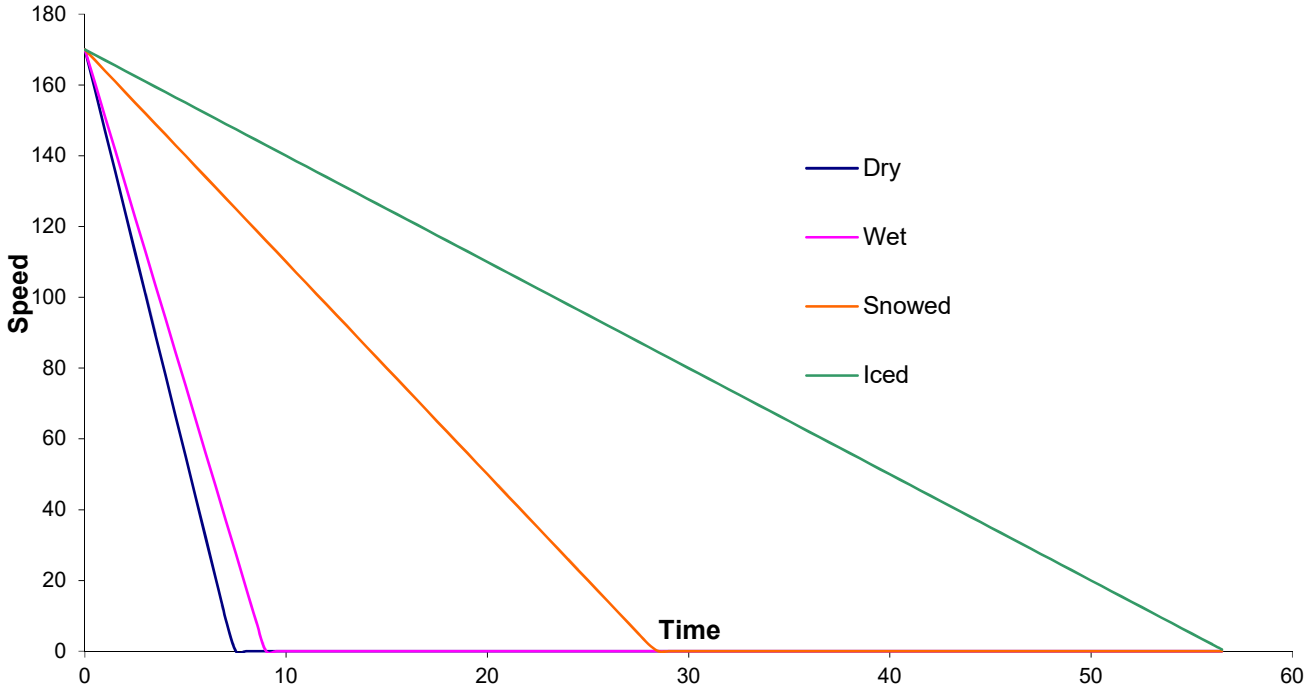
The wheel / ground adhesion coefficients are as follows:

- Dry : 0.8
- Wet : 0.65
- Snow-covered : 0.2
- Icy : 0.1

The stopping distances and time do not depend on the vehicle's weight

The starting speed is 170 Km/h

Conditions	Stopping time (in seconds)	Stopping distance (in m)	Fluid pressure before lock-up (in bars)
Dry	6	142	80.8
Wet	7.4	175	56.3
Snow-covered	24	568	8.7
Icy	48	1136	3.4



7. USING THE ABSCOM SOFTWARE

7.1. Installation

The CD Rom provided with the console has 2 programs:

- Software which allows you to download possible updates of the ABS1000 console.
- The ABSCom software which allows you to plot the curves recorded by the console.

This software is installed thanks to the CD Rom :

- Insert the CD Rom into the computer's reader.
- Click on « Install ABSCom v1.0».
- Follow the installation instructions.

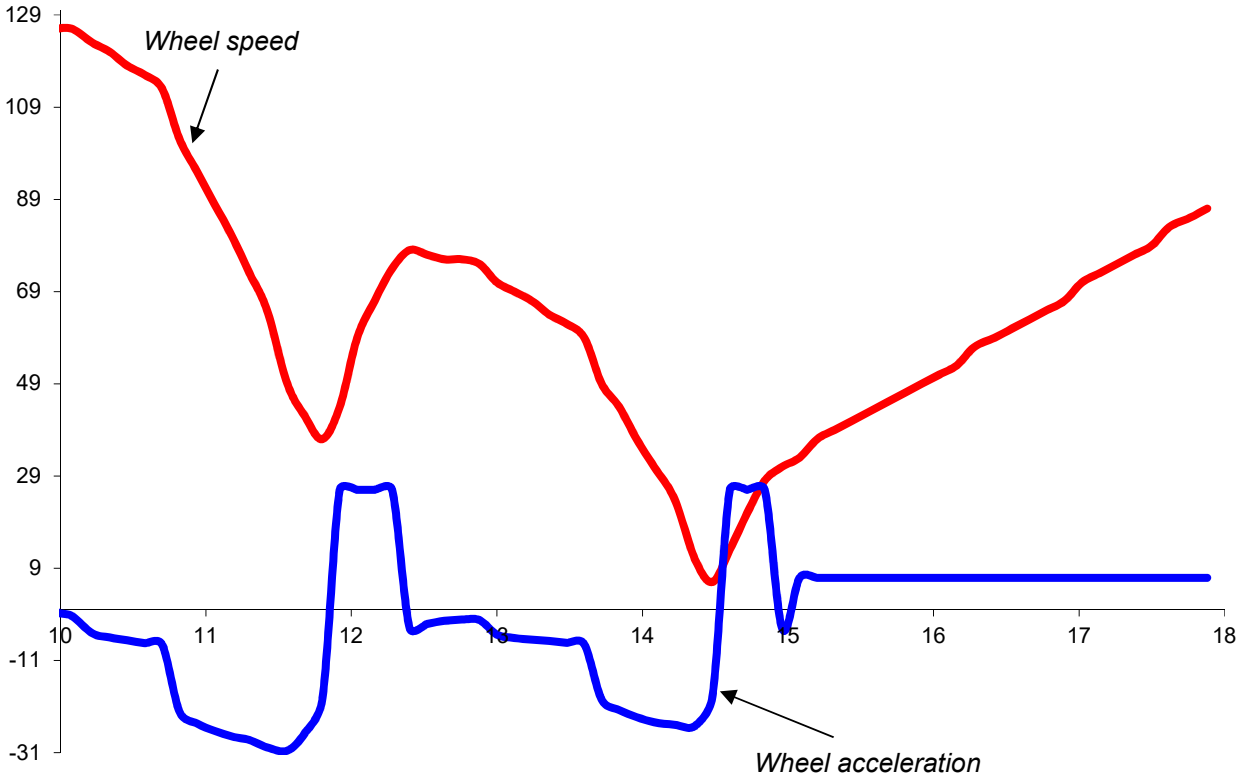
Downloading the console :

- Insert the CD Rom into the computer's reader.
- Click on « Updating ABS1000 ».
- Follow the instructions.

7.2. Use

- Connect the console to the computer's COM port using the cord provided.
- Record a sequence using the recorder of the ABS1000 console
- Start the ABSCom software.
- In the menu « Communication », « Configuration », check the communication parameters, then click on « OK ».
- Click on 
- The computer will retrieve and store the data sent by the ABS1000 console.
- Click on « OK » or modify the name and the location of the file and then click on « OK ». Caution : Excel must be closed during this operation.
- The software will start Excel and all measuring points will be displayed
- Plot the requested curves using Excel.
- Thanks to the ABSCom software, the ABS1000 console can transfer all the data available on the console, as well as certain calculated data:
- List of the data transferred:
  - Time (s)
  - Vehicle speed (Km/h)
  - Master cylinder pressure (Bar)
  - Vehicle acceleration (m/s²)
  - LH wheel speed (Km/h)
  - LH brake system pressure (Bar)
  - LH wheel acceleration (m/s²)
  - RH wheel speed (Km/h)
  - RH brake system pressure (Bar)
  - RH wheel acceleration (m/s²)
  - LH wheel solenoid valve control
  - RH wheel solenoid valve control

Viewing the wheel signals

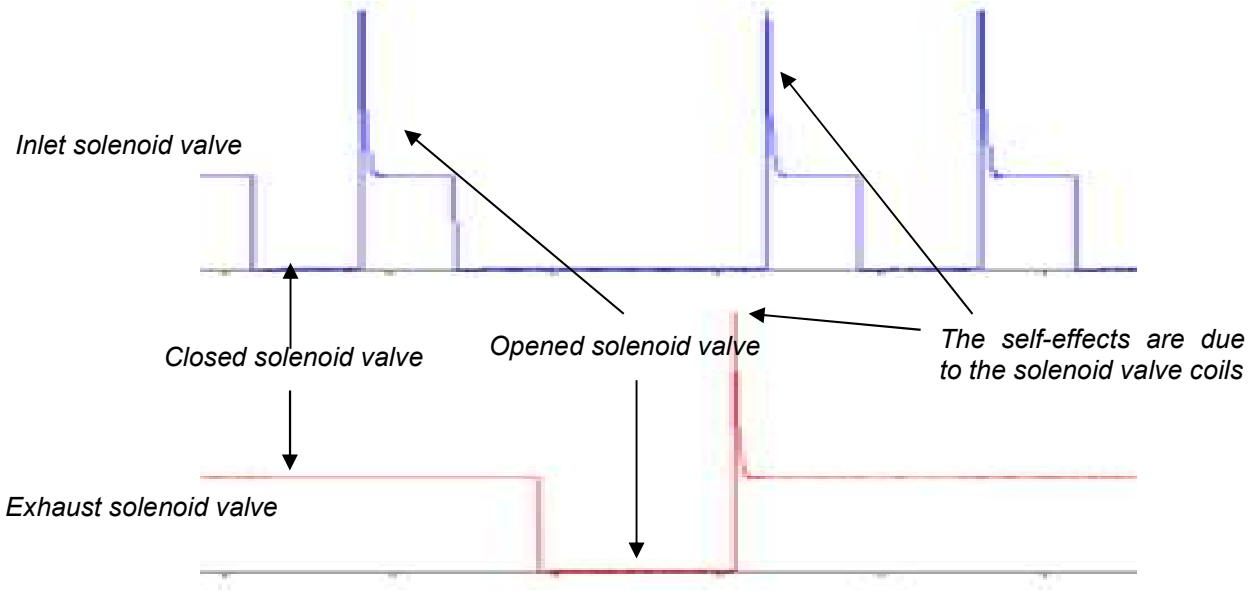


The red curve is the wheel's speed expressed in Km/h.
The blue curve is the derivative of the red curve and corresponds to the wheel's acceleration. It is calculated by the console and can only be viewed with the ABSCom software :

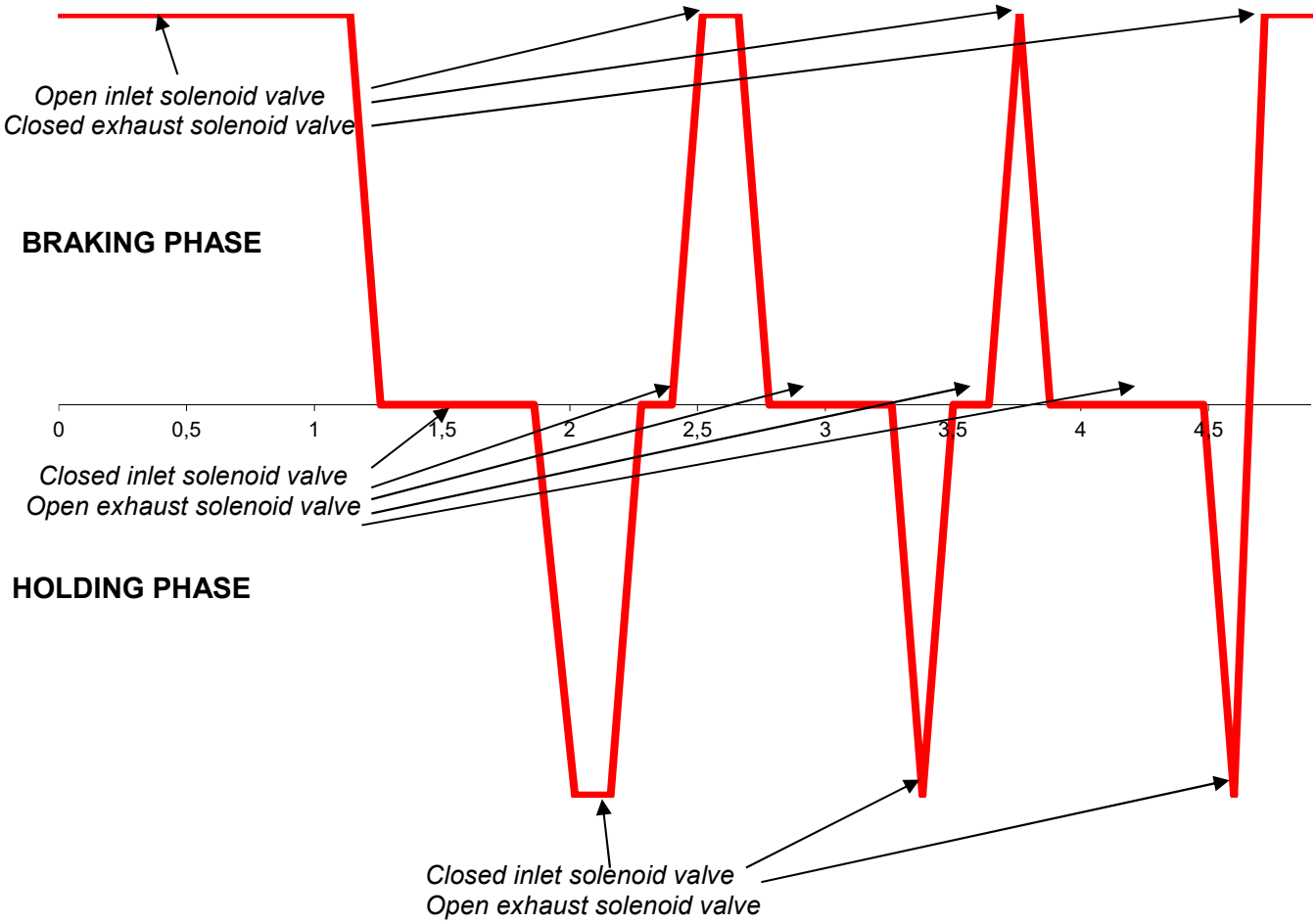
- When this curve is above 0, it means that the wheel is accelerating
- When this curve is under 0, it means that the wheel is decelerating
- When this curve equals 0, it means that the wheel has a constant speed
- When this curve is parallel to the X-axis, it means that the wheel is decelerating or accelerating constantly.

7.3. Curve examples with REFLET2000W

The inlet solenoid valves are open when inoperative and the exhaust solenoid valves are closed when inoperative.
They are controlled by the ABS control unit by means of weights :

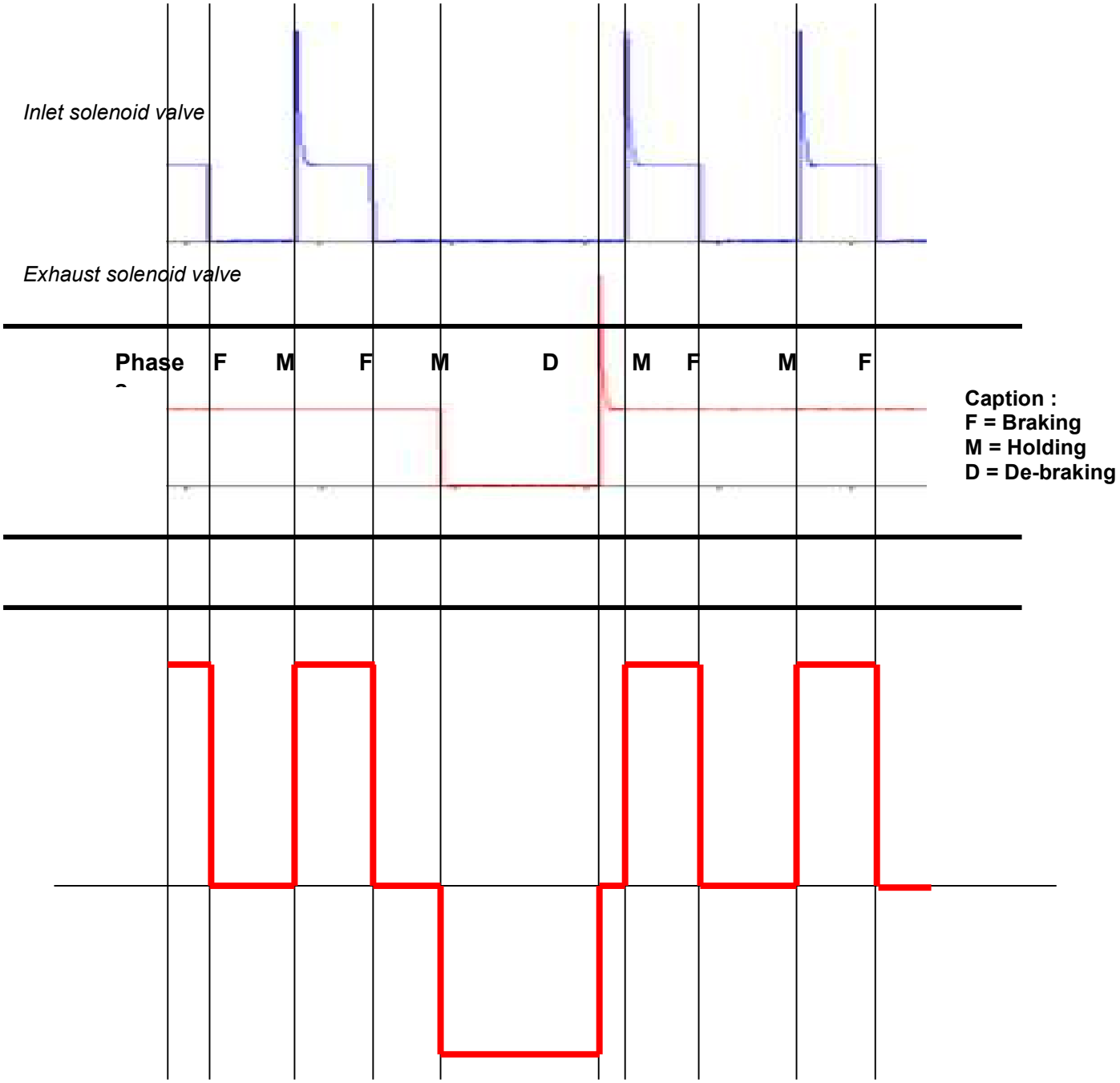


Explaining the solenoid valve signals:



In fact this curve is a calculation carried out by the ABS1000 console. It allows you to view the positions of the solenoid valves quickly.

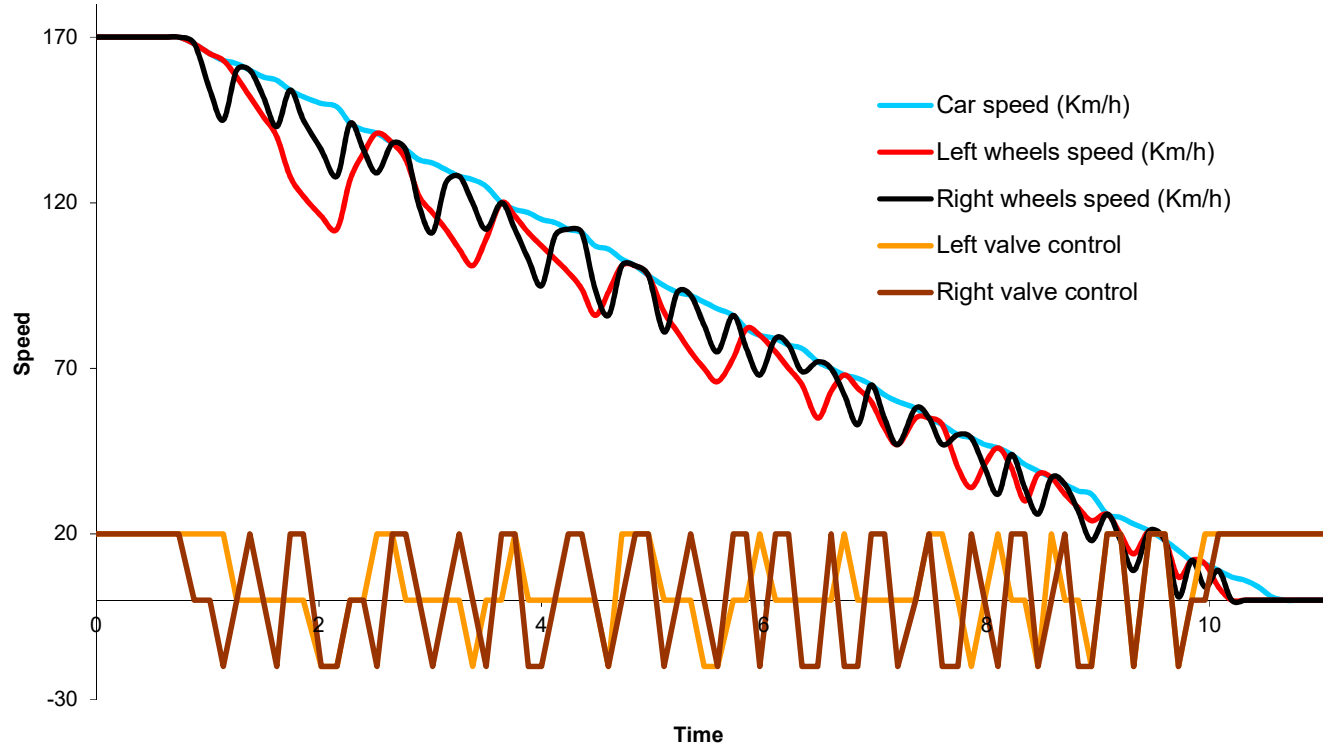
Breakdown of the solenoid valves' actual signal:

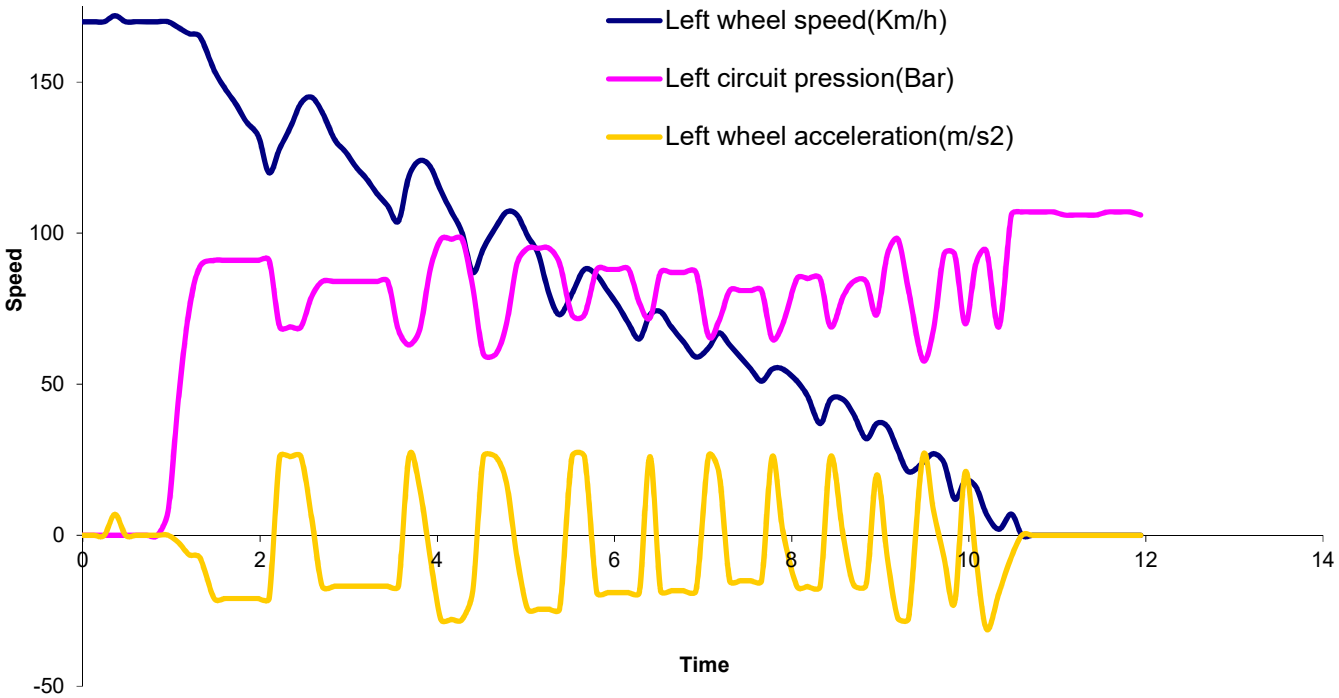


The curve on the previous page recorded by the ABS1000 console has no vertical lines. This is due to the sampling frequency (the number of measurements made per second).

Example of graphs in the braking phase with ABS

Conditions:
The LH wheel is on a dry ground and the RH wheel is on black ice.



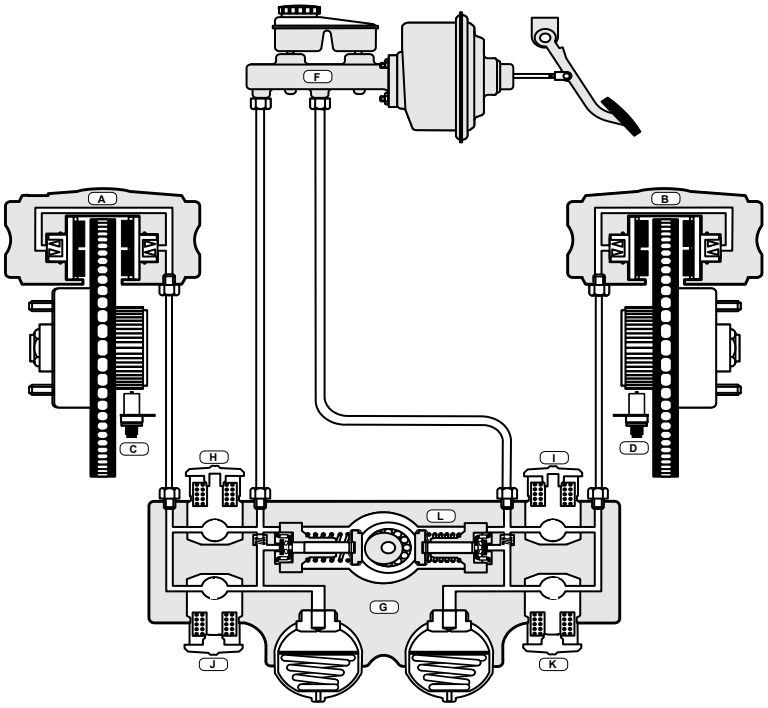


8. TEACHER-TRAINING COURSE

Practical work N°1

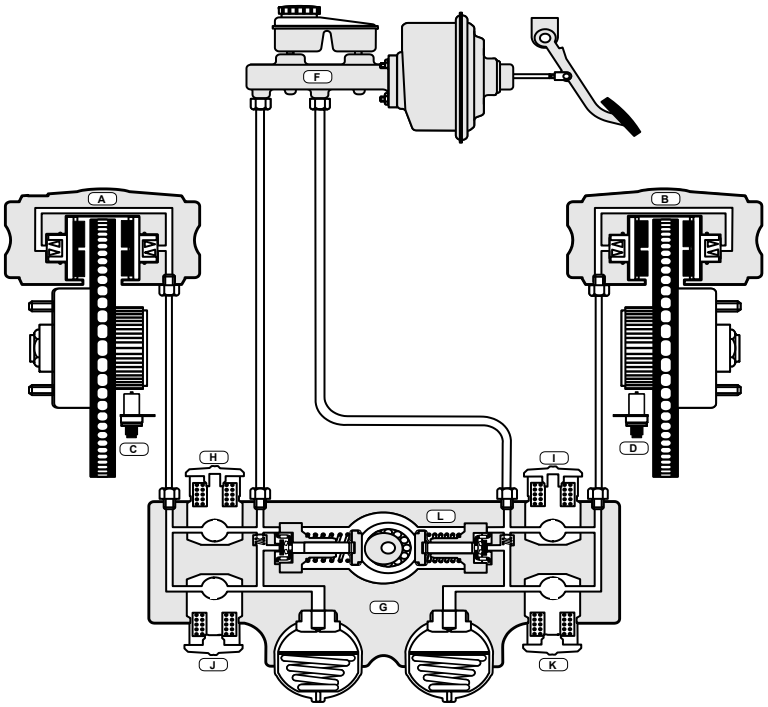
In the following sketches, indicate the positions of the solenoid valves, the braking efforts, the operation of the feeding pump, the fluid flow direction (consider the same adhesion on each wheel).

Question1: Is it in the pressure increase phase?

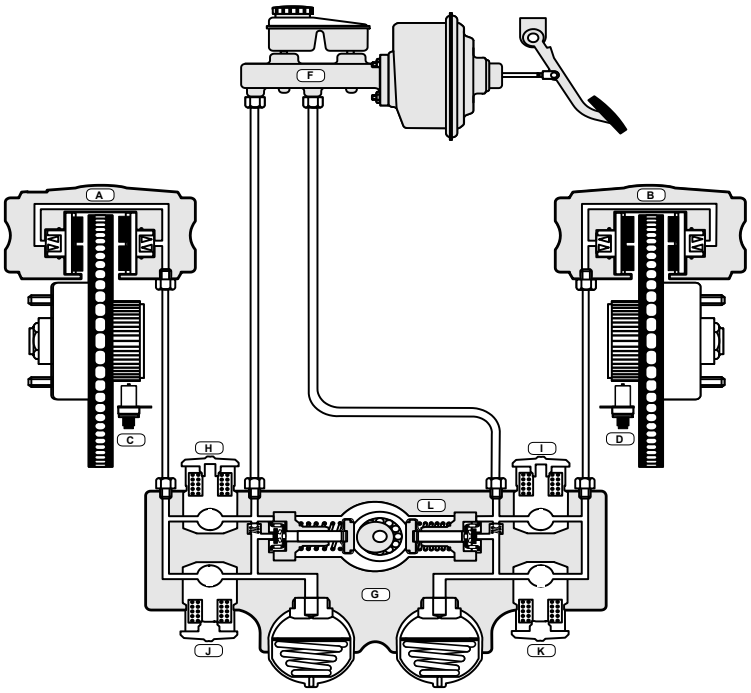


(Answer: Refer to Operation in the file on resources)

Question2: Is it in the pressure holding phase?



Question3: Is it in the pressure decrease phase?



Practical work N°2

With the ABSCOM software, give the stopping time for breaking with the ABS system, with two wheels on a dry road and with an initial speed of 170 Km/h.

~ 6.42 seconds

Give the same stopping time for the same braking but with the ABS system disconnected.

~ 9. 2 seconds

What can be inferred from this?

The ABS system reduces the stopping distance on a dry road.

Carry out the operation for the other adhesion conditions with an initial speed of 170 Km/h on a wet road, 80 Km/h on a snow-covered road and 25 Km/h on an icy road.

Adhesion	*Initial speed*	*Without ABS*	*With ABS*
Wet	*170*	*13.1*	*7.7*
Snow covered	*80*	*8.4*	*12.32*
Icy	*25*	*18.22*	*7.16*

What do we notice on a snow-covered road?

It is the only condition in which the ABS system increases the stopping distance.

What is this phenomenon due to?

When a vehicle locks its wheels on a snow-covered road, snow packs in front of the wheel and the adhesion coefficient increases thus increasing the deceleration.

Why isn't the ABS system disconnected on a snow-covered road?

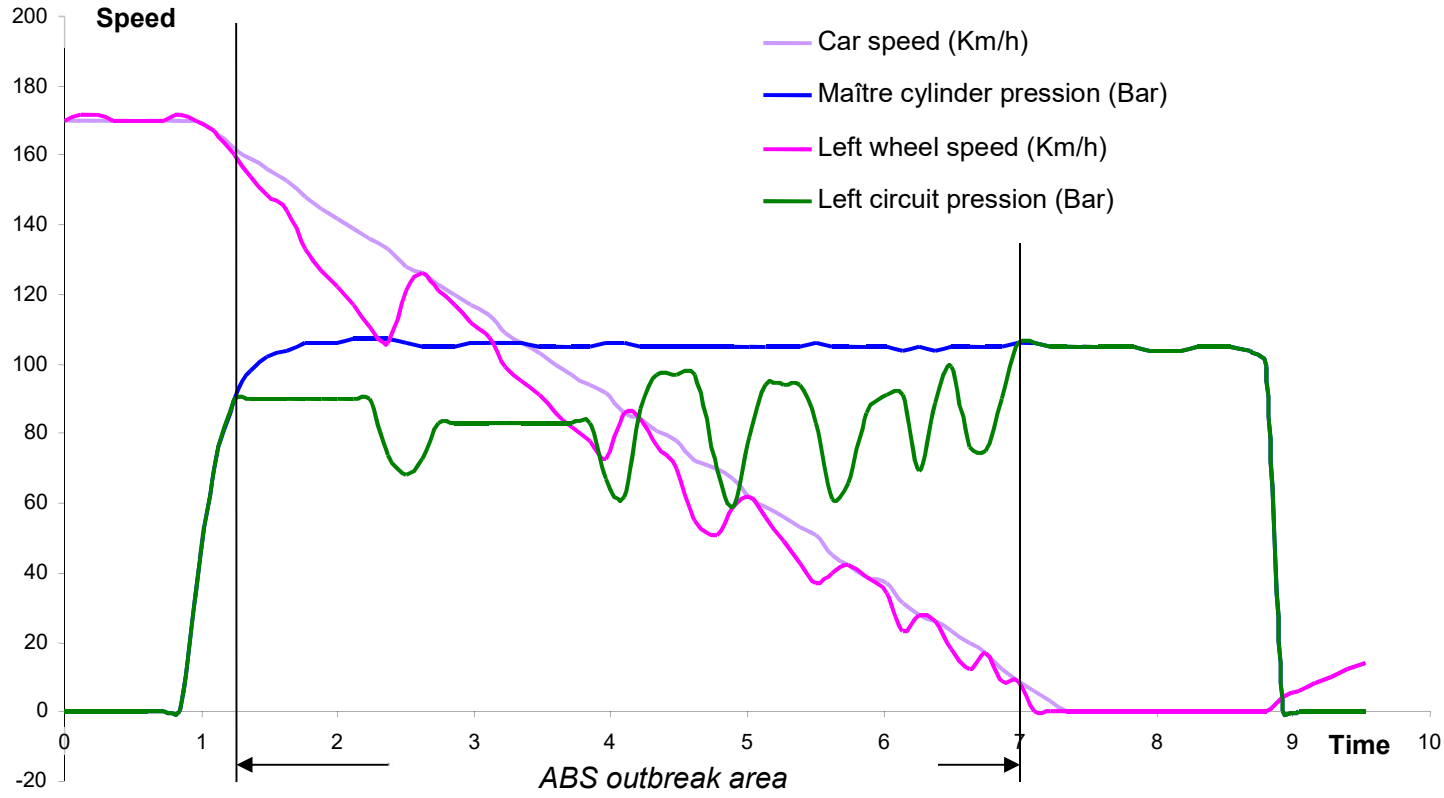
In order to keep the vehicle's steering-ability.

Make a recording on a dry road by slamming on the brakes with the ABS system being operative until the vehicles stops.

Then plot the following curves:

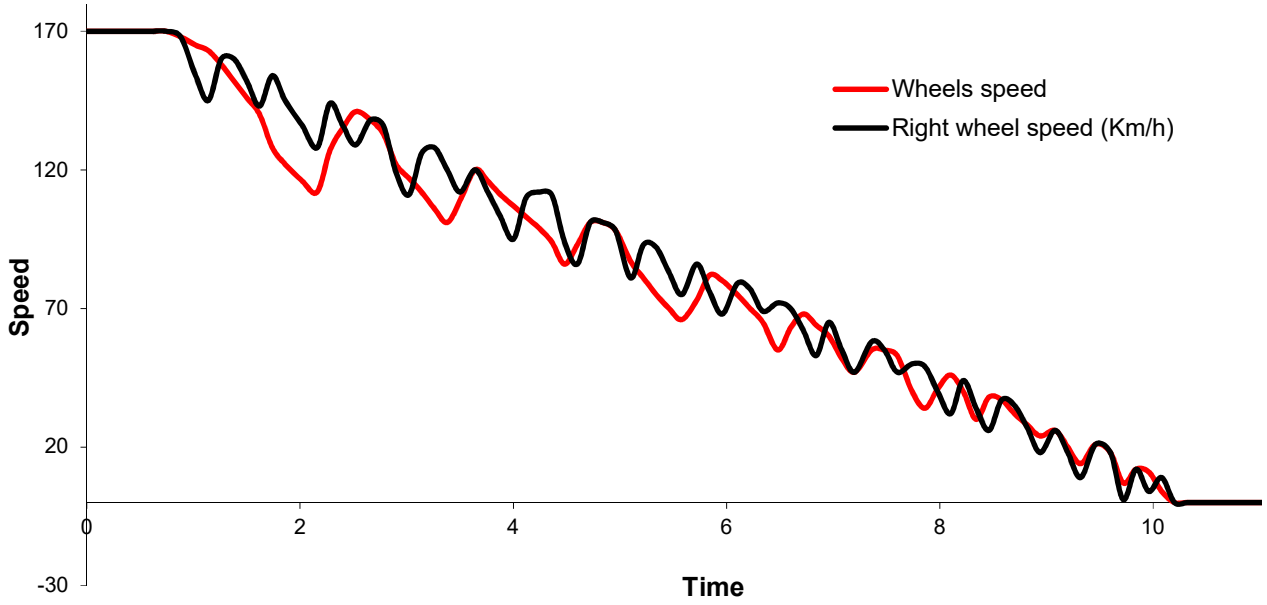
- Vehicle speed
- Pressure in the master cylinder
- LH wheel speed
- Pressure in the LH caliper

By means of two vertical lines indicate the zone in which the ABS system is triggered off.



Practical work N°3

The curves shown below were plotted with a wheel on dry ground and a wheel on black ice. Indicate which wheel was on the dry ground and why?



It is the LH wheel because the regulation cycles are slower than those of the RH wheel.

The wheel on the icy ground tends to lock up much faster than the wheel on the dry ground. That is why the ECU must control its solenoid valves much quicker, which thus accelerates the regulation cycles

Practical work N°4

Gives the theoretical formula and the corresponding units of the maximum possible deceleration according to the adhesion coefficient and to the acceleration of due to gravity:

Maximum deceleration (m/s²) adhesion coefficient x 9.8 (m/s²)

Use this formula to calculate the theoretical stopping distance for a vehicle speeding at 100 Km/h and braking on snow (adhesion coefficient of 0.2):

0.2 x 9.81 = 1.962

The maximum theoretical deceleration is 1.962 m/s²

100 / 3.6 / 1.962 = 14.158

The vehicle will stop in 14.158 seconds

100 / 3.6 / 2 x 14.158 = 196.63

The vehicle will stop in 196.63 meters

This calculation proves that the vehicle's weight has no influence on the theoretical stopping distance.

Connect REFLET2000W to the rear wheel sensors' signals (these wheels are supposed to never lock up, they indicate the vehicle's reference speed).

On the console, set the vehicle speed to 100 Km/h

Make an oscilloscope curve of the wheel sensors on REFLET 8:

Considering that the console's sensor rings have 48 teeth per revolution, what is the diameter of the wheels that can be inferred in mm?
The measurement made with REFLET2000W indicates that for a speed of 100 Km/h, the wheels make 1 revolution in 5.74 ms (the 48 teeth are visible in 57.42 ms)

Therefore

10^3 / 57.42 = 17.41

The wheel's speed is 17.41 revolutions per second (1045 rpm)

100 / 3.6 = 27.77

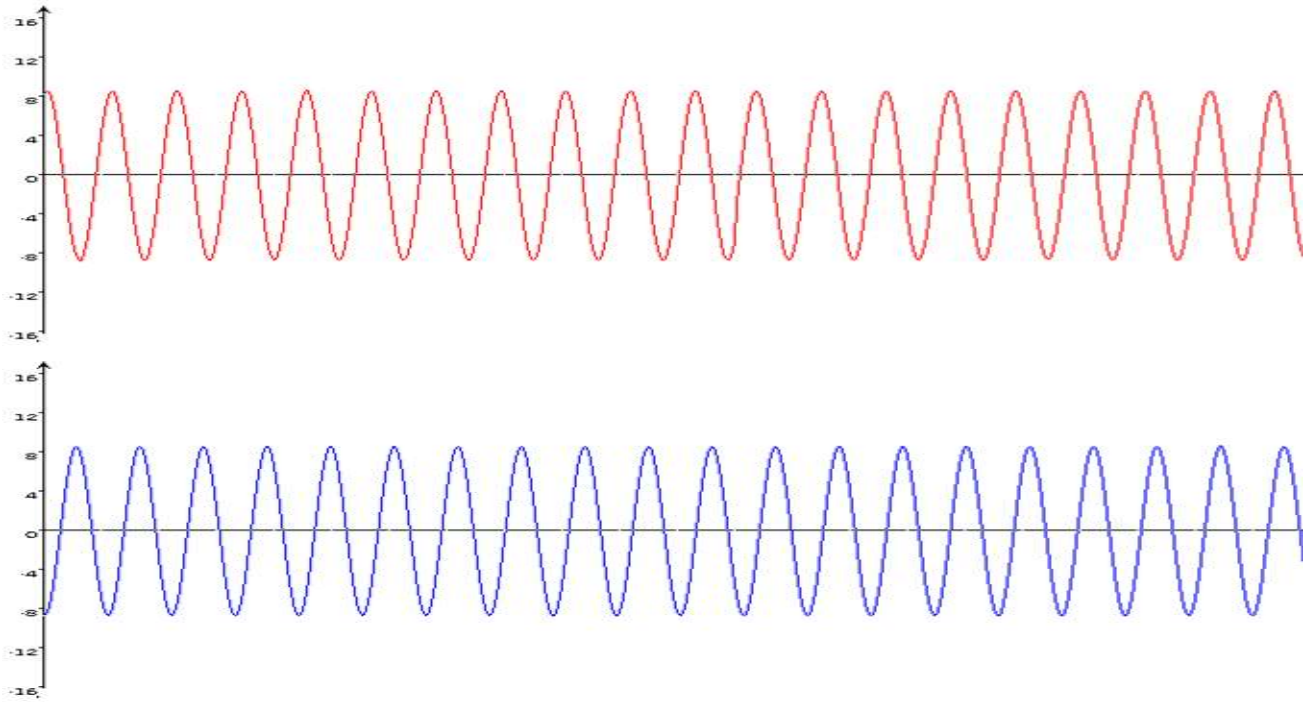
100 Km/h = 27.77 m/s

Distance travelled in 1 wheel revolution:

27.77 / 17.41 = 1.59 m

The circumference of the wheel is thus 1.59 m
The diameter of the wheels is:

1.59 /π x 1000



DECLARATION CE OF CONFORMITY

By means of this declaration of conformity, as defined by the European Directive on Electromagnetic Conformity 2004/108/EC, the company:

ANNECY ELECTRONIQUE S.A.S.
Parc Altaïs – 1, rue Callisto
F-74650 CHAVANOD

Declares that the following product:

Brand	Model	Description
EXXOTEST	**DTP-ABS1000 model**	**TRAINING MODEL: automatically controlled vehicle air conditioning**

I - Has been manufactured in accordance with the requirements of the following European Directives:

- LV Directive 2006/95/EC - 12 December 2006
- Machinery Directive 98/37/EC - 22 June 1998
- EMC Directive 2004/108/EC - 15 December 2004

and satisfies the requirements of the following standard:

- NF EN 61326-1 dated 07/1997 +A1 of 10/1998 +A2 of 09/2001
  Electrical measurement, control and laboratory equipment, EMC-related requirements.

II - Has been manufactured in accordance with the requirements of the European Directives relating to EEE design and WEEE management for the EU. :

- Directive 2002/96/EC dated 27 January 2003 on Waste Electronic and Electrical Equipment (WEEE)
- Directive 2002/95/EC dated 27 January 2003 on the limitations for the use of certain hazardous substances in the construction of Electronic and Electrical Equipment (EEE).

Drawn up in Saint-Jorioz on 12 December 2011.

CEO - Stéphane SORLIN