SCANIA

After Sales Services

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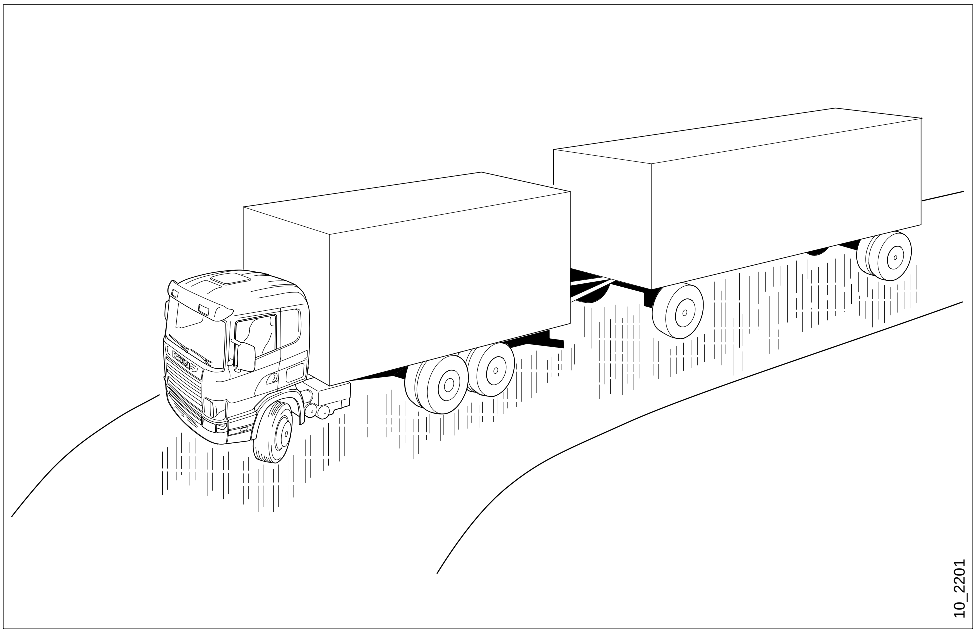
Issue 1 **en**

ABS/TC

Description of operation



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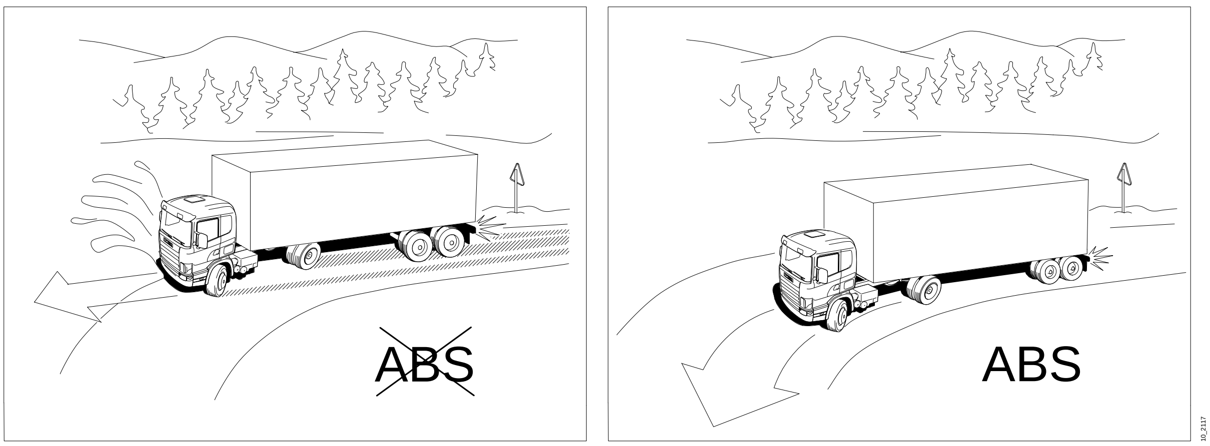
Contents

ABS

ABS stands for Anti-lock Brake System. The advantage of ABS is mainly when emergency braking. As wheel lock is prevented, braking distance is shortened and steering is improved, irrespective of the road surface. Improved steering during ABS also reduces the danger of jackknifing, even if the trailer does not have ABS. Optimum braking performance is achieved if both tractor and trailer are equipped with ABS. The part of the vehicle which does not have ABS will brake in the normal way with the danger of the wheels locking.

Remember that on slippery road surfaces, friction is lower and braking distance is increased, even for a vehicle with ABS brakes.



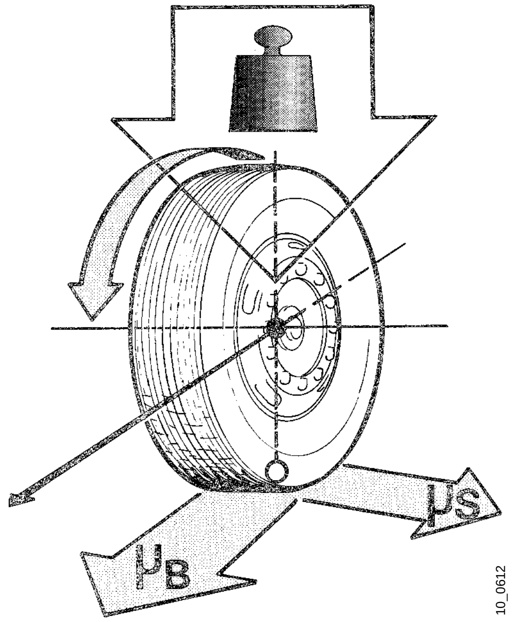
Friction

In order to understand the principle of how the ABS/TC system works, it is necessary to look at what happens between the tyre and the road surface in different situations.

Friction between tyre and road surface can be split into two parts:

- braking force friction (µB)
- lateral force friction (µS)

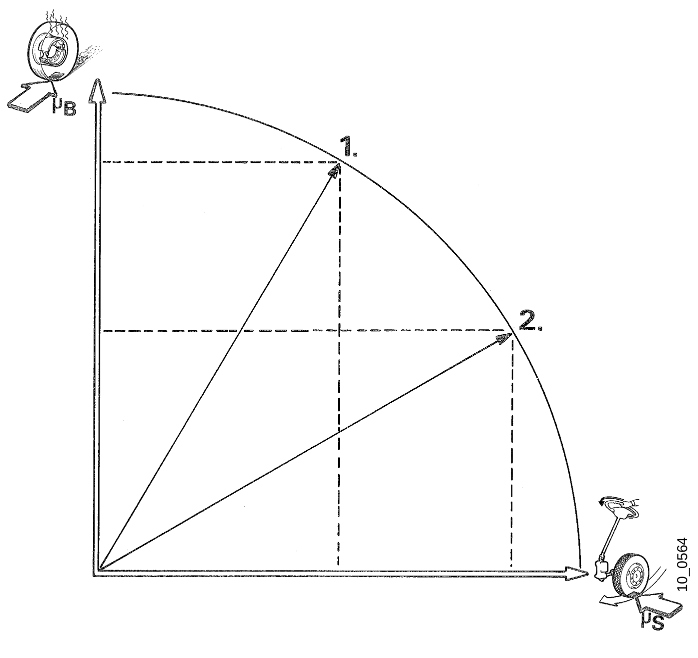
The latter is used for steering and stability.



In order to show the correlation between braking force friction and lateral force friction during braking in a simple way, total available friction can be illustrated as a curve on a graph as below. Braking force friction (µB) is on the vertical axis and lateral force friction (µS) on the horizontal axis.

If two random points, 1 and 2, are selected on the graph, total friction remains constant, but the distribution between braking force friction and lateral force friction is different. In example 1, µB is greater than µS and in example 2, µS is greater than µB.

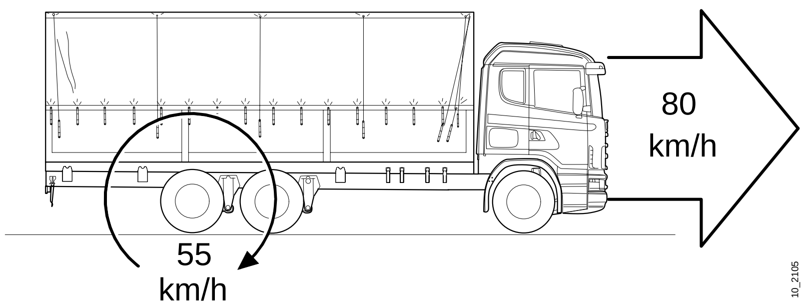
It can also be seen that if all available friction is used for braking, there is no friction left for lateral force, that is to say no steering.



Slip

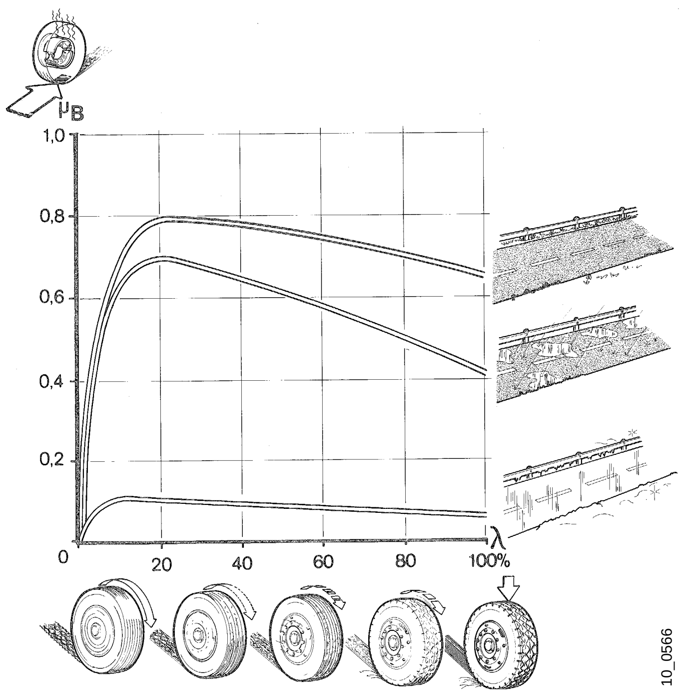
As a wheel turns, there is always a certain movement between the contact surface of the tyre and the road surface. As the wheel brakes, there is a certain loss of traction in the direction of rotation, which we call slip.

A wheel which is rotating entirely free without being braked or powered has 0 % slip. When the wheel is locked, slip is 100 %. If the wheel of a vehicle has 30 % slip and vehicle speed is 80 km/h, wheel speed is about 55 km/h. See illustration.

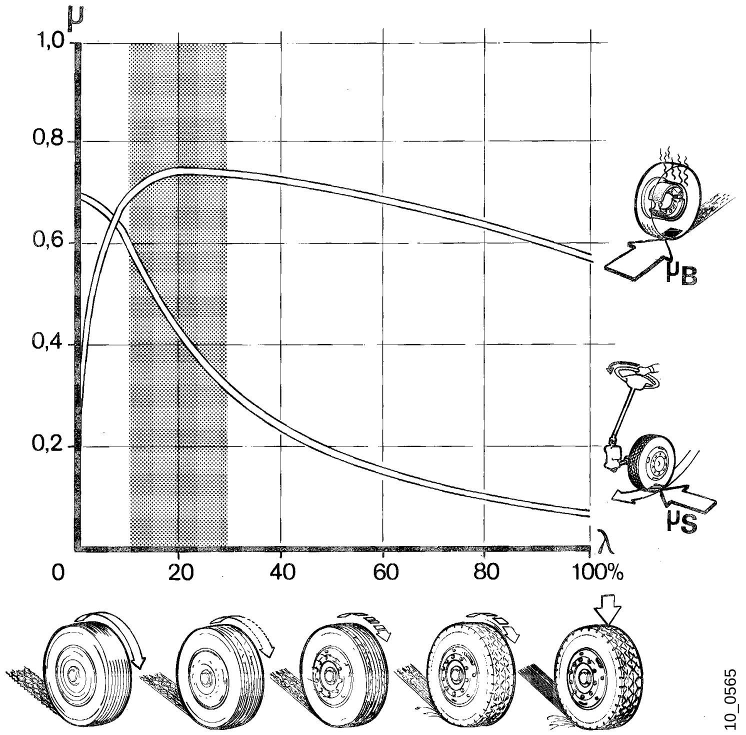


Correlation between friction and slip

The correlation between friction coefficient in the direction of rotation µB and slip λ on different types of surfaces is illustrated below. It can be seen that braking force can be increased until slip is 10-20 %, depending on the surface, before maximum braking force is used. If you then brake harder, increasing slip, the friction coefficient will decrease and the wheel will finally lock.



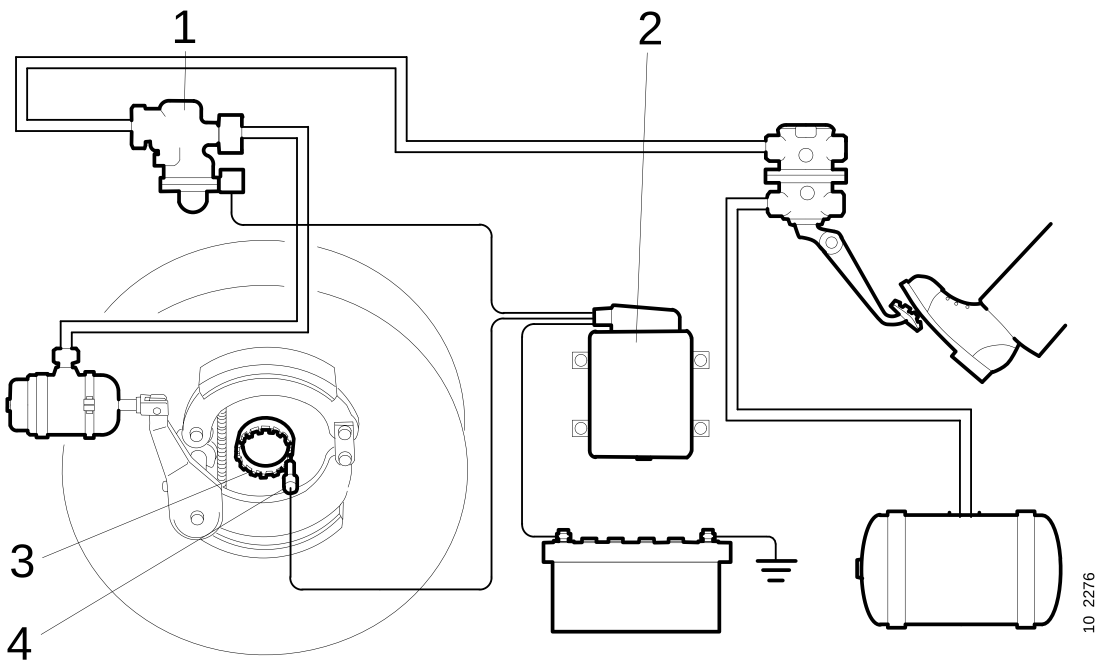
The illustration below shows the correlation between brake force coefficient μB and lateral force coefficient μS as a function of slip λ. The graph shows that with a slip of 10-30 %, braking capacity and steering are still very good, which means that the stability of the vehicle is satisfactory.



It is thus the range up to 30 % slip that is the stable range for different types of surface and it is in this slip range that ABS works.

ABS senses when a particular wheel is loosing grip and starting to lock. Brake pressure is then automatically controlled so that the wheel is always held within the most effective slipping zone, irrespective of friction against the road surface.

ABS, layout and operation



The system has four main components.

1 ABS control valve: two front and two rear (four circuit system).

2 Electronic control unit, ABS.

3 Pulse ring: two front and two rear (four circuit system).

4 Wheel sensors: two front and two rear (four circuit system).

The pulse ring (3) is attached to the wheel hub. The sensor (4), which is an electromagnetic sensor, is attached to the axle and senses wheel rotation. The signals from these are passed to the electronic control unit (2). In the control unit, the electronics sense the tendency of each controlled wheel to lock.

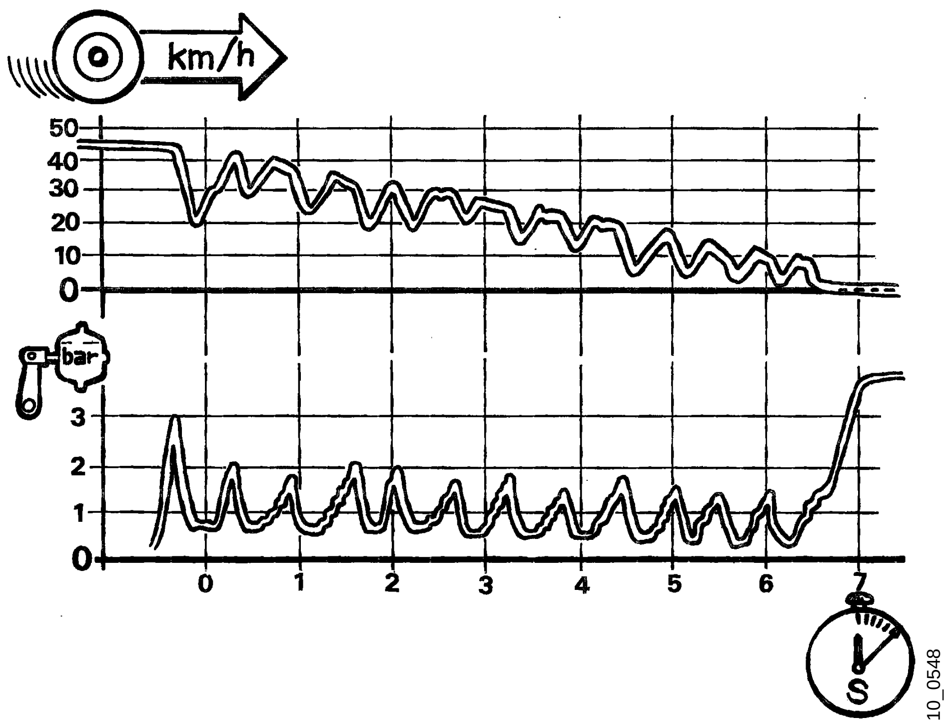
If any wheel is about to lock, a signal is sent from the control unit to the wheel control valve (1). The control valve than eases brake pressure so that wheel lock ceases. This achieves extremely fast pumping of the brakes.

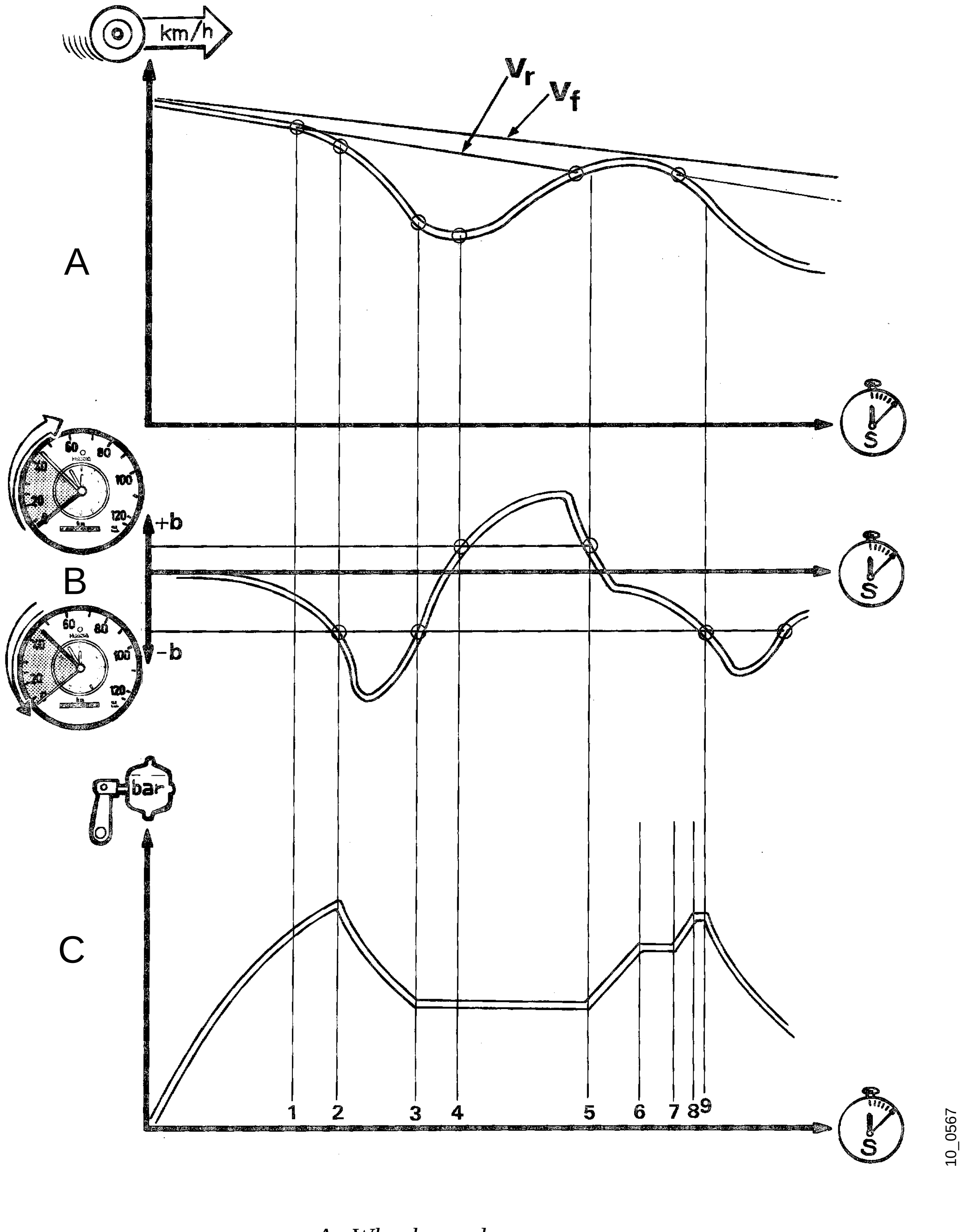
What happens during control (ABS)

What happens when a particular wheel with ABS control is braked to stationary can be seen in the illustration below. In this case, the road surface has a low friction coefficient (e.g ice).

The illustration shows the speed variation for the particular wheel as brake pressure is controlled in an ABS system in order to avoid wheel lock.

It can be seen in the illustration that the time taken for pressure to be lowered and raised is less than one second. This process, called a control cycle, happens 2-3 times per second during full braking, depending on speed and surface. A full control cycle is described in detail on the next page.





A. Wheel speed
Vr=reference speed
Vf=vehicle speed

B. Wheel retardation and acceleration

C. Brake chamber pressure

The control example illustrated applies to a surface with high friction coefficient. In the case of other friction coefficients, the microcomputer built into the control unit will calculate a control process, where the various control graphs looks slightly different.

Up to point 1, wheel speed follows the programmed reference curve (calculated based on speed signals), Vr. From there, wheel retardation increases and has at point 2 reached the limit -b for retardation as in graph B and brake pressure is therefore reduced quickly. Due to the time taken for evacuating and the inertia in the brake system, the wheel will be retarded slightly more and enter the so called unstable slip zone (>30%) before wheel retardation decreases and once again passes the -b limit at point 3.

Brake pressure is now kept constant for a short time and the wheel therefore accelerates. At high friction values (e.g dry asphalt) as shown in the illustration, the wheel will accelerate quickly up to the +b limit (point 4) and brake pressure is therefore kept constant the whole time acceleration is above +b.

In the case of low friction values (e.g wet asphalt), the wheel will not accelerate up to the +b value if brake pressure is maintained. Instead, a signal will be sent to the valve to lower the pressure even further, as the -b limit for slip will be exceeded.

If the friction value is extremely low (e.g. ice) or if the lower limit for maximum slip has been exceeded, brake pressure will continue to be lowered until acceleration exceeds the +b value.

At point 5, the wheel is back in the stable slip zone and the +b limit has been passed. Brake pressure is now quickly raised for a short period (point 6) in order to overcome the inertia in the system.

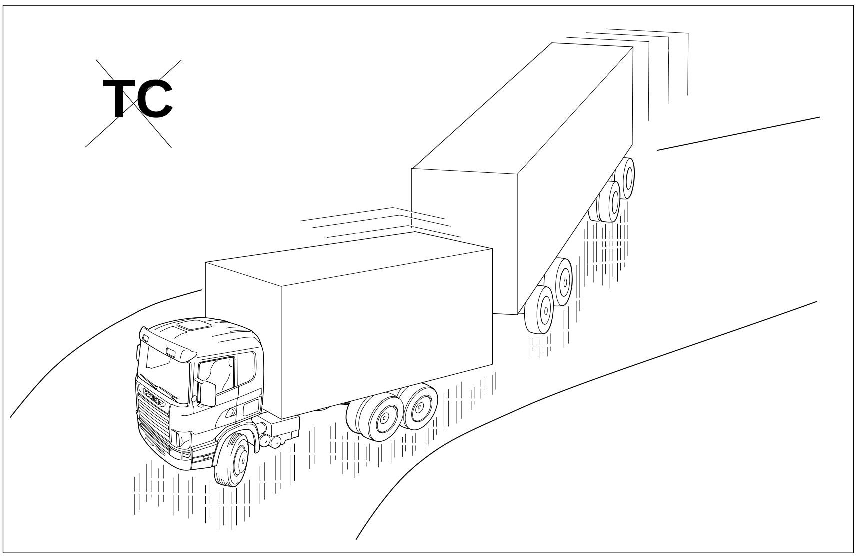
Pressure will then be raised successively, alternating between being raised and being maintained for short time periods, until the -b limit for retardation is again reached at point 9 and brake pressure is lowered. A complete control cycle has now been carried out.

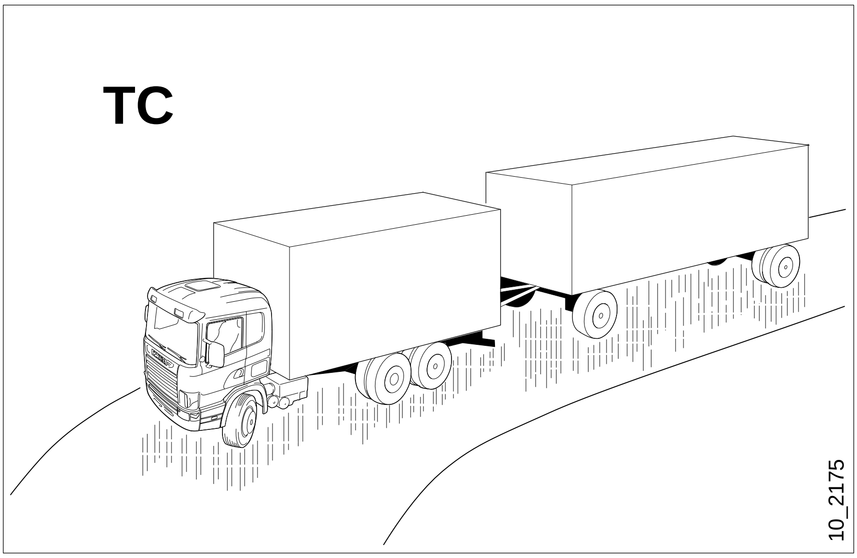
Advantages of the TC system

TC stands for Traction Control. TC prevents the drive wheels from spinning during excessive acceleration. TC has the following advantages:

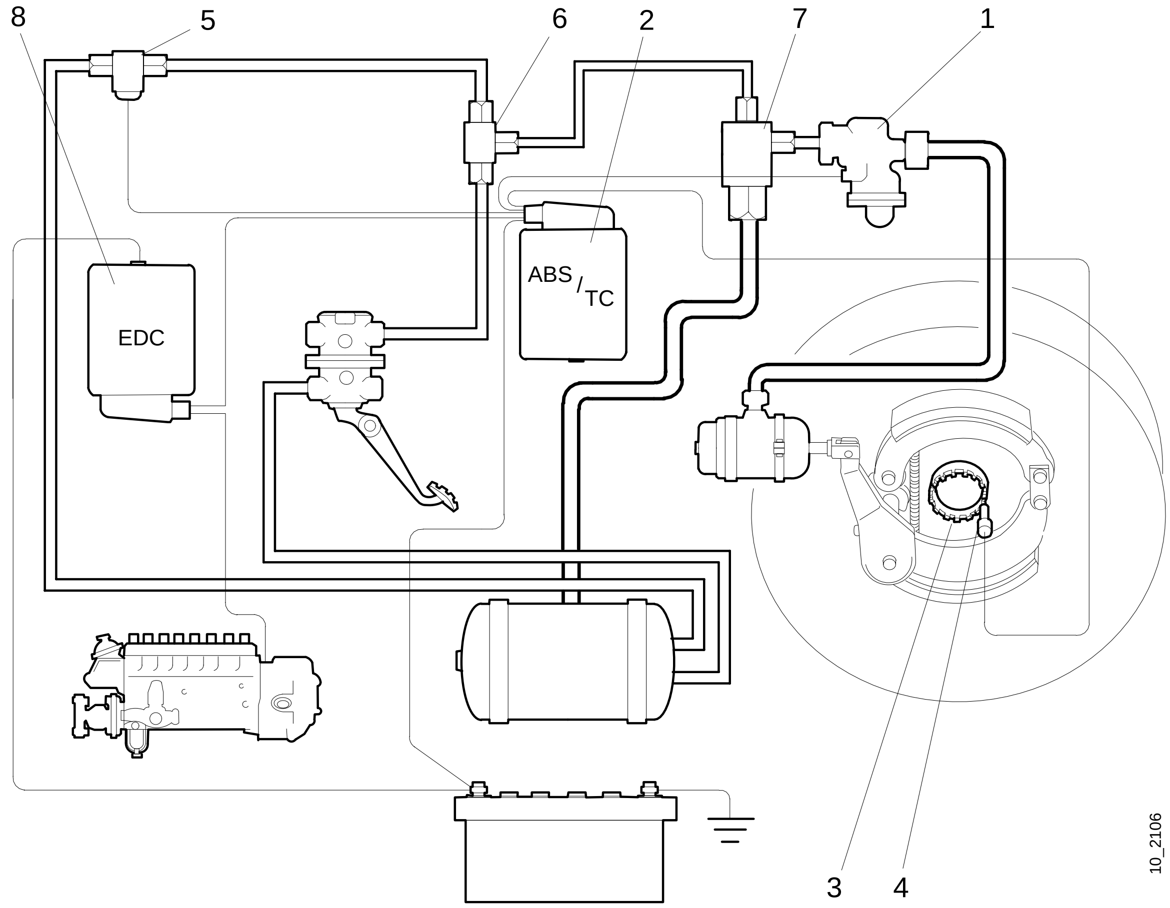
- Easier to pull away on slippery surfaces.
- Reduced risk of skidding when cornering.
- Improved hill climbing capacity
- Less wear to tyres and transmission.
- Improved stability compared with conventional differential lock when driving on sideways slopes.
- Better steering than conventional differential lock.

TC is a complement to ABS and uses the same components.





ABS/TC, layout and operation



The system has eight main components:

1 ABS modulating valve: two front and two rear (four circuit system).

2 Electronic control unit, ABS/TC.

3 Pulse ring: two front and two rear (four circuit system).

4 Wheel sensors: two front and two rear (four circuit system).

5 Solenoid valve (TC brake control), one unit for the driving wheel pair.

6 Double check valve, one unit for the driving wheel pair.

7 Relay valve, one unit for the driving wheel pair.

8 Electronic control unit, electronic diesel control (EDC) for TC engine control.

The pulse ring (3) is attached to the wheel hub. The sensor (4), which is an electromagnetic sensor, is attached to the axle and senses wheel rotation.

Signals from the wheel sensors are passed to the electronic control unit (2). The electronics in the control unit sense slipping. TC control has two control circuits:

- Brake control circuit
- Engine control circuit

Brake control

The brake control circuit is activated when only one drive wheel is slipping. This happens when the grip on the road surface is different between the driving wheels. The brake chamber receives compressed air via the solenoid valve (5). The level of brake chamber pressure is then controlled by the ABS modulating valve (1). Brake torque is thus transferred via the differential gear as drive torque to the wheel which is not slipping.

Brake torque is increased until both wheels have the same speed. The speed of the drive wheels is thus adjusted, meaning that TC brake control acts has a differential lock.

To prevent the brakes overheating, the TC brake control is only activated at speeds of under approx. 40 km/h.

Engine control

Engine control is active at all speeds and is engaged when both wheels spin at the same speed. It is also engaged when one wheel spins and vehicle speed is greater than about 40 km/h. The electronic governor on the injection pump is actuated via the EDC control unit (8). The quantity of fuel decreases and engine speed and output decrease until the average speed of the driving wheels, compared with that of the vehicle is within the permitted values (programmed into the control unit).

Information about required reduction of engine drive torque is transmitted between the ABS/TC control unit and the EDC control unit via two cables.

Note: Malfunctions can arise if tyre sizes between the front and rear axle vary too much. See the work description in the Workshop manual.

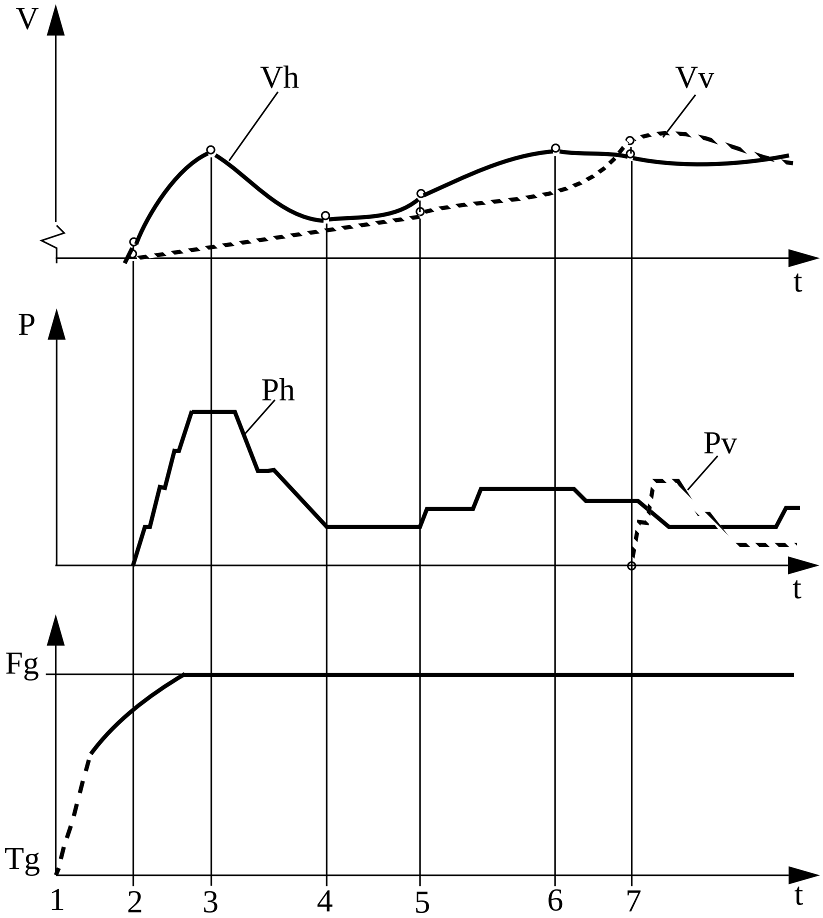
TC Off Road

A greater wheel spin is achieved with the TC-Off Road operation engaged than with ordinary TC operation. This can be desirable when, for example, driving through mud, gravel or deep snow.

When the TC Off Road switch is depressed, the slip limit is raised by approx. 10 km/h compared to normal. This means the drive wheels can have an approx. 10 km/h greater speed than the front wheels.

What happens during control (TC)

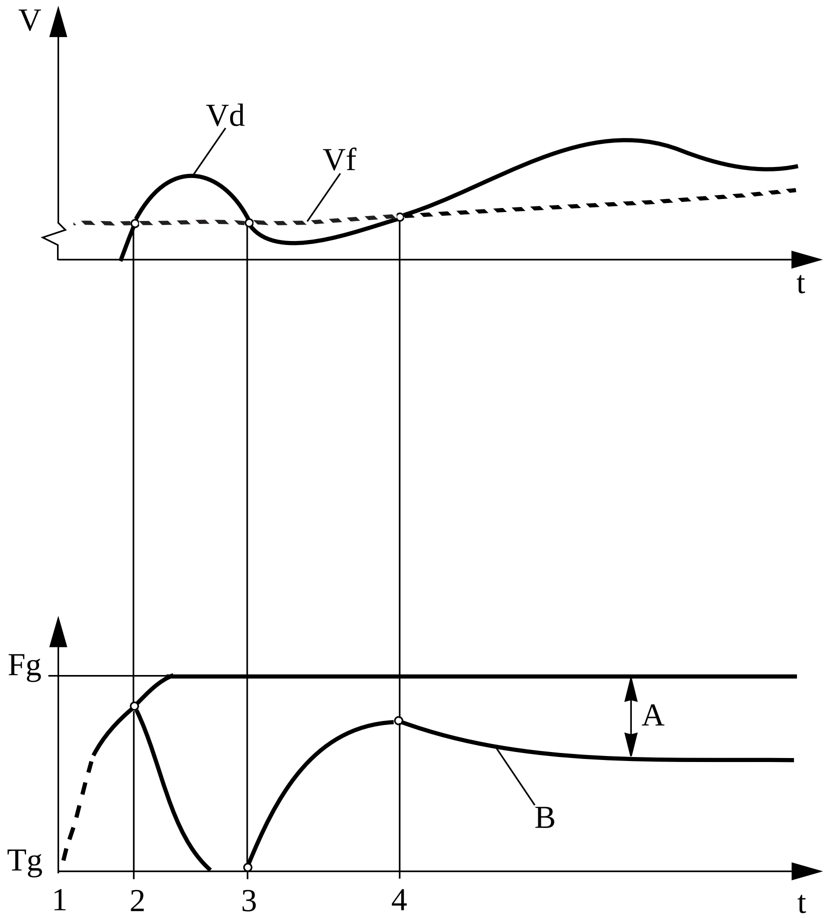
Brake control



Vh = Wheel speed, RH rear
Vv = Wheel speed, LH rear
Ph = Brake chamber pressure, RH rear
Pv = Brake chamber pressure, LH rear
Fg = Full throttle
Tg = Idling

Point	Event
1	Driver accelerates.
2	The right-hand wheel slips. The speed of the right-hand wheel is compared with that of the left-hand wheel. Brake control pressure is built up in pulses.
3	The right-hand wheel stops accelerating. Pressure is lowered in pulses.
4	The right-hand wheel is no longer slowing. There is a small difference in speed between the right-hand and left-hand wheels. Pressure is maintained at a constant level.
5	The right-hand wheel accelerates. The speed of the right-hand wheel is compared with that of the left hand wheel. Brake control pressure is raised in pulses.
6	The right-hand wheel stops accelerating. Pressure is lowered in pulses.
7	The left-hand wheel slips. The speed of the left-hand wheel is compared with that of the right-hand wheel. Brake control pressure is raised in pulses.

Engine control



Vd = Wheel speed, driving axle
Vf = Wheel speed, front axle plus driving slip*
A = Reduction
B = Position of injection pump control rack
Fg = Full throttle
Tg = Idling

Point	Event
1	Driver accelerates.
2	The speed of the driving axle is greater than that of the front axle plus driving slip*. Engine control is reduced.
3	The speed of the driving axle is less than that of the front axle plus driving slip*. Engine control ceases.
4	The speed of the driving axle is greater than that of the front axle plus driving slip*. Engine control is reduced.

*Driving slip = programmed slip tolerance. With the Off Road switch pressed, the difference in speed between the front and rear wheels rises by approx. 10 km/h.

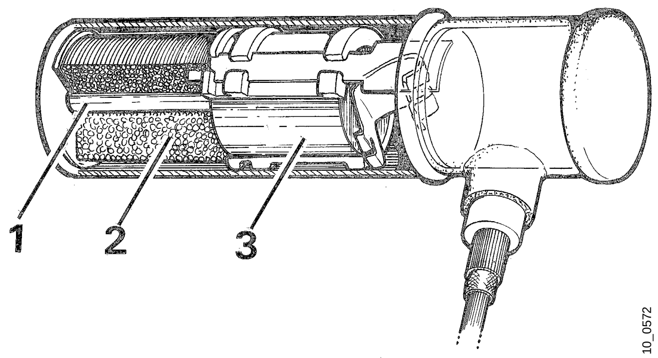
Wheel sensor

The inductive wheel sensor basically consists of a permanent magnet with a coil and a round terminal pin.

When the pulse wheel rotates, the magnetic flow in the coil is converted to alternating current, whose frequency is proportional to the speed of rotation of the wheel.

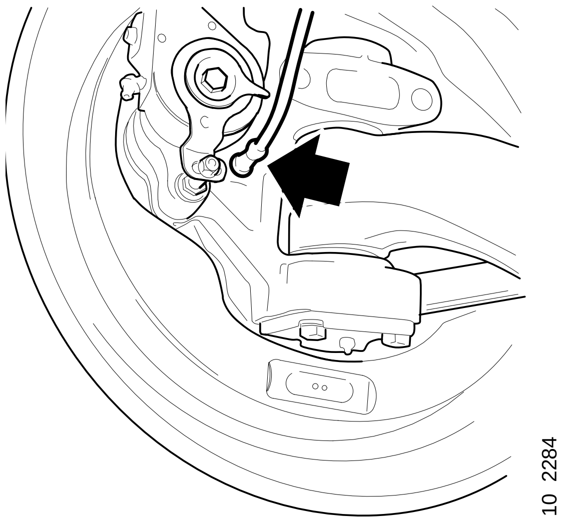
This alternating current is then converted to digital signals in the control unit.

1 Terminal pin.
2 Coil.
3 Permanent magnet.

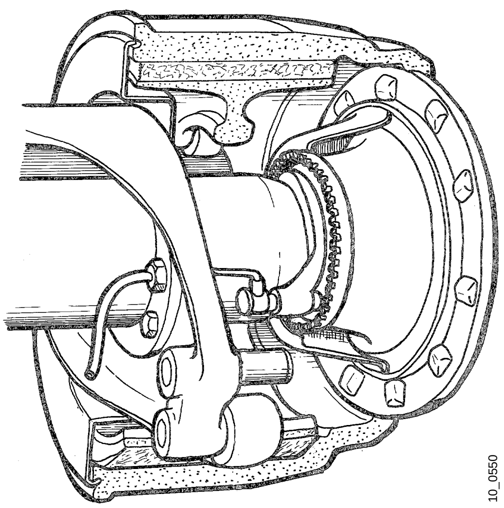


The sensor is fitted with a corrosion resistant clamp sleeve. At the front wheel, it is attached to the steering knuckle and at the rear wheel, in a special holder on the rear axle, so that it is held in contact with the pulse wheel. The wheel sensor will then adjust itself with a sufficient air gap when started up.

The air gap between the wheel sensor and the pulse ring must not be too large. If it is, the system will stop working. The cause of this might, for example, be too much play in the wheel bearings.



Example of installation on front wheel



Example of installation on rear wheel

Control unit design

Inside the control unit housing is a circuit board mounted on a frame. This frame also holds power transistors and the control unit switch.

The control unit consists of integrated circuits and microprocessors.

Control unit subsystems

Power supply

The power supply part delivers a stable voltage for powering the control unit.

Input stage

At the input stage, any transmitted signal disturbance is filtered out. The sine wave signal from the sensors is converted to a square wave signal. Via a special connector, the diagnostic lead can transmit information in both directions, for example to a diagnostic computer.

Computer

Two microprocessors are used to control each vehicle diagonal. When the control unit is powered (starter switch turned), a self test is carried out in each microprocessor. The program memory is also checked continuously as long as the control unit is in use.

The rotation speed of each wheel is calculated by the ABS program. The average speed of the front wheels is used as a reference speed for engine control. Both driving wheels are used as a reference speed for TC brake control. The following control signals are calculated using wheel speed and the reference speed:

- TC solenoid valve
  If one driving wheel, when compared to the other driving wheel, exceeds a permitted slip limit (when vehicle speed is below about 40 km/h), the TC solenoid valve is activated. At a set time after brake control ends, the TC solenoid valve is released and the line is vented.

- ABS modulating valve
  Brake chamber pressure increase, decrease or the maintenance of pressure is calculated in the same way as during ABS control, that is to say using wheel speed and the reference speed. Pressure is dependent on slip, acceleration and retardation.

- Engine control
  Control deviation is the difference between the average speed of the wheels of the front axle and that of the driving axle. Engine torque is reduced via the EDC control unit.

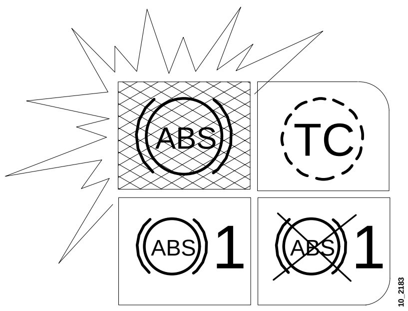
Final stage

The final stage controls the solenoid valves and units such as warning and information indications.

ABS Indicator lamps

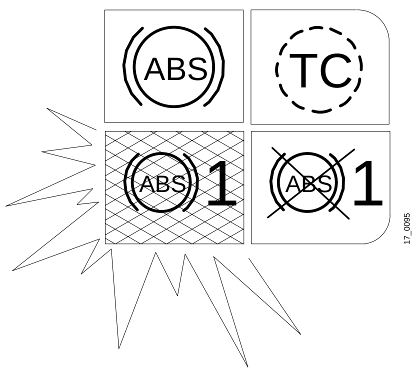
The ABS system has two warning lamps and one information lamp. If the vehicle has no trailer attachment, there is only a truck warning lamp. The warning lamp lights if there is a fault in the ABS or if the TC brake control solenoid valve is not working. If there is a fault, the faulty part is disconnected, but ordinary brake system function is maintained.

- Yellow truck warning lamp:
  This light comes on when the starter switch is turned to drive position and then goes off after approx. 3 seconds or at a speed of 5-7 km/h provided there are no faults in the vehicle's system. If a fault has arisen, it comes on immediately or at a speed of 5-7 km/h.

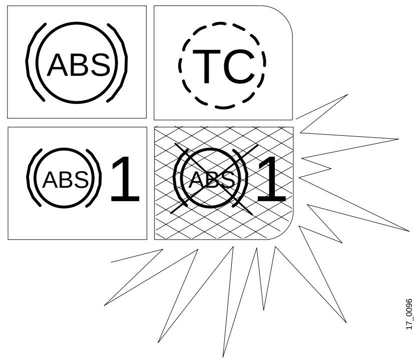


- Yellow trailer warning lamp:
  This lights when the starter switch is turned to the drive position if a trailer with ABS is coupled to the vehicle. This goes out after 1 second or at a speed of 5-7 km/h (depending on which ABS system the trailer has), provided there are no faults in the trailer system.

  This lamp comes on if there is a fault in the trailer's ABS system when driving.

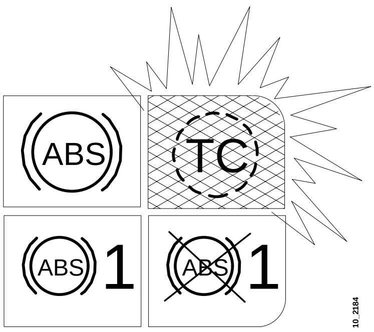


- Yellow information lamp:
  The yellow information lamp lights for about 3 s when the starter switch is turned to the drive position. This lamp remains on if a trailer without ABS is coupled. It goes out if a trailer with ABS is coupled or if no trailer is coupled.



If any of the indicator lamps does not come on when the starter switch is turned to the drive position, there is a fault in the lamp or its power supply.

TC indicator lamp



In the TC system, the information lamp and the warning lamp are one and the same. This lamp should come on for one second when the starter switch is turned to the drive position and then go out when the brake pedal is depressed. This is a safety feature. The TC system does not operate before the TC lamp has been switched off with the brake pedal. The TC lamp is on when:

- brake or engine control are engaged.
- there is fault in the engine control circuit or the EDC control unit is disconnected.

If TC Off Road is activated using the TC Off switch, the TC lamp flashes as long as the switch is in the Off Road position.

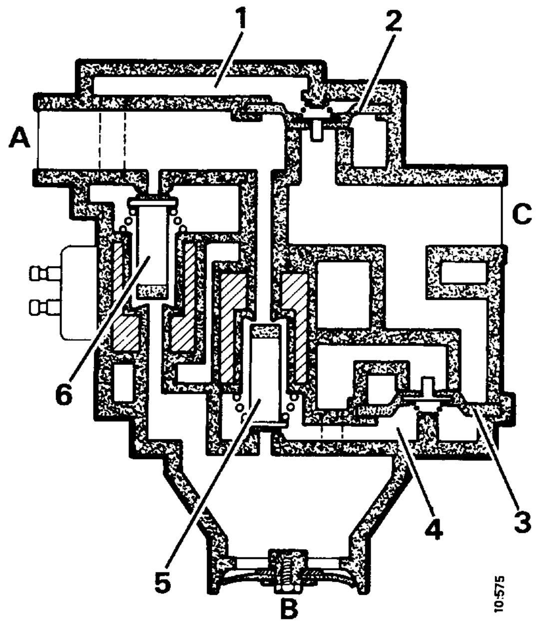
If the TC lamp does not come on when the starter key is turned to the drive position, there is a fault in the lamp or its power supply.

Control valve functions

The electropneumatic control valve consists of a double magnet and two diaphragm valves. The solenoids are of low mass and are very quick, which is essential for high efficiency and low air consumption. The control signals can be as short as a few milliseconds.

The valves has three control functions:

- Increasing pressure
- Decreasing pressure
- Maintaining pressure



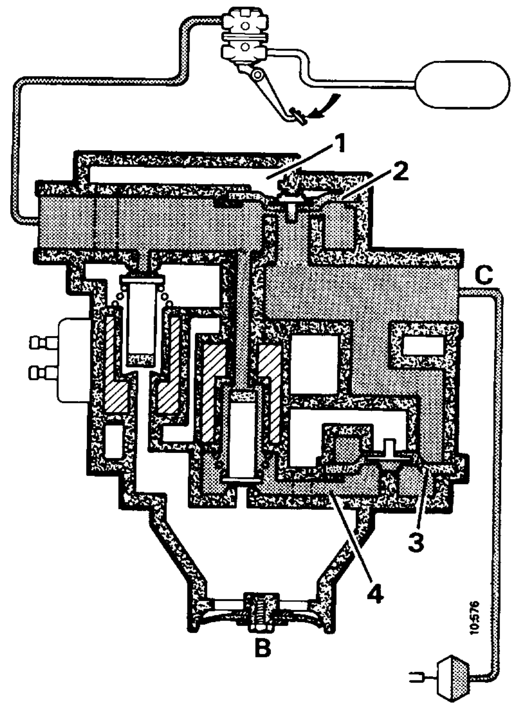
1 Control chamber for charging
2 Diaphragm valve for charging
3 Diaphragm valve for venting
4 Control chamber for venting
5 Solenoid valve for charging 2
6 Solenoid valve for charging 1

A = Intake
B = Evacuation
C = Outlet to wheel

Increasing pressure

Both solenoid valves are unactivated. This means that the control chamber (1) for the inlet is at atmospheric pressure and the diaphragm (2) is therefore pressed upward by the incoming compressed air, allowing it to pass through the valve to outlet C.

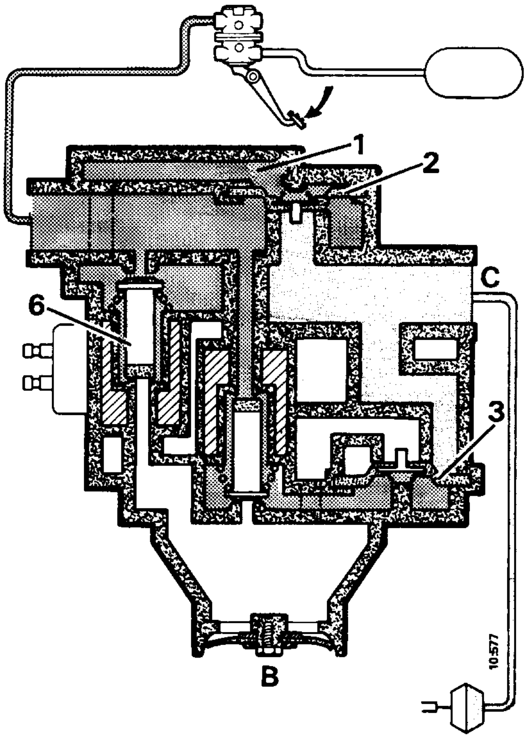
At the same time, incoming brake pressure works in the evacuating control chamber (4) and presses the diaphragm (3) upward, thereby closing evacuation B.



Maintaining pressure

When maintaining pressure, only solenoid valve (6) is activated. Input brake pressure then works in the control chamber (1) and presses down the membrane (2) so that the channel to outlet C is closed.

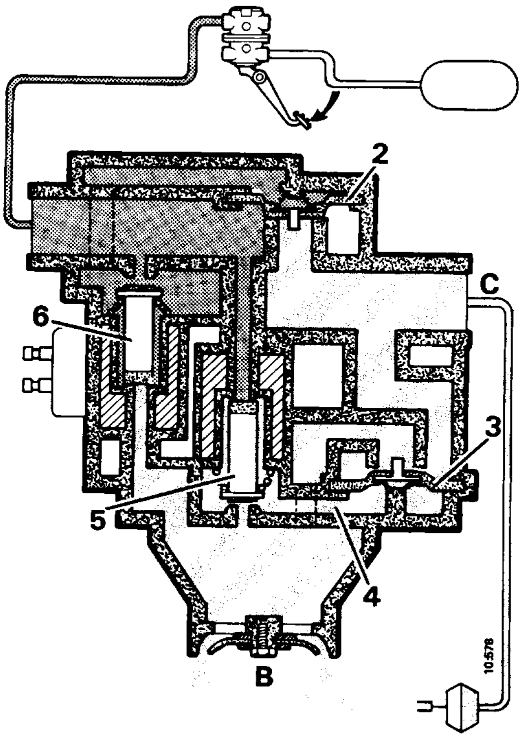
As input pressure also actuates the diaphragm (3), the channel to evacuation B is closed and pressure is maintained.



Lowering pressure

When pressure is lowered, both solenoid valves are activated. When solenoid valve (5) opens towards evacuation B, pressure drops in the control chamber and the membrane (3) then opens the channel from valve outlet C to evacuation B.

The solenoid valve (6) is in the same position as when pressure is maintained, as input pressure presses down the membrane and closes outlet C.



Solenoid valve function

The TC brake control solenoid valve is normally closed. The solenoid valve receives a signal from the ABS/TC control unit to open. A control pressure is then sent via the double check valve to the relay valve which supplies brake pressure to each control valve. The wheel which is not slipping is not braked as the hold function in the control valve is activated. Operation, see Workshop Manual group 10, solenoid valve 81.

Double check valve function

The double check valve ensures that the highest pressure from either the service brake valve or the solenoid valve reaches control valve. Operation, see Workshop Manual group 10, double check valve 11.

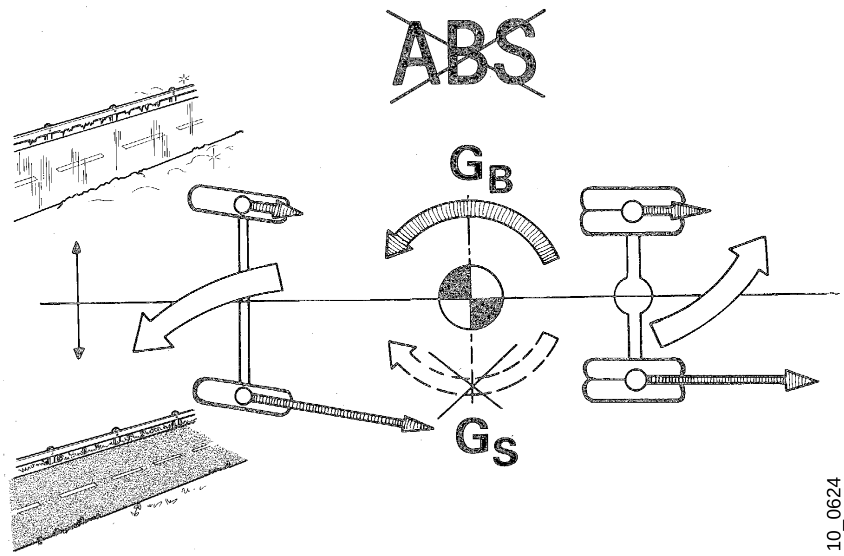
Relay valve on trucks with tag axle

Trucks with tag axle and TC are equipped with two relay valves to prevent the tag axle from being braked during TC brake control. This means that the air that comes via the ABS modulating valve only reaches the tag axle, when the foot brake valve is activated. Operation, see Workshop Manual group 10, relay valve 12A.

Installation of ABS in other types of vehicle

All vehicle types use a 4 circuit system with modified independent regulation (MIR) on the front wheels and independent regulation (IR) on the rear wheels.

MIR means that in cases where the friction coefficients are very different between the front wheels (so called split surface), it is still possible to steer the vehicle. This is made possible as the difference in brake pressure between the right-hand and left-hand front wheels is gradually built up without the turning forces on the vehicle becoming so great that it is difficult to steer.



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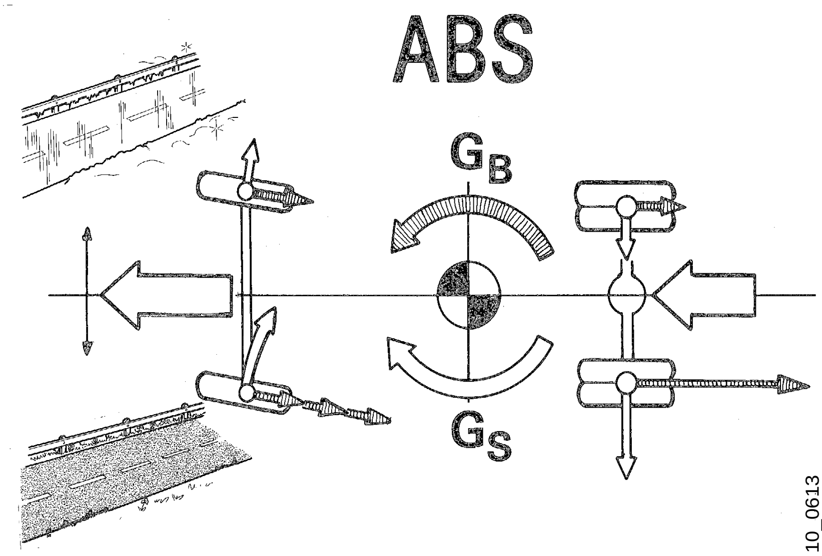

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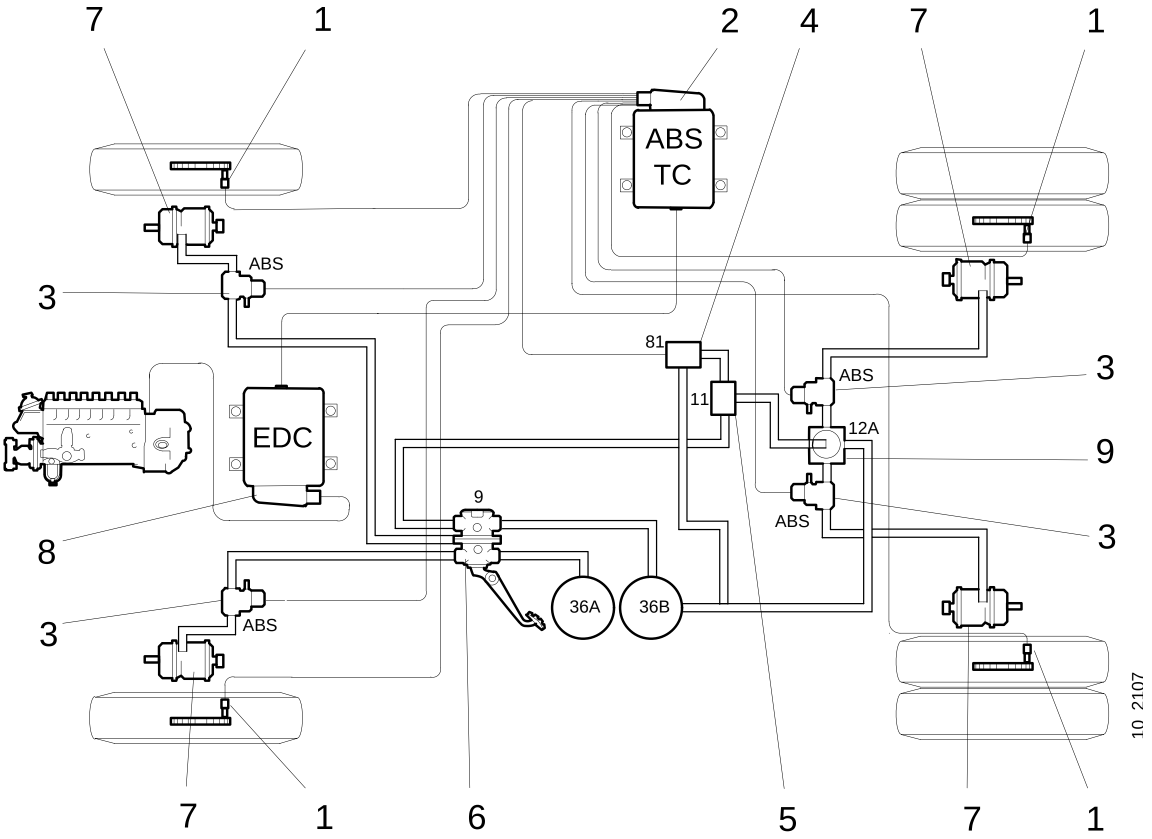
G_B= Yaw moment due to braking forces
G_S= Yaw moment due to lateral forces

With ABS, G_B is approximately equal to G_S

ABS/TC skeleton diagram, 4x2



1. *Wheel sensor*
2. *Electronic control unit, ABS/TC*
3. *Control valve*
4. *Solenoid valve (TC brake control)*
5. *Double check valve*
6. *Service brake valve*
7. *Brake chamber*
8. *Electronic control unit, EDC*
9. *Relay valve*