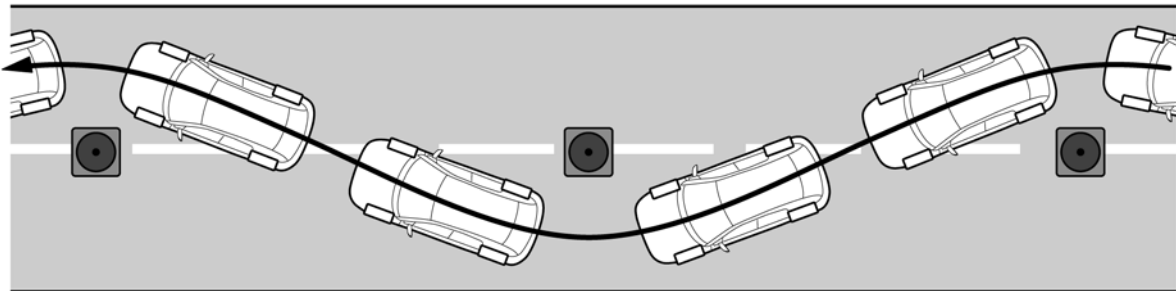


Training Manual

Dynamic Driving Safety Systems

CT-L2003



No part of this hardcopy may be reproduced in any form without prior permission of Mazda Motor Europe GmbH.

The illustrations, technical information, data and descriptive text in this issue, to the best of our knowledge, were correct at the time of going to print.

No liability can be accepted for any inaccuracies or omissions in this publication, although every possible care has been taken to make it as complete and accurate as possible.

© 2006
Mazda Motor Europe GmbH
Training Services



ZOOM-ZOOM

Introduction.....	00-1
Fundamentals	01-1
Forces Acting on the Vehicle.....	01-2
Yaw Moment.....	01-3
Longitudinal Force.....	01-3
Lateral Force	01-3
Vertical Force	01-3
Coefficient of Friction.....	01-4
Wheel Slip	01-6
Kamm's Circle	01-8
Antilock Brake System.....	01-10
Electronic Brakeforce Distribution	01-12
Traction Control System.....	01-15
Dynamic Stability Control	01-17
Emergency Brake Assist	01-19
Antilock Brake System.....	02-1
Parts Location.....	02-1
Hydraulic Unit / Control Module.....	02-2
Wiring Diagram.....	02-4
Layout.....	02-5
Hydraulic Circuit	02-5
Hydraulic Diagram	02-6
Operation.....	02-6
During Normal Braking	02-7
During ABS Control	02-8
Pressure Hold Mode.....	02-8
Pressure Reduction Mode.....	02-10
Pressure Increase Mode	02-11
Servicing.....	02-12
Bleeding.....	02-12
Diagnostics	02-14
Replacement	02-14
Wheel Speed Sensor.....	02-15
Passive Wheel Speed Sensor.....	02-16
Diagnostics	02-17
Checking the Air Gap	02-18
Active Wheel Speed Sensor.....	02-19
Diagnostics	02-20
Brake Switch.....	02-21
Diagnostics	02-22
ABS Warning Light	02-22
Diagnostics	02-24

ABS on Vehicles with 4WD	02-25
G-Sensor	02-25
Diagnostics	02-26
Replacement	02-26
Electronic Brakeforce Distribution	02-27
Brake System Warning Light	02-29
Diagnostics	02-30
Traction Control System	02-31
TCS Control Module	02-32
Wiring Diagram.....	02-32
Hydraulic Circuit	02-33
Hydraulic Diagram	02-34
During TCS Control	02-35
Pressure Increase Mode	02-36
Pressure Hold Mode.....	02-38
Pressure Reduction Mode	02-40
Bleeding.....	02-42
Diagnostics	02-42
TCS Indicator Light.....	02-43
Diagnostics	02-43
TCS OFF Indicator Light.....	02-44
Diagnostics	02-44
TCS OFF Switch.....	02-45
Diagnostics	02-45
TCS on Vehicles with 4WD	02-46

Dynamic Stability Control	02-46
Parts Location.....	02-47
Wiring Diagram.....	02-48
Hydraulic Circuit.....	02-50
Hydraulic Diagram.....	02-51
Operation.....	02-52
During DSC Control.....	02-55
Pressure Increase Mode.....	02-56
Pressure Hold Mode.....	02-58
Pressure Reduction Mode.....	02-60
Bleeding.....	02-62
Diagnostics.....	02-63
Combined Sensor.....	02-64
Diagnostics.....	02-65
Replacement.....	02-65
Steering Angle Sensor.....	02-65
Diagnostics.....	02-67
Replacement.....	02-67
Brake Fluid Pressure Sensor.....	02-67
Diagnostics.....	02-68
Replacement.....	02-68
DSC Indicator Light.....	02-68
Diagnostics.....	02-69
DSC OFF Indicator Light.....	02-70
Diagnostics.....	02-71
DSC OFF Switch.....	02-71
Diagnostics.....	02-72
Emergency Brake Assist	02-73
Electronic EBA.....	02-73
Mechanical EBA.....	02-74
Overview.....	02-75
Operation.....	02-76
Normal Braking.....	02-77
Emergency Braking.....	02-78
List of Abbreviations	03-01

Notes:

Introduction

- Recent decades have witnessed an ongoing series of advances in driving safety and comfort of automotive suspension. But ever-higher engine power and growing traffic volume have led to an increasing demand to improve the active driving safety of automobiles. However, a consistent stability in critical driving situations had to wait until advent of electronic control systems.
- The ever increasing use of electronics in vehicle systems has led to highly precise and miniaturized sensors that can exactly detect dynamic forces created during acceleration, deceleration, and cornering. These sensors and an appropriate electronic control system have been the crucial prerequisite for the development of dynamic driving safety systems that help the driver maintain vehicle control in critical driving situations.
- Although the dynamic driving safety systems offer a huge advantage for the passenger safety, it should be remembered that the extended driving safety does not extend the physical limitations valid for all vehicles.
- The following dynamic driving safety systems are used on current Mazda models and will be described in this training manual:
 - **Antilock Brake System (ABS)**
 - **Electronic Brakeforce Distribution (EBD)**
 - **Traction Control System (TCS)**
 - **Dynamic Stability Control (DSC)**
 - **Emergency Brake Assist (EBA)**
- The skills needed to diagnose and repair dynamic driving system related concerns require comprehensive system knowledge, because any mistake can lead to malfunctions on the brake system and consequently affect the passenger's safety. This course is a theoretical and practical guide to gain general and Mazda specific knowledge about the various driving dynamics safety systems, i.e. their components, function and diagnosis.
- Any person involved in the diagnosis and repair of the dynamic driving safety system must have the knowledge to deliver a "Fix it right first time" repair. The Mazda Masters Development and Qualification path provides the following training course required for the service on the dynamic driving safety system.
 - Dynamic Driving Safety Systems CT-L 2003
- The ranking of this course within the Mazda Masters educational system is Level 2 – 'Senior Technician'. It is focused on technicians who have passed the 'Mazda Technician' level already.

- The training manual “Driving Dynamic Safety Systems” is divided into the following main chapters:
 - Introduction
 - Fundamentals
 - Antilock Brake System
 - Electronic Brakeforce Distribution
 - Traction Control System
 - Dynamic Stability Control
 - Emergency Brake Assist

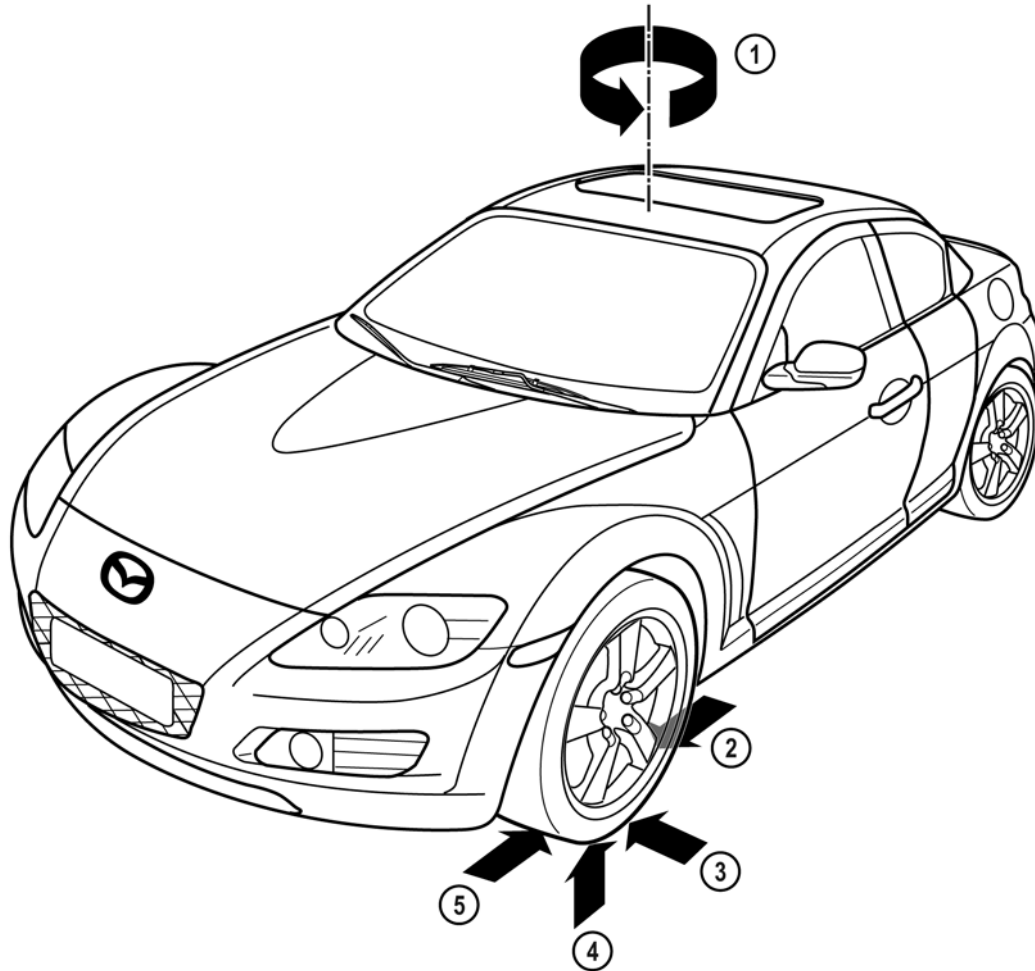
NOTE: The data, tables and procedures represented in this training manual serve only as examples. They are taken from the service literature and subjected to major or minor changes over the course of time. To prevent any misdiagnosis always refer to the current service literature while working on the driving dynamic safety system.

Fundamentals

- Various forces, that constantly change depending on the driving situation, determine the driving stability of a normal passenger vehicle. Whether or not these forces are properly transferred to the road completely depends on the four contact areas of the tyres; each one barely the size of a postcard! The key for this transfer is the right amount and type of friction between tyre and road surface. In the event the traction between tyre and road surface is lost, because the affecting forces have exceeded an appropriate limit, the vehicle handling becomes instable.
- The dynamic driving safety systems monitor specific parameters that indicate an impending traction loss of the wheels or vehicle skidding. In case of such situations the respective system counteracts this development by modulating either the brake pressure and / or the engine torque to maintain the vehicle stability.

Forces Acting on the Vehicle

- A large number of forces act on a vehicle during driving. The forces most important for understanding the dynamic driving system are shown in the illustration below.



L2003_01001

- 1 Yaw moment
- 2 Longitudinal drive force
- 3 Lateral force

- 4 Vertical force
- 5 Longitudinal brake force

Yaw Moment

- The yaw moment around the vehicle's vertical axis is caused by different longitudinal forces acting on the left and right side of the vehicle, or different lateral forces acting at the front and rear axles. Yaw moments are required to turn the vehicle when cornering. Undesired yaw moments can occur when a vehicle rotates too strongly around the yaw axis.

Longitudinal Force

- During driving, accelerating, decelerating, and braking, the longitudinal force acts in the driving direction of the vehicle.

Lateral Force

- The lateral force, that is applied to the vehicle by wind and cornering, acts sideways on the vehicle.

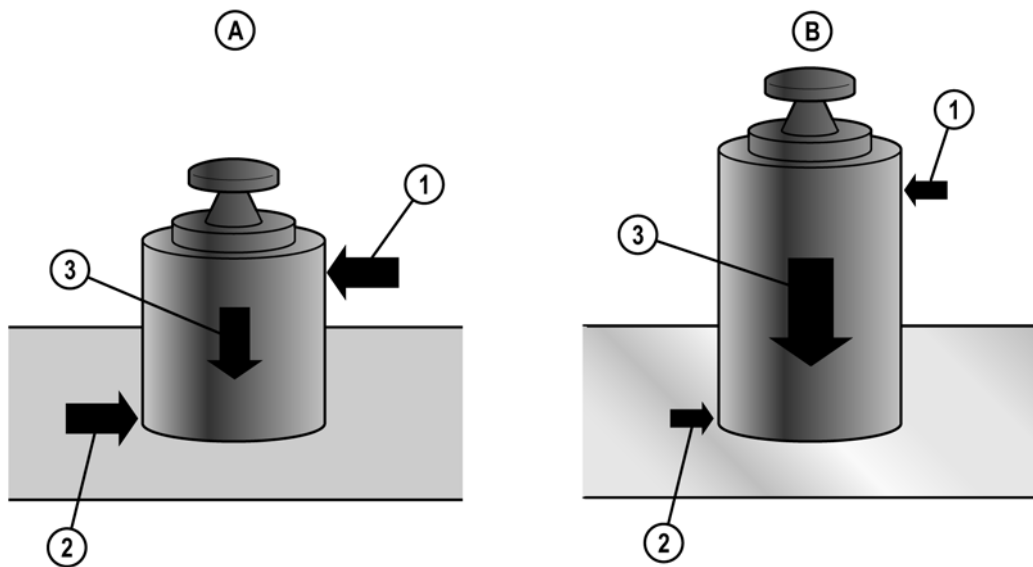
Vertical Force

- The vertical force is the weight that is transmitted vertically by a tire. It depends on the vehicle's gross weight, the vehicle's centre of gravity, and other dynamic influences.

Coefficient of Friction

- The frictional force is additionally affected by the coefficient of friction, which differs according to the materials and the surfaces rubbing against each other.
- The illustration shows that less force is necessary to push the larger weight across iced tarmac. It can be easily seen that the force required is much less than the vertical force due to the object's gross weight.
- The relationship between the frictional force and the vertical force is the coefficient of friction μ :

$$\mu = \frac{\text{Frictional force}}{\text{Vertical force}}$$

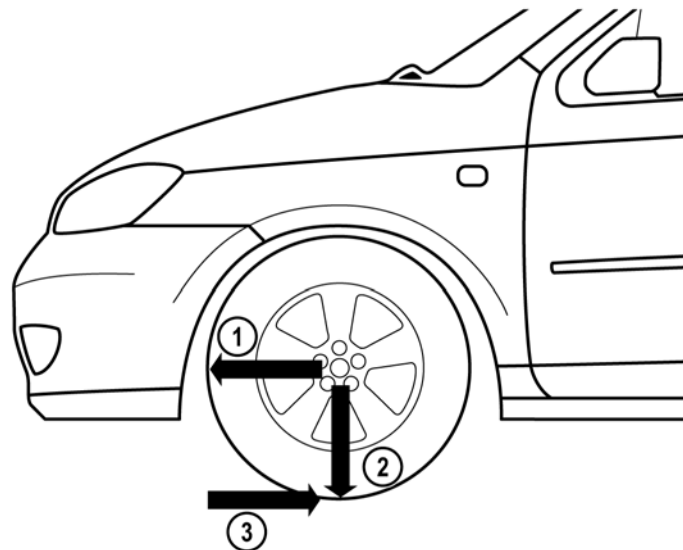


L2003_01004

- A Small weight on tarmac
B Heavy weight on iced tarmac
1 Necessary force to push the object

- 2 Frictional force
3 Vertical force

- The illustration shows the relationship between the tire downforce and the friction on a vehicle.



L2003_01017

- 1 Linear velocity of the vehicle
- 2 Tire downforce
- 3 Frictional force

- The table shows some sample values for the coefficient of friction between a tire and the road surface at various conditions.

Vehicle speed	50 km/h		90 km/h		130 km/h	
Tire condition	New	Worn	New	Worn	New	Worn
Dry road	0,85	1	0,8	0,95	0,75	0,9
Rain (depth of water approx. 0.2 mm)	0,65	0,5	0,6	0,2	0,55	0,2
Heavy rain (depth of water approx. 1 mm)	0,55	0,4	0,3	0,1	0,2	0,1
Puddles (depth of water approx. 2 mm)	0,5	0,25	0,05	0	0	0
Icy road	0,3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

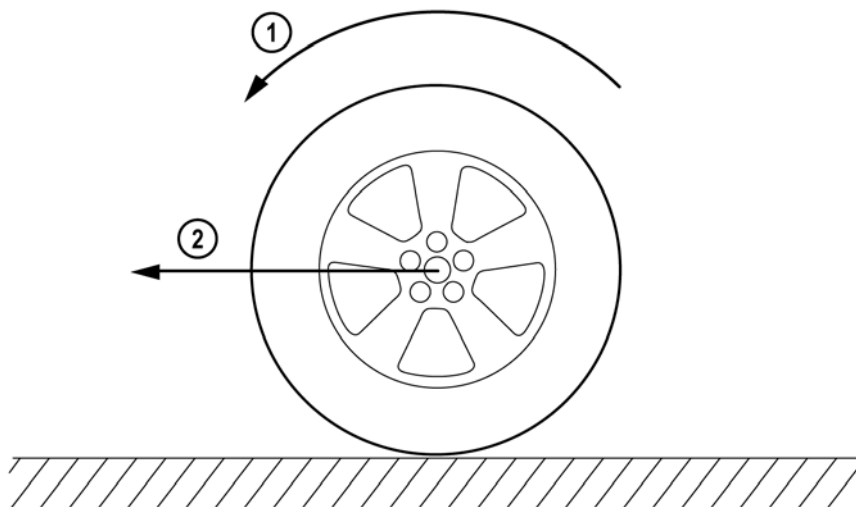
L2003_T01001

Wheel slip

- The wheel speed is, depending on the driving conditions, more or less different to the actual vehicle speed (what is the theoretical wheel speed). The difference between the theoretical and the actual wheel speed is the wheel slip.
- The circumferential speed of a driven wheel is higher than the vehicle speed during accelerating, and the circumferential speed of a braked wheel is less than the vehicle speed.
- The relationship between the speed difference (between vehicle speed and wheel speed) and the vehicle speed is the wheel slip λ :

$$\lambda = \frac{\text{Vehicle speed} - \text{wheel speed}}{\text{Vehicle speed}} * 100$$

- The wheel slip λ is calculated as a percentage. A fully locked wheel during driving, or a spinning wheel while the vehicle is stationary has a slip of 100 % while a wheel rotating with the vehicle speed has a slip of 0 %.
- The correct wheel slip is very important for the stability and driveability of a vehicle. Since the most force can be transmitted with a wheel slip of approximately 20 %, the ABS keeps the wheel slip between approximately 15...20 % in order to achieve a short braking distance while maintaining high driving stability and steerability of the vehicle.

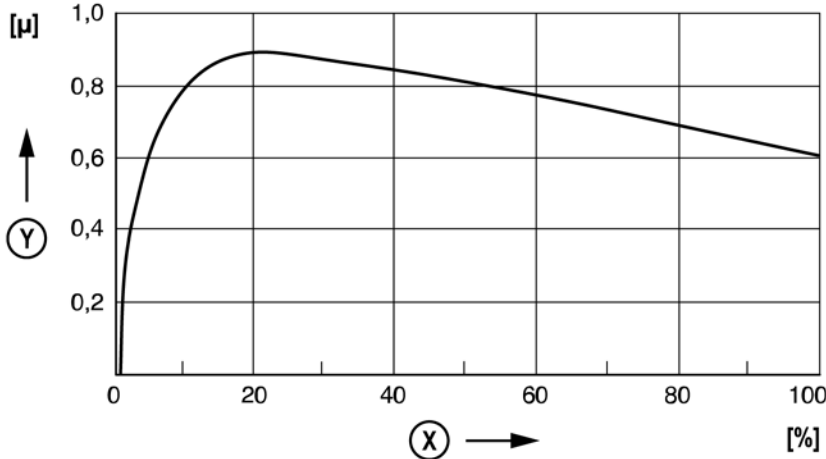


L2003_01005

1 Circumferential wheel speed

2 Vehicle speed

- The illustration below shows the influence of the wheel slip to the coefficient of friction between a tire and a dry normal road.



L2003_01015

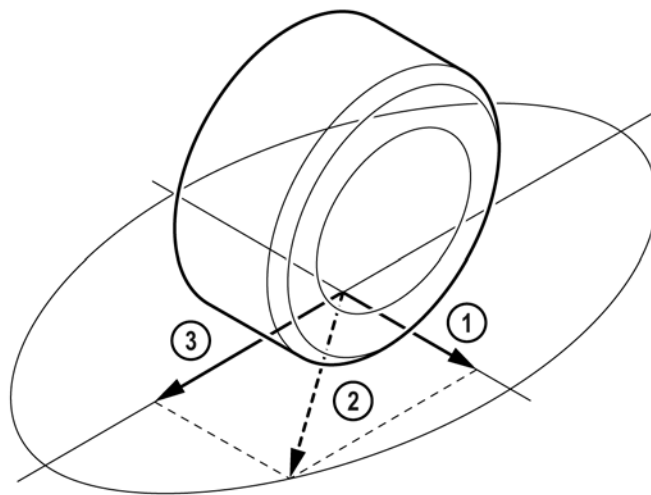
X Wheel slip

Y Coefficient of friction

Kamm's Circle

- A tire transmits both longitudinal and lateral forces to the road surface. Both forces form the resulting force that must be transmitted by the tire.
- A completely blocked wheel can no longer exert any cornering force. On the other hand, a vehicle that is subjected to additional braking when being pushed to the limit of adhesion during cornering will start to skid.
- The dependence on longitudinal and lateral force is shown in the so-called "Kamm's circle". As long as the resulting force remains within the illustrated circle, driving stability of the vehicle is ensured. If the resulting force leaves the circle, the vehicle becomes unstable and skids.

NOTE: The diameter of the Kamm's circle, (the maximum transmittable force) depends on the above mentioned values.

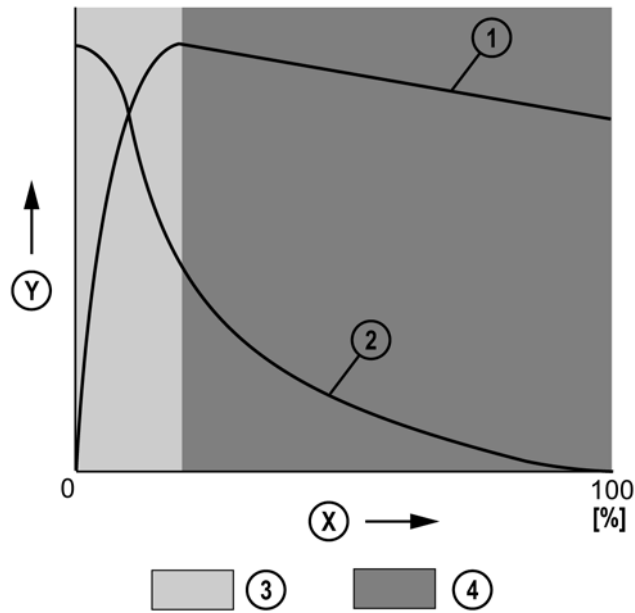


L2003_01007

- 1 Lateral force
- 2 Resulting force

- 3 Longitudinal force

- The illustration below shows the dependency between longitudinal and lateral force in a diagram.

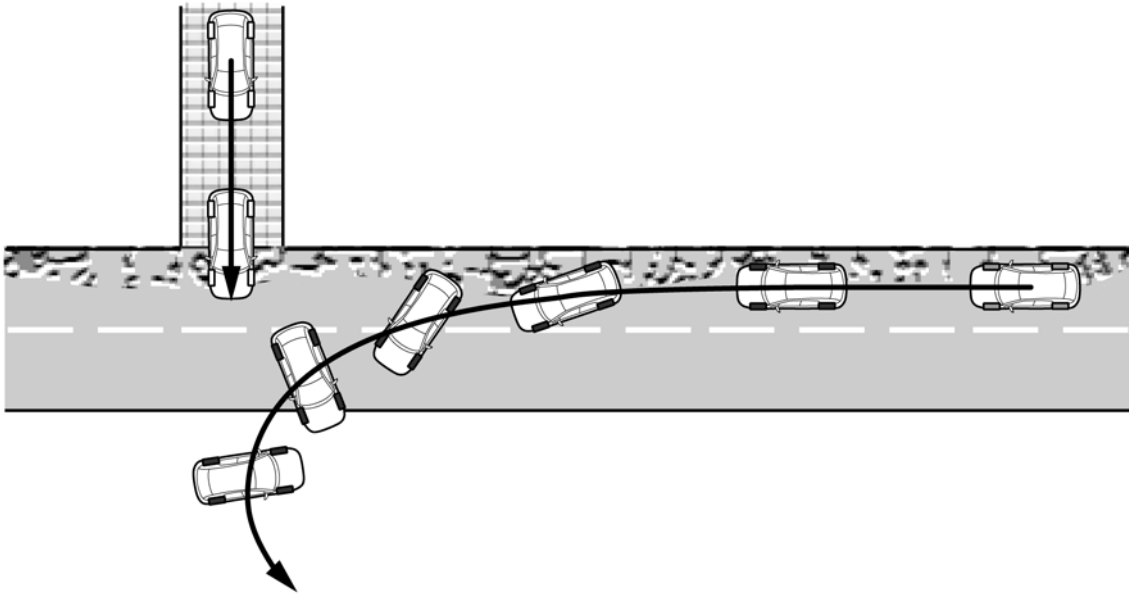


L2003_01018

- | | | | |
|---|---------------------|---|----------------------------|
| X | Slip | 2 | Lateral force |
| Y | Transmittable force | 3 | Stable driving condition |
| 1 | Longitudinal force | 4 | Instable driving condition |

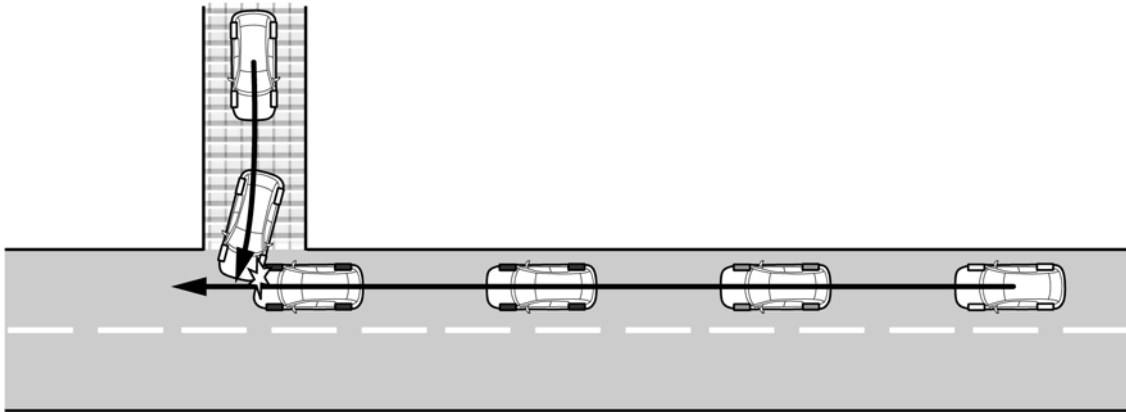
Antilock Brake System

- Although all Mazdas are equipped with powerful and reliable brake systems that provide excellent braking power even at high speeds, a standard brake system cannot prevent a driver from over-reacting in an emergency situation and applying too much force to the brake pedal (especially under bad road / weather conditions or in case of an emergency braking).
- If the driver applies too much force to the brake pedal, the wheels will lock-up and the vehicle might skid, especially on irregular road surfaces.



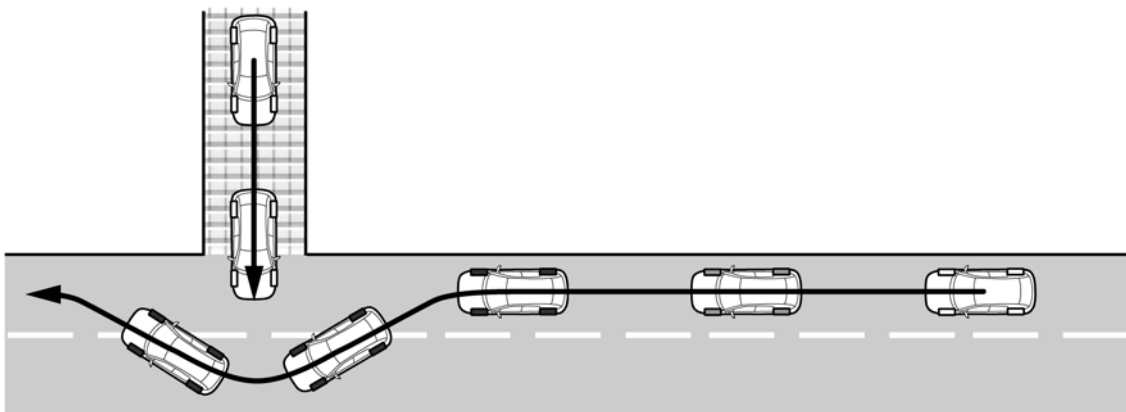
L2003_01008

- Even if the vehicle does not skid, an accident may result, because it is not possible for the driver to steer around an obstacle with locked wheels.



L2003_01009

- The brake pressure regulation of the ABS prevents the wheels from locking-up. It applies the correct brake pressure to all brake callipers to maintain the vehicle's steerability while simultaneously achieving a short braking distance.

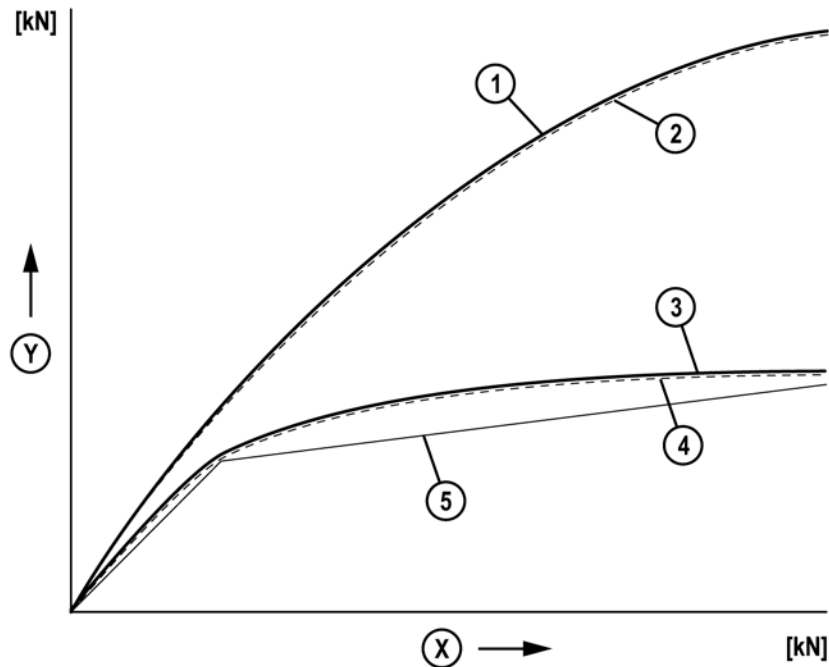


L2003_01010

Electronic Brakeforce Distribution

- On former vehicles, only mechanical solutions were used for brakeforce distribution between the front axle and the rear axle. One of the disadvantages was that, to avoid early wheel lock-up under all circumstances (e.g. due to wet or slippery roads), the brake pressure applied to the rear wheels was never optimal.
- Now all Mazdas with ABS also have EBD, which allows the brakeforce distribution between the front and the rear axles to be adjusted based on actual conditions.
- Under most conditions the proportion of the brakeforce applied to the rear wheels is increased, resulting in optimal vehicle stability during all conditions. This results in: reduced braking distance, reduced thermal stress to the front brakes, and evenly worn front and rear brake pads.
- While a standard vehicle had a brakeforce distribution of approx. 80 % to the front wheels and 20 % to the rear wheels, the brakeforce distribution for vehicles with EBD changes up to approximately 60 % to 40 % (variable).

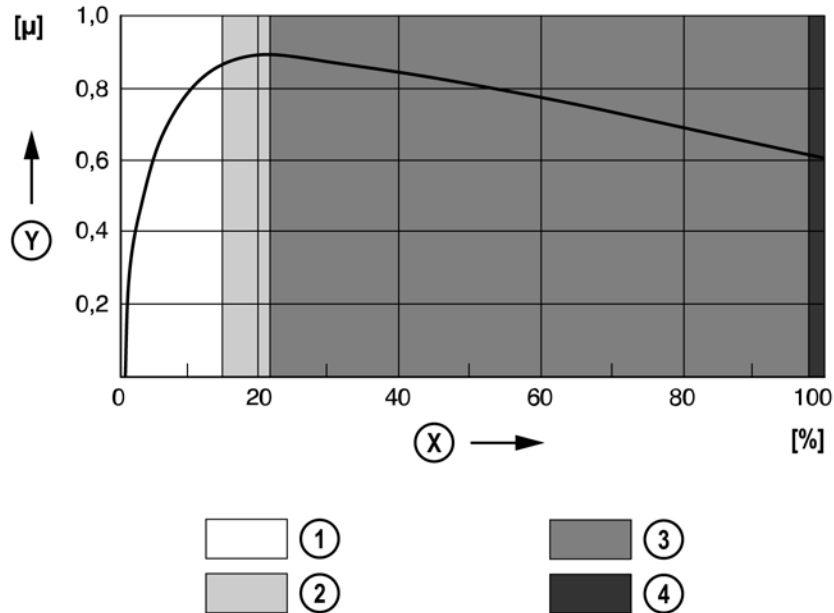
- The illustration shows the differences in applied brakeforce between a vehicle with fixed brakeforce distribution and with EBD.



L2003_01011

- | | | | |
|---|--|---|--|
| X | Brakeforce applied to the front wheels | 3 | Ideal brakeforce distribution on the unloaded vehicle |
| Y | Brakeforce applied to the rear wheels | 4 | Brakeforce distribution on the unloaded vehicle with EBD |
| 1 | Ideal brakeforce distribution on the fully loaded vehicle | 5 | Brakeforce distribution with proportioning valve (unloaded and fully loaded) |
| 2 | Brakeforce distribution on the fully loaded vehicle with EBD | | |

- The first portion of the illustration (areas 1 and 2) shows the range of wheel slip where the EBD and ABS operate. The remaining part of the illustration shows the conditions of less than optimal brakeforce / steerability.



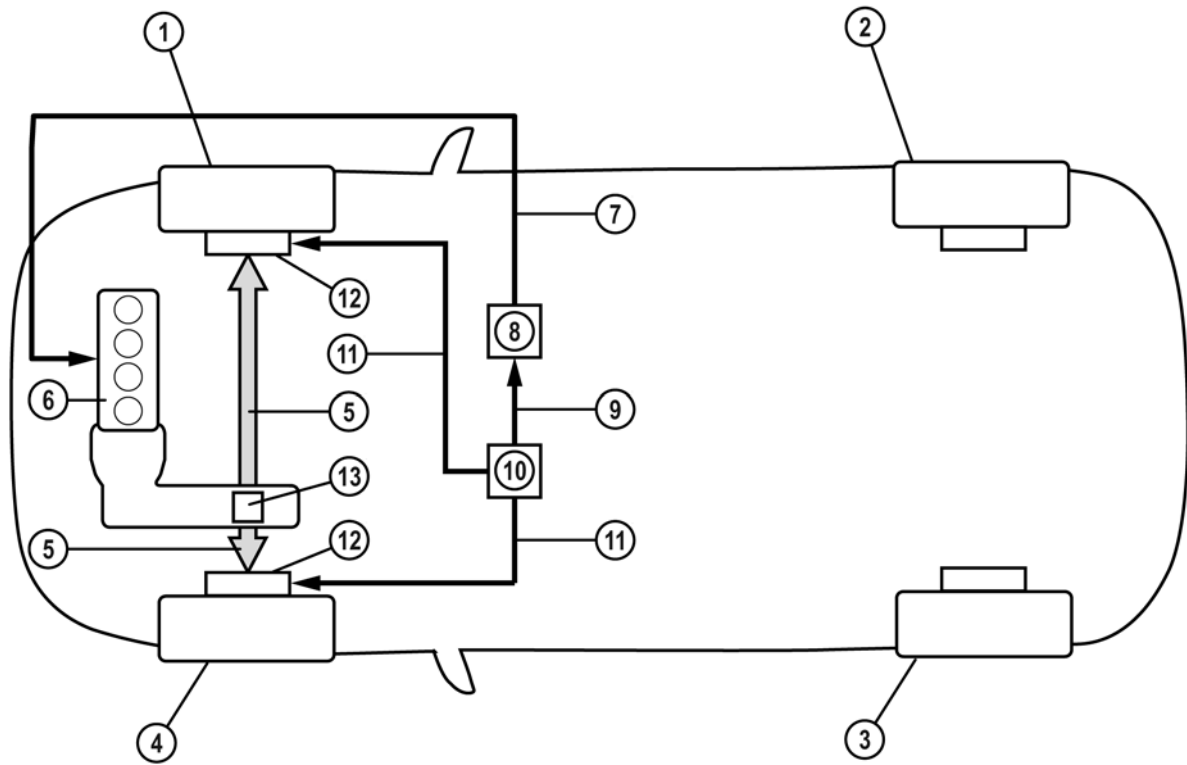
L2003_01006

- | | | | |
|---|---------------------------------|---|----------------------------|
| X | Wheel slip | 2 | ABS operation range |
| Y | Coefficient of dynamic friction | 3 | Instable driving condition |
| 1 | EBD operation range | 4 | Locking wheel |

Traction Control System

- Critical driving situations can occur not only during braking, but also while driving, cornering, starting off, and accelerating (especially on wet or slippery roads). These situations can make it difficult for the driver to react correctly, and can cause the vehicle to become unstable.
- The TCS helps to solve these problems by avoiding / reducing wheel spin. This is achieved either by reducing the engine torque by sending a corresponding signal to the **PCM (Powertrain Control Module)** and / or by applying brakeforce to the spinning wheel(s).
- The TCS is incorporated to some ABS Hydraulic Unit/Control Module by minor changes to the basic system, but is also integrated to all DSC systems installed on Mazda vehicles.
- Depending on the vehicle, different strategies may be used for the operation of the TCS. The most common is that, when the control module recognizes that the wheel speed of the driven wheels exceeds the wheel speed of the other wheels by a specified value, a signal is sent to the PCM to reduce the engine torque. The PCM accordingly reduces the engine torque output by closing the throttle valve (only on vehicles with electronic throttle valve), adjusting the ignition timing, and / or by cutting fuel off. If the wheel spin still exceeds the limit or if the speed of one wheel exceeds the wheel speed of the other driven wheel by a specified value, brake force is applied by the hydraulic unit to the corresponding wheel(s).

NOTE: TCS does not completely avoid wheel spin, it operates only above a specified limit of wheel spin.



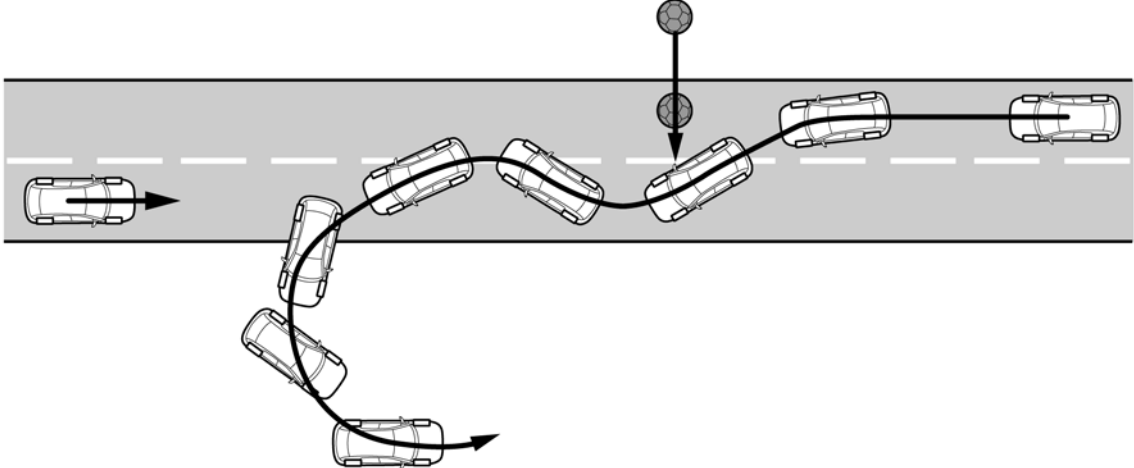
L2003_01012

- | | | | |
|---|--------------------------|----|------------------------------|
| 1 | RF wheel | 8 | Powertrain control module |
| 2 | RR wheel | 9 | Signal for torque reduction |
| 3 | LR wheel | 10 | ABS/TCS HU/CM |
| 4 | LF wheel | 11 | Applied brake fluid pressure |
| 5 | Transmitted torque | 12 | Brake calliper |
| 6 | Engine with transmission | 13 | Differential |
| 7 | Engine control | | |

Dynamic Stability Control

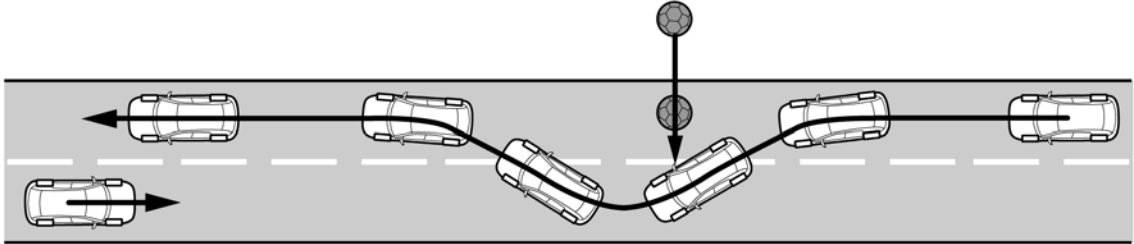
- Due to external circumstances, such as an obstacle on the road, wet or slippery roads, or driving at inappropriate vehicle speed, a vehicle can reach critical limits, where the driver cannot keep the vehicle under control anymore.
- The DSC improves vehicle handling and stability in these critical situations. A vehicle's driving direction can be controlled by either turning the steering wheel or by a yaw moment built up by applying brake force to one wheel. The driver uses the steering wheel, whereas the DSC uses the brake system to control the vehicles driving direction.
- The DSC constantly monitors the vehicle's movement, not only the speed, but also the yaw rate, the lateral acceleration, and the steering angle. The control module calculates the direction the driver wants to drive to by using the steering angle. This is compared to the actual vehicle speed, the vehicle's yaw rate, and lateral acceleration. If a critical situation is detected, the DSC accordingly applies controlled brakeforce and reduces the engine torque output as required (in the same way as for TCS operation), to ensure that the vehicle follows the desired direction.
- The DSC uses an advanced ABS HU/CM and additional sensors.

- The illustration shows the vehicle handling with and without DSC intervention in a critical situation.



L2003_01016

Obstacle suddenly appearing, vehicle without DSC

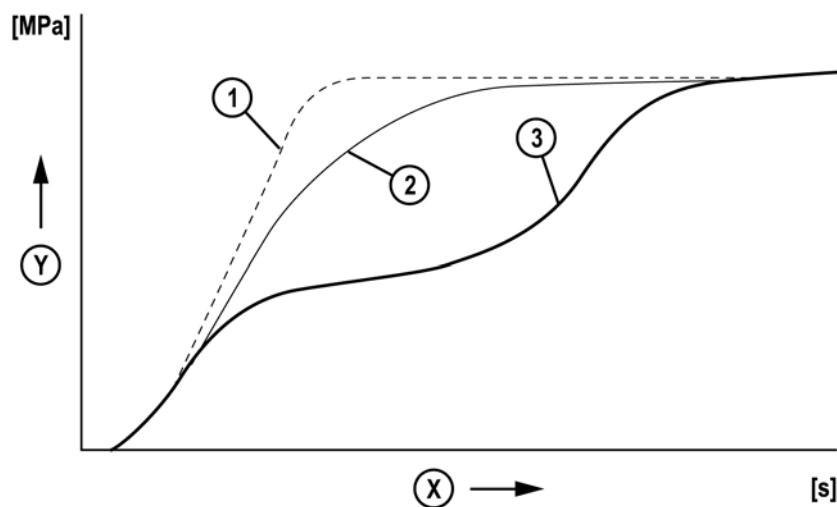


L2003_01013

Obstacle suddenly appearing, vehicle with DSC

Emergency Brake Assist

- Although all Mazdas are equipped with powerful and reliable brake systems that provide excellent braking power even at high speeds, a standard brake system cannot prevent a driver from reacting incorrectly and applying less force to the brake pedal than required to achieve the shortest braking distance. Especially when the brake pedal starts vibrating due to ABS operation, many drivers either instinctively release the brake pedal, or do not increase the applied force further, which does not allow all the wheels to transmit the maximum possible brakeforce.
- The EBA automatically detects emergency braking situations by a combination of the speed and force with which the driver presses the brake pedal. Once such a situation is detected, the EBA automatically applies full brake pressure to both brake circuits, until either the driver fully releases the brake pedal and / or the vehicle comes to a stand still (depending on the vehicle). Of course the vehicle remains steerable during brake actuation, because the ABS ensures that no wheel locks up.
- The EBA is either incorporated into the ABS/DSC HU/CM and operates electronically, or it operates mechanically and is incorporated into the brake booster.
- The illustration shows typical differences during emergency braking with and without EBA.



L2003_01014

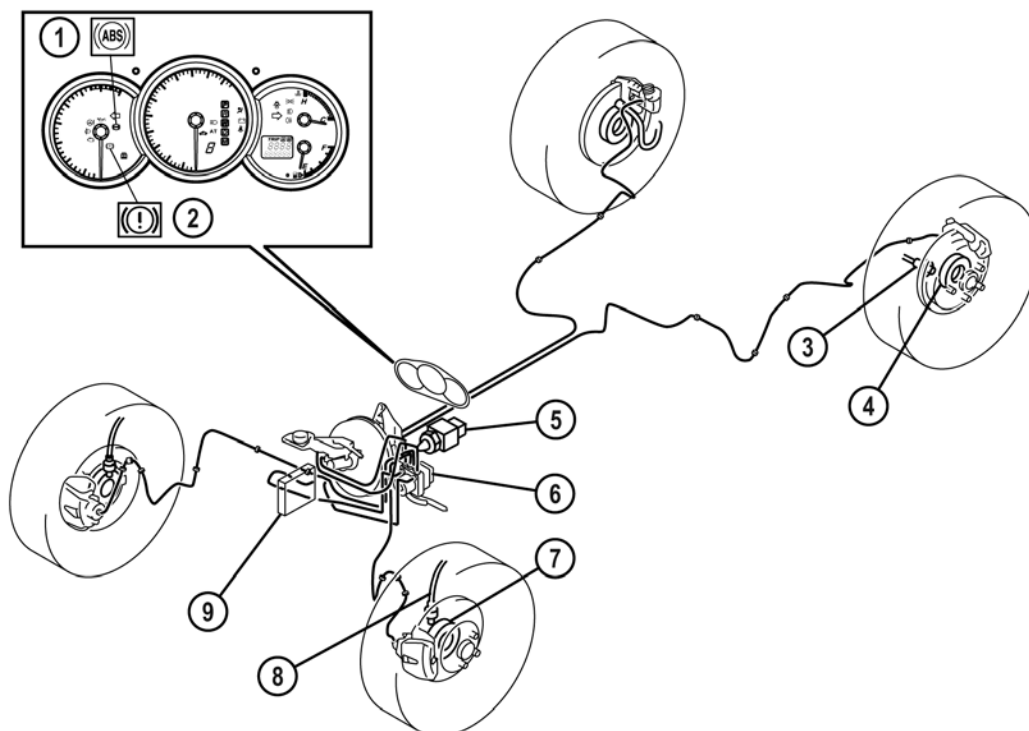
- | | | | |
|---|-------------------------|---|--------------------------------|
| X | Time | 2 | Experienced driver without EBA |
| Y | Brake fluid pressure | 3 | Average driver without EBA |
| 1 | Average driver with EBA | | |

Notes:

Antilock Brake System

Parts Location

- The picture is an example and shows the components of the **Antilock Brake System (ABS)** on a Mazda3. The ABS consists of the following components:
 - Control module
 - Hydraulic unit
 - Wheel speed sensor
 - Brake switch
 - Brake system warning light
 - ABS warning light



L2003_02001

- | | | | |
|---|-----------------------------|---|------------------------------|
| 1 | ABS warning light | 6 | ABS HU/CM |
| 2 | Brake system warning light | 7 | Front ABS pulse rotor |
| 3 | Rear ABS wheel-speed sensor | 8 | Front ABS wheel-speed sensor |
| 4 | Rear ABS pulse rotor | 9 | PCM |
| 5 | Brake switch | | |

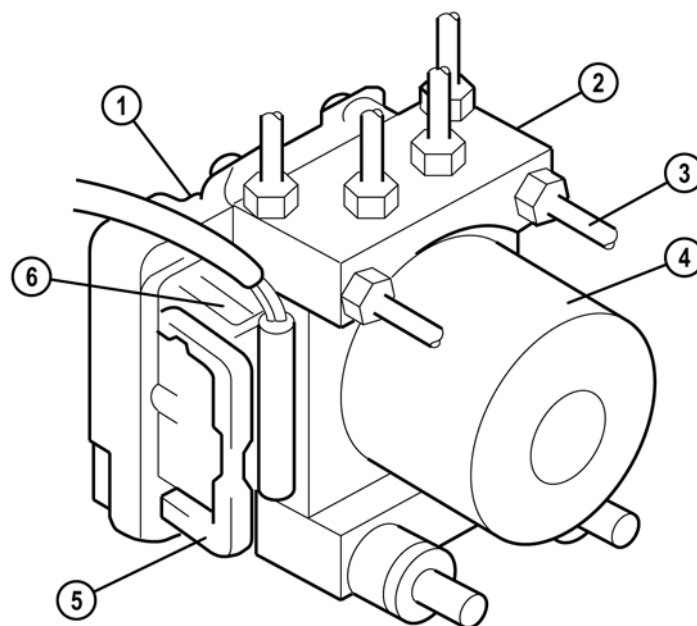
Hydraulic Unit / Control Module

- The ABS **HU/CM** (**H**ydraulic **U**nit / **C**ontrol **M**odule) is located in the engine compartment and is the core component of the ABS. As the name suggests, it controls the hydraulic operation of the ABS.
- It regulates the pressure in the brake lines to prevent the wheels from locking up during braking. This helps the vehicle remain steerable even during emergency braking.
- Most Mazda vehicles have a control module that is combined with the hydraulic unit. Depending on the vehicle it is possible to replace only a HU or a CM. On other vehicles, whenever there is a malfunction in one of the components, the entire HU/CM needs to be replaced as a complete unit. The last Mazdas built with a control module separated from the HU (i.e. the CM module is located elsewhere) were the 323 (BJ) with DSC and the Premacy (CP) with DSC.
- The ABS HU/CM is connected to all ABS related components and is programmed with vehicle-specific parameters. The CM decides whether or not it is necessary to assist the driver in using the brake system, and accordingly operates the brake system via the HU.
- The CM is connected to all electrical components of the ABS. It activates the valves and the pump motor inside the HU, the warning light in the **IC** (**I**nstrument **C**luster), and monitors the components and wiring for malfunction. It provides the power supply for the wheel speed sensors (only vehicles with active wheel speed sensors), and receives the wheel speed signals. Based on those signals it calculates the speed of each wheel individually and the vehicle speed. The difference calculated between the individual wheel speed and the vehicle speed indicates the slip of each wheel.
- The wheel speed sensors and the components inside the HU are hardwired to the CM. Other components can be either hardwired or connected via CAN.
- The HU is designed to regulate the pressure in the brake lines according to signals from the CM. In addition to maintaining the steerability, the regulation of the brake fluid pressure also helps decrease braking distance, wheel spin during acceleration (vehicles with TCS), and understeering/oversteering during cornering (vehicles with DSC).
- The components inside the HU are only operated when ABS operation is required. Then the CM accordingly actuates the pump motor and the valves.

NOTE: Depending on the model, the ABS HU/CM performs a selftest at a vehicle speed of approximately 20 km/h after switching the ignition on. An operating pump during this selftest does not indicate a malfunction.

- The HU consists of the hydraulic pump and of 6...12 solenoid controlled hydraulic valves. One inlet and one outlet valve for each wheel (for B-Series only one inlet and one outlet valve for the rear axle), two traction control valves for vehicles with TCS and two additional stability control valves for vehicles with DSC. The HU cannot be disassembled.
- Most HUs feature a flow control valve downstream of each inlet valve. The flow control valve has been integrated to reduce the brake fluid flow noise by narrowing a passage, and is actuated hydraulically in case of a high-pressure difference upstream and downstream of the inlet valve.

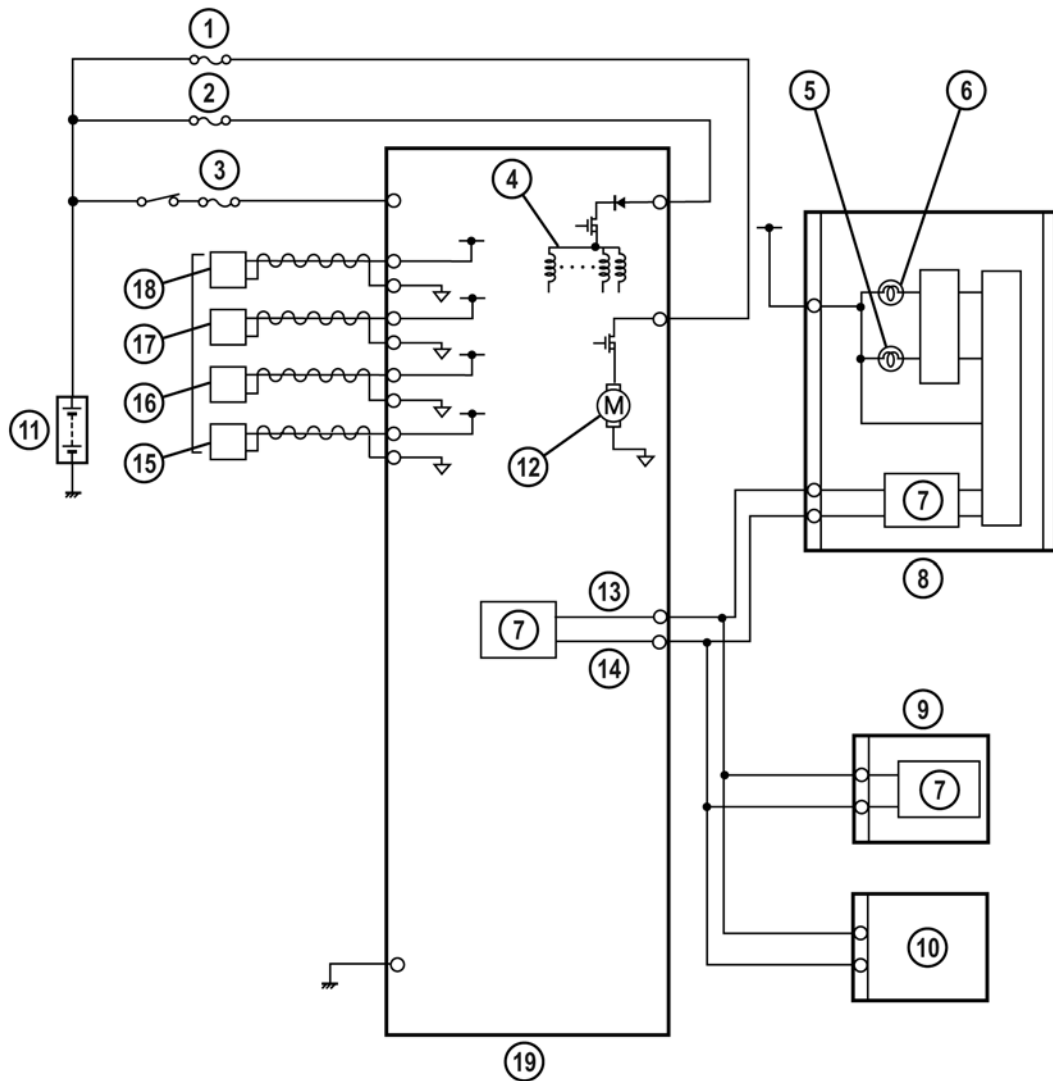
NOTE: Always keep in mind, that the Dynamic Driving Safety Systems cannot override the law's of physics.



L2003_02002

- | | | | |
|---|----------------|---|-----------------------------|
| 1 | Control module | 4 | ABS pump motor |
| 2 | Hydraulic unit | 5 | Lock lever for connector |
| 3 | Brake pipe | 6 | ABS connector / wiring loom |

Wiring Diagram



L2003_02003

Mazda3

- | | | | |
|----|----------------------------|----|---------------------------|
| 1 | ABS fuse 1 | 11 | Battery |
| 2 | ABS fuse 2 | 12 | ABS pump motor |
| 3 | ABS fuse ignition ON | 13 | CAN H |
| 4 | Solenoid valves | 14 | CAN L |
| 5 | Brake system warning light | 15 | ABS wheel-speed sensor LR |
| 6 | ABS warning light | 16 | ABS wheel-speed sensor RR |
| 7 | CAN driver | 17 | ABS wheel-speed sensor LF |
| 8 | IC | 18 | ABS wheel-speed sensor RF |
| 9 | PCM | 19 | ABS HU/CM |
| 10 | DLC-2 | | |

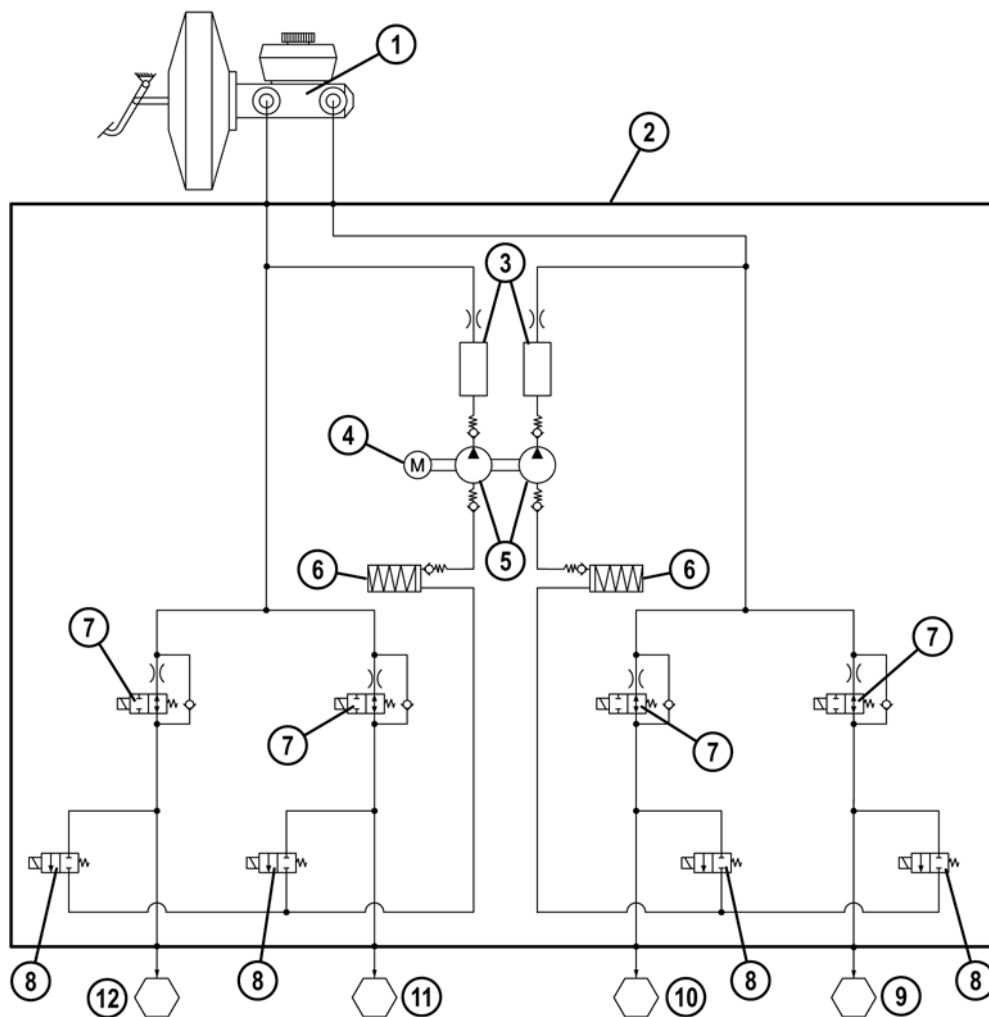
Layout

- Current Mazda models use ABS with 4 wheel speed sensors and a three or four channel layout:
 - A three channel layout provides ABS control for each front wheel individually and for the rear wheels in common according to the “select low” principle. The B-Series is the only Mazda vehicle still featuring this layout. “Select low” principle means an ABS control strategy adjusting brake pressure for both rear wheels determined by the wheel that tends to lock first. Because, the largest influence on a vehicle’s driving stability is the ability of the rear axle to continue to travel in the desired direction.
 - A four channel layout allows individual brake pressure control for each wheel. This is required when either the brake system has a diagonal split layout, as all Mazda models with front wheel drive have, or when a rear wheel driven vehicle has TCS. During ABS operation the rear axle is also controlled corresponding to the “select low” principle. A four channel layout is mandatory for DSC.

Hydraulic Circuit

- The hydraulic circuit that is explained on the following pages, is a four channel ABS. A three channel ABS operates similar, except for the fact, that it features only 6 solenoid valves.
- The HU for a 4 channel ABS is equipped with 8 solenoid valves that can be activated for the ABS operation. Four of those valves are the inlet valves, they are used to separate each single brake calliper from the brake master cylinder and avoid further pressure increase if the corresponding wheel is about to lock-up. These valves are always open when not actuated. The other four valves are the outlet valves. They are necessary to be able to release pressure from each single brake calliper to reduce the applied brake force on each wheel individually, if a wheel is still about to lock-up after the inlet valve has been closed. These valves are always closed when not actuated.

Hydraulic Diagram



L2003_02004

Mazda3

- | | |
|-------------------|-------------------------|
| 1 Master cylinder | 7 Inlet solenoid valve |
| 2 ABS HU/CM | 8 Outlet solenoid valve |
| 3 Damper chamber | 9 Brake calliper LF |
| 4 Pump motor | 10 Brake calliper RR |
| 5 Pump | 11 Brake calliper LR |
| 6 Reservoir | 12 Brake calliper RF |

Operation

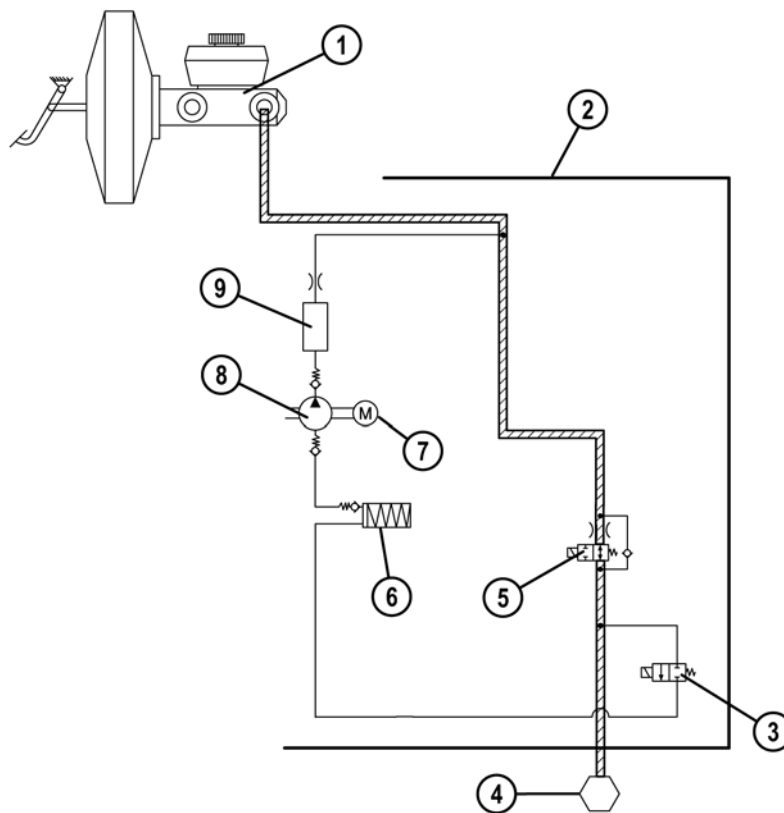
- For easier understanding, only the operation of the left front brake circuit is explained. The other circuits act similarly.

During Normal Braking

- During normal braking, the solenoid valves are not energized. When the brake pedal is pressed, brake fluid pressure is built up by the master cylinder and passes through the inlet solenoid valves and then to the brake callipers.
- The brake fluid pressure is fully controlled by the driver. When the brake pedal is released, the pressure decreases the opposite way it was built up.

Inlet solenoid valve	Outlet solenoid valve	Pump motor
OFF (open)	OFF (closed)	OFF (stopped)

L2003_T02001



L2003_02005

- | | |
|-------------------------|------------------|
| 1 Master cylinder | 6 Reservoir |
| 2 ABS HU/CM | 7 Pump motor |
| 3 Outlet solenoid valve | 8 Pump |
| 4 Brake calliper | 9 Damper chamber |
| 5 Inlet solenoid valve | |

During ABS Control

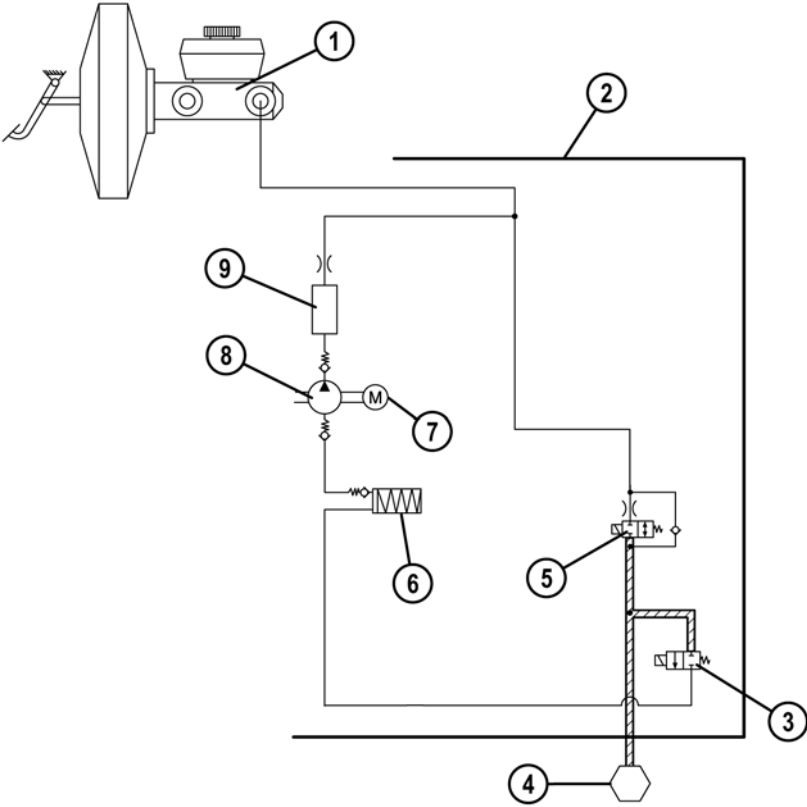
- When wheel lock-up is about to occur, the system starts with the ABS control operation. ABS can operate three ways:
 - Pressure hold mode
 - Pressure reduction mode
 - Pressure increase mode (which is the same as the “Normal Braking” already explained on the previous page)

Pressure Hold Mode

- When the CM detects wheel slip increasing above a specified value, it holds constant the brake force applied to that wheel to avoid lock-up.
- Therefore, it energises the corresponding inlet solenoid valve, closing the hydraulic circuit between the brake calliper and the brake master cylinder. Thus, the brake fluid pressure inside the related brake calliper cannot increase further.
- Even if the driver presses the brake pedal further and the brake fluid pressure in the master cylinder increases, the brake pressure will not increase on a wheel that is currently in pressure hold mode.

Inlet solenoid valve	Outlet solenoid valve	Pump motor
ON (closed)	OFF (closed)	OFF (stopped)

L2003_T02002



L2003_02006

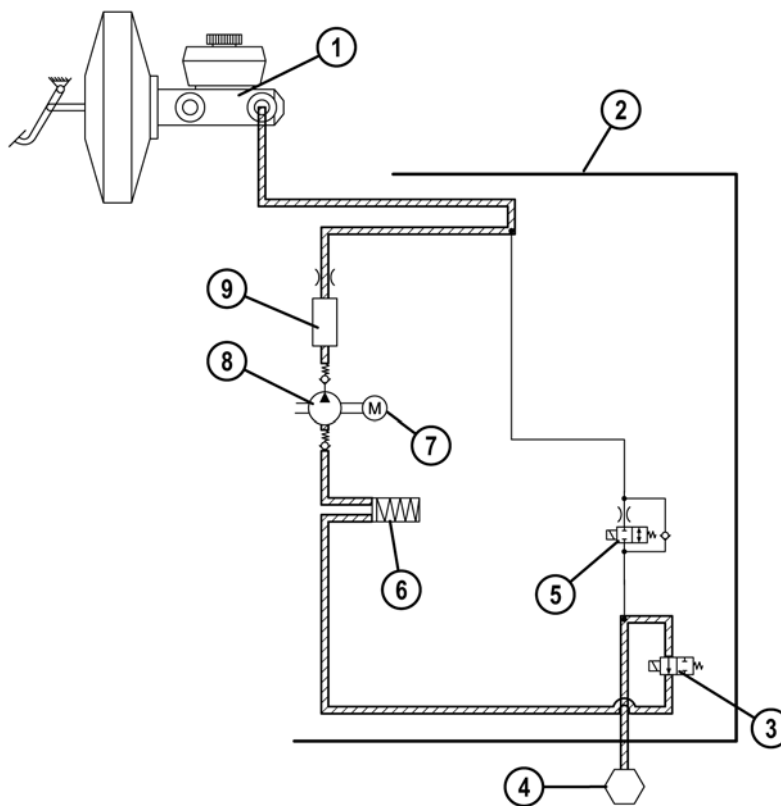
- 1 Master cylinder
- 2 ABS HU/CM
- 3 Outlet solenoid valve
- 4 Brake calliper
- 5 Inlet solenoid valve
- 6 Reservoir
- 7 Pump motor
- 8 Pump
- 9 Damper chamber

Pressure Reduction Mode

- When the CM detects that wheel slip is still increasing and reaches a specified value, it reduces the brake force applied to that wheel.
- The inlet solenoid valve remains actuated and additionally the appropriate outlet solenoid valve and the pump motor are energised. Thus the brake fluid pressure in the brake calliper decreases and the released brake fluid is pumped from the reservoir towards the brake master cylinder.

Inlet solenoid valve	Outlet solenoid valve	Pump motor
ON (closed)	ON (open)	ON (operating)

L2003_T02003



L2003_02007

- | | |
|-------------------------|------------------|
| 1 Master cylinder | 6 Reservoir |
| 2 ABS HU/CM | 7 Pump motor |
| 3 Outlet solenoid valve | 8 Pump |
| 4 Brake calliper | 9 Damper chamber |
| 5 Inlet solenoid valve | |

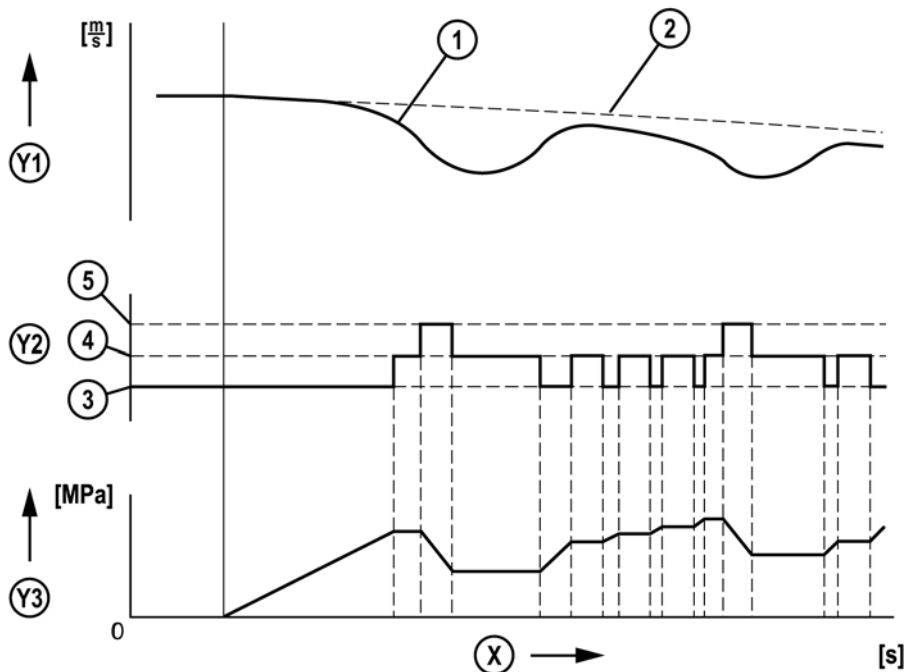
Pressure Increase Mode

- When the CM detects that the wheel slip decreases below a specified value, it increases the brake force to that wheel, in order to keep the wheel slip in the specified range.
- It deactivates the inlet and outlet solenoid valve and the pump. Thus, the pressure increase is performed in the same way as during normal braking, the brake pressure is increased by the driver's foot, still pressing the brake pedal.

Inlet solenoid valve	Outlet solenoid valve	Pump motor
OFF (open)	OFF (closed)	OFF (stopped)

L2003_T02004

- These three modes are repeated as required until either: the brake pedal is released, the speed of the vehicle is below the specified value for ABS operation (approx. 5...15 km/h, depending on the vehicle) or the wheel slip does not exceed the specified value anymore.



L2003_02008

- | | | | |
|----|------------------------|---|--------------------------|
| X | Time | 2 | Calculated vehicle speed |
| Y1 | Speed | 3 | Pressure increase |
| Y2 | Solenoid valve control | 4 | Pressure hold |
| Y3 | Brake fluid pressure | 5 | Pressure reduction |
| 1 | Wheel speed | | |

Servicing

- The ABS HU contains delicate mechanical parts. If foreign materials get into the component the ABS may fail to operate. Also, it will likely become extremely difficult to find the location of the malfunction in the event that the brakes operate but the ABS does not. Make sure foreign materials do not get inside when servicing the ABS (e.g. brake fluid replacement, pipe removal).
- To avoid trouble coming from the hydraulic system of the ABS and the brake it is best to protect the whole system with a regular exchange of brake fluid and flushing of the hydraulic ABS unit.

NOTE: To avoid that the HU runs dry and air enters the HU, always install appropriate closing covers when removing hydraulic lines.

Bleeding

NOTE: In most cases it is not necessary to bleed the HU with the aid of the M-MDS during exchange of the brake fluid. Always follow the procedure of the corresponding **W/M** (**Workshop Manual**).

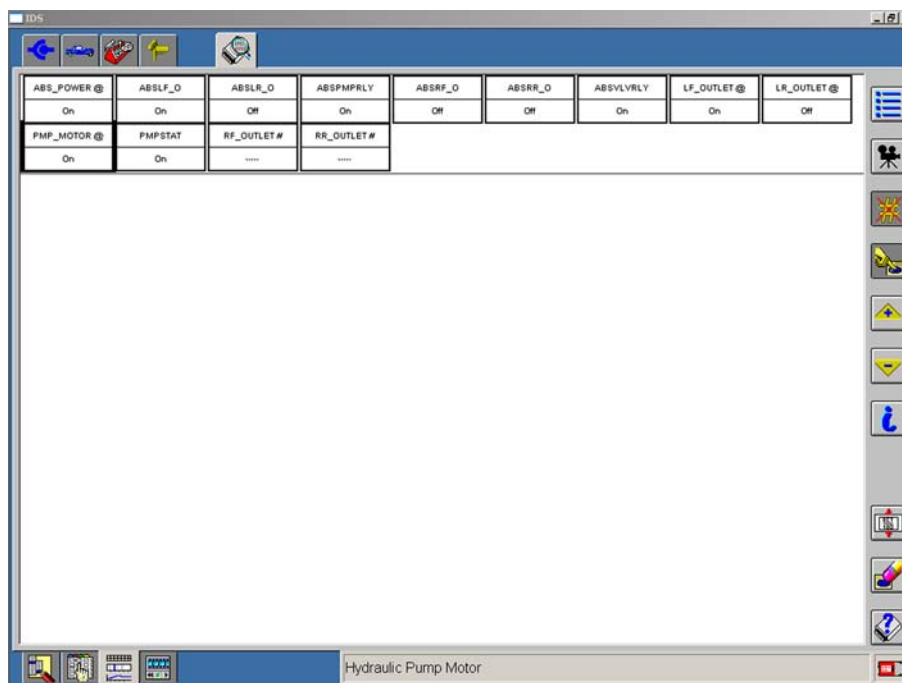
- If the ABS HU needs to be flushed or bled, it is necessary to switch on the pump and the outlet valves.

NOTE: Always perform the manual bleeding procedure before performing any bleeding procedure with the aid of the M-MDS

- Connect the brake-bleeding device with the brake fluid reservoir ensuring that fresh brake fluid will get to the HU.
- For Mazda2 and Tribute the M-MDS provides the “ABS Service Bleed” function. Connect the M-MDS with DLC2 and select → **16PINDLC** → **Toolbox** → **Chassis** → **Braking** → **ABS Service Bleed** and follow the screen instructions

- For models the M-MDS does not provide a service bleed function, ABS valves and the ABS pump can be activated via the Simulation Test Mode available in the DataLogger menu. Connect the M-MDS and select → **Toolbox** → **Datalogger** → **Modules** → **ABS**
- Then select PIDs as displayed below.
- To start the activation of the valve and the pump in the HU:
 - Select and activate → **ABS_POWER**
 - Select and activate the outlet solenoid valve of the corresponding brake calliper a bleeding bottle is connected with (here it is the left front side) → **LF_OUTLET** and **PMP_MOTOR**

NOTE: To prevent the ABS unit from overload, the solenoid valves and pump motor must not be activated permanently when bleeding. Depending on the model, the pump motor and the solenoid valves are either automatically deactivated 10 seconds after being activated with the aid of the M-MDS or they must be deactivated manually.



L2003_02052

- Repeat the procedure for each outlet valve.

Diagnostics

- The HU/CM can be checked by:
 - Reading out DTCs
 - Checking voltage signals
 - Monitoring / Activating the corresponding PIDs (see below)

NOTE: The ABS warning light might stay illuminated after deleting DTCs, until the unit performed a self test. Therefore it is necessary to perform a test drive after deleting DTCs.

PID	Definition	Unit/Condition
BOO_ABS	Brake switch	ON/OFF
CCNTABS	Number of detected DTCs	-
LR_OUTLET#	LR ABS pressure outlet solenoid valve	ON/OFF
LR_INLET#	LR ABS pressure inlet solenoid valve	ON/OFF
LR_WSPD	LR ABS wheel-speed sensor input	km/h, mph
RR_INLET#	RR ABS pressure inlet solenoid valve	ON/OFF
RR_OUTLET#	RR ABS pressure outlet solenoid valve	ON/OFF
RR_WSPD	RR ABS wheel-speed sensor input	km/h, mph
LF_INLET#	LF ABS pressure inlet solenoid valve	ON/OFF
LF_OUTLET#	LF ABS pressure outlet solenoid valve	ON/OFF
LF_WSPD	LF ABS wheel-speed sensor input	km/h, mph
RF_INLET#	RF ABS pressure inlet solenoid valve	ON/OFF
RF_OUTLET#	RF ABS pressure outlet solenoid valve	ON/OFF
RF_WSPD	RF ABS wheel-speed sensor input	km/h, mph
PMP_MOTOR#	ABS motor	ON/OFF

L2003_T02006

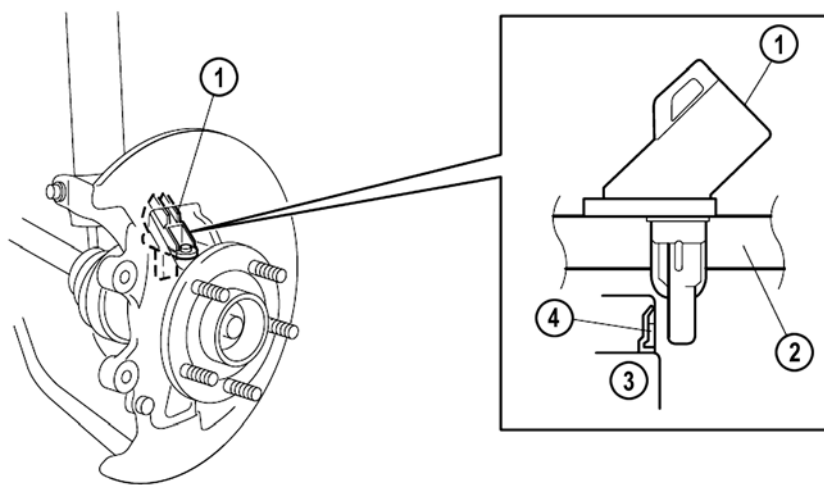
NOTE: Depending on the model, the availability of the PIDs varies. In addition, different PID names may be used for identical parameters (see W/M).

Replacement

- A new HU is usually delivered pre filled. Nevertheless, the brake system must be bled according to the W/M.
- A new CM must be configured (except for Mazda2 (DY) and B-Series (UN)) with the aid of the M-MDS, via the option “Programmable Module Installation” (refer to W/M). If a new DSC HU/CM has been installed, additional initialisation procedures of the sensors must be performed (refer to W/M).

Wheel Speed Sensor

- Depending on the vehicle, the ABS uses passive or active wheel speed sensors. Each wheel sensor sends a pulsed speed signal to the ABS control module. Based on those signals, the control module calculates the speed of each wheel and the vehicle speed. When a wheel speed difference occurs, while comparing the vehicle speed with each individual wheel speed, this is used as an indication of changing grip on an individual wheel.
- Based on this information, the ABS control module calculates the slip of each wheel during braking. With the aid of the ABS operation the ABS control module keeps the slip of the wheels in the range of 15...30 % to ensure good steerability and high brake forces.



L2003_02009

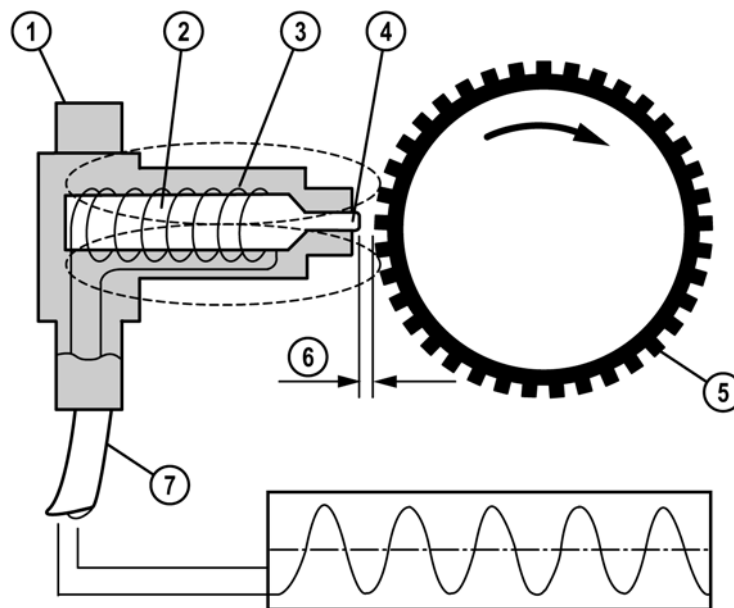
Mazda3

- | | | | |
|---|--------------------|---|---------------|
| 1 | Wheel speed sensor | 3 | Wheel bearing |
| 2 | Steering knuckle | 4 | Pulse rotor |

Passive Wheel Speed Sensor

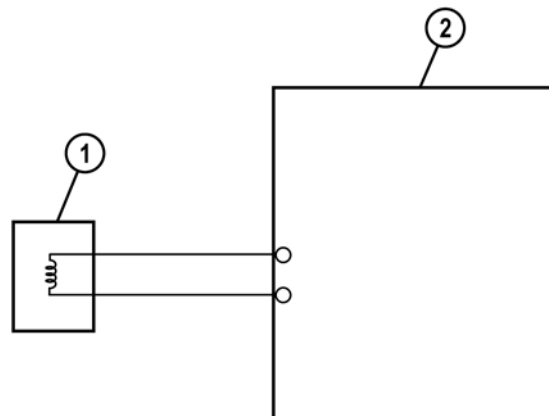
- The passive wheel speed sensors are an inductive-type, i.e. the sensors produce an analog voltage signal via induction due to a changing magnetic field, caused by the turning wheel.
- Passive wheel speed sensors are installed on B-Series (UN), Premacy (CP), MX-5 (NB), Mazda6 (GG/GY), MPV (LW), and RX-8 (SE).
- The voltage output increases with increased wheel speed. With very low wheel speed (below approx. 6 km/h), the voltage output is too low to deliver a proper wheel speed signal to the CM.
- The CM uses the number of pulses per second to calculate the wheel speed. The vehicle speed is calculated by the CM, based on the wheel speed of all wheels.

NOTE: Strong vibrations can demagnetise permanent magnets. Hammer blows in the vicinity of the wheel sensor (e.g. when repalcing a wheel bearing) could permanently damage the sensor, if it is not previously removed.



L2003_02010

- | | |
|----------------------|------------------------|
| 1 Wheel speed sensor | 5 Pulse rotor |
| 2 Permanent magnet | 6 Air gap |
| 3 Coil | 7 Connection to ABS CM |
| 4 Iron core | |



L2003_02053

1 Wheel speed sensor

2 ABS HU/CM

Diagnostics

- The inductive wheel speed sensor can be checked by:
 - Reading out DTCs
 - Checking the voltage signal
 - Measuring its resistance
 - Checking the air gap
 - Monitoring the corresponding PIDs (see below)

PID	Definition	Unit/Condition
LF_WSPD	LF ABS wheel-speed sensor input	km/h, mph
LR_WSPD	LR ABS wheel-speed sensor input	km/h, mph
RF_WSPD	RF ABS wheel-speed sensor input	km/h, mph
RR_WSPD	RR ABS wheel-speed sensor input	km/h, mph

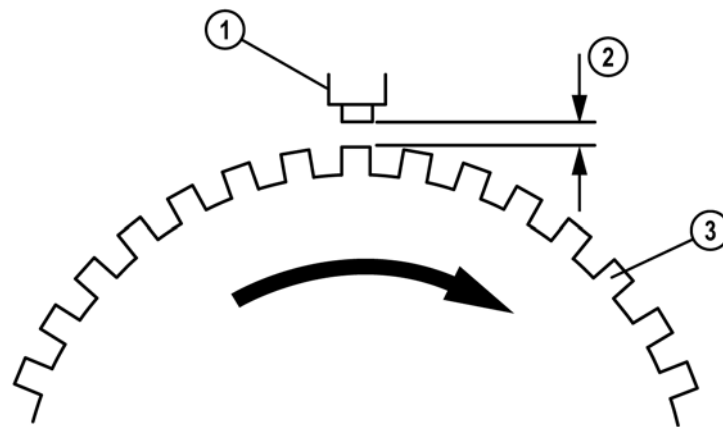
L2003_T02005

Checking the Air Gap

- If the wheel speed signal is faulty, or when replacing a wheel speed sensor (active or passive), make sure to adjust the gap between the sensor and the rotor according to the W/M. If the gap is too large, this can cause inaccurate wheel speed signals. If the gap is too small, the rotor and the sensor could be damaged.

NOTE: An air gap exceeding the specifications could be caused by excessive wheel-bearing clearance.

- Keep the rotor and the sensor clean from metal debris and other dirt to ensure a proper signal is generated.



L2003_02012

- 1 Wheel speed sensor
- 2 Gap

- 3 Pulse rotor

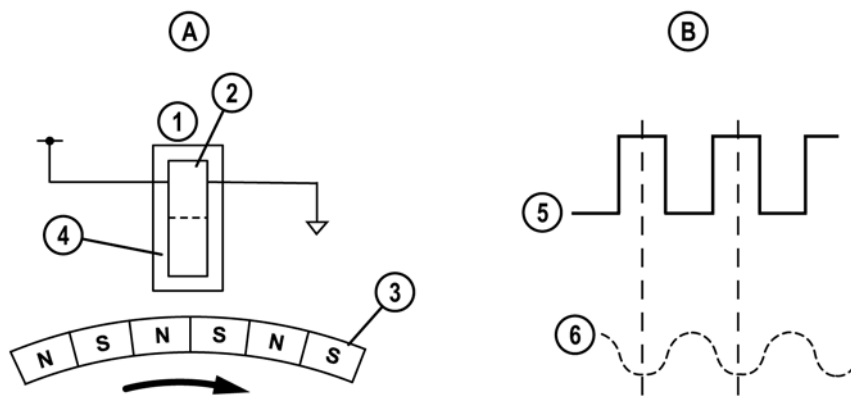
Active Wheel Speed Sensor

- The active wheel speed sensors are either hall element type or giant magneto resistor type, i.e. the sensors need a power supply (provided by the CM) and output a rectangular signal with the aid of an integrated circuit.
- The height of the signal is not affected by the wheel speed. This means the active wheel speed sensor can transmit a proper wheel speed signal even at very low speeds (approx. 0.1 km/h).
- The CM uses the number of pulses per second to calculate the wheel speed. The vehicle speed is calculated by the CM based on the wheel speed of all wheels.

NOTE: An active wheel speed sensor must not be inspected using an ohmmeter.

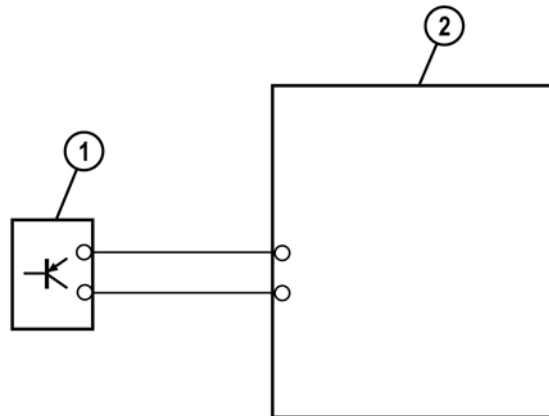
NOTE: The difference between the High and Low signal can be as low as 0.2 Volt.

NOTE: Strong vibrations can demagnetise permanent magnets. Hammer blows in the vicinity of the magnetic layer on a wheel bearing (e.g. when replacing the bearing) could permanently damage the magnetic layer, causing a faulty wheel speed signal.



L2003_02011

- | | | | |
|---|------------------------|---|------------------------------------|
| A | Detection principle | 3 | Magnetic rubber (magnetic encoder) |
| B | Output waveform | 4 | Semiconductor element |
| 1 | ABS wheel-speed sensor | 5 | Sensor output signal |
| 2 | Active drive circuit | 6 | Semiconductor element signal |



L2003_02054

1 Wheel speed sensor

2 ABS HU/CM

Diagnostics

- The active wheel speed sensor can be checked by:
 - Reading out DTCs
 - Checking the voltage signal
 - Checking the air gap
 - Monitoring the corresponding PIDs (see below)

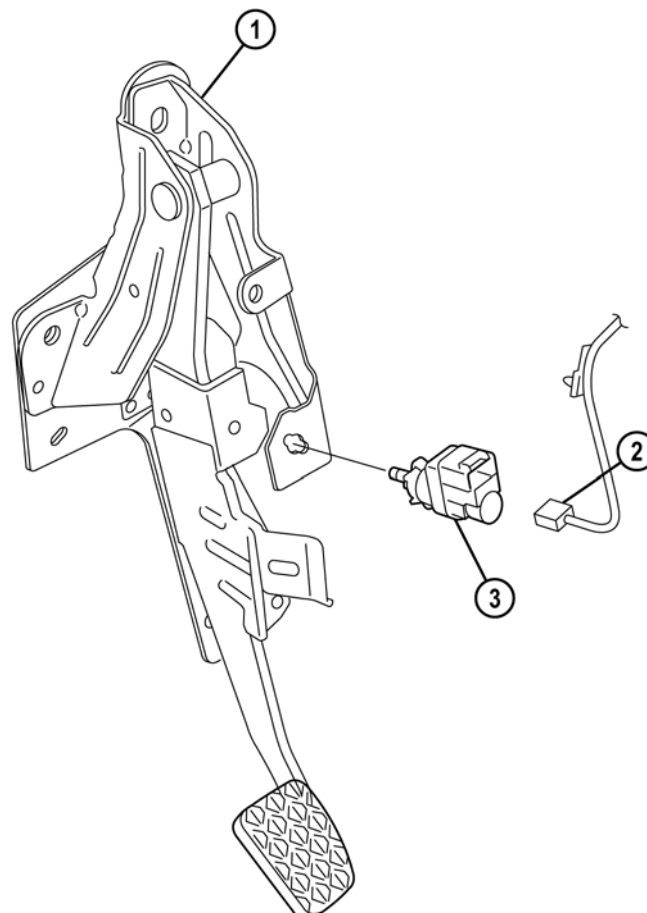
PID	Definition	Unit/Condition
LF_WSPD	LF ABS wheel-speed sensor input	km/h, mph
LR_WSPD	LR ABS wheel-speed sensor input	km/h, mph
RF_WSPD	RF ABS wheel-speed sensor input	km/h, mph
RR_WSPD	RR ABS wheel-speed sensor input	km/h, mph

L2003_T02005

Brake Switch

- The brake switch, which is actuated by the brake pedal, informs the ABS control module when the brake pedal is pressed. This signal is necessary to recognize that the driver wants to slow down the vehicle using the brake. The ABS will not start operating until a corresponding signal from the brake switch is received.
- The brake switch is a standard On/Off switch that is either hardwired to the ABS control module or its information is forwarded via CAN (e.g. on Mazda6 F/L where it is hardwired to the PCM and forwarded from there via HS-CAN to the ABS control module).

NOTE: On some vehicles, if the brake switch has been removed it must be discarded, and a new one must be installed (refer to the W/M).



L2003_02013

1 Brake pedal

2 Brake switch connector

3 Brake switch

Diagnostics

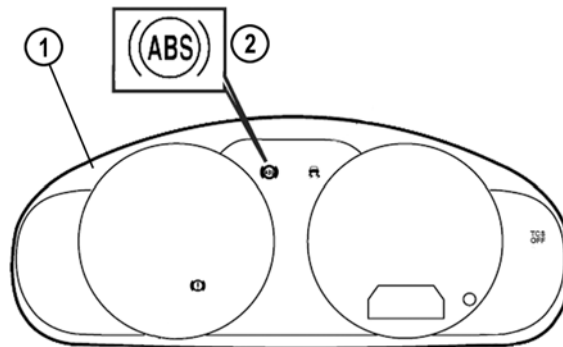
- The brake switch can be checked by:
 - Reading out DTCs
 - Checking the voltage signal
 - Measuring its resistance
 - Monitoring the corresponding PID (see below)

PID	Definition	Unit/Condition
BOO_ABS	Brake pedal switch	ON/OFF

L2003_T02028

ABS Warning Light

- The yellow ABS warning light is located in the IC. It illuminates after ignition on for a few seconds to inform the driver that the warning light has no malfunction.
- If it stays on or illuminates during driving, a malfunction has been detected. As long as the warning light is illuminated the ABS control is switched off, but the standard brake system is fully operational, if there is no other warning light illuminated. All current Mazda vehicles feature a DTC memory function, which stores the malfunction in the ABS control module.
- If a temporary malfunction has been detected that does not exist any more, the failure will be stored and the warning light will go off after switching the ignition off and on.

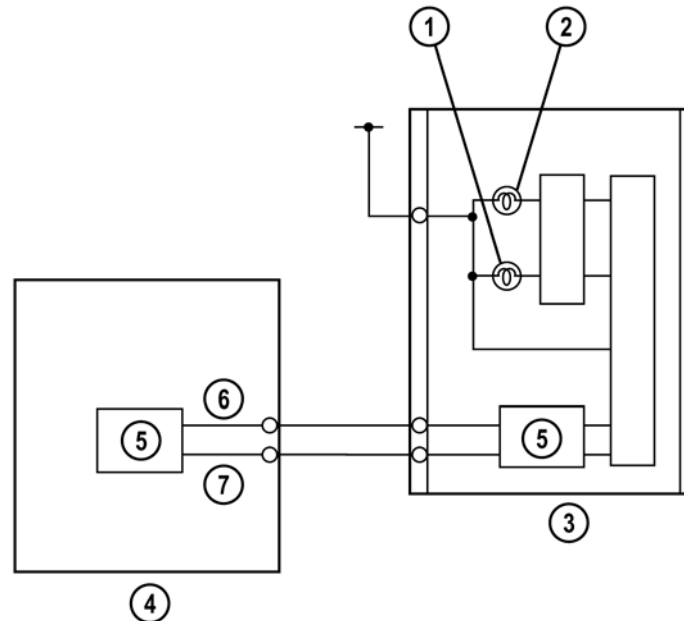


L2003_02014

1 IC

2 ABS warning light

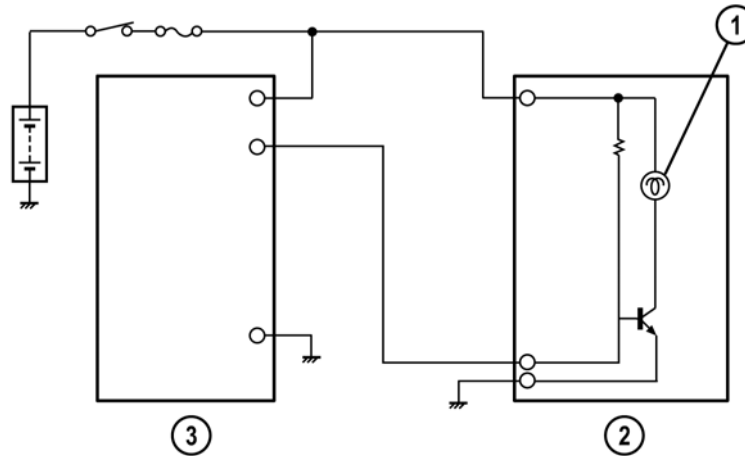
- The ABS warning light is either hardwired to the ABS control module or switched from a microcomputer in the IC. In the second case the IC receives an ABS warning light ON request via CAN if the ABS CM detects a malfunction.
- If there is an open circuit between the ABS CM and the IC, the ABS warning light will be illuminated by the microcomputer or a transistor inside the IC. On earlier models a short-circuit bridge was installed to the connector of the ABS CM to ensure that the warning light is illuminated if the connector is disconnected.



L2003_02015

CAN controlled

- | | | | |
|---|----------------------------|---|------------|
| 1 | Brake system warning light | 5 | CAN driver |
| 2 | ABS warning light | 6 | CAN H |
| 3 | IC | 7 | CAN L |
| 4 | ABS HU/CM | | |



L2003_02047

Hard wired transistor controlled

- 1 ABS warning light
- 2 IC
- 3 ABS CM

Diagnostics

- The ABS warning light can be checked by:
 - Visually inspecting the warning light after switching the ignition on
 - Checking voltage signals
 - Using the input/output check mode for the IC
 - Monitoring the corresponding PID (see below)

PID	Definition	Unit/Condition
ABS_LMP	ABS warning light	ON/OFF

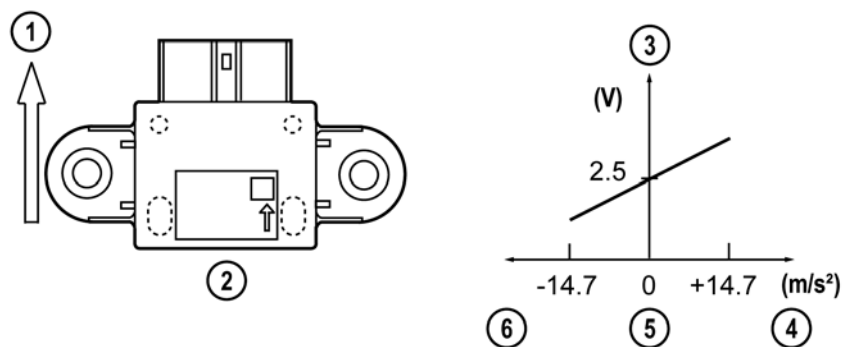
L2003_T02023

ABS on Vehicles with 4WD

- The ABS on vehicles with **4WD (4 Wheel Drive)** is essentially the same as on other vehicles, except for the following features:
 - A **G-sensor (Gravity)** has been installed on vehicles with 4WD.
 - On the Mazda6, 4WD operation is disabled during ABS operation. To do so, the ABS HU/CM transmits a signal via CAN to the 4WD CM, and the 4WD CM correspondingly disables the electronically controlled clutch.

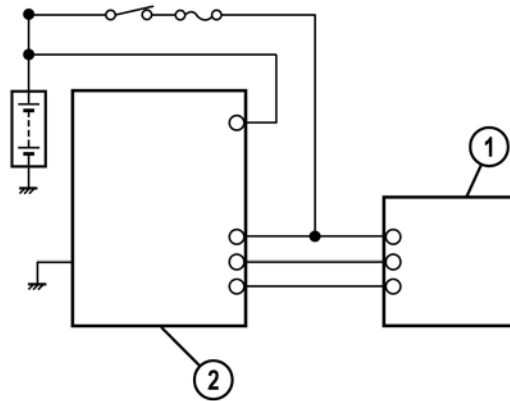
G-Sensor

- On the B-Series the G-sensor is mounted under the passenger's seat, and on Mazda6 it is incorporated in the combined sensor, while on Tribute it is integrated in the ABS HU/CM.
- The G-sensor features a longitudinal accelerometer and is connected to the ABS HU/CM. It sends an acceleration/deceleration signal to the CM.
- The signal from the G-sensor is necessary as a vehicle speed correction factor. Because, on 4WD vehicles, under some circumstances, the movement of the vehicle cannot be measured as precisely as necessary when using the wheel speed sensors only.



L2003_02016

- | | |
|----------------------------------|----------------|
| 1 Front of vehicle | 4 Acceleration |
| 2 G-Sensor | 5 Neutral-G |
| 3 Output voltage characteristics | 6 Deceleration |



L2003_02055

1 G-sensor

2 ABS HU/CM

Diagnostics

- The G-sensor and 4WD related components can be checked by:
 - Reading out DTCs
 - Checking the voltage signal
 - Monitoring the corresponding PIDs (see below)

PID	Definition	Unit/Condition
ACCLMTR	Longitudinal acceleration in G	G
AWD_MSG	Communication with 4WD CM (only on Mazda6)	Present / Not Present

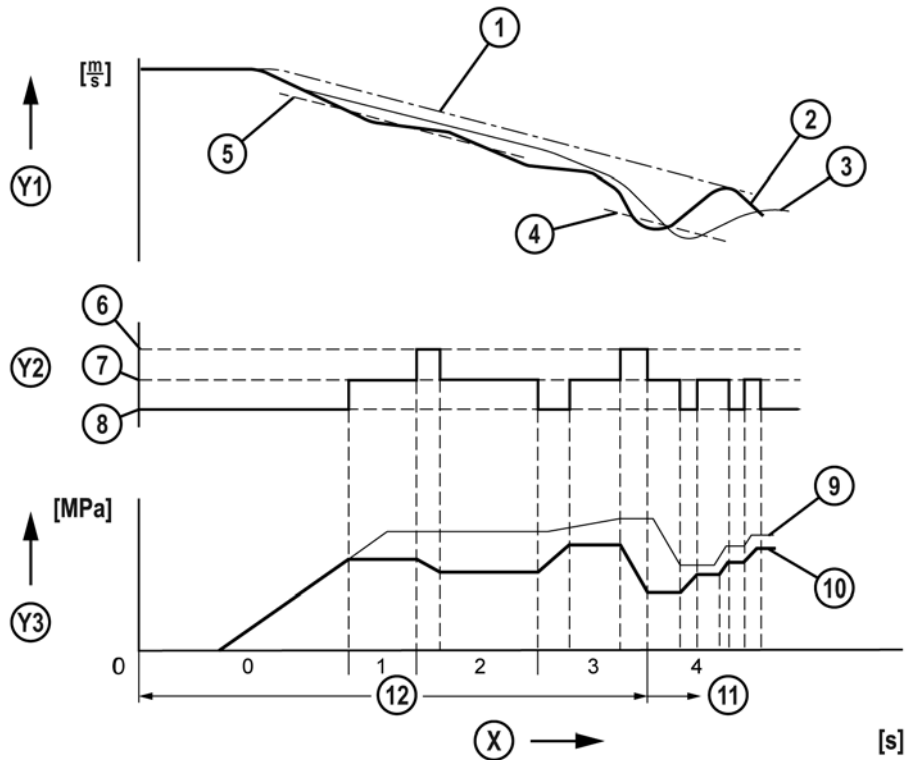
L2003_T02012

Replacement

- If the G-sensor on a Mazda6 needs to be replaced, the new sensor must be initialised using the M-MDS (refer to W/M).

Electronic Brakeforce Distribution

- All current Mazdas with ABS have EBD (Electronic Brakeforce Distribution) which eliminates the need for a proportioning valve. The B-Series is the only current Mazda that still uses a proportioning valve (load sensing type) even though it is also equipped with EBD.
- The EBD is a function, which is programmed in the ABS CM and needs only minor modifications to the system. It allows the split in brake force to be adjusted much more accurately according to the current driving conditions. The EBD detects the difference in wheel slip between the front and rear wheels with the aid of the wheel speed sensors. If wheel slip of the rear wheels compared to the front wheels exceeds a specified limit, it reduces the brake fluid pressure applied to the rear wheels with the aid of the hydraulic valves in the ABS HU/CM.
- Handling response is continuously monitored and a larger proportion of the overall braking force can be applied to the rear brakes when conditions allow. This results in shorter brake distances and reduced wear due to less thermal stress on the front brakes.
- EBD operation stops when ABS operation starts.
- The graph shows when EBD operation begins, and when the CM changes to ABS operation mode. Furthermore you will notice that the operation by the CM is always done in advance, and that there is a difference in time between actuating the valves and the resulting change in pressure/speed. This is because the electronic control is much faster than hydraulics, and there is also an additional delay due to the momentum of the vehicle and wheels.



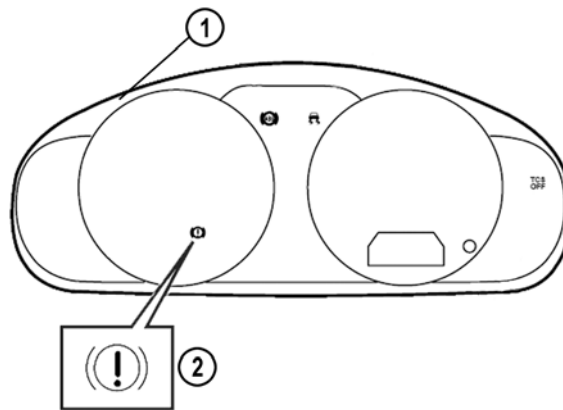
L2003_02017

- | | | | |
|----|-----------------------------|----|----------------------------|
| X | Time | 5 | EBD initial control value |
| Y1 | Speed | 6 | Pressure reduction |
| Y2 | Rear solenoid valve control | 7 | Pressure hold |
| Y3 | Brake fluid pressure | 8 | Pressure increase |
| 1 | Vehicle speed | 9 | Front brake fluid pressure |
| 2 | Rear wheel speed | 10 | Rear brake fluid pressure |
| 3 | Front wheel speed | 11 | ABS control range |
| 4 | ABS initial control value | 12 | EBD control range |

Brake System Warning Light

- The EBD system uses the red brake system warning light to indicate a malfunction. The brake system warning light also indicates malfunctions concerning brake fluid level or parking brake operation, but whenever the light illuminates the EBD operation is disabled.

NOTE: If a malfunction occurs and the EBD is disabled, the red brake system warning light will illuminate. If this happens the driver should stop immediately and check the brake fluid level and the brake pressure. If the brake fluid level and the brake pressure are okay, and the parking brake is released, the vehicle should be driven slowly, or towed by a professional towing service (refer to appropriate owners manual), to the workshop. Because, if the EBD system fails, the rear wheels can lock-up easily due to full brake pressure applied to the rear wheels. If this happens, the vehicle is difficult to steer and tends to skid during braking.



L2003_02018

1 IC

2 Brake system warning light (red)

Diagnostics

- Because the EBD is incorporated in the ABS HU/CM, there is no special procedure available for diagnosis of the EBD. The system is inspected together with the ABS HU/CM and the related components.
- The brake system warning light can be inspected:
 - Visually, after switching the ignition on
 - With the aid of the input/output check mode for the IC
 - Monitoring the corresponding PID (see below)

PID	Definition	Unit/Condition
BRAKE_LMP	Brake system warning light	ON/OFF

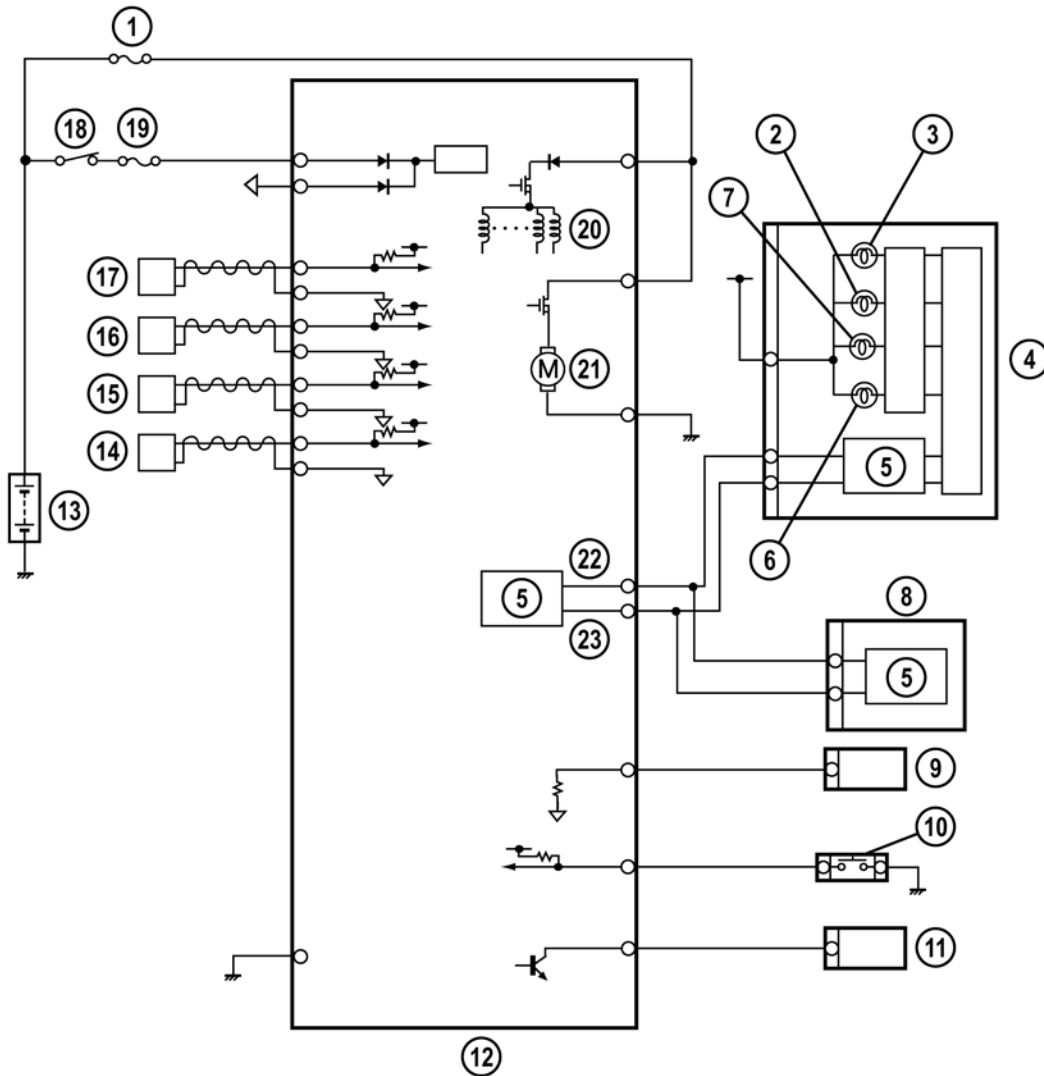
L2003_T02024

Traction Control System

- The **TCS** (Traction Control System) is installed on most Mazdas with ABS to ensure good traction for the driven wheels.
- Some earlier systems used only engine torque reduction through fuel cut-off and ignition timing control for TCS operation, others used only brake control. This course emphasizes systems installed on most current Mazda vehicles. It reduces engine torque and/or applies brake pressure to the spinning wheel, as needed.
- The system is incorporated into the ABS HU/CM. The TCS features the following changes in components over an ABS:
 - Two traction solenoid valves are added to the HU/CM.
 - A TCS OFF switch is added to the dashboard.
 - A TCS OFF indicator light and a TCS indicator light are included in the IC.
 - The CM can send a torque reduction signal to the PCM when required.

TCS Control Module

Wiring Diagram



Mazda6

L2003_02019

- | | | | |
|----|----------------------------|----|---------------------------|
| 1 | ABS fuse | 13 | Battery |
| 2 | Brake system warning light | 14 | ABS wheel-speed sensor LR |
| 3 | ABS warning light | 15 | ABS wheel-speed sensor RR |
| 4 | IC | 16 | ABS wheel-speed sensor LF |
| 5 | CAN driver | 17 | ABS wheel-speed sensor RF |
| 6 | TCS OFF indicator light | 18 | Ignition switch |
| 7 | TCS indicator light | 19 | ABS ignition fuse |
| 8 | PCM | 20 | Solenoid valves |
| 9 | BCM | 21 | ABS pump motor |
| 10 | TCS OFF switch | 22 | CAN H |
| 11 | DLC-2 | 23 | CAN L |
| 12 | ABS/TCS HU/CM | | |

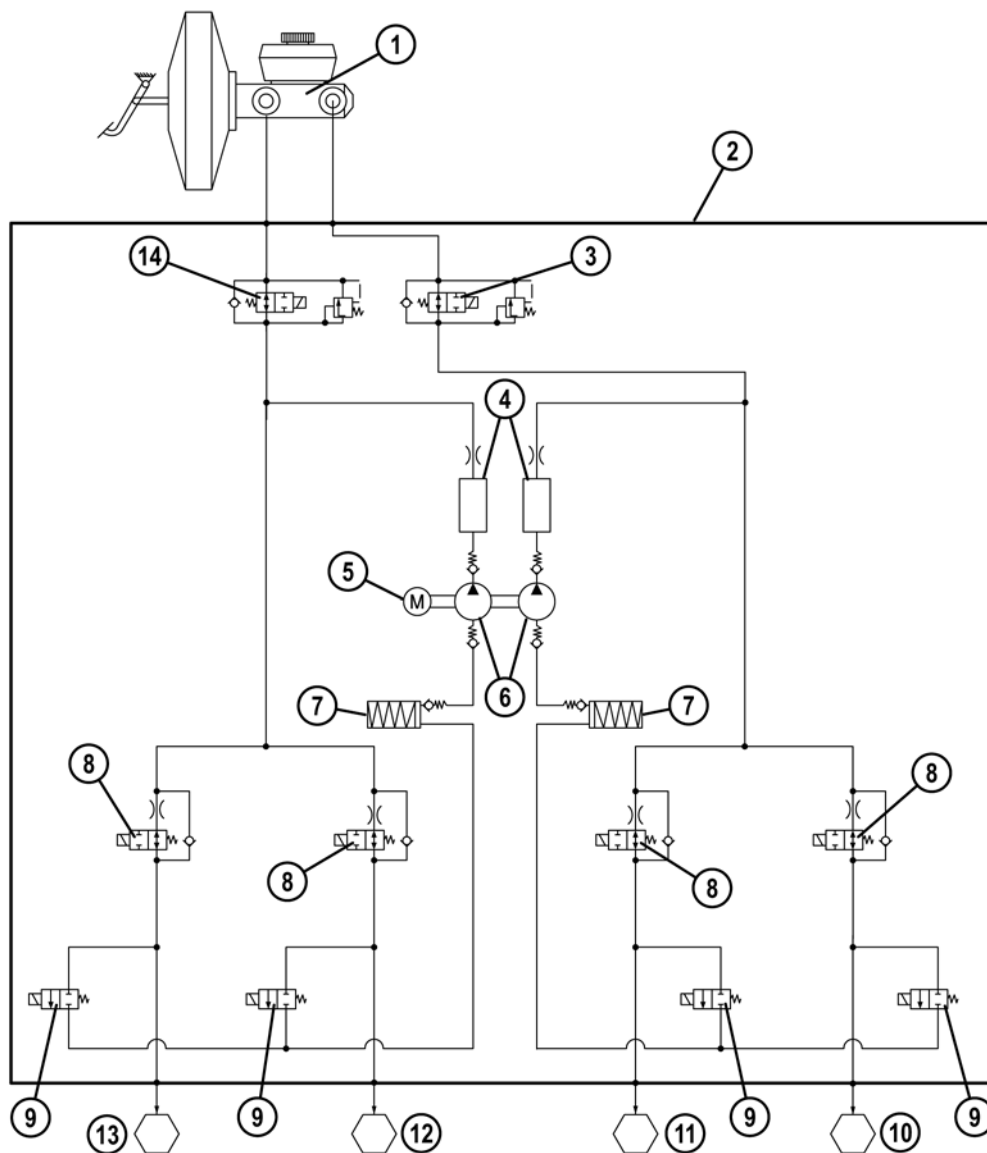
Hydraulic Circuit

- The HU for TCS is equipped with 10 solenoid valves that can be activated for the ABS, and TCS operation. It has two more solenoid valves than a vehicle with four channel ABS. The additional valves are the traction control solenoid valves, which are open when not actuated by the CM. One valve is used for each brake circuit. They are in line with the brake master cylinder and the inlet solenoid valves in the HU. This ensures that the brake circuit can be separated from the brake master cylinder during TCS operation.

Traction control solenoid valve	LF-RR	OFF (open)
	RF-LR	OFF (open)
Inlet solenoid valve	LF	OFF (open)
	RF	OFF (open)
	LR	OFF (open)
	RR	OFF (open)
Outlet solenoid valve	LF	OFF (closed)
	RF	OFF (closed)
	LR	OFF (closed)
	RR	OFF (closed)
Pump motor		OFF (closed)

L2003_T02008

Hydraulic Diagram



L2003_02020

- | | |
|---|--|
| 1 Master cylinder | 8 Inlet solenoid valve |
| 2 ABS/TCS HU/CM | 9 Outlet solenoid valve |
| 3 Traction control solenoid valve LF/RR | 10 Brake calliper LF |
| 4 Damper chamber | 11 Brake calliper RR |
| 5 Pump motor | 12 Brake calliper LR |
| 6 Pump | 13 Brake calliper RF |
| 7 Reservoir | 14 Traction control solenoid valve RF/LR |

During TCS Control

- When the wheel spin of the driven wheels exceed a specified limit, engine torque is reduced via the PCM by cutting the fuel off, changing the ignition timing, closing the throttle valve (only on vehicles with electronic throttle valve) and/or brake force is applied to the corresponding wheel in order to prevent it from spinning.
- The traction control via the brake system can operate in three ways:
 - Pressure increase mode
 - Pressure hold mode
 - Pressure reduction mode
- To simplify the explanation, the following pages describe TCS control when the right front wheel, on a front wheel drive vehicle, is spinning.

Pressure Increase Mode

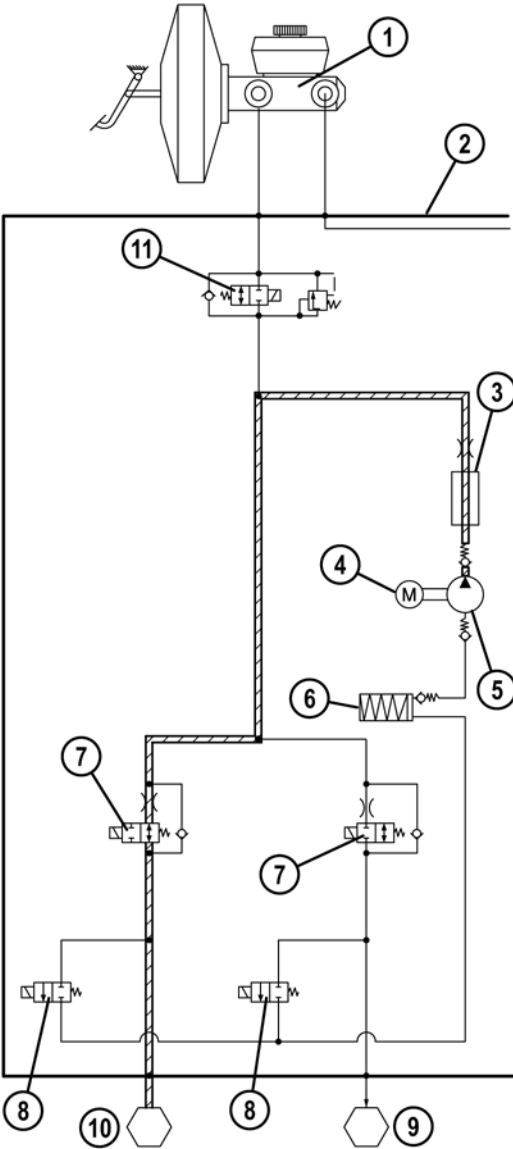
- Based on the input signals from the wheel speed sensors, the CM recognizes that the wheel is spinning. Based on all input signals, programmed parameters and internal calculations the CM decides whether it is necessary to actuate the brake system and/or to reduce the engine torque. The following steps explain how the wheel spin is prevented by activating the brake system.

NOTE: If the CM decides that the engine torque has to be reduced, it sends a corresponding signal to the PCM. The PCM then reduces the engine torque by cutting the fuel off, changing the ignition timing and/or by closing the throttle valve (only on vehicles with electronic throttle valve).

- The CM actuates the traction switching solenoid valve in the brake circuit for the RF and LR wheel. This is done to separate the brake circuit from the brake master cylinder and to enable the pump to build up pressure in the corresponding brake circuit.
- To make sure the TCS operation for the RF wheel does not affect the LR wheel, the CM activates the LR inlet solenoid valve.
- The pump motor is switched on, pressure in the corresponding brake circuit is built up, and brake force is applied to the spinning wheel.

Traction control solenoid valve	LF-RR	OFF (open)
	RF-LR	ON (closed)
Inlet solenoid valve	LF	OFF (open)
	RF	OFF (open)
	LR	ON (closed)
	RR	OFF (open)
Outlet solenoid valve	LF	OFF (closed)
	RF	OFF (closed)
	LR	OFF (closed)
	RR	OFF (closed)
Pump motor		ON (operating)

L2003_T02009



L2003_02021

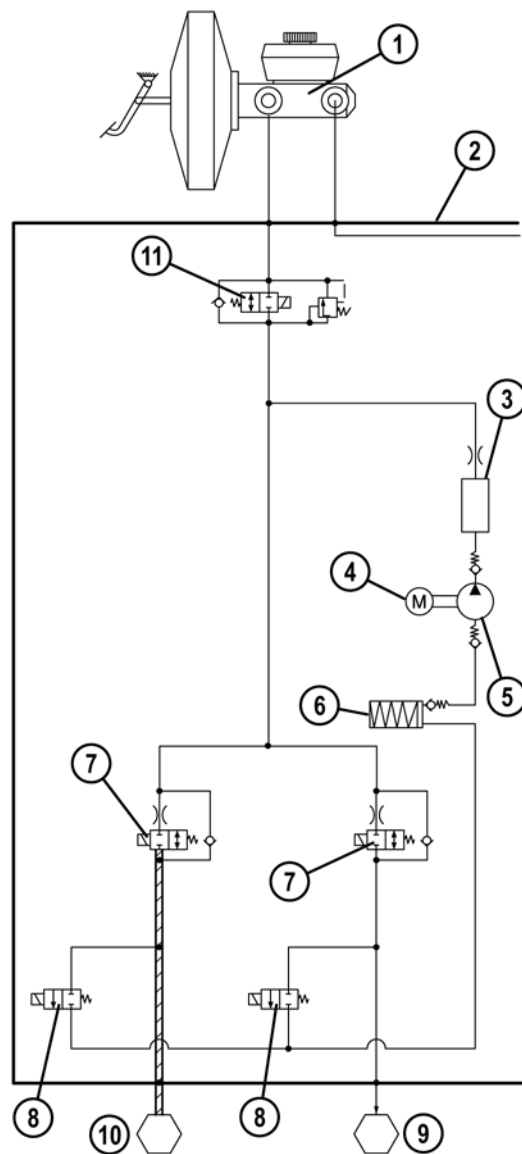
- 1 Master cylinder
- 2 ABS/TCS HU/CM
- 3 Damper chamber
- 4 Pump motor
- 5 Pump
- 6 Reservoir
- 7 Inlet solenoid valve
- 8 Outlet solenoid valve
- 9 Brake calliper LR
- 10 Brake calliper RF
- 11 Traction control solenoid valve RF/LR

Pressure Hold Mode

- When the CM detects that wheel spin is reduced, it switches to pressure hold mode by additionally activating (closing) the RF inlet solenoid valve, to maintain the built up pressure inside the corresponding brake calliper. Furthermore, the CM switches the pump motor off.

Traction control solenoid valve	LF-RR	OFF (open)
	RF-LR	ON (closed)
Inlet solenoid valve	LF	OFF (open)
	RF	ON (closed)
	LR	ON (closed)
	RR	OFF (open)
Outlet solenoid valve	LF	OFF (closed)
	RF	OFF (closed)
	LR	OFF (closed)
	RR	OFF (closed)
Pump motor		OFF (stopped)

L2003_T02010



L2003_02022

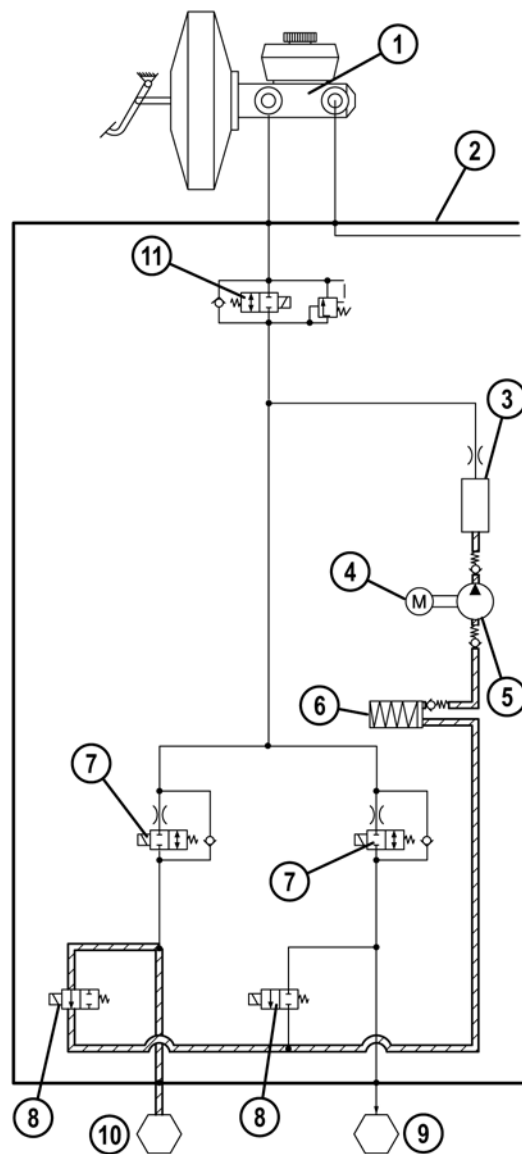
- | | |
|-------------------|--|
| 1 Master cylinder | 7 Inlet solenoid valve |
| 2 ABS/TCS HU/CM | 8 Outlet solenoid valve |
| 3 Damper chamber | 9 Brake calliper LR |
| 4 Pump motor | 10 Brake calliper RF |
| 5 Pump | 11 Traction control solenoid valve RF/LR |
| 6 Reservoir | |

Pressure Reduction Mode

- When the CM detects that wheel speed is less than appropriate for the vehicle speed, it reduces the brake force applied to the wheel by opening the outlet solenoid valve and activating the pump. The brake fluid pressure is thereby reduced and the wheel speed increases.
- If the wheel speed increases too much, more than a specified limit above the vehicle speed, the TCS operation starts again from the pressure increase mode

Traction control solenoid valve	LF-RR	OFF (open)
	RF-LR	ON (closed)
Inlet solenoid valve	LF	OFF (open)
	RF	ON (closed)
	LR	ON (closed)
	RR	OFF (open)
Outlet solenoid valve	LF	OFF (closed)
	RF	ON (closed)
	LR	OFF (closed)
	RR	OFF (closed)
Pump motor		ON (operating)

L2003_T02011



L2003_02023

- | | | | |
|---|-----------------|----|---------------------------------------|
| 1 | Master cylinder | 7 | Inlet solenoid valve |
| 2 | ABS/TCS HU/CM | 8 | Outlet solenoid valve |
| 3 | Damper chamber | 9 | Brake calliper LR |
| 4 | Pump motor | 10 | Brake calliper RF |
| 5 | Pump | 11 | Traction control solenoid valve RF/LR |
| 6 | Reservoir | | |

Bleeding

NOTE: In most cases it is not necessary to bleed the HU with the aid of the M-MDS during exchange of the brake fluid. Always follow the procedure of the corresponding W/M.

- The bleeding procedure for a HU with TCS is similar to that for a vehicle with ABS.

NOTE: Always perform the manual bleeding procedure before performing any bleeding procedure with the aid of the M-MDS

Diagnostics

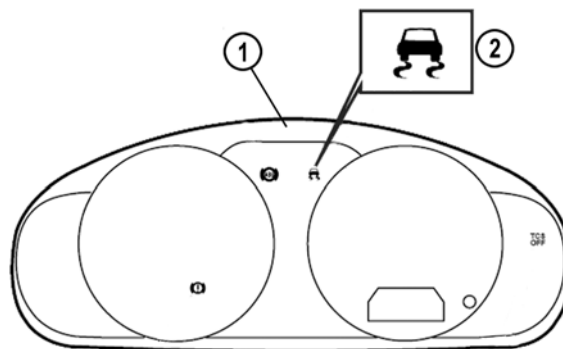
- Due to the fact that the TCS is incorporated to the ABS HU/CM, the system can be inspected together with the ABS HU/CM and the related components, and by monitoring the following additional PIDs:

PID	Definition	Unit/Condition
LF_TCS_WV	LF traction control solenoid valve	ON/OFF
RF_TCS_WV	RF traction control solenoid valve	ON/OFF
TCSOUTD	Torque reduction request signal	%
TPI	Throttle position status	%

L2003_T02013

TCS Indicator Light

- The yellow TCS indicator light is located in the IC. It illuminates after ignition on for a few seconds to inform the driver that the warning light has no malfunction. During driving it flashes whenever TCS operates, to visually inform the driver that the system is currently operating.
- If it stays on or illuminates without flashing during driving, a malfunction is detected. An illuminated indicator light, does not necessarily indicate that the system is disabled. It only indicates, that the driver should have the system inspected as soon as possible. All current Mazda vehicles feature a DTC memory function. The malfunction is stored in the ABS CM.



L2003_02024

1 IC

2 TCS indicator light

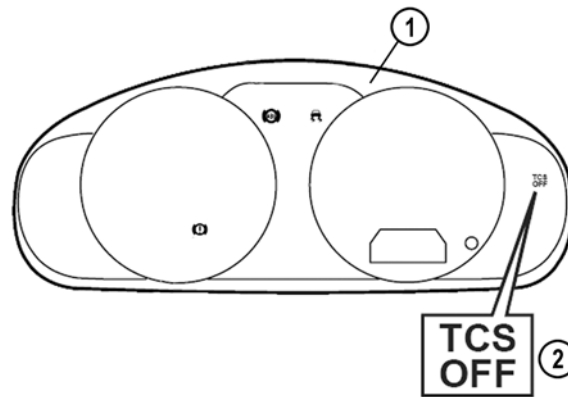
Diagnostics

- The TCS indicator light can be checked by:
 - Visually inspecting the light after switching the ignition on
 - Using the input/output check mode for the IC

TCS OFF Indicator Light

- The yellow TCS OFF indicator light is located in the IC. It illuminates after ignition on for a few seconds to inform the driver that the indicator light has no malfunction. It is also illuminated when the TCS is switched off by the driver, or if the TCS is disabled due to a malfunction.
- If it illuminates without the TCS having been switched off by the driver, a malfunction is detected. All current Mazda vehicles feature a DTC memory function. The malfunction is stored in the ABS control module.

NOTE: On vehicles without electronic throttle valve, the TCS OFF indicator light might stay illuminated after the engine has been started at an engine coolant temperature below 0° C. Because, the system is automatically disabled until the engine coolant temperature reaches a specified value (depending on the model approx. 35° C), to avoid engine running problems caused by changing the ignition timing of the cold engine. This does not indicate a malfunction.



L2003_02025

1 IC

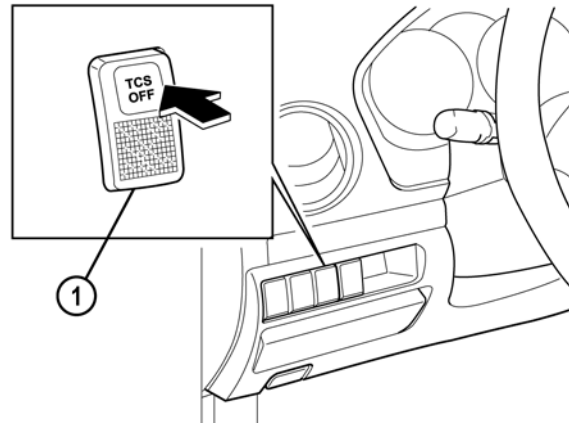
2 TCS OFF indicator light

Diagnostics

- The TCS OFF indicator light can be checked by:
 - Visually inspecting the light after switching the ignition on
 - Using the input/output check mode for the IC

TCS OFF Switch

- The TCS OFF switch is located in the dashboard. With this momentary switch, the driver can disable the TCS operation in case the vehicle is stuck and spinning the wheels may help to free the vehicle.
- Whenever the TCS is switched off, the TCS OFF indicator light will be illuminated in the IC. The TCS will automatically be switched on again, after switching the ignition off and on.



L2003_02026

- 1 TCS OFF switch

Diagnostics

- The TCS OFF switch can be checked by:
 - Visually inspecting the TCS OFF indicator light while switching the TCS on and off
 - Measuring voltage signals and resistance

TCS on Vehicles with 4WD

- The system is similar to that on a 2WD vehicle, except that a torque request signal can be transmitted to the 4WD CM
- When the TCS CM detects a condition where it is necessary to increase the torque transmitted to the rear wheels, it transmits a torque request signal via CAN to the 4WD CM. Based on this request signal, the 4WD CM activates the electronically controlled clutch to increase the torque forwarded from the propeller shaft to the rear differential and on to the rear wheels.

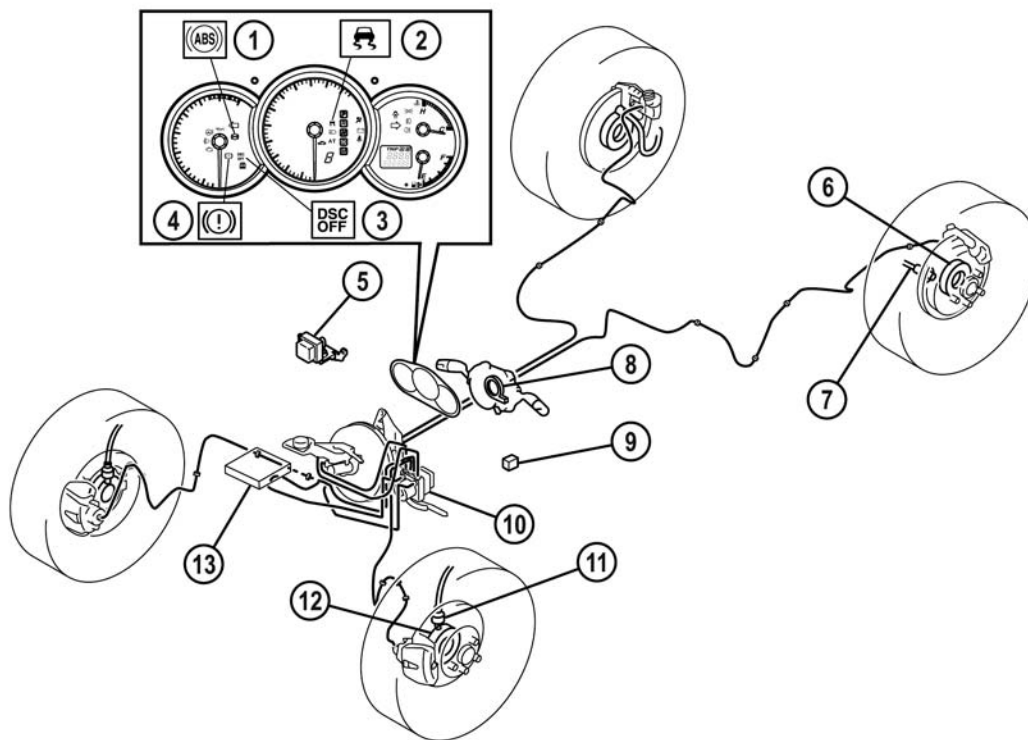
NOTE: Due to the fact that the TCS on vehicles with 4WD is similar to that on vehicles with 2WD, the system can be inspected in the same way.

Dynamic Stability Control

- The **DSC (Dynamic Stability Control)** system is designed to increase the vehicle's driving stability, especially if the vehicle tends to understeer/oversteer, e.g. when cornering too fast.
- The DSC detects tendency for swerving with the aid of its input signals, and reduces this by applying a calculated amount of brake force to a single wheel and/or by controlling the engine torque (similar to TCS control).
- The DSC is incorporated into the ABS HU/CM. The module is called a DSC HU/CM. The DSC features the following changes in components over an ABS with TCS:
 - Two stability control solenoid valves are added
 - A combined sensor is added
 - A steering angle sensor is added
 - A brake fluid pressure sensor is either attached to the brake master cylinder or integrated to the HU
 - A DSC indicator light and a DSC OFF indicator light are added to the IC
 - A DSC OFF switch is added to the dashboard
 - The vehicle has neither a TCS OFF indicator light nor a TCS OFF switch

NOTE: Because a large number of components is similar to those of an ABS with TCS, only the differences are explained.

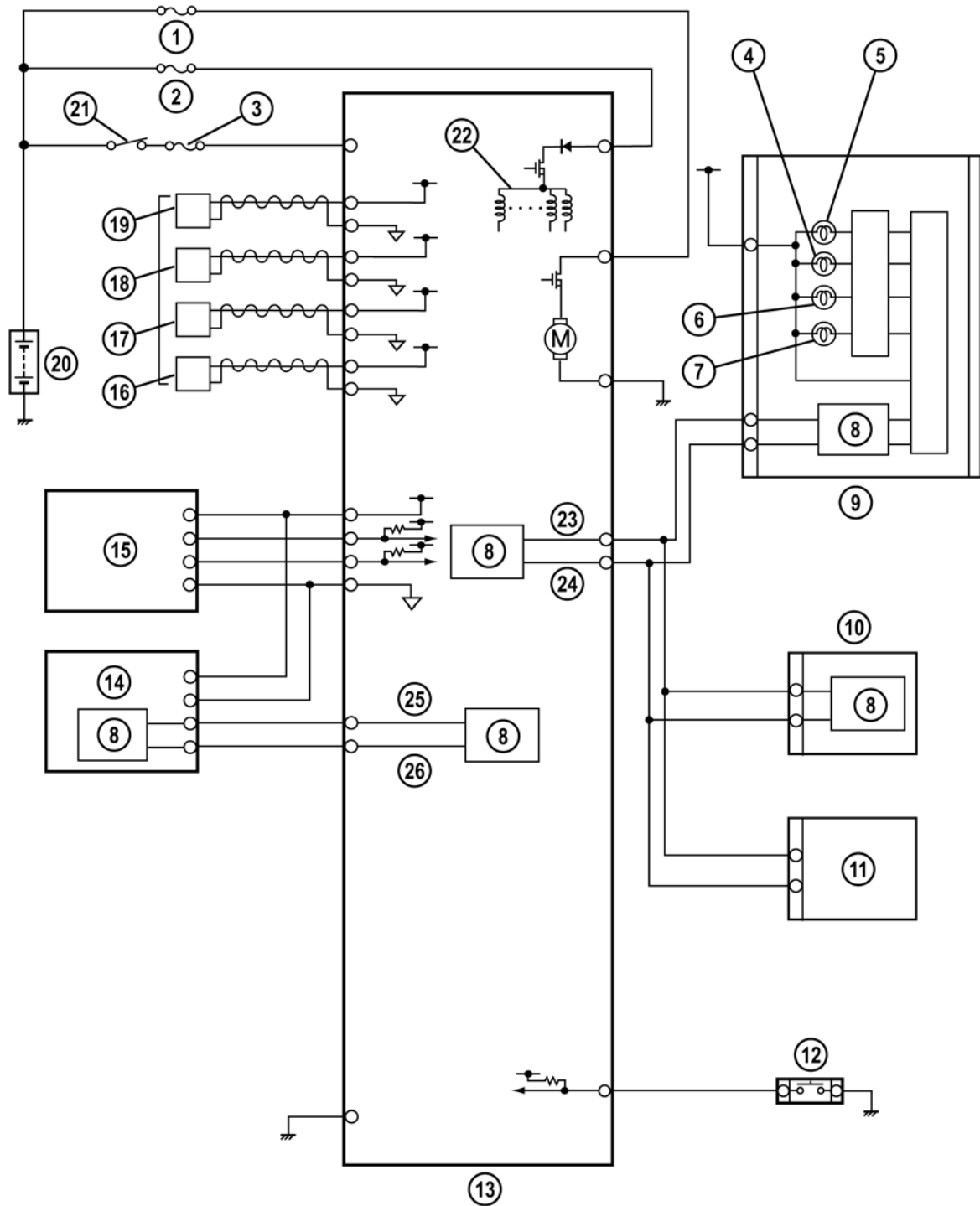
Parts Location



L2003_02027

- | | | | |
|---|-----------------------------|----|------------------------------|
| 1 | ABS warning light | 8 | Steering angle sensor |
| 2 | DSC indicator light | 9 | DSC OFF switch |
| 3 | DSC OFF indicator light | 10 | DSC HU/CM |
| 4 | Brake system warning light | 11 | Front ABS wheel-speed sensor |
| 5 | Combined sensor | 12 | Front ABS pulse rotor |
| 6 | Rear ABS pulse rotor | 13 | PCM |
| 7 | Rear ABS wheel-speed sensor | | |

Wiring Diagram



L2003_02028

- | | | | |
|----|----------------------------|----|---------------------------|
| 1 | ABS fuse 1 | 14 | Combined sensor |
| 2 | ABS fuse 2 | 15 | Steering angle sensor |
| 3 | ABS ignition fuse | 16 | ABS wheel-speed sensor LR |
| 4 | Brake system warning light | 17 | ABS wheel-speed sensor RR |
| 5 | ABS warning light | 18 | ABS wheel-speed sensor LF |
| 6 | DSC OFF indicator light | 19 | ABS wheel-speed sensor RF |
| 7 | DSC indicator light | 20 | Battery |
| 8 | CAN driver | 21 | Ignition switch |
| 9 | IC | 22 | Solenoid valves |
| 10 | PCM | 23 | CAN H |
| 11 | DLC-2 | 24 | CAN L |
| 12 | DSC OFF switch | 25 | CAN2 L |
| 13 | DSC HU/CM | 26 | CAN2 H |

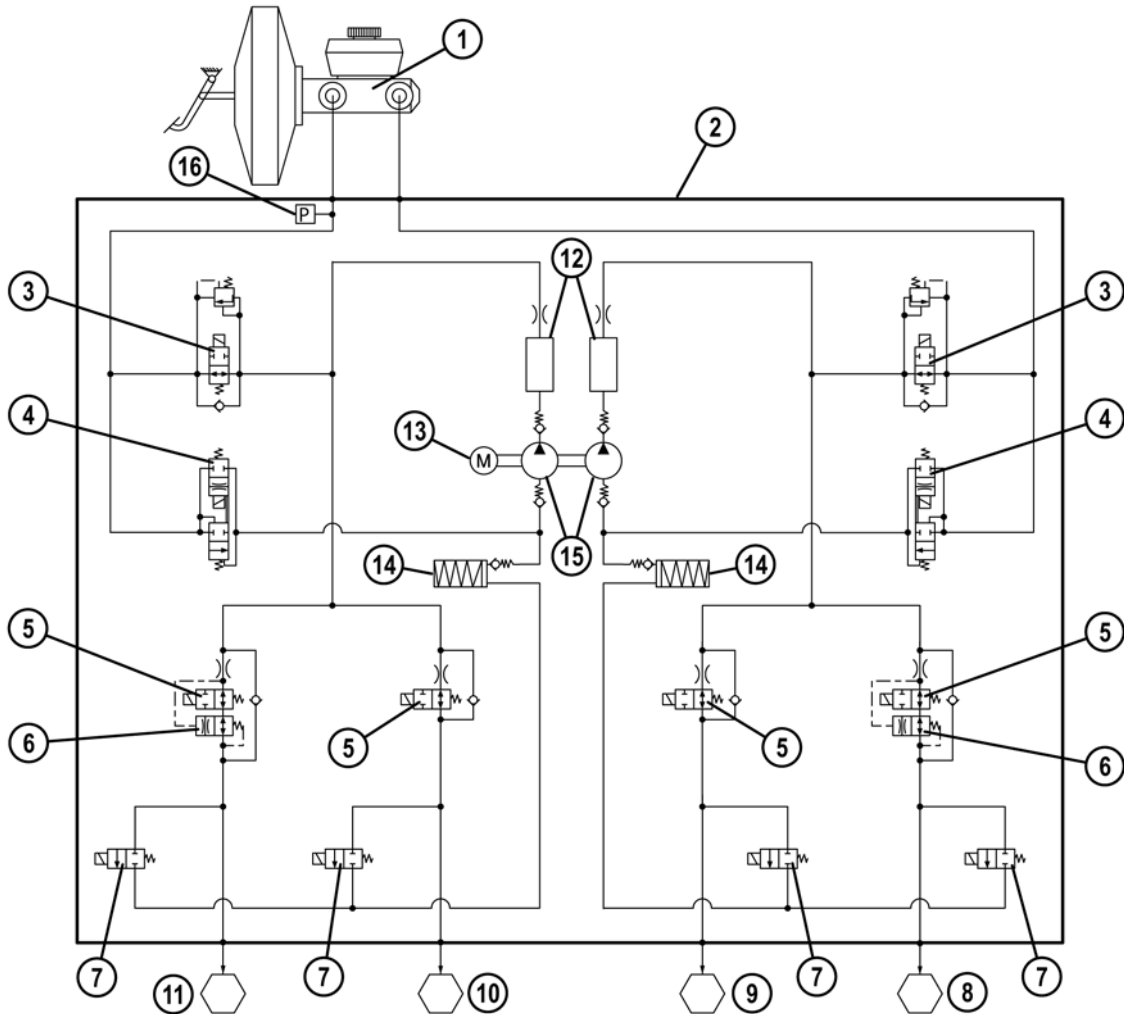
Hydraulic Circuit

- The HU for DSC is equipped with 12 solenoid valves that can be activated for the ABS, TCS and DSC operation. It has two more solenoid valves than a vehicle with four channel ABS and TCS. The additional valves are the stability control solenoid valves, which are closed when not actuated by the CM. One valve is used for each brake circuit. They are in line with the brake master cylinder and the suction side of the pump in the HU. This ensures that a sufficient amount of brake fluid is available during DSC operation.

Traction control solenoid valve	LF-RR	OFF (open)
	RF-LR	
Stability control solenoid valve	LF-RR	OFF (closed)
	RF-LR	
Inlet solenoid valve	LF	OFF (open)
	RF	
	LR	
	RR	
Outlet solenoid valve	LF	OFF (closed)
	RF	
	LR	
	RR	
Pump motor		OFF (stopped)

L2003_T02015

Hydraulic Diagram

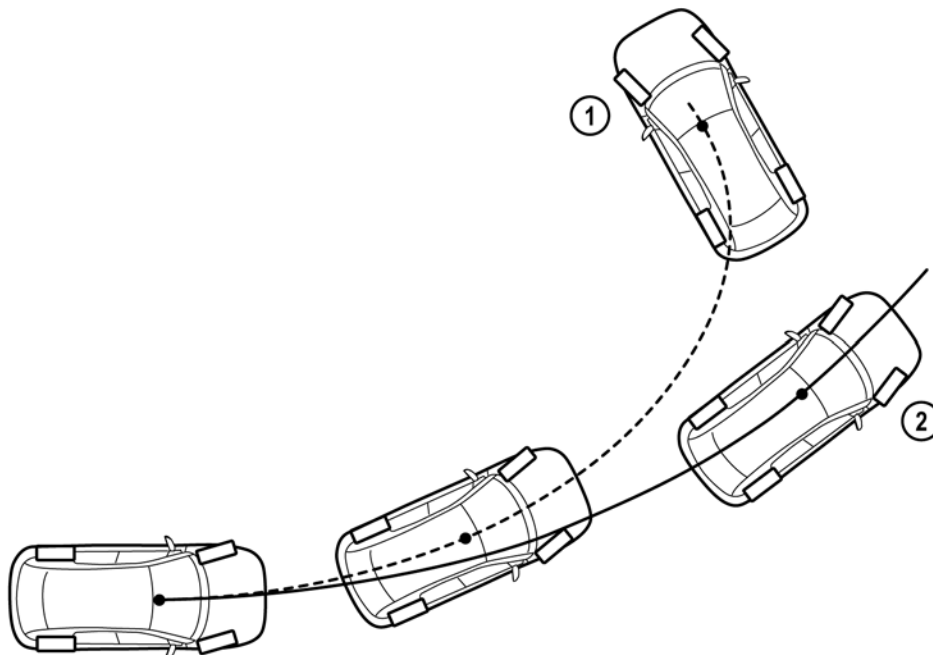


L2003_02029

- | | |
|------------------------------------|--------------------------------|
| 1 Master cylinder | 9 Brake calliper RR |
| 2 DSC HU/CM | 10 Brake calliper LR |
| 3 Traction control solenoid valve | 11 Brake calliper RF |
| 4 Stability control solenoid valve | 12 Damper chamber |
| 5 Inlet solenoid valve | 13 Pump motor |
| 6 Flow control valve | 14 Reservoir |
| 7 Outlet solenoid valve | 15 Pump |
| 8 Brake calliper LF | 16 Brake fluid pressure sensor |

Operation

- The operation of the standard brake system, the ABS, and the TCS has already been explained on the previous pages. Therefore, only the operation of the DSC is explained on the following pages.
- DSC permanently compares vehicle speed, wheel speed, steering angle, yaw rate, and lateral acceleration with each other and with stored values. If they do not match up (e.g. yaw rate indicates that the vehicle is turning to the left while steering angle indicates that the driver wants to make a turn to the right) the DSC starts operation according to a stored map data and internal calculations.
- According to its calculations, the DSC reduces engine torque and/or applies a specified amount of brake force to single wheels, in order to counteract unwanted forces (e.g. yaw moment against the driving direction). Due to this, the DSC can correct an unstable driving condition especially during emergency manoeuvres.
- When e.g. a vehicle tends to oversteer during cornering, the vehicle's tail slides towards the outside, the vehicle becomes unstable and the driver loses control.

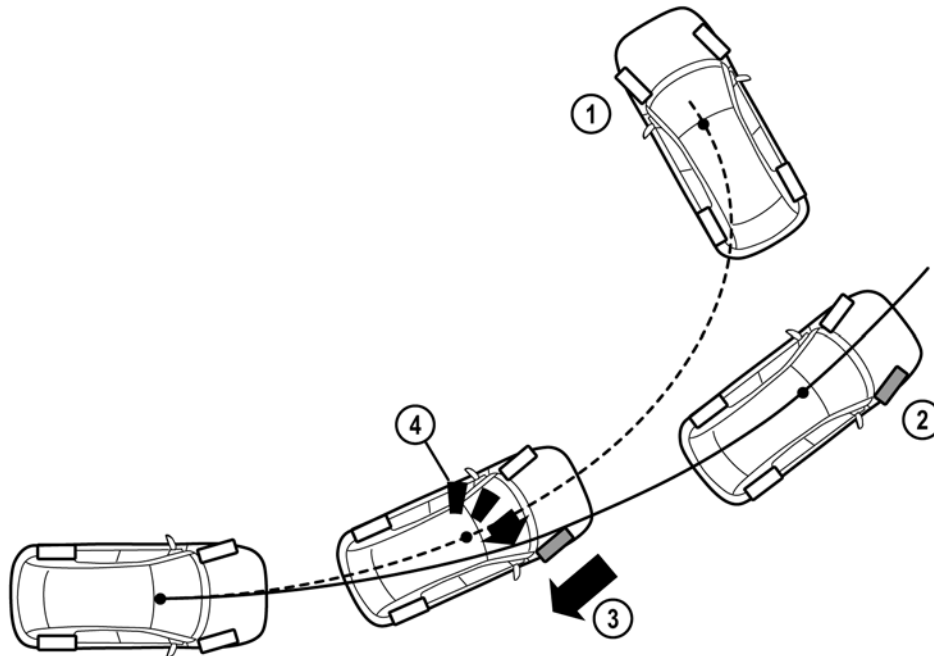


L2003_02030

1 Actual direction of travel

2 Intended direction of travel

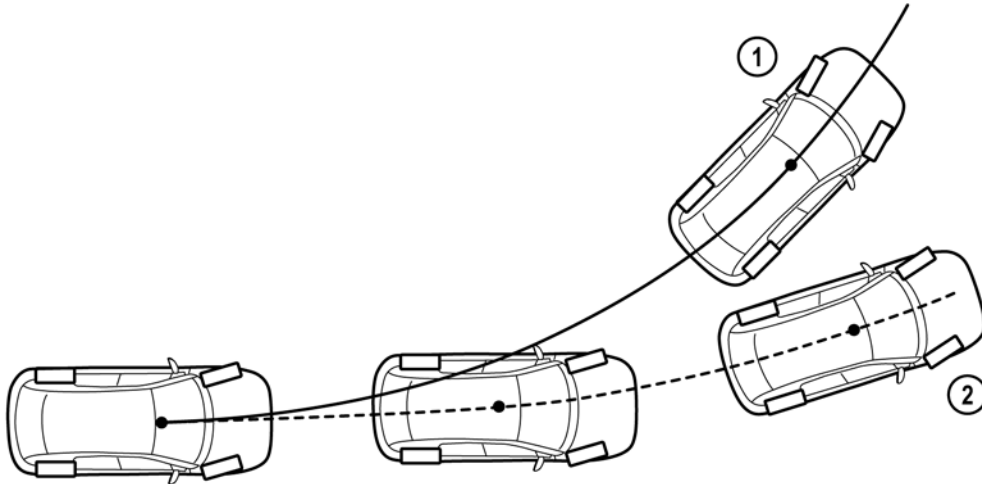
- The DSC counteracts this tendency by applying brake force to one or more wheels (in this case to the outside front wheel). Due to the brake force, a momentum is built up, counteracting the unintentionally movement of the vehicle, as shown in the illustration below:



L2003_02031

- | | | | |
|---|--|---|--------------------------|
| 1 | Direction of travel without DSC intervention | 3 | Brake force applied |
| 2 | Direction of travel with DSC intervention | 4 | Counteracting yaw moment |

- When a vehicle tends to understeer during cornering, the vehicle's circular path is of larger diameter than the circle indicated by the direction its wheels are pointed. The vehicle does not turn as tightly as it should and leaves its track instead of following the intended path.

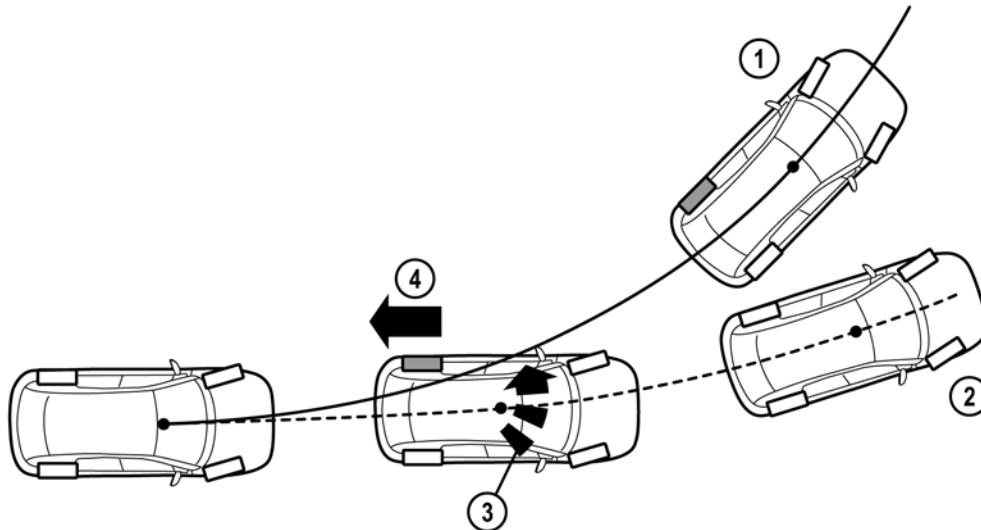


L2003_02032

1 Intended direction of travel

2 Actual direction of travel

- The DSC counteracts this tendency by applying brake force to one or more wheels (in this case to the inside rear wheel). Thus a momentum is built up, overcoming the tendency of the vehicle to continue in a wider circle than intended, as shown in the illustration below.



L2003_02033

- | | | | |
|---|--|---|--------------------------|
| 1 | Direction of travel with DSC intervention | 3 | Counteracting yaw moment |
| 2 | Direction of travel without DSC intervention | 4 | Brake force applied |

During DSC Control

- The brake force is applied in three ways:
 - Pressure increase mode
 - Pressure hold mode
 - Pressure reduction mode
- These modes will be explained on the following pages. The sample is for a vehicle that is oversteering during a left turn.

Pressure Increase Mode

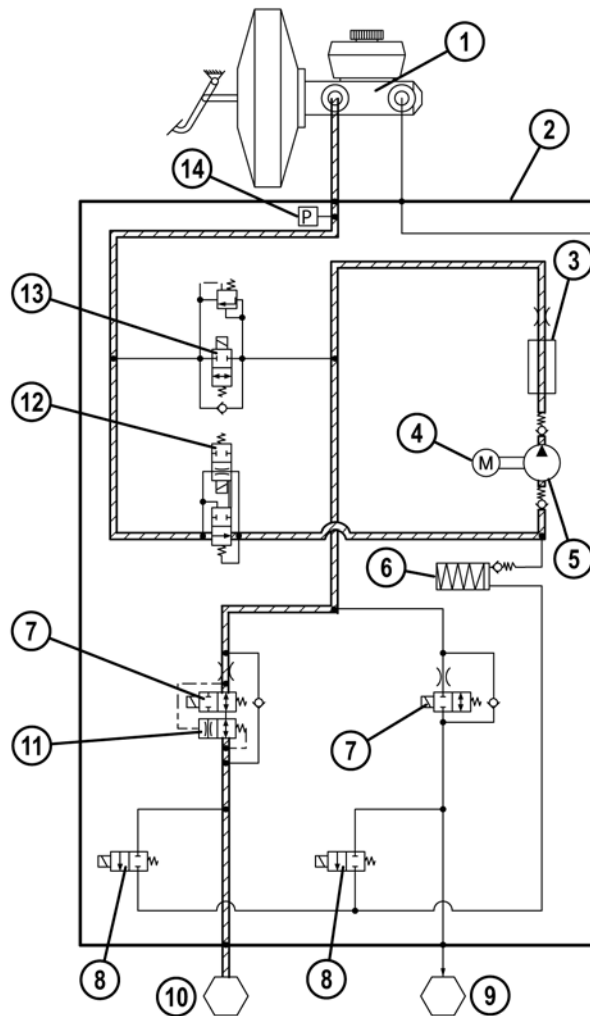
- Based on the input signals, the stored map values and internal calculations, the CM recognizes that the vehicle is about to oversteer during a left turn. The CM decides whether it is necessary to actuate the brake system and/or to reduce the engine torque. The following steps explain how the vehicle is kept on the track by activating the brake system.

NOTE: If the CM decides that the engine torque has to be reduced, it sends a corresponding signal to the PCM. The PCM then reduces the engine torque by cutting the fuel off, changing ignition timing and/or by closing the throttle valve (only on vehicles with electronic throttle valve).

- When the CM decides that it is necessary to apply brake force to the outer front wheel to keep the vehicle under the driver’s control, it actuates the traction control solenoid valve in the brake circuit for the RF and LR wheel. This is done to separate the brake circuit from the brake master cylinder and to enable the pump to build up pressure in the corresponding brake circuit.
- To make sure the DSC operation for the RF wheel does not affect the LR wheel, the CM activates the LR inlet solenoid valve.
- The stability control solenoid valve for the RF and LR wheel is actuated and opens a channel to supply a sufficient amount of brake fluid to the high-pressure pump.
- The pump motor is switched on, pressure in the RF brake circuit is built up, and brake force is applied to the wheel. This counteracts the undesired yaw force neutralising the oversteer tendency, allowing the driver to maintain control.

Traction control solenoid valve	LF-RR	OFF (open)
	RF-LR	ON (closed)
Stability control solenoid valve	LF-RR	OFF (closed)
	RF-LR	ON (open)
Inlet solenoid valve	LF	OFF (open)
	RF	
	LR	ON (closed)
	RR	OFF (open)
Outlet solenoid valve	LF	OFF (closed)
	RF	
	LR	
	RR	
Pump motor		ON (operating)

L2003_T02016



L2003_02034

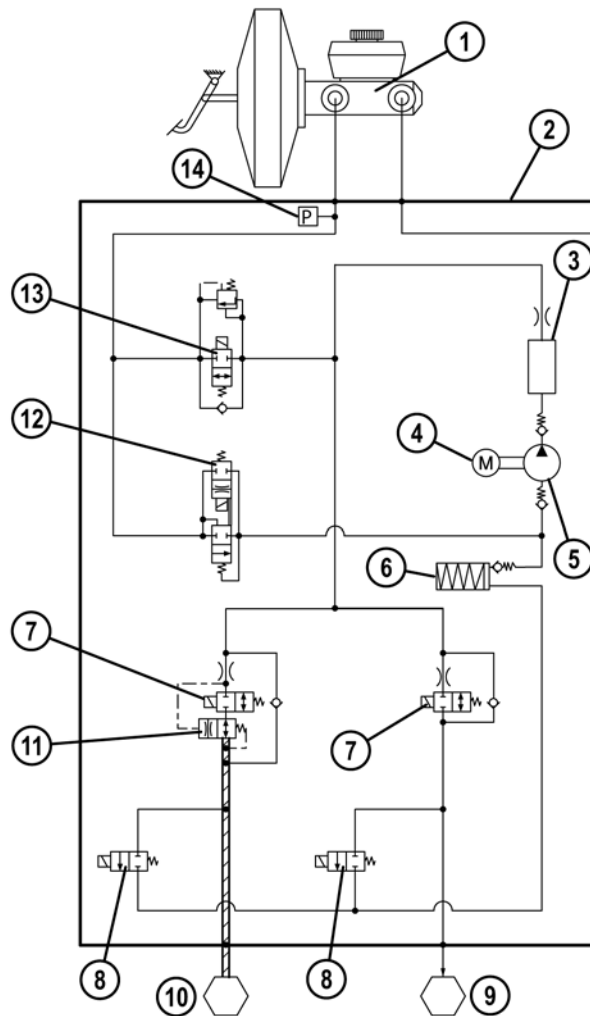
- | | | | |
|---|----------------------|----|----------------------------------|
| 1 | Master cylinder | 8 | Outlet solenoid valve |
| 2 | DSC HU/CM | 9 | Brake calliper LR |
| 3 | Damper chamber | 10 | Brake calliper RF |
| 4 | Pump motor | 11 | Flow control valve |
| 5 | Pump | 12 | Stability control solenoid valve |
| 6 | Reservoir | 13 | Traction control solenoid valve |
| 7 | Inlet solenoid valve | 14 | Brake fluid pressure sensor |

Pressure Hold Mode

- After the appropriate pressure has been built up, the DSC switches to the pressure hold mode and deactivates the high-pressure pump. The RF-LR traction control solenoid valve remains actuated, while the RF-LR stability control solenoid valve closes, because it is deactivated by the CM. In addition, the RF inlet solenoid valve is activated. The LR inlet solenoid valve remains closed during the entire process.

Traction control solenoid valve	LF-RR	OFF (open)
	RF-LR	ON (closed)
Stability control solenoid valve	LF-RR	OFF (closed)
	RF-LR	OFF (closed)
Inlet solenoid valve	LF	OFF (open)
	RF	ON (closed)
	LR	
	RR	OFF (open)
Outlet solenoid valve	LF	OFF (closed)
	RF	
	LR	
	RR	
Pump motor		OFF (stopped)

L2003_T02017



L2003_02035

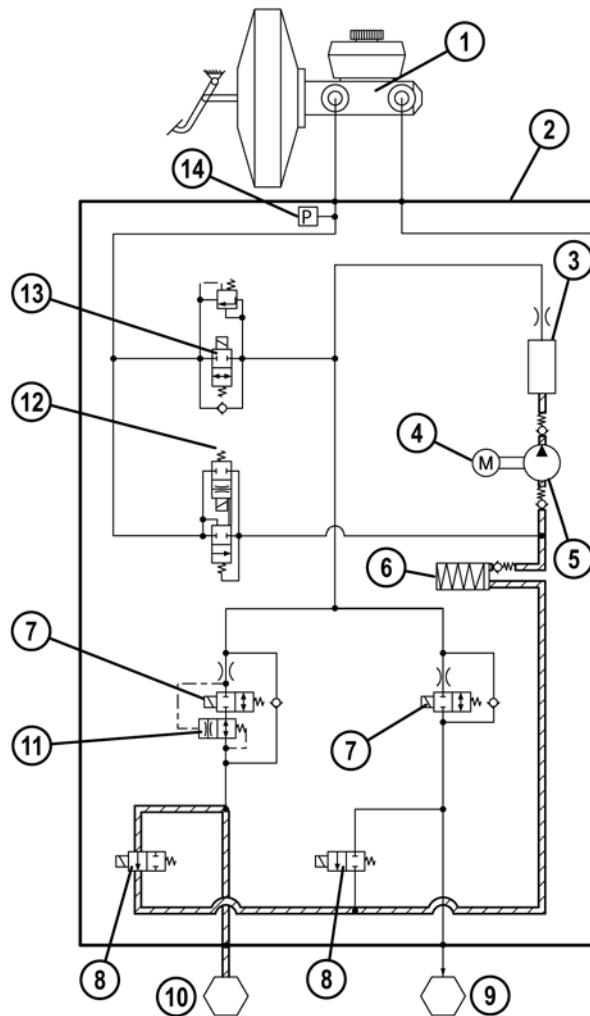
- | | | | |
|---|----------------------|----|----------------------------------|
| 1 | Master cylinder | 8 | Outlet solenoid valve |
| 2 | DSC HU/CM | 9 | Brake calliper LR |
| 3 | Damper chamber | 10 | Brake calliper RF |
| 4 | Pump motor | 11 | Flow control valve |
| 5 | Pump | 12 | Stability control solenoid valve |
| 6 | Reservoir | 13 | Traction control solenoid valve |
| 7 | Inlet solenoid valve | 14 | Brake fluid pressure sensor |

Pressure Reduction Mode

- When the CM determines that the applied brake pressure has to be reduced to allow the vehicle to follow its desired path, it switches to pressure reduction mode and activates the high-pressure pump. The only valve that changes its condition compared to the pressure hold mode is the RF outlet solenoid valve, which now opens as a reaction to a signal from the CM.
- The brake fluid pressure decreases inside the brake calliper and as a result the applied brake force is reduced.
- Pressure is built up between the high-pressure pump and the inlet solenoid valve of the brake calliper, to be able to apply brake force again if required. The CM repeats the operation as necessary from the beginning.

Traction control solenoid valve	LF-RR	OFF (open)
	RF-LR	ON (closed)
Stability control solenoid valve	LF-RR	OFF (closed)
	RF-LR	OFF (closed)
Inlet solenoid valve	LF	OFF (open)
	RF	ON (closed)
	LR	
	RR	OFF (open)
Outlet solenoid valve	LF	OFF (closed)
	RF	ON (open)
	LR	OFF (closed)
	RR	
Pump motor		ON (operating)

L2003_T02018



L2003_02036

- | | |
|------------------------|-------------------------------------|
| 1 Master cylinder | 8 Outlet solenoid valve |
| 2 DSC HU/CM | 9 Brake calliper LR |
| 3 Damper chamber | 10 Brake calliper RF |
| 4 Pump motor | 11 Flow control valve |
| 5 Pump | 12 Stability control solenoid valve |
| 6 Reservoir | 13 Traction control solenoid valve |
| 7 Inlet solenoid valve | 14 Brake fluid pressure sensor |

Bleeding

NOTE: In most cases it is not necessary to bleed the HU with the aid of the M-MDS during exchange of the brake fluid. Always follow the procedure of the corresponding W/M.

- The bleeding procedure for the DSC HU is similar to that for an ABS HU with TCS. If possible, the stability control valves must be switched on and bled in addition.

NOTE: Always perform the manual bleeding procedure before performing any bleeding procedure with the aid of the M-MDS

Diagnosics

- The HU/CM can be checked by:
 - Reading out DTCs
 - Checking voltage signals
 - Monitoring / Activating the corresponding PIDs (see below)

PID	Definition	Unit/Condition
BOO_ABS	Brake switch	ON/OFF
CCNTABS	Number of detected DTCs	-
ESP_VOLT	IVD/DSC sensor supply voltage	V
LATACCEL#	Initialisation start-up for combined sensor	True / False
LAT_ACCL	Lateral G-force from combined sensor	G
LF_INLET#	LF ABS pressure inlet solenoid valve	ON/OFF
LF_OUTLET#	LF ABS pressure outlet solenoid valve	ON/OFF
LF_TC_PRV#	LF stability control solenoid valve	ON/OFF
LF_TC_SWV#	LF traction control solenoid valve	ON/OFF
LF_WSPD	LF ABS wheel-speed sensor input	km/h, mph
LR_INLET#	LR ABS pressure inlet solenoid valve	ON/OFF
LR_OUTLET#	LR ABS pressure outlet solenoid valve	ON/OFF
LR_WSPD	LR ABS wheel-speed sensor input	km/h, mph
MCYL_S_CAL#	Initialisation start-up for brake fluid pressure sensor	True / False
MPREDTDR	Brake fluid pressure	kPa, psi, bar
PMP_MOTOR#	ABS motor	ON/OFF
RF_INLET#	RF ABS pressure inlet solenoid valve	ON/OFF
RF_OUTLET#	RF ABS pressure outlet solenoid valve	ON/OFF
RF_TC_PRV#	RF stability control solenoid valve	ON/OFF
RF_TC_SWV#	RF traction control solenoid valve	ON/OFF
RR_INLET#	RR ABS pressure inlet solenoid valve	ON/OFF
RR_OUTLET#	RR ABS pressure outlet solenoid valve	ON/OFF
RF_WSPD	RF ABS wheel-speed sensor input	km/h, mph
RR_WSPD	RR ABS wheel-speed sensor input	km/h, mph
SWA_POS	Steering angle sensor	°
TCYC_FS	DSC stand by	ON/OFF
TCYC_SW	DSC OFF switch	Pressed/Not pressed
YAW_RATE	Yaw rate value from combined sensor	°/s

L2003_T02019

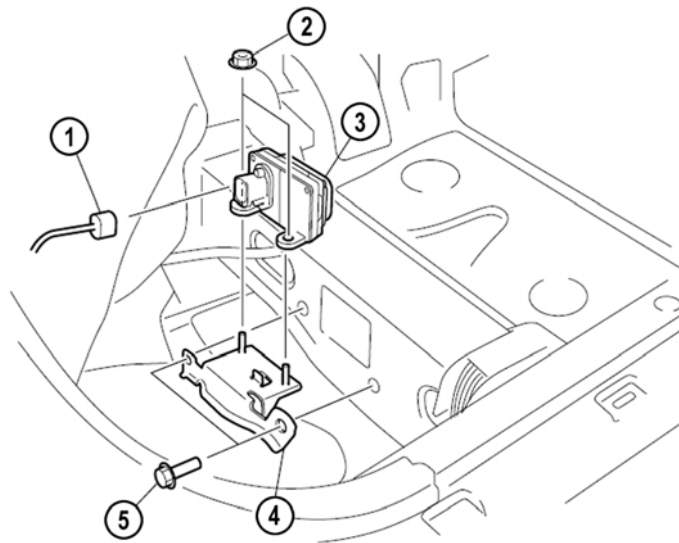
Mazda3

Combined Sensor

- On current Mazda vehicles, the combined sensor is located either below the passenger's seat, or below the centre console (MX-5 and Mazda6). As the name implies, it incorporates a combination of at least two sensors, that measure yaw rate and transverse acceleration.
- The combined sensor is either hardwired or connected via a separate CAN to the DSC HU/CM.
- The sensors themselves are a special kind of accelerometer built into a microchip (or a similar type). They operate both mechanically and/or electronically and are used to detect yaw rate and lateral G force acting on the vehicle. The combined sensor transmits detected forces either via CAN to the DSC CM or, if hardwired, as a corresponding voltage signal. These signals are used to assist the DSC CM to distinguish between stable and unstable driving conditions.

NOTE: The combined sensor is highly sensitive against impacts. Therefore, the sensor has to be replaced after it fell down.

NOTE: The mounting bolts and nuts of the combined sensor must always be tightened to the specified torque in the compulsory sequence (refer to W/M). Ensure that the sensor is correctly aligned, otherwise the measurement results for yaw rate and transverse acceleration could be affected, causing a malfunction of the DSC.



L2003_02037

- 1 Combined sensor connector
- 2 Nut
- 3 Combined sensor

- 4 Bracket
- 5 Bolt

Diagnosics

- The combined sensor can be checked by:
 - Reading out DTCs
 - Checking voltage signals
 - Monitoring / Activating the corresponding PIDs (see below)

PID	Definition	Unit/Condition
LATACCEL#	Initialisation start-up for combined sensor	ON/OFF
LAT_ACCL	Lateral G-force from combined sensor	G
YAW_RATE	Yaw rate value from combined sensor	°/s

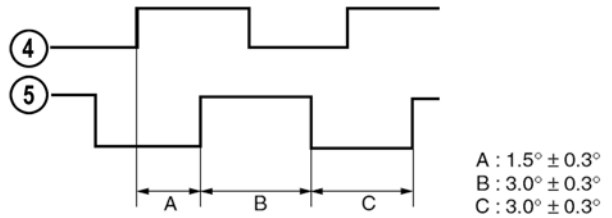
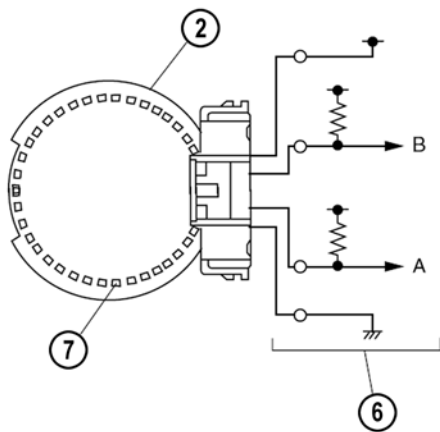
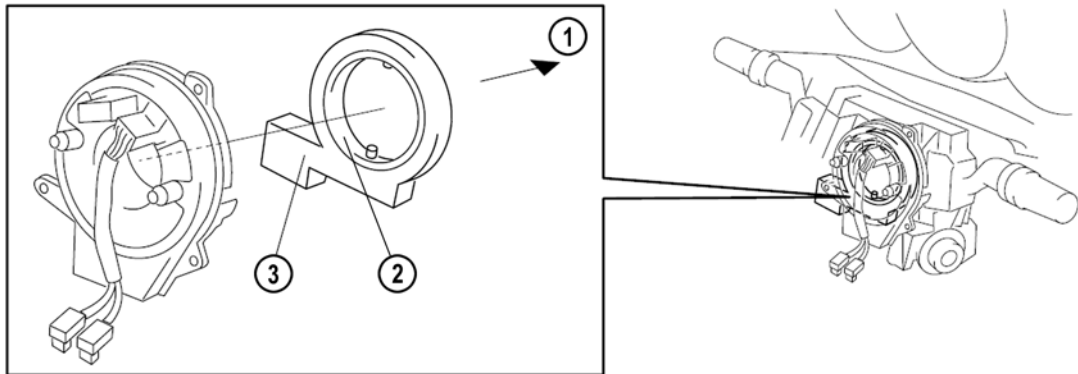
L2003_T02025

Replacement

- If a combined sensor needs to be replaced, the new sensor must be initialised with the aid of the M-MDS (refer to W/M).

Steering Angle Sensor

- The steering angle sensor is attached to the steering column, and is located between the clock spring and the combination switch. It is either integrated into the combination switch or is a separate component.
- Mazda vehicles are equipped with different types of combination sensors. They always transmit a steering wheel turn signal allowing the DSC CM to detect any rotation (degrees and direction) and the neutral position of the steering wheel. The steering angle sensor is either hardwired or connected via HS-CAN to the DSC HU/CM. Up to three different voltage signals can be transmitted from a hardwired steering angle sensor, depending on the model.
- Signal generation is done either with the aid of a photoelectric barrier, hall element type sensors, or **GMR (Giant Magneto Resistor)** type sensors. The operation of the photoelectric barrier type is explained below.
- The steering angle sensor on the Mazda3 (BK) is a separate unit. It features a sensor unit with a photo transistor, positioned opposite a LED straddling a slitted disc, that rotates together with the steering wheel.
- As the disc rotates, the LED light, received by the photo transistor, varies due to the slits on the disc. The photo transistor outputs an ON signal when it receives light and an OFF signal when the light is blocked. The DSC HU/CM calculates the steering angle and the turning speed of the steering wheel based on the phase difference between sensor A and B outputs.



L2003_02038

- 1 Vehicle front
- 2 Disc
- 3 Sensor unit
- 4 Steering angle signal B
- 5 Steering angle signal A
- 6 Detection circuit (inside DSC HU/CM)
- 7 Slit

Diagnostics

- The steering angle sensor can be checked by:
 - Reading out DTCs
 - Checking voltage signals
 - Monitoring the corresponding PID (see below)

PID	Definition	Unit/Condition
SWA_POS	Steering angle sensor	°

L2003_T02026

NOTE: The steering angle sensor does not have any serviceable parts, regardless of its type. Whenever a malfunction occurs, it needs to be replaced as a unit. Depending on the vehicle, the sensor must be initialised after it had been disconnected from the power supply (refer to W/M). The steering wheel must be turned fully to the left and then fully to the right with the engine idling. Afterwards, the DSC indicator light will turn off. Then the ignition has to be switched off and then back on, and it must be confirmed that the DSC indicator light stays off after a 10 minute test drive.

Replacement

- On some models, the steering angle sensor needs to be programmed with the aid of the M-MDS, after the sensor or the DSC HU/CM has been replaced (refer to W/M).

Brake Fluid Pressure Sensor

- Depending on the model, the brake fluid pressure sensor is attached to or incorporated in the DSC HU/CM or attached to the brake master cylinder (see W/M). A brake fluid pressure sensor that is attached to the DSC HU/CM cannot be replaced as a single part. If it has a malfunction, the entire DSC HU/CM must be replaced.

Diagnostics

- The brake fluid pressure sensor can be checked by:
 - Reading out DTCs
 - Checking voltage signals
 - Monitoring / Activating the corresponding PIDs (see below)

PID	Definition	Unit/Condition
MCYL_S_CAL#	Initialisation start-up for brake fluid pressure sensor	True/False
MPRETDR	Brake fluid pressure	kPa, psi, bar

L2003_T02027

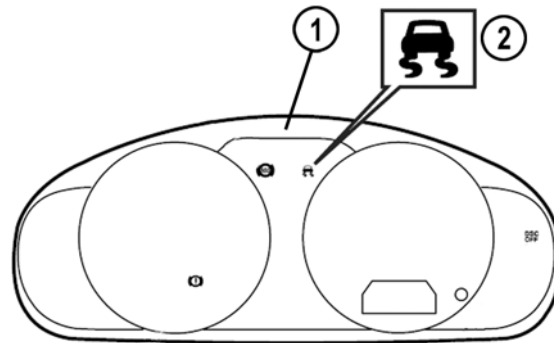
Replacement

- If a DSC HU/CM has been replaced, the brake fluid pressure sensor must be initialised with the aid of the M-MDS (depending on the model, refer to W/M).

DSC Indicator Light

- The yellow DSC indicator light is located in the IC. It illuminates after ignition on for a few seconds to inform the driver that the indicator light has no malfunction. During driving, it flashes whenever DSC operates, to visually inform the driver that the system is currently operating.
- If it stays on or illuminates without flashing during driving, a malfunction has been detected. An illuminated indicator light does not necessarily indicate that the system is disabled. It only indicates that the driver should have the system inspected as soon as possible. All current Mazda vehicles feature a DTC memory function. The malfunction is stored in the DSC HU/CM.

NOTE: Current Mazda vehicles with DSC do not feature a separate TCS indicator light. The DSC indicator light is used for both, the DSC and the TCS. Depending on the model, the speed of flashing may vary between TCS and DSC operation.



L2003_02039

1 IC

2 DSC indicator light

Diagnostics

- The DSC indicator light can be checked by:
 - Visually inspecting the indicator light after switching the ignition on
 - Using the input/output check mode for the IC
 - Monitoring/Activating the corresponding PID (see below)

PID	Definition	Unit/Condition
STAB_IND	DSC / TCS indicator light	ON / OFF

L2003_T02021

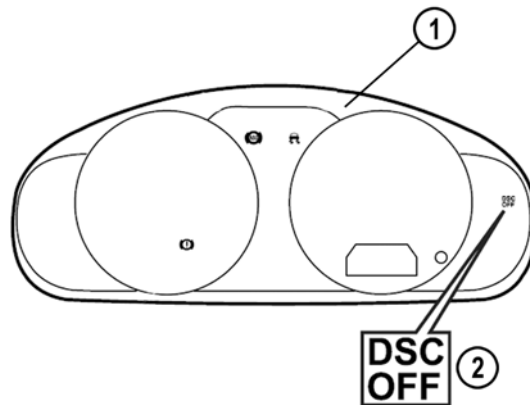
DSC OFF Indicator Light

- The yellow DSC OFF indicator light is located in the IC. It illuminates after ignition on for a few seconds to inform the driver that the indicator light has no malfunction. It is also illuminated when the DSC is switched off by the driver or due to a malfunction.
- If it illuminates without the DSC having been switched off by the driver, a malfunction is detected. All current Mazda vehicles feature a DTC memory function. The malfunction is stored in the DSC HU/CM.

NOTE: On vehicles without electronic throttle valve, the DSC OFF indicator light might stay illuminated after the engine has been started at an engine coolant temperature below 0° C. Because, the system is automatically disabled until the engine coolant temperature reaches a specified value (depending on the model approx. 35° C), to avoid engine running problems caused by changing the ignition timing of the cold engine. This does not indicate a malfunction.

NOTE: Current Mazda vehicles with DSC do not feature a separate TCS OFF indicator light. The DSC OFF indicator light is used as indicator for both, the DSC and the TCS.

NOTE: Depending on the vehicle, the DSC OFF indicator light might flash after the vehicle's battery had been disconnected. In this case, the initialisation procedure for the steering angle sensor needs to be performed.



L2003_02040

1 IC

2 DSC OFF indicator light

Diagnostics

- The DSC OFF indicator light can be checked as follows:
 - Visually inspecting the light after switching the ignition on
 - Using the input/output check mode for the IC
 - Monitoring the corresponding PID (see below)

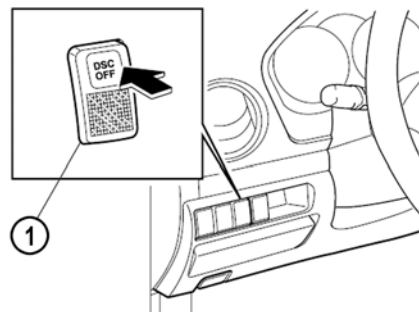
PID	Definition	Unit/Condition
TRAC_OFF	DSC OFF indicator light	ON/OFF

L2003_T02022

DSC OFF Switch

- The DSC OFF switch is located in the dashboard. With this momentary switch, the driver can disable the DSC operation in case the vehicle is stuck, and spinning the wheels may help to free the vehicle.
- Whenever the DSC is switched off, the DSC OFF indicator light in the IC will be illuminated. The DSC will automatically be switched on again, after switching the ignition off and on.

NOTE: Current Mazda vehicles with DSC do not feature a special switch for disabling the TCS function. The TCS is automatically disabled / enabled together with the DSC.



L2003_02041

- 1 DSC OFF switch

Diagnostics

- The DSC Off switch can be checked as follows:
 - Visually inspecting the DSC OFF indicator light while switching the DSC on and off
 - Reading out DTCs
 - Measuring voltage signals and resistance
 - Monitoring the corresponding PIDs (see below)

PID	Definition	Unit/Condition
TCYC_SW	DSC Off switch	Pressed / Not pressed

L2003_T02029

NOTE: Depending on the vehicle, a DTC might be stored in the DSC HU/CM when the DSC Off switch is pressed and held for more than approx. 10 s. In this case, the DSC is re-enabled and cannot be disabled again, unless the ignition is switched off and on again.

Emergency Brake Assist

- If the driver does not press the brake pedal hard enough in emergency braking situations, the brake pressure is increased by the **EBA (Emergency Brake Assist)**. The advantage is a significantly reduced braking distance. The EBA is available only in combination with ABS.
- The EBA is automatically activated if the driver presses the brake pedal very fast, as he usually automatically does in an emergency situation. Once the system is activated, it applies full brake pressure to all wheels regardless of pedal pressure applied by the driver. Of course, the ABS ensures that no wheels lock-up and that the vehicle remains fully steerable.
- Mazda uses two different types of EBA:
 - The electronically operated EBA, that is installed on Mazda6
 - The mechanical operated EBA, that is installed on Mazda2, Mazda3 and Mazda5

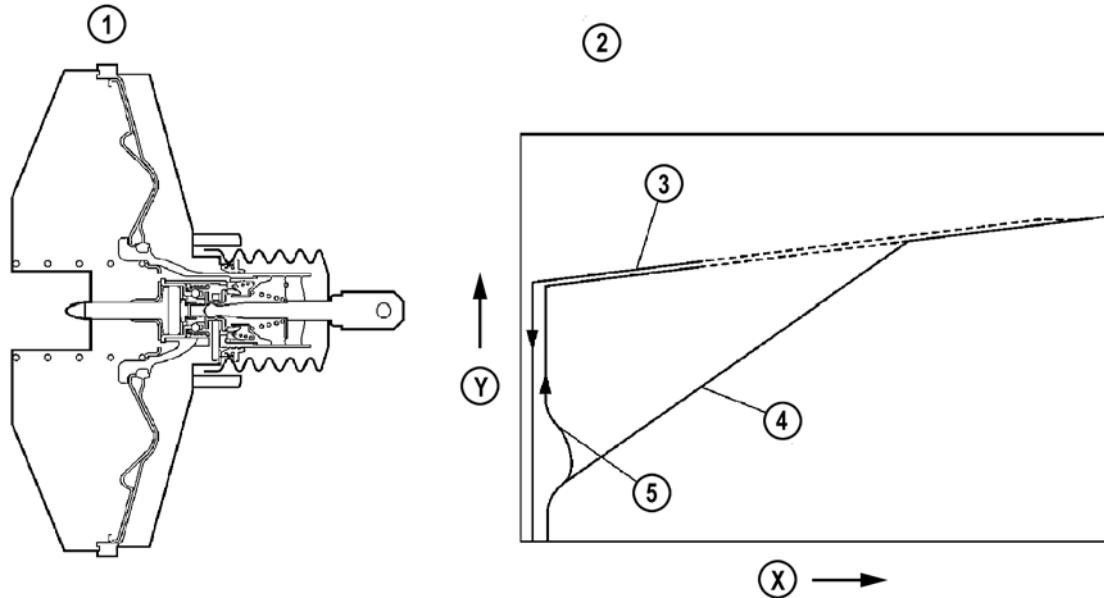
Electronic EBA

- The electronic EBA system is based on the DSC function, but applies brake pressure simultaneously for each wheel.
- It uses the built-in brake fluid pressure sensor to monitor the speed at which the brake fluid pressure increases when the brake pedal is pressed. If the brake pedal is pressed faster than a specified value, the brake fluid pressure increases very fast, and the DSC HU/CM consequently decides to initiate EBA operation.
- When the EBA operation is initiated, the DSC HU/CM increases the brake fluid pressure in the same way as it does for the TCS / DSC operation during pressure increase mode.

NOTE: The vehicle must be driven faster than approx. 17 km/h to initiate the electronic EBA. Once initiated, it is disabled when the vehicle speed is less than approx. 5 km/h or when the driver releases the brake pedal.

Mechanical EBA

- The mechanical EBA is a function incorporated into the brake booster. It detects mechanically how fast the brake pedal is pressed. If it is pressed faster than a specified value, the system uses the brake booster to apply full brake fluid pressure.



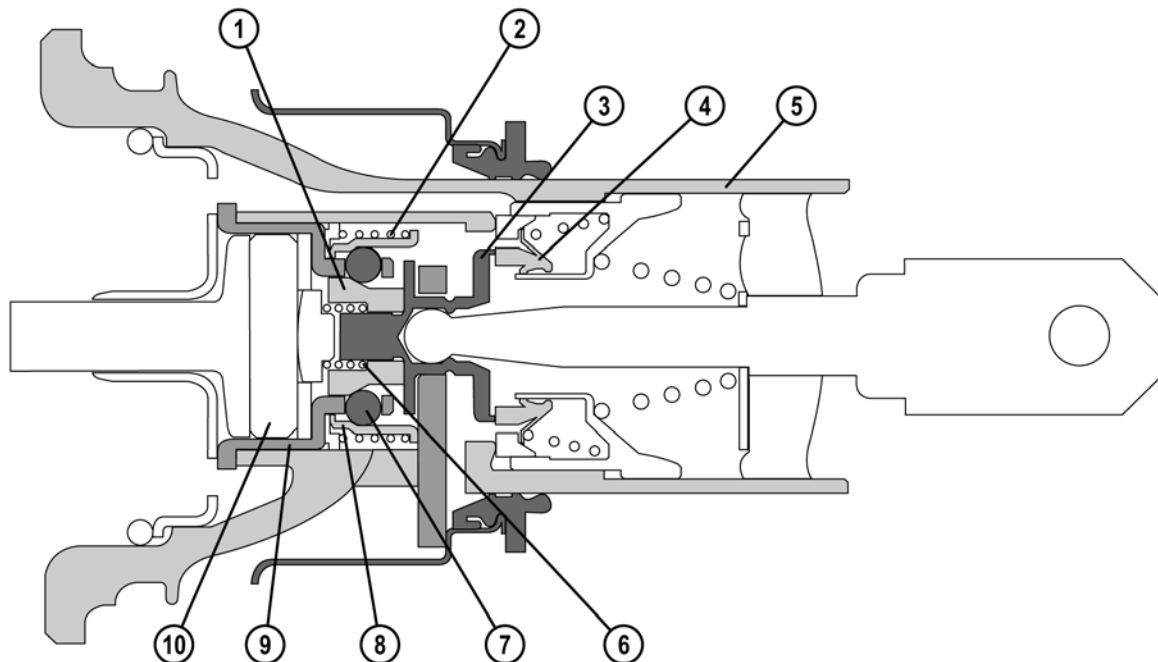
L2003_02042

- 1 Cross-sectional view
- 2 Output characteristics
- 3 During brake assist operation

- 4 During normal braking
- 5 Operation characteristics (varies according to pedal force)

Overview

- The basic construction of the brake booster with EBA is similar to a conventional type, except that the following parts have been added:
 - Balls
 - Ball cage
 - Ball sleeve
 - Lock sleeve
 - Spring
 - Centre spring



L2003_02043

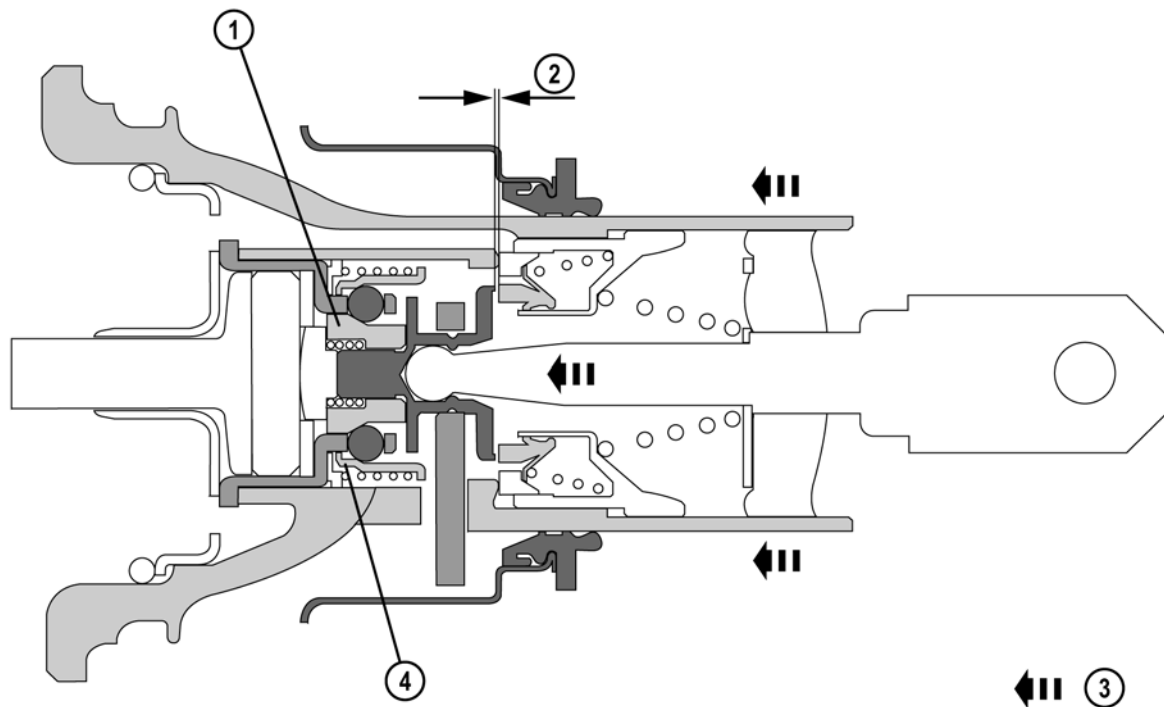
- | | | | |
|---|-----------------|----|----------------|
| 1 | Ball sleeve | 6 | Centre spring |
| 2 | Spring | 7 | Ball |
| 3 | Valve piston | 8 | Lock sleeve |
| 4 | Disc valve | 9 | Ball cage |
| 5 | Control housing | 10 | Rubber element |

Operation

- During normal braking situations, the brake booster with EBA operates in the same way as a conventional one. This means that the driver can always modulate the brake force applied to the wheels.
- If the activation threshold, defined by a pre-set characteristic curve, is exceeded during braking, the EBA operates. The determination of the activation threshold is based on pedal movement parameters. It is a result of how fast and how hard the brake pedal is pressed.
- The mechanical EBA uses the fact that, in a brake booster the valve piston moves ahead of the control housing when brake operation starts. Thus, there is a relative travel distance between the control housing and the valve piston. The value of this varies depending on the force applied to the brake pedal and on the pedal speed.
- The relative travel distance is small when the pedal moves slowly with low force applied to it, and it is larger when the pedal moves faster with higher force applied to it.

Normal Braking

- During normal braking, the movement of the pedal causes only a small relative travel distance, and the EBA does not operate. The lock sleeve is held in its rest position by the force applied by the spring, and the ball sleeve remains free to move axially.



L2003_02045

1 Ball sleeve

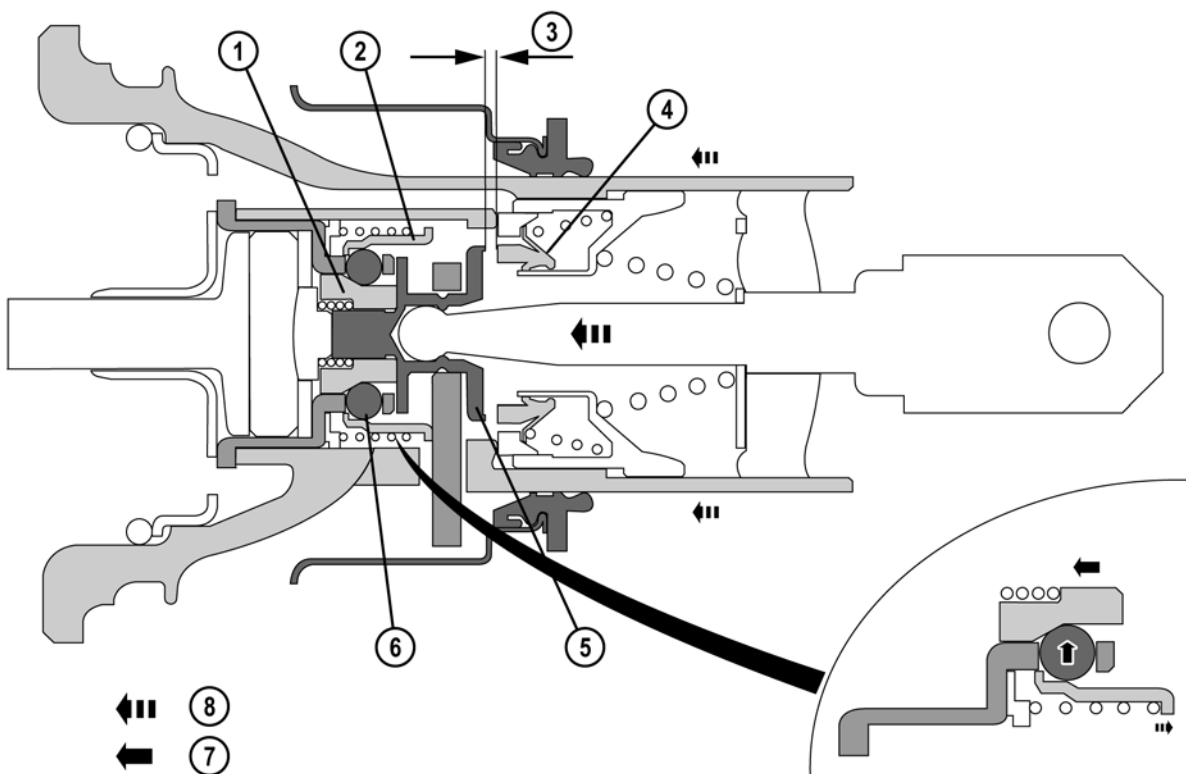
2 Relative travel distance

3 Speed of movement

4 Lock sleeve

Emergency Braking

- If the activation threshold is exceeded because of an emergency braking situation, i.e. the driver presses the brake pedal very fast causing a large relative travel distance, the balls move on the ball sleeve toward the valve piston, allowing the spring-loaded lock sleeve to move completely to its end position. Now, the balls are locked, and the ball sleeve can no longer be moved in the closing direction of the disc valve. Thus, the valve piston cannot close the disc valve.
- Consequently the EBA is active, the brake pressure is increased up to the wheel locking limit, and the brake pedal can be moved to its maximum pressure point without any effort. The brake pressure remains at the ABS control limit until the brake pedal is completely released again.



L2003_02046

- | | | | |
|---|--------------------------|---|-------------------|
| 1 | Ball sleeve | 5 | Valve piston |
| 2 | Spring | 6 | Ball |
| 3 | Relative travel distance | 7 | Locking movement |
| 4 | Disc valve | 8 | Speed of movement |

Dynamic Driving Safety Systems

List of Abbreviations

ABS	Antilock Brake System	PID	Parameter IDentification
CM	Control Module	TCS	Traction Control System
DTC	Diagnostic Trouble Code	WD	Wiring Diagram
DSC	Dynamic Stability Control	W/M	Workshop Manual
EBD	Electronic Brakeforce Distribution	2WD	2 Wheel Drive
EBA	Emergency Brake Assist	4WD	4 Wheel Drive
ECT	Engine Coolant Temperature		
GMR	Giant Magneto Resistor		
G	Gravity		
HU	Hydraulic Unit		
IC	Instrument Cluster		
M-MDS	Mazdas Modular Diagnostic System		
PCM	Powertrain Control Module		

Notes: