Wabco Trailer EBS

3 Introduction
   EBS on the Towing Vehicle

4 System Design

5 System Functions

6 Generating the Braking Index Valve

6 Integration of Sustained-Action Brake

7 Deceleration Control

8 Brake Force Distribution

8 Improved ABS and ASR Control

9 EBS on the Trailer

11 System Description

12 Redundancy Operation

13 Components of Trailer EBS

13 EBS Relay Emergency Valve

14 EBS Trailer Module

15 EBS Relay Valve

15 Axle Load Sensor

16 Operating of Trailer EBS

20 Safety Concept

21 Compatibility of Towing Vehicle and Trailer
Introduction

In order to meet the demands of the growing market in the transport trade, conventional braking systems for motor vehicles and trailers have continuously been enhanced. It is expected today that operation of modern commercial vehicles is safe, efficient, comfortable and ecologically compatible.

Milestones of a continuous further development of trailer braking systems have been the introduction of the EC braking system in 1973 and the development and the introduction of the anti-lock system for air-sprung commercial vehicles in 1981.

The introduction of the Electronic Braking System EBS is thus the next logical step in meeting this and other requirements. EBS allows the continuing best possible synchronization of the brake forces between the towing vehicle and its trailer.

Since the autumn of 1996, an electronically controlled braking system has been available as standard equipment in “ACTROS”, the new heavy-duty vehicle class from Mercedes-Benz. This EBS system has been jointly developed by WABCO and Daimler-Benz.

EBS not only considerably enhances both vehicle and thus road safety, especially by reducing the stopping distance and improving braking stability, but also represents a major improvement in terms of economy and driving comfort by means of:

- shorter response times and simultaneous response of wheel brakes in the whole of the tractor-trailer combination and thus a braking behaviour which is similar to that in passenger cars, regardless of the load carried.
- reduction of the number of individual components and their connecting elements (e.g. by eliminating the load-sensing valve, pressure ratio valves and pressure limiting valves on drawbar trailers).
- synchronization of brake lining wear on the individual vehicle axles.
- a considerable improvement in the compatibility between the towing vehicle and its trailer.
- easier installation of the braking system by the vehicle manufacturer.

A number of improvements are achieved even when using EBS on the motor vehicle only. A further enhancement of this progress can be achieved by also using EBS on trailers. By additionally fitting disk brakes which show less thermal fading than drum brakes, further improvements can be attained, especially for extended braking processes.

WABCO is planning to offer EBS also for trailers in early 1998, thereby making sure that fully electronic braking systems with future-oriented technology are also available for tractor-trailer combinations.

In the coming years, this will initially cause mixed operation of towing vehicles and trailers with electronic and conventional braking systems. For this reason, compatibility in the partial braking range and for rapid retardation must be ensured. This paper deals with this problem, its background, and its solutions.
**System Design**

The WABCO EBS shown in fig. 1 electronically controls the front axle, the rear axle, and trailer actuation. In addition to electronic braking pressure control, a pneumatic redundancy has been implemented for the front axle, the rear axle, and trailer actuation (secondary safety circuit).

The so-called EBS hybrid system consists of:

- a foot braking power generator which generates both electrical and pneumatic index value signals when the brake pedal is actuated;
- a proportional relay valve for actively controlling the braking pressure on the front axle and the ABS control valves for ABS control on the front axle in keeping with an advanced control logic (MIR logic);
- a compact axle modulator with an integrated electronics module on the rear axle for individual pressure control and for picking up and evaluating the sensor signals, wheel speeds and brake lining wear;
- a redundancy valve on the rear axle;
- an electro-pneumatic trailer control valve for improving the actuation of conventionally braked trailers, allowing the trailer’s actuating pressure to be increased, reduced or automatically commenced, e.g. for control cycles caused by driving dynamics, depending on the index value;
- a digital data interface for actuating new trailers which have EBS fitted. The interface is integrated in an extended ABS plug-in connection to ISO 7638 (additional CAN information via PINs 6 + 7);
EBS on the Towing Vehicle
System Functions

and a central module for overriding brake management functions, front axle and trailer actuating pressure control, picking up and evaluating the front axle sensor signals and an exchange of data with the axle modulator via the system data bus, and with other vehicle control systems via the vehicle bus.

In “ACTROS”, the air processing system consisting of the air dryer, unloader valve, multiple-circuit protection valve and several pressure limiting valves has been combined in one unit.

System Functions

This Electronic Braking System which has now gone into series production allows a number of braking functions which result in a reduction of operating costs and improved braking comfort. The ACTROS system contains some software functions developed by Daimler-Benz themselves. The system functions described below are in keeping with the general WABCO solution and have been comprised in the respective brake management for motor vehicles and trailers. The signal flow is being shown in fig. 2. Brake management consists of several software modules.
**Generating the Braking Index Value**

The electrical index value provided by the driver by pushing the pedal is initially converted into an index deceleration in the module for “feeling”. The index deceleration increases progressively with the amount of pedal travel. The parameters for the characteristic, also known as the “feeling curve”, can be set according to the manufacturer’s needs, or the type of vehicle operated.

**Integration of Sustained-Action Brake**

In the module for integrating the sustained-action brake, the brake force is distributed between the sustained-action and friction brakes. This distribution is achieved in such a way that the sustained-action brakes always take over a maximum of the desired brake force. This reduces wear on the friction brakes of the towing vehicle and the trailer. Whenever emergency braking is necessary, the full power of the friction brakes is then available. The integration of the sustained-action brake thus offers a maximum in safety, economy and comfort.

Regardless of the integrated sustained-action brake actuation, the driver still has the option, e.g. when driving the vehicle down a long gradient, to activate the sustained action brake via a hand lever or foot switch independently from the friction brake. The sustained-action brake can, for instance, consist of the engine brake, a throttle brake and/or retarder. Depending on the braking needs, they are switched on one after another or simultaneously, and are either variable infinitely or in steps.
Deceleration Control

In deceleration control it is assumed that by pushing the brake pedal the driver intends to slow down the vehicle in addition to the existing vehicle deceleration caused by uphill or downhill gradients and, for instance, rolling and air resistance. For this reason, the prevailing deceleration, or fundamental deceleration, is used as a basis. The actual deceleration is picked up by the wheel speed sensors. Depending on the difference between the index and actual deceleration values, an index value adjustment is made to compute the torque for the sustained-action brake and the service braking pressures. Irrespective of the vehicle load, deceleration control achieves an even relation between the position of the brake pedal and the vehicle’s deceleration. By means of additional measures, such as outputting the response pressures and the braking hysteresis, the driver is offered a much more direct response to any changes in the index values, i.e. improved “braking feeling”. Depending on the given index deceleration and the load carried, the braking pressures are computed individually for both the towing vehicle and its trailer, in the modules for the brake force distribution. The distribution of brake forces across the towing vehicle and its trailer is computed in the module for trailer actuation.
EBS on the Towing Vehicle System Design

Brake Force Distribution

Fig. 3 shows an example of the brake force distribution on a towing vehicle, both when it is laden and when it is unladen. What has been implemented is what is known as combined distribution of brake forces.

It permits a combination of optimized brake force distribution for the applicable adhesion at higher index deceleration values and optimized brake force distribution in terms of lining wear at lower index deceleration values. If wear sensors have also been fitted, as in ACTROS, their signals are evaluated by the EBS and converted for adaptive lining wear control. For this purpose, the braking pressure distribution can be defined for slower deceleration in such a way that the linings on the front and rear wheels can be changed at the same times. Deceleration optimized for the applicable adhesion values in the higher braking range results in the approximately simultaneous response of ABS control on all axles.

Improved ABS and ASR Control

The functions of both ABS and ASR have been integrated in EBS, and further enhancements have been achieved in terms of control performance and improved comfort by means of additional information on actuation of the brake, index value, axle load and braking pressure.
EBS on the Trailer

Fig. 4 and 5 each show EC air braking systems widely used in Europe today. On a semi-trailer, this braking system essentially consists of a relay emergency valve, a load-sensing valve and the ABS.

In the Vario-Compact System shown here, the ABS relay valves and the electronic control unit have been combined. Frequently, however, these components are fitted separately. On the drawbar trailer, another load-sensing valve, a third ABS relay valve, an adapter valve on the front axle and a pressure limiting valve on the rear axle are added to the components listed above. Although this EC braking system is now highly sophisticated, especially through the use of ABS, there is still room for the improvements listed below:
EBS on the Trailer

- Reduction of the variety/number of components and thus installation costs for the vehicle manufacturer.
- Dispensing with the required air valves and their adjustment by introducing electronic control and the simple setting of parameters this permits.
- By using pressure control circuits which operate with a high degree of precision, it is possible to almost completely eliminate the deviations in characteristics encountered today.
- The “electrical brake line” and electronic control can considerably improve the time response and thus contribute towards reducing the stopping distance and improving the stability of the tractor-trailer combination.
- Extending the diagnostic features for the whole of the braking system, including maintenance and repair instructions.
- Permitting more comprehensive testing after production with automatic recording of the test findings.

It was these possible improvements which provided the basis for the development of an electronically controlled EBS on the trailer.
System Description

Fig. 6 shows the standard EBS for a 3-axle semitrailer. It electronically controls lateral braking pressures. The system consists of a compact dual-circuit trailer modulator with a digital data interface to ISO 1199-2 to the EBS towing vehicle, an EBS relay emergency valve, an axle load sensor and ABS sensors. When used on drawbar trailers or semitrailers with a steering axle, a system is needed which includes an additional EBS relay valve on the steering axles, see fig. 7.

Trailers with the electronic braking system described must be compatible with both conventional towing vehicles and towing vehicles which use EBS, allowing pneumatic redundant braking in the event of EBS failure. This results in three possible types of operation:

**Operation with new towing vehicles with EBS and extended ISO 7638 plug-in connection with CAN interface.**

All EBS functions can be utilized. The trailer receives the index values from the towing vehicle via the data interface.
Components of Trailer EBS

**Operation with conventional towing vehicles with ISO 7638 plug-in connection for the trailer’s ABS supply but with no CAN interface.**

All EBS functions can be utilized, with the exception of the transmission of the index values via the CAN data interface. The index values are provided by the pressure sensor in the relay emergency valve which picks up the actuating pressure for the trailer.

**Redundancy Operation**

In the event of a failure of the electrical voltage supply, ordinary pneumatic braking can always be achieved, although with no load sensing or ABS functions.

In redundancy operation, the time response is similar to that of today’s conventional braking systems. If the EBS trailer is operated pneumatically, an improved time response is achieved since electrical sensing of the actuating pressure saves time. When used with an EBS towing vehicle and actuation via CAN, the pressure in the EBS trailer builds up almost simultaneously with that in the towing vehicle.

**Components of Trailer EBS**

As explained under System Description, the EBS relay emergency valve, the compact dual-circuit EBS trailer modulator which forms the heart of the system, the EBS relay valve which may be required, and the axle load sensor are the key components of trailer EBS.

![Diagram of EBS for drawbar trailers 4S/3M](image)

**Fig. 7:** EBS for drawbar trailers 4S/3M

![Graph showing brake pressure vs. time](image)

**Fig. 8**
Components of Trailer EBS

EBS Relay Emergency Valve
(Fig. 9)

Since trailers with EBS can also be used with towing vehicles that have a conventional braking system, the conventional functions of the relay emergency valve, such as the breakaway function and the check valve, continue to be required. Only the adjustable advance is dispensible since this is achieved electronically. In addition, a pressure sensor (1) for providing the braking power from the actuating pressure and a pressure switch (2) for monitoring the pressure sensor, have been integrated.
Components of Trailer EBS

The pressure switch is fitted at the inlet of the brake valve, the pressure sensor at its outlet. Due to this arrangement, automatic braking is detected behind a towing vehicle with EBS in the event of the supply line breaking. This information may prevent automatic braking of the trailer which would normally ensue, provided, however, that the supply pressure is sufficiently high. In this case, the driver is alerted by the warning lamp, thereby further enhancing safety.

EBS Trailer Module (Fig. 10)

The EBS trailer module is designed for two channels and, in the case of a semi-trailer, controls the brake cylinder pressure for each side. For this reason it has two independent pneumatic pressure control channels consisting of two relay valves (1) controlled by solenoid valves (2, 3), the electronic control unit (ECU) (4) and two braking pressure sensors (5). The redundancy valve (6) and a sensor (7) for monitoring the supply pressure have also been integrated. The trailer modulator communicates with towing vehicles with EBS via a trailer interface to ISO 11992 standard. Fig. 10 shows the valve position on the right as it is being pressurized, and on the left as it is vented during EBS operation. The proven technology of connecting all electrical wiring from the outside via plugs has been adopted from the Vario-Compact System (VCS), so that the ECU does not have to be opened.
Components of Trailer EBS

The trailer module provides connections for:

- a voltage supply to ISO 7638 including CAN
- EBS relay emergency valve
- EBS relay valve
- diagnostics
- speed sensors
- axle load sensor
- separate electronic levelling control.

**EBS Relay Valve**

If a 4S/3M system is installed, i.e. in drawbar trailers or semitrailers with a steering axle, an EBS relay valve is required in addition to the two modulators integrated in the EBS trailer modulator. This valve consists of a relay valve with two solenoid valves (inlet and outlet valves), a redundancy valve and a braking pressure sensor. It has no ECU of its own but is actuated and monitored by the trailer modulator. Up to four brake cylinders can be connected to this relay valve.

**Axle Load Sensor**

The axle load sensor picks up the pressure of the air suspension. This is a pressure sensor which, on air-sprung vehicles, picks up the bellows pressure. This information, together with the specific vehicle parameters, is used to compute the actual load carried.
Operation of Trailer EBS

The software of trailer EBS consists of different partial functions. As shown in Fig. 11, the EBS is actuated either via the CAN trailer interface if used with EBS towing vehicles that have a 7-pin EBS socket, or via the air pilot line if used with conventional towing vehicles with a 5-pin socket. The index value module selects the applicable value from the two available index values, the more rapid CAN index value of course having priority. If, however, the handbrake, for example, is actuated, this working on the conventional pneumatic basis, this braking requirement has to be met first. Trailer EBS comprises load-sensitive brake control, with differences having to be taken account between semitrailers, or central axle trailers, and drawbar trailers. The actual load carried is determined by sensors picking up the bellows pressure. In semitrailers, a static beam valve is used, similar to today’s configuration (fig. 12).

The transmitting function hose coupling pressure/braking pressure is divided into two ranges:

- contact range
- stability range

In this example, the brake cylinder pressure in the contact range rises from between $p_m = 0$ bar and $p_m = 0.6$ bar from 0 to 0.4 bar. At $p_m = 0.7$ bar the response pressure of the wheel brake has been reached, thereby allowing the vehicle to begin building up brake power. This point, i.e. the response pressure for the whole of the trailer's braking system, can be set via a parameter. On a laden vehicle, the braking pressure then follows the straight line running through the computed value at $p_m = 6.5$ bar. When the vehicle is empty, the response pressure is also output at $p_m = 0.7$ bar, and the braking pressure is then reduced according to the load car-
Operation of Trailer EBS

In the partial braking range, the pressures are output to optimize wear. On drawbar trailers with, for instance, type 24 brake chambers on the front axle and type 20 brake chambers on the rear axle, pressure is reduced slightly on the front axle, in keeping with the design, and increased slightly on the rear axle. This, compared with the current adapter valve, achieves more accurate distribution of forces across all wheel brakes. Within the stability range, the pressures are output in keeping with even utilization of adhesion, as a function of the axle load.

Irrespective of whether the vehicle is laden or not, the EC “laden” band is being complied with.

On drawbar trailers, the brake force distribution achieved by means of software (fig. 13) renders the commonly used load-sensing valves, the adapter valve on the front axle and the pressure limiting valve on the rear axle, obsolete.

Here the transmission function is divided into three ranges:

- contact range
- wearing range
- stability range

In the partial braking range, the pressures are output to optimize wear. On drawbar trailers with, for instance, type 24 brake chambers on the front axle and type 20 brake chambers on the rear axle, pressure is reduced slightly on the front axle, in keeping with the design, and increased slightly on the rear axle. This, compared with the current adapter valve, achieves more accurate distribution of forces across all wheel brakes. Within the stability range, the pressures are output in keeping with even utilization of adhesion, as a function of the axle load.
Operation of Trailer EBS

In the **unloader valve** the index values provided by the brake force distribution module are converted into energizing of the solenoid valves. The output braking pressures are picked up by braking pressure sensors and passed back to the ECU where they are compared with the index values and adjusted in the event of any divergence.

The **configuration of the ABS** has been taken from the time-tested Vario-Compact System, i.e. 2S/2M, 4S/2M and 4S/3M. Since the cutoff pressures are now available through the use of the integrated braking pressure sensors when ABS is used, this information can be used to further improve the control process. Thus it is possible, for instance, after ABS venting, to much more quickly and specifically input pressure to a level slightly below the preceding cutoff pressure, thereby optimizing utilization of adhesion.

The electronically controlled braking system is based on a conventional pneumatic braking system, the so-called pneumatic **redundancy**. If, for instance, the connection to ISO 7638 with the towing vehicle has not been plugged in or interrupted, or if the electrical brake has failed altogether, the vehicle can still be braked, albeit purely pneumatically. Thus it is always possible to brake a trailer, although without load-sensitive braking, and without ABS.
One essential benefit of the electronic braking system for trailers is that the loadsensing valve, available in a wide range of variants and mechanical settings, has become dispensable. Instead, load-sensitive braking is achieved by setting the parameters accordingly in the ECU. All of the load-sensing valve’s (valves’) functions, such as outputting the secured unladen braking pressure should the bellows rupture, are safeguarded by the ECU. WABCO’s well-known brake computation programme has been extended by the calculation of the EBS parameters. This programme provides the required parameters on hardcopy, or as a file. For testing after production, and for the purpose of diagnosis, WABCO’s diagnostic controller and PC diagnosis under Windows are available, offering different options to the vehicle manufacturers for setting the parameters on the ECU.

Major vehicle manufacturers will provide the required parameters in their own company network when an order is processed and the brakes are calculated, allowing the record to be transferred to the ECU from the network as the vehicle leaves the production line. Smaller manufacturers have that calculation done by WABCO and receive their documents by fax or E-mail. The parameters are then set by means of the PC, or the Diagnostic Controller.
Operation of Trailer EBS

Safety Concept

The additional system of sensors and the intelligence of the system permit a large number of monitoring functions and plausibility tests beyond the scope of today’s ABS safety functions. In the event of any defects being encountered, only the system function affected will be selectively switched off, thereby ensuring availability of the greatest possible part of the system.

For use with EBS towing vehicles, for instance, the system will perceive whenever a pneumatic pilot line has not been connected or has parted, and alert the driver.
Compatibility of Towing Vehicle and Trailer

For reasons of safety and economy, the brake forces of the towing vehicle and its trailer have to be synchronized at all times. A tractor-trailer combination is considered well-synchronized if any differences between the motor vehicle’s and the trailer’s delay times and response pressure behaviours are kept to an absolute minimum, and if the brake forces are distributed according to the load carried. The brake force distribution is ideal when the dynamic retardation of the respective axles in a tractor-trailer combination is identical, i.e. each of the combination’s axles decelerates its own share of dynamic masses according to the level of braking provided by the driver. Fig. 14 shows such ideal distribution of brake forces.

As shown in the above illustration, the ratio of brake force and axle load, or the braking angle \( \alpha \), is identical on all axles. In such a situation, ideal composite forces are achieved for the towing vehicle and its trailer. On articulated combinations, the drawbar force \( F_D = 0 \), and on semi-trailer trains the ratio of horizontal versus vertical forces on the kingpin equals the braking angle \( \alpha \). To ensure adequate synchronization of the brake forces of the towing vehicle and its trailer, the applicable legislation for braking systems, ECE R13 and RREG 71/320 of the same wording, require minimum pressure build-up times at the hose coupling and an allocation of the braking ratio \( z \) to the pressure at the hose coupling \( p_m \).
Compatibility of Towing Vehicle and Trailer

Although new vehicles with ABS have to comply with the compatibility band only when fully laden, vehicle manufacturers are trying to achieve a high degree of compatibility for any load carried by continuing to use load-sensing valves. To the extent that this is technically feasible, a position around the middle of the band is desirable. If combinations change frequently, this achieves a satisfactory average wear pattern for all vehicles involved. In addition, well-balanced braking behaviour in rapid retardation is achieved for the vehicle combination. In actual operation, however, complaints are often heard about unsatisfactory compatibility of the tractor-trailer combination. This manifests itself mainly in major differences in brake lining wear. For the wear pattern of the combination, it is the retardation of each part of the combination at low pressures which is important, i.e. within the range of $p_m = 0.2 \ldots 1.5$ bar. It is this range to which most braking processes are attributable. Fig. 15 shows a towing vehicle with a response pressure of 0.5 bar and a trailer with a response pressure of 0.8 bar. Both vehicles achieve the same deceleration at the computation pressure. In the partial braking range at $p_m = 1.2$ bar, however, the difference in response pressures causes 50% underbraking of the trailer compared with its towing vehicle. Fig. 16 shows two vehicles whose brakes have identical response pressures but with major differences in their design. At $p_m = 6.5$ bar, the towing vehicle shows a deceleration of 0.63, the trailer of 0.50.

The difference in brake forces within the partial braking range at $p_m = 1.2$ bar is only 23%. 

Fig. 15: Example for the Position of Vehicles within the Compatibility Band
The worst case would prevail if the trailer also had a high response pressure. This example shows that wear problems are not so much caused by different gradients in the individual vehicles’ characteristics within the compatibility band, but mainly by excessive differences in response pressures.

Additional problems may be caused by the towing vehicle and its trailer having had different types of brakes fitted. More and more towing vehicles have disk brakes, whilst most trailers still have drum brakes. Since disk brakes show less thermal fading than drum brakes, their brake force falls less rapidly at high temperatures. Extended application of the brakes will then cause the braking energy to be increasingly transferred from the trailer with its drum brakes to the motor vehicle with its disk brakes.

For this reason, one major objective of EBS development was to achieve a higher degree of synchronization for tractor-trailer combinations, i.e. to improve their compatibility.
Compatibility of Towing Vehicle and Trailer

This is achieved by the following three measures:

- The basic design of trailers with WABCO EBS is located around the middle of the band, similar to trailers without EBS. The starting point within the EC band, i.e., the response pressure, is defined at 0.7 bar.

- The basic design of EBS towing vehicles for the whole of the braking range lies in the middle of the band for the laden vehicle (fig. 17). The deceleration control described in Section 2 allows the allocation of vehicle retardation to the hose coupling pressure in driving operation to be continuously synchronized. In ACTROS, synchronization of the tractor-trailer combination is achieved by band position control.

- The response pressure recognition developed by WABCO results in automatic perception of any differences between the response pressures of the towing vehicle and its trailer, and any difference is added to the hose coupling pressure $p_m$ to provide an advance pressure, as shown in fig. 18. The operating range lies within the ECE band limits, i.e., between 0.2 and 1.0 bar. Once the response pressure has been perceived, all wheel brakes of the vehicle combination make contact simultaneously when the brakes are first applied. The advance function of the conventional trailer control valve is thus replaced by an electrical advance function which is adjusted automatically when the towing vehicle has a different trailer attached.

The combination of these measures, identical response pressure and middle
Compatibility of Towing Vehicle and Trailer

Fig. 18: Adjusting the Band Position by Response Pressure Recognition

band position, causes the retardation characteristics of the individual parts of a vehicle combination to be almost identical within the range of lower brake pressures, thereby achieving the most even lining wear possible on both vehicles within a tractor-trailer combination. In addition, total wear is reduced since the mean temperature level of the wheel brakes is reduced by optimizing brake force distribution. The improvement in compatibility through EBS is also achieved by means of a dynamic change of the band position, including the adaptation of the response pressure during the braking process, although the basic design of the individual parts of the tractor-trailer combination still has to lie within the compatibility band. For reasons of compatibility, the new EBS regulations allow a dynamic change of the towing vehicle’s band position only, i.e., the position of the trailer within the compatibility band must not be subject to any dynamic change during the braking process.

The change in the band position on the towing vehicle can be achieved by controlling the brake cylinder pressures and/or the hose coupling pressure.
Compatibility of Towing Vehicle and Trailer

The information given on the hose coupling pressure also applies to electrical index values for the trailer. The easiest way to synchronize the brake forces of a towing vehicle and its trailer would be to increase or decrease the braking pressure of the towing vehicle’s axles as a ratio of the hose coupling pressure whilst maintaining trailer control through the conventional trailer control valve. This would, however, result in the whole of the tractor-trailer combination taking its bearings from the part with the poorest time response and braking behaviour.

For this reason, a more effective solution is provided by an electro-pneumatic circuit within the trailer control valve which allows the hose coupling pressure to be increased or decreased as a ratio of the trailer’s braking performance. The WABCO system permits the unaltered basic design of the towing vehicle to be conventionally examined by picking up the pressure while the vehicle is stationary and its ignition is switched off. When the brakes are actuated, the ignition still being off, EBS is actuated via the switch integrated in the brake force emitter, and the unaltered identification can be determined. If, however, the ignition stays on when a vehicle has been stopped, the adapted identification can be used.

New towing vehicles, such as ACTROS with EBS, usually provide greater brake forces than conventional vehicles. This is not achieved, however, by a steeper characteristic in the EC band but by an increase in the permanently available supply pressure through the introduction of constant pressure systems. Thus the characteristic is extended beyond a computation pressure of 6.5 bar to 8.5 bar. All trailers used with these new towing vehicles, even those of an earlier production date, also produce greater brake forces
Compatibility of Towing Vehicle and Trailer

<table>
<thead>
<tr>
<th>Braking Situation</th>
<th>Towing Vehicle</th>
<th>Trailer</th>
<th>EBS</th>
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<tbody>
<tr>
<td></td>
<td>conventional</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>partial braking range</td>
<td>frequently different response pressures</td>
<td>improved adaptation to towing vehicle by setting parameters</td>
<td></td>
</tr>
<tr>
<td>stability range</td>
<td>deferred response of trailer brake</td>
<td>improved response of trailer brake</td>
<td></td>
</tr>
<tr>
<td>max breaking ratio z</td>
<td>towing vehicle and trailer approx. 0.55 ... 0.6</td>
<td>towing vehicle and trailer approx. 0.55 ... 0.6</td>
<td></td>
</tr>
<tr>
<td>supply 3rd circuit 6.5 bar</td>
<td>EBS</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>partial braking range</td>
<td>adaptation through towing vehicle EBS</td>
<td>best possible synchronization</td>
<td></td>
</tr>
<tr>
<td>stability range</td>
<td>improved response of trailer brake</td>
<td>best possible synchronization</td>
<td></td>
</tr>
<tr>
<td>max breaking ratio z</td>
<td>towing vehicle and trailer approx. 0.7 ... 0.75</td>
<td>towing vehicle and trailer approx. 0.7 ... 0.75</td>
<td></td>
</tr>
<tr>
<td>supply 3rd circuit 8.5 bar constant pressure</td>
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</table>

since they receive a constant pressure of 8.5 bar, and at full brake application they provide approx. 8 bar.

For this reason, the basic design of a trailer braking system of \( z = 0.55 \ldots 0.6 \) at \( p_m = 6.5 \) bar as commonly used today should be maintained. In principle, when designing the brakes it also makes no difference whether the trailer has drum or disk brakes.

The table above once again shows the potential problems with possible vehicle combinations.

If you would like to know more about WABCO’s Trailer EBS, if you have any questions or would like some personal advice, please contact WABCO’s field staff, one of our Service Centers or our Trailer Product Team.
WABCO is an international group of companies and co-operation partners located in Austria, Belgium, Brazil, China, Czech Republic, France, Germany, Great Britain, Hungary, India, Italy, Japan, Korea, Poland, Russia, South Africa, Spain, Sweden, Switzerland, The Netherlands, USA and other countries.

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