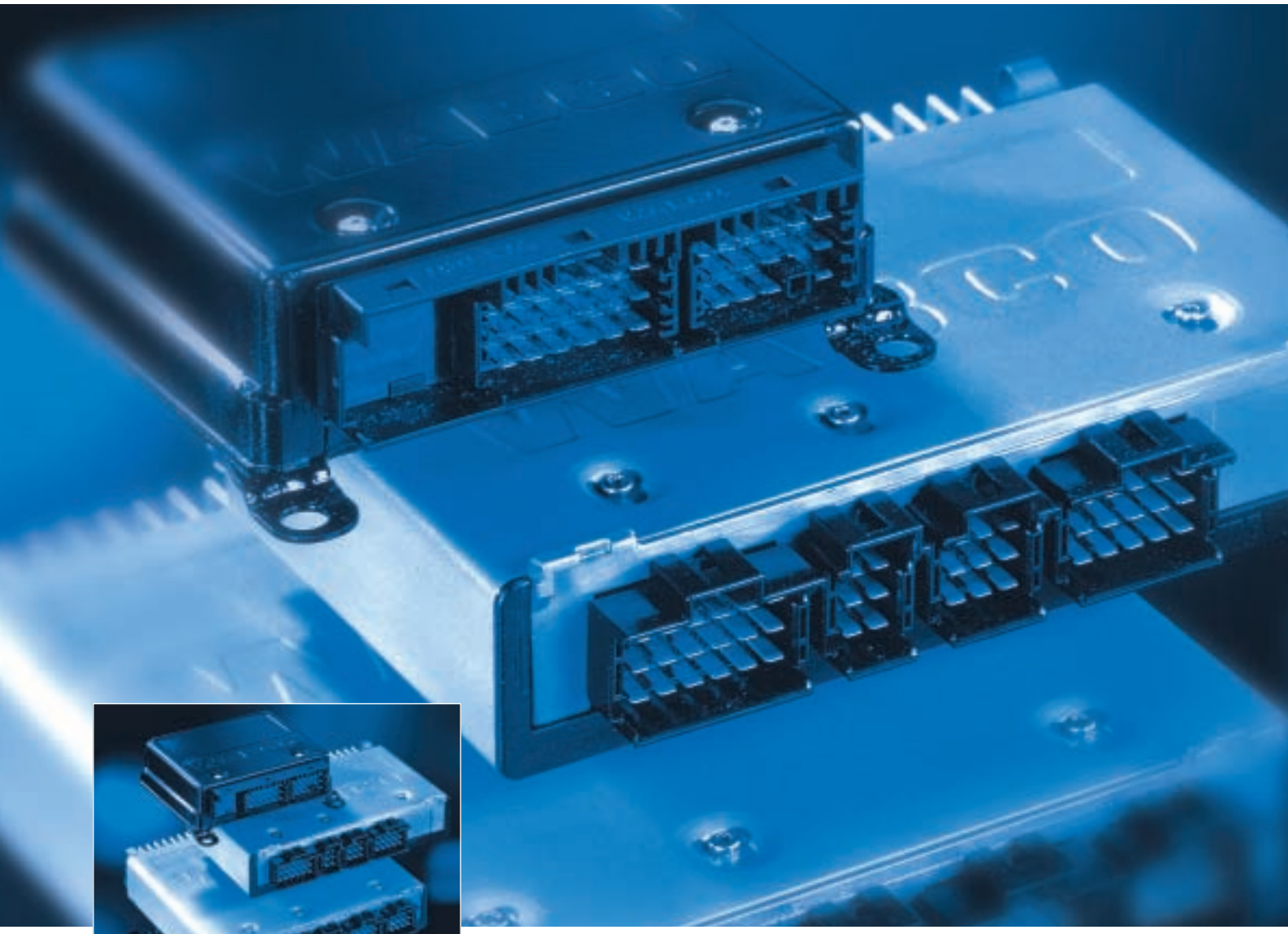
TRUCK ABS/EBS

Electronically Controlled Braking System



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WABCO Truck ABS/EBS

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Introduction

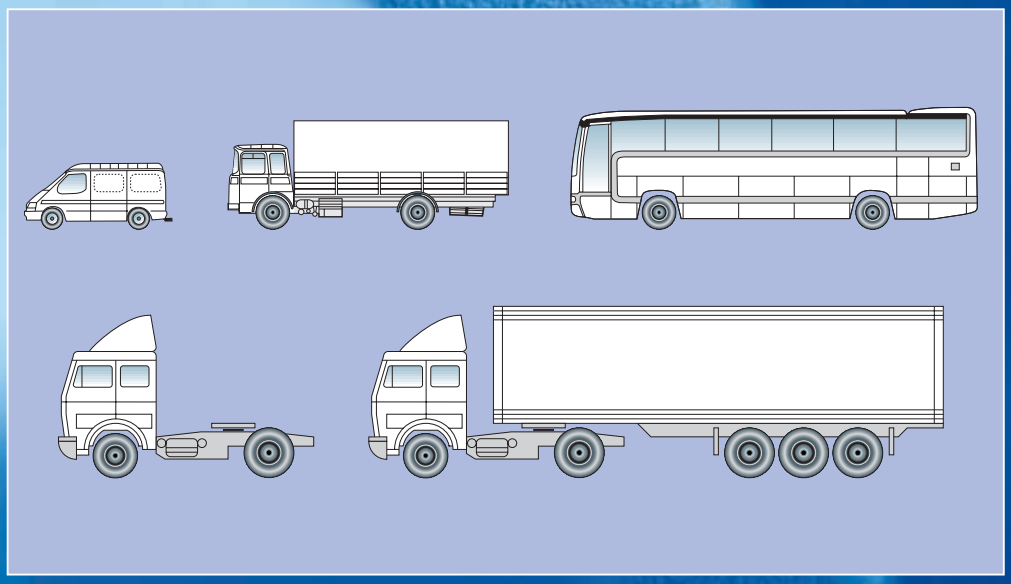

Figure 1

Over the past few years, virtually no other aspect of commercial vehicle technology has changed as much as the brakes.

In this area of technology, the designer has to take into consideration a wide range of vehicles – from vans through light-duty trucks to heavy-duty trucks with trailers, or semitrailers and buses – in which various braking systems are used. Furthermore, different usage demands are to be satisfied. And last but not least, there are various possible service brake designs. Other systems and functions will also be added over the next few years.

Viewed historically, the past few decades have seen a vast number of major developments and changes. The introduction of the dual circuit compressed air brake in the 1960s or the launch of the automatically load-dependent braking power governor in the 1970s are just two of many examples.

We are now experiencing the 1980s and 1990s as the decades of electronic vehicle feedback control systems which also made their mark on vehicle braking systems. The anti-lock system (ABS) was the first system of this kind and was launched into volume production in commercial vehicles back in 1981. European legislation recognized the tremendous improvement in safety standards achieved by the ABS system, making ABS a mandatory requirement for certain vehicle types.

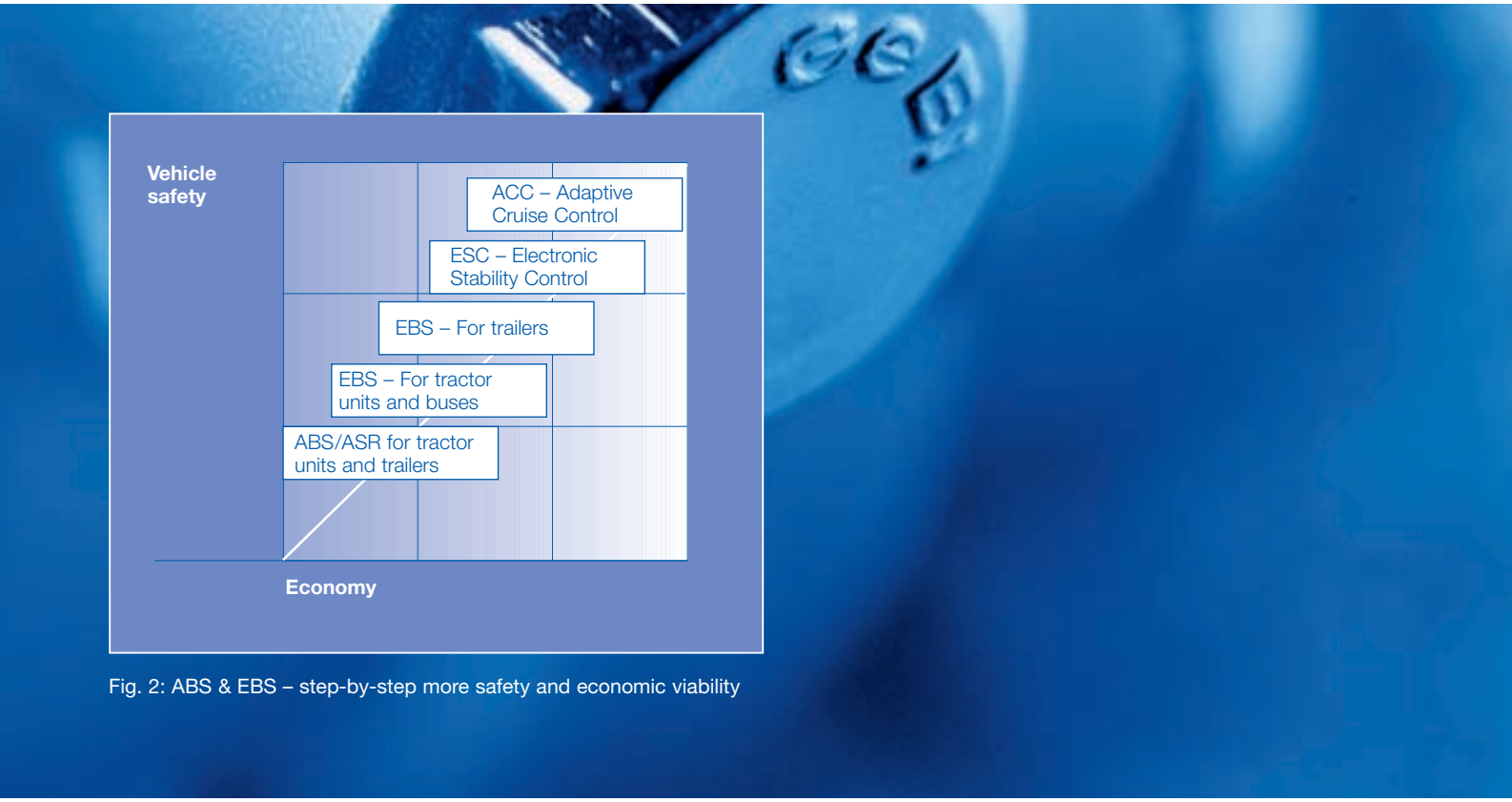

Fig. 2: ABS & EBS – step-by-step more safety and economic viability

In 1987, ABS was then extended to include anti-slip control (ASR) whereby traction was improved significantly by means of brake intervention.

The increasing pressure of competition in the transport trade also increased the requirements placed on the braking system.

This was followed by the introduction of the electronically controlled braking system (EBS) in 1996. This step represented a considerable increase in safety levels and a notable increase in vehicle economic viability.

Attempts to improve the rollover resistance of commercial vehicles have been achieved through extending the functions of ABS and EBS. Dynamic Drive Control combined with EBS delivers yet another increase in vehicle safety.

The aim of this brochure is to provide an overview of the function and structure of the various ABS and EBS systems as well as of new parts and amendments to legislation.

The ABS regulations situation

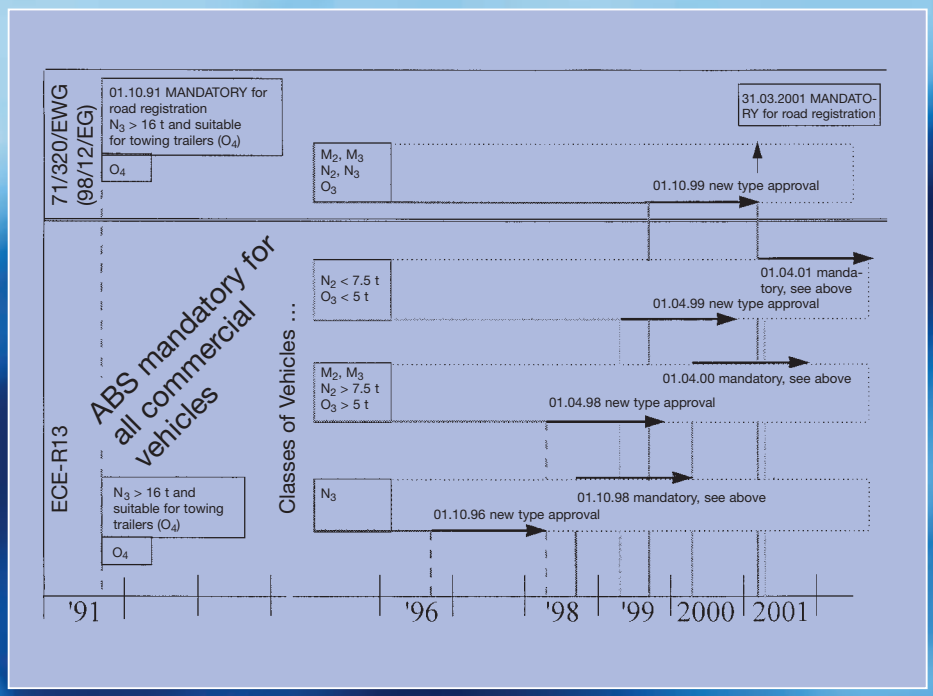

Figure 3

Standard specifications apply to all vehicles used within Europe. The regulations for braking systems incl. ABS can be found in ECE-R13 and Council Directive 71/320/EEC.

The ECE rulings are accepted throughout Europe and exist in parallel to the EU Directives. For various reasons, different dates for introducing the EC and ECE regulations have however been established so that different usage dates were required for ABS (refer to Figure 3).

Heavy commercial vehicles > 16 t (categories N3, …) should be fitted with ABS as standard as of October 1991. Following the latest round of specialist advice, ABS had been phased in progressively as a mandatory requirement for all other vehicles by 31.03.2001, whereby vans and light-duty buses in excess of 5 t will also belong to the ABS club.

ABS control unit family

Figure 4

The WABCO ABS/ASR modular system

Modified vehicle concepts, the desire for greater optimisation of functionality and ongoing reductions in system costs have resulted in the development of the ABS/ASR E generation. This describes a whole system family. WABCO provides vehicle manufacturers with different control unit installation options ranging from driver's cab to frame mounted, depending on the vehicle concept.

All versions of the modular system also satisfy the most stringent of statutory requirements and at the same time provide the manufacturer with the options of e.g. selecting between a pure ABS application right up to the greatest ABS/ASR scope of function.

Basic version ABS from 4S/3M to 4S/4M

In order to satisfy extreme cost requirements even in the light-duty vehicle ranges, WABCO has defined a basic ABS version. This satisfies all statutory ABS requirements and is designed for 4S/3M and 4S/4M applications (in special instances, also available as 4S/2M). The E generation is also available with ASR and EBL (Electronic Brake Limiter).

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ABS control unit family

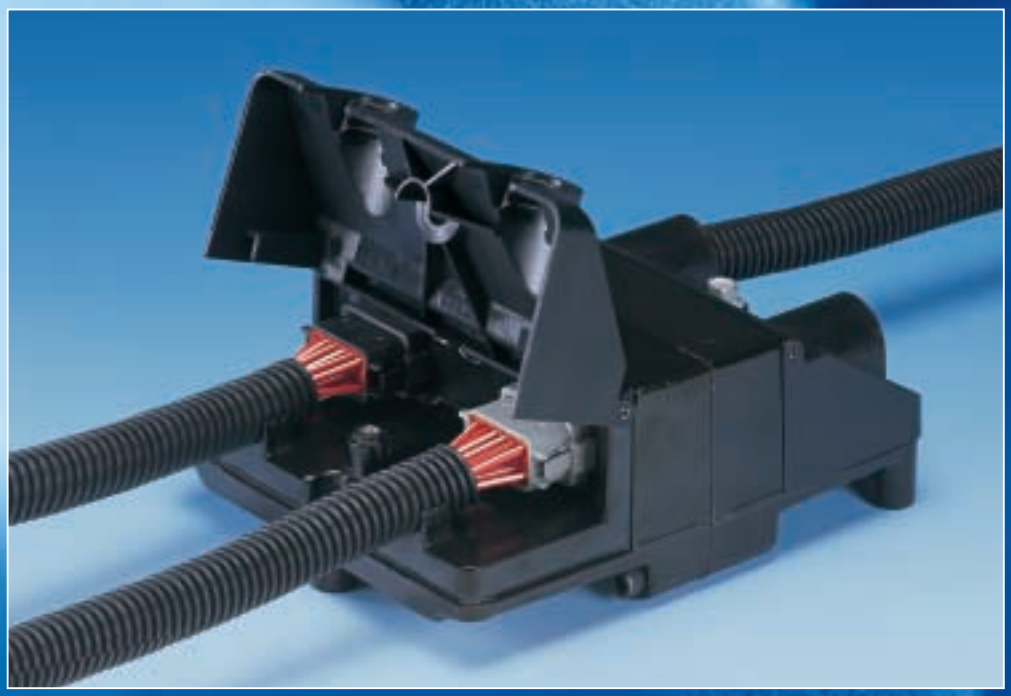

Figure 5

ABS/ASR

The traditionally familiar ABS/ASR control unit version is fitted in the driver's cab. These various ABS versions are available in a flexible modular system:

- From 4S/3M to 6S/6M
- With and without ASR
- For 12 V or 24 V voltage supply
- CAN bus in accordance with SAE J 1939
- Trailer interface in accordance with SAE J 2497 PLC 4 Truck
- RSC
- Diagnosis interfaces in accordance with SAE J 1587, ISO 9141, KWP 2000
- Diagnosis via flashing code

Frame assembly

Some driver's cab concepts – especially in US vehicles – prefer fitting the ABS/ASR control unit on the frame. In these instances, WABCO provides a special housing suitable for this purpose. At present, this family is only designed for 12 V applications.

EBS in tests

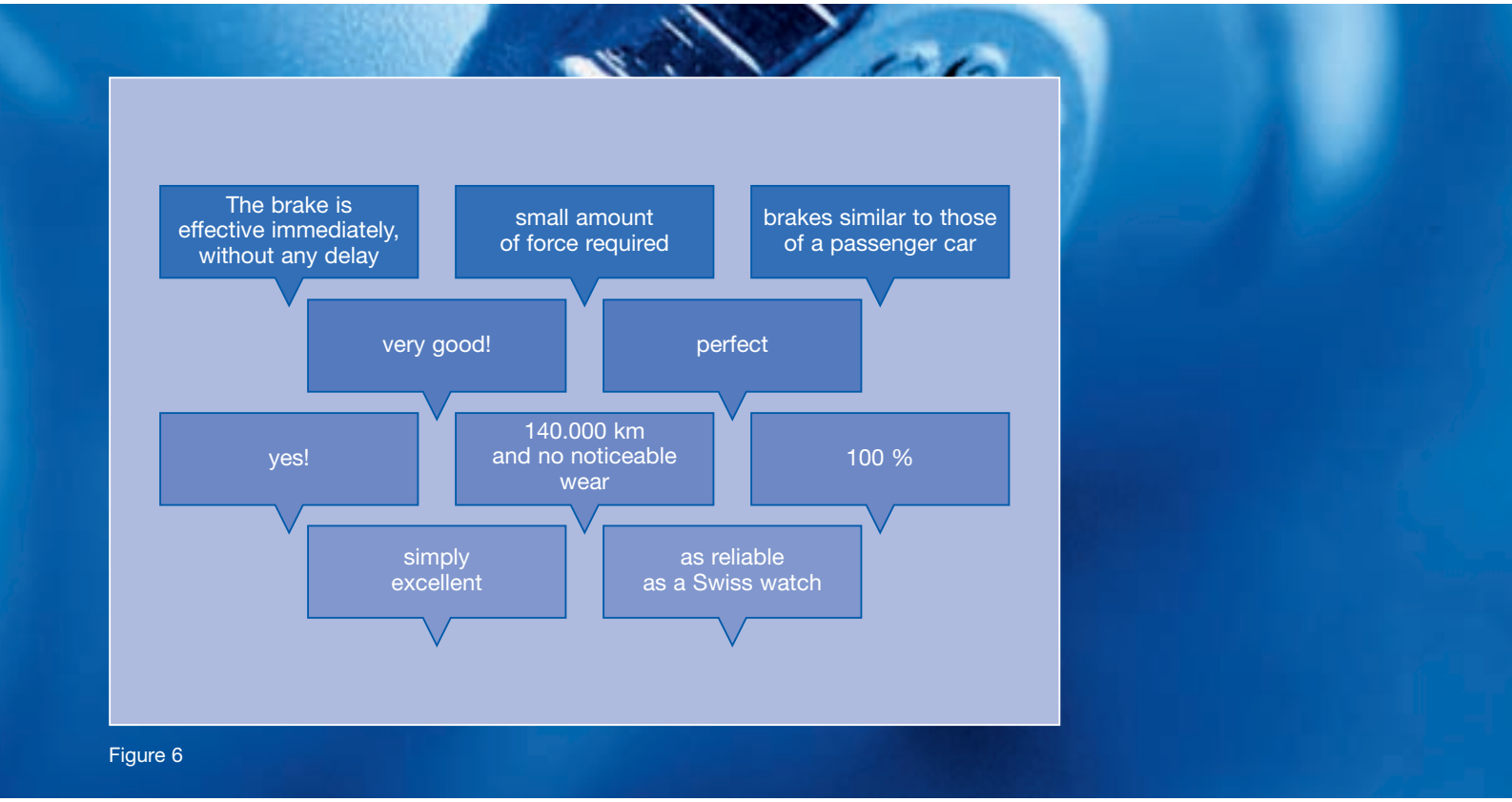

Figure 6

EBS has been used in volume production runs since 1996.

It is important for us to know what our customers say about our products. Is there anything they would like us to improve?

- How do you find the braking feeling in comparison with a conventional braking system?
- Can you feel the shorter braking distance of the EBS?
- What have been your experiences with regard to brake lining wear?
- How does the EBS behave in terms of actuation and pedal feel?
- The conventionally braked trailer is also controlled by the EBS. How does this affect tractor trailer balance?
- How resistant to failure have you found the EBS system to be?

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EBS – cost-effective, safe and innovative

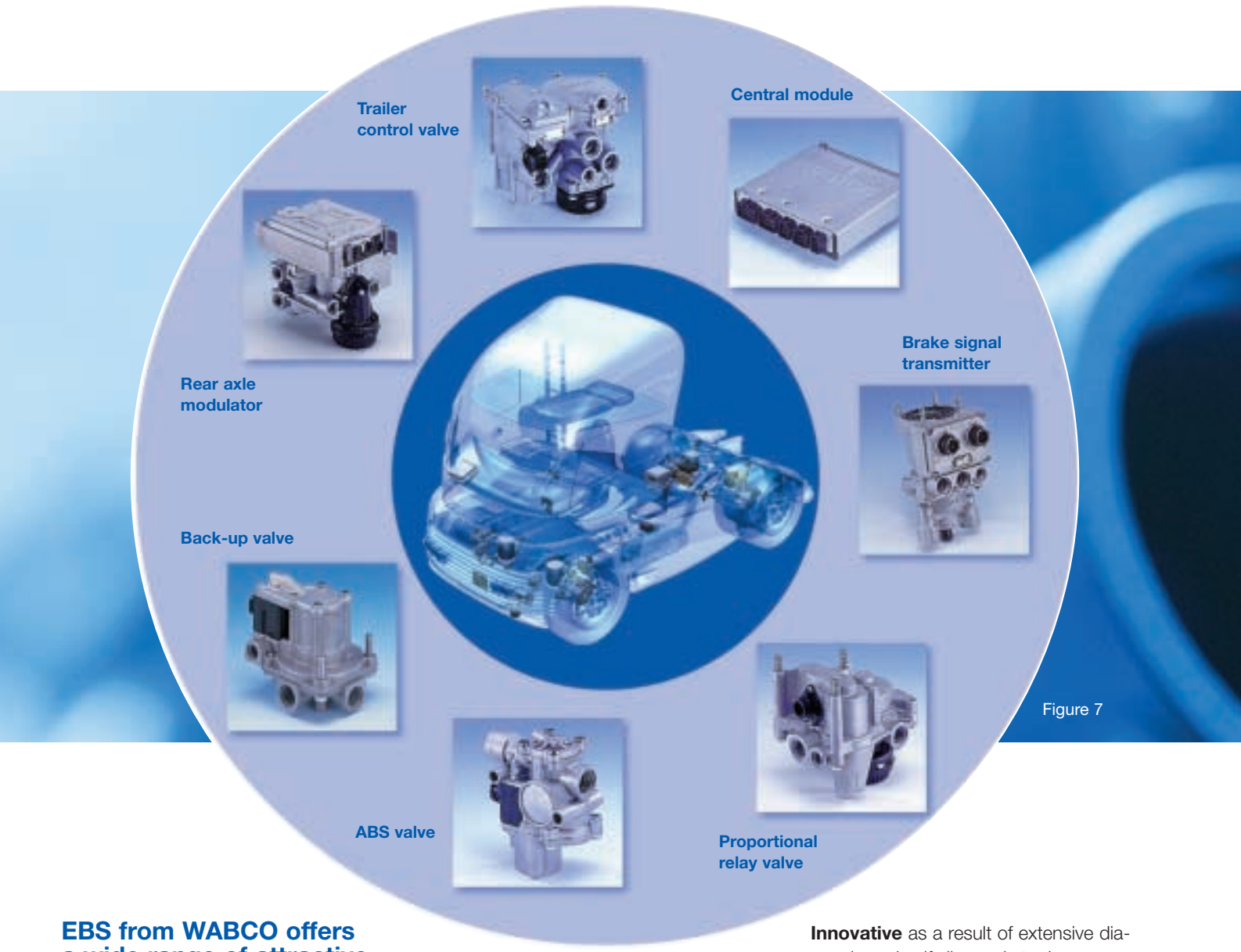


Figure 7

EBS from WABCO offers a wide range of attractive benefits

Cost-effective for the manufacturer through the use of standard components and simple assembly.

Cost-effective for the operator through the minimized and even spread of wear on the front and rear axles and through good tractor-trailer balance.

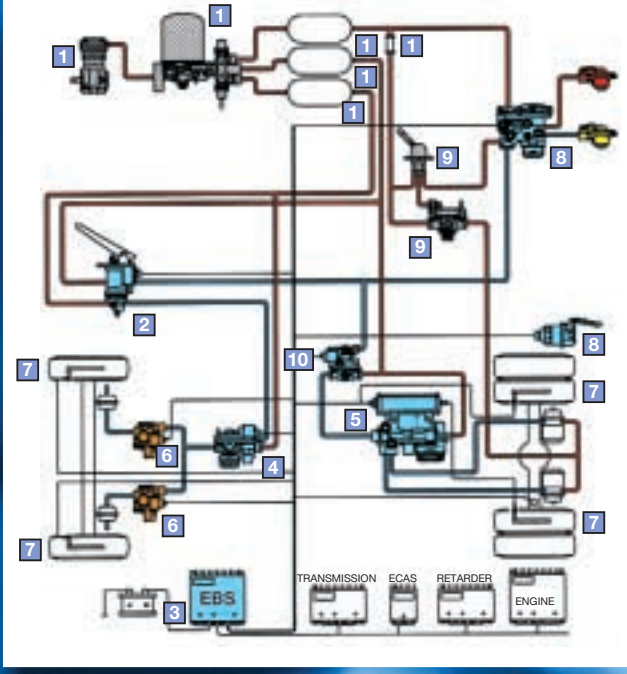
Safe thanks to improved ABS and ASR functions which are integral components of the system.

Safe thanks to convenient braking, virtually comparable with braking in cars.

Innovative as a result of extensive diagnosis and self-diagnosis tools.

Innovative as a result of new functions combined with other vehicle systems, such as continuous braking integration and drag torque control.

EBS electro-pneumatically controls the braking pressure levels of the front and rear axle as well as the trailer control pressure. Redundant pressure control is also available if the vehicle electrics fail.



1 Pneumatic group
2 Brake signal transmitter
3 Central control unit
4 Proportional relay valve
5 Axle modulator
6 ABS control valve
7 Sensors
8 Trailer control
9 Auxiliary/parking brake
10 Back-up valve

Figure 8: EBS system

EBS features

- A brake signal transmitter which creates both an electrical and a pneumatic nominal retardation value from driver pedal actuation
- A proportional relay valve for controlling the front axle braking pressure with rear-mounted ABS control valves
- An axle modulator for controlling the braking pressure on the rear axle
- An electro-pneumatic trailer control valve for controlling the trailer control pressure
- A digital data interface to trailers with EBS
- A central control unit for primary brake management functions, for front axle and trailer pressure control, for evaluating sensor signals and for communicating with other vehicle systems
- **System functions**
  EBS has a multitude of functions which reduce operating costs, increase braking comfort levels and improve safety.
- **Brake management functions**
  Continuous brake integration is responsible for correct usage of the brakes available. It ensures that the zero-wear brakes – retarder, engine brake – take on a maximum degree of braking work for the entire roadtrain during every instance of braking. This leaves the wheel brakes cold and saves brake linings and drums and/or brake discs.

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EBS – cost-effective, safe and innovative

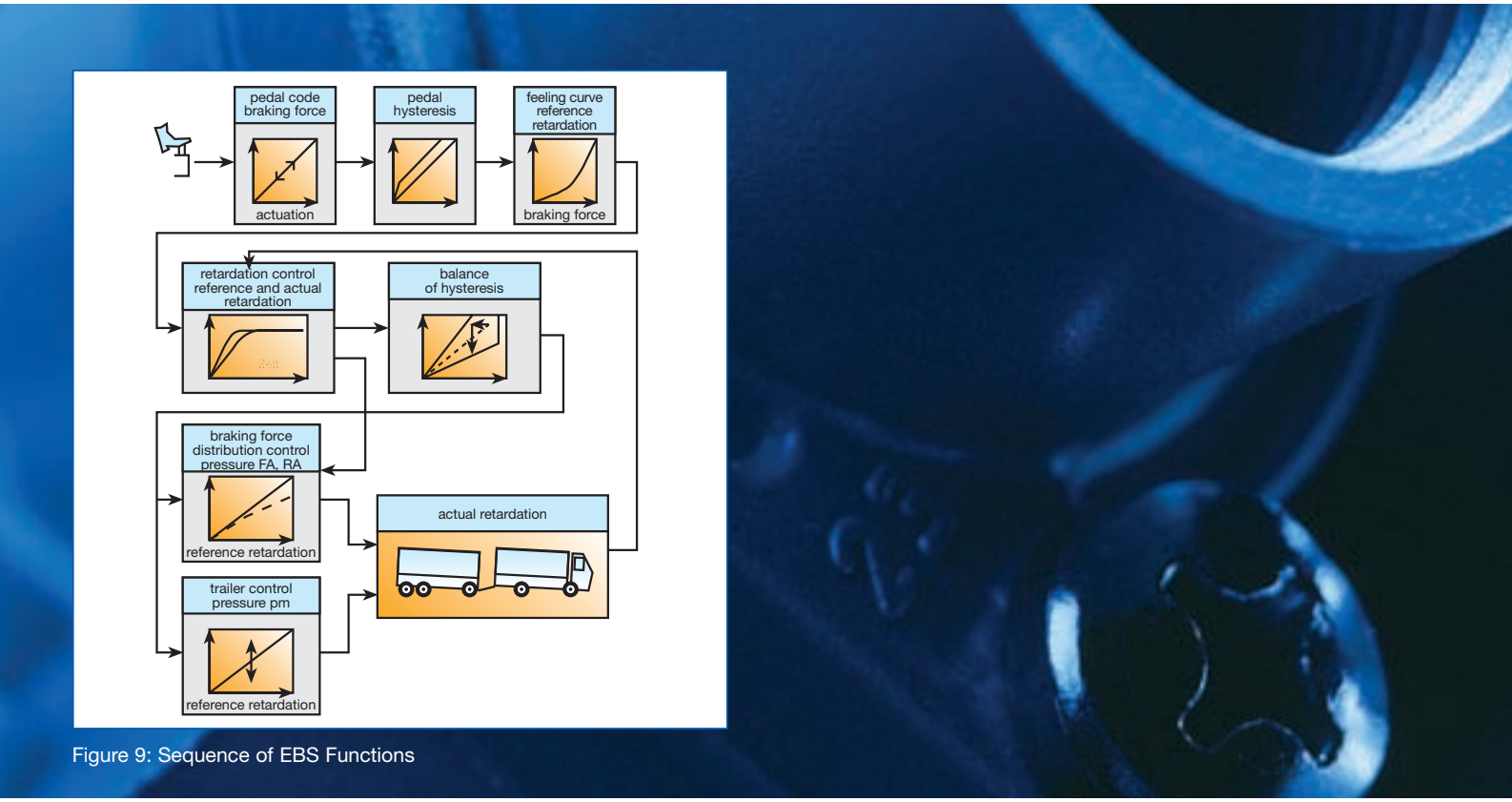


Figure 9: Sequence of EBS Functions

The braking force distribution function is responsible for the correct distribution of braking force to the axles of the towing vehicle and trailer. The braking force distribution function adaptively adapts to the loading ratios of the towing vehicle. The correct braking pressure is therefore automatically applied adaptively to each axle.

At the same time, the integrated trailer control determines the correct braking pressure for the towed vehicle. Good compatibility is therefore ensured even with ever changing vehicle combinations. The brake management functions are perfected by the addition of the retardation control function. This determines possible deviations between the desired and actual retardation and compensates for this in a manner barely perceptible to the driver. All in all, this provides for a braking feeling comparable with that of a car.

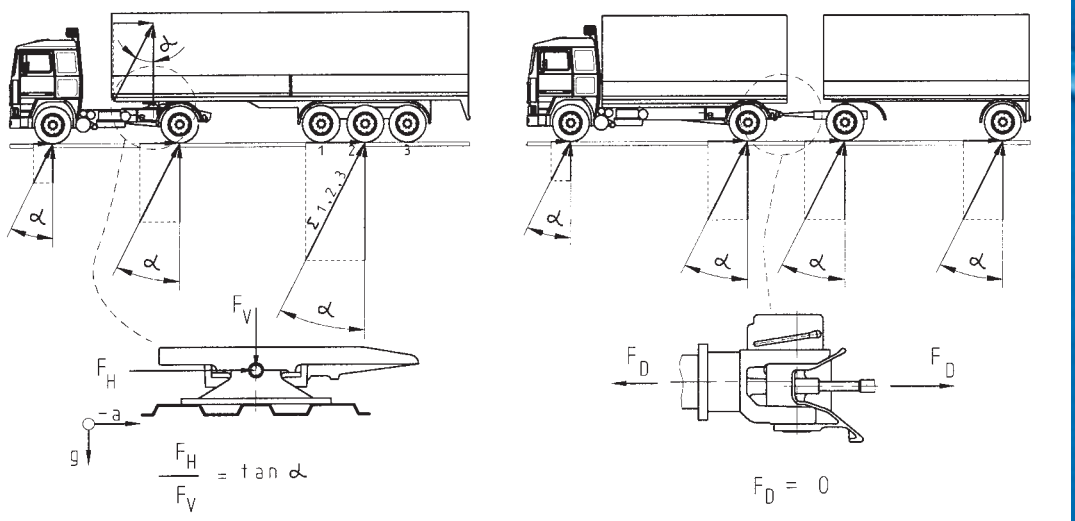
- **ABS and ASR**
  The ABS and ASR functions are integrated in the EBS system. Through the use of information which is available only to an EBS unit, such as nominal retardation value, engine torque or the actual braking pressure levels, it has been possible to further improve control quality and comfort when compared with conventional systems.

With regard to ABS, the modified individual control system (MIR) on the front axle ensures a tremendous ability to control the vehicle, while independent control of the rear axle minimises all braking travel to that actually required.

Figure 10

- **Diagnosis functions**
  The EBS uses a multitude of functions to test itself. In the event of a malfunction, such as a defective electrical wire, EBS reports it via the relevant warning device. Such an error can be rapidly determined with the assistance of diagnosis tools. The EBS will also at the same time inform you as to whether the issue is actually a wire interrupt or short circuit. It goes without saying that the EBS also reduces undesirable workshop visits.

Compatibility between tractor and trailer vehicles



ideal retardation: $\tan \alpha_i = \frac{a}{g} = Z$; α_i on all axles

Figure 11: Ideal distribution of braking force between the axles

Compatibility between tractor and trailer vehicles

For reasons associated with safety and cost effectiveness, a well-balanced braking force between the tractor and trailer vehicles is needed at all times. A towing process is considered to be well balanced if there are only slight differences in the dead time and activation pressure characteristics of the powered vehicle and trailer vehicle and if the braking forces are distributed in accordance with the loading. The distribution of braking force is ideal if the dynamic deceleration of the related axles of one combination is the same, i.e. each axle in the combination retards their own dynamic share of mass in accordance with the deceleration specified by the driver. This ideal distribution of braking force is shown in Figure 11.

As can be seen in the Figure, the ratio of braking force and axle load or the deceleration angle α of all axles is the same. In such instances, ideal coupling forces exist between the tractor and trailer vehicles. With road trains, the towbar force equals zero. With semitrailer trains, the ratio of horizontal force to vertical force on the fifth wheel ideally corresponds to the deceleration angle α.

In order to ensure that there is sufficient balanced of braking force between tractor and trailer vehicles, ECE R13 and Council Directive 71/320 specify minimum threshold times for the buildup of pressure on the coupling head and an assignment of deceleration z to pressure on the coupling head pm.

These rulings were adapted in 1998 for vehicles with EBS. The situation required of tractor vehicles is described in ECE-R13 §5.2.1.28.5.

Compatibility between tractor and trailer vehicles

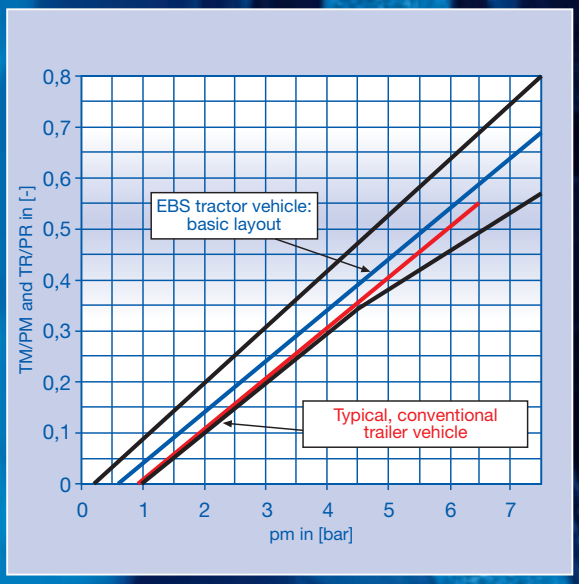


Figure 12: Example basic layout of vehicles in compatibility band

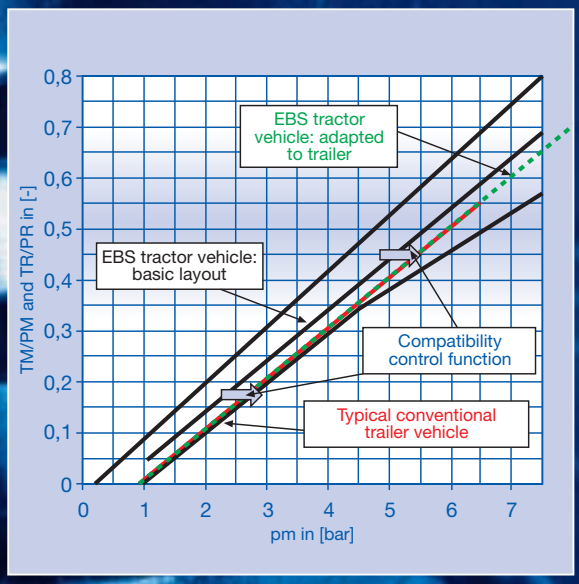


Figure 13: Compatibility control function

Although new vehicles with ABS only have to satisfy the compatibility band when fully laden, vehicle manufacturers are attempting to achieve good compatibility for all loading statuses. As far as is technically possible, a central band position is striven for. If combinations are changed frequently, on average satisfactory wear characteristics are therefore achieved for all vehicles involved. Furthermore, the combination has good balanced braking characteristics during severe retardation. In reality, more and more complaints relating to tractor-trailer compatibility are however lodged. This can in particular be explained by the different levels of brake lining wear.

Thanks to WABCO EBS and automatic compatibility control function, these complaints have increasingly become a thing of the past. Differences between the braking characteristics of the tractor and trailer vehicles are detected by the EBS in the tractor vehicle and automatically reduced. This feedback control takes place in every instance of deceleration. Figures 12 and 13 show the function of automatic compatibility control function on a sample vehicle.

Figure 13 contains the familiar diagrams used for checking compatibility, firstly showing the braking characteristics of a typical conventional trailer vehicle and an EBS tractor vehicle by way of basic layout. Right from the first instance of braking after starting a journey, the difference in braking characteristics is detected and, as is shown in Figure 13, corrected. It can be clearly seen that the braking characteristics of the tractor vehicle are adapted to that of the trailer vehicle with regard to the braking pressure on the coupling head brake (pm). The comparison is undertaken again with every instance of deceleration and further corrections undertaken if required. Tractor trailer compatibility is therefore continuously improved.

Compatibility between tractor and trailer vehicles

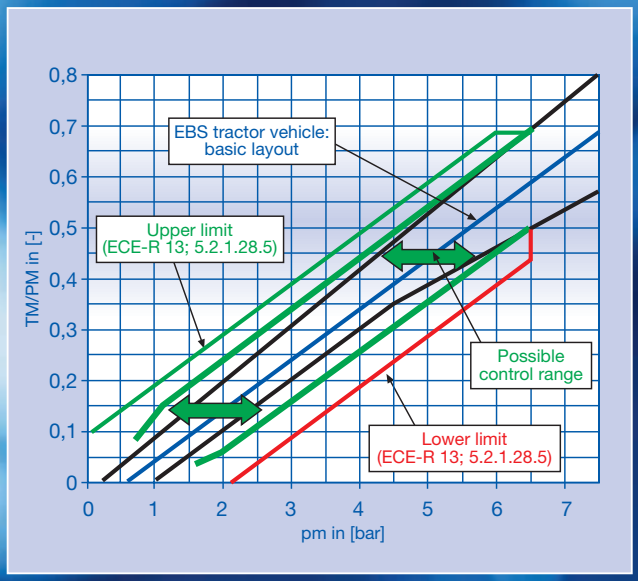


Figure 14: Possible control range of EBS-braked tractor vehicle

The automatic compatibility control function always pursues the aim of reducing the coupling forces between the vehicles to the ideal level. On this basis, it is permissible for the tractor vehicle to exit the original band limits of ECE-R13. This is also necessary when you take into account particularly old or poorly maintained trailer vehicles which only satisfy the intended band situation at lower braking pressure levels. Figure 14 shows the usual control range of a tractor vehicle with EBS. This range would however only be fully utilised if the trailer vehicle were to make this necessary.

Further problems may arise if the tractor and trailer vehicles are fitted with different brakes. Tractor vehicles are increasingly fitted with disc-type brakes, whereas the majority of trailer vehicles still have drum brakes. Since disc-type brakes are subject to less thermal fading than drum brakes, the braking force in such brakes falls less considerably at high temperatures. During long periods of braking, braking energy could therefore be increasingly transferred from the trailer vehicle (fitted with drum brakes) to the tractor vehicle (fitted with disc-type brakes). One of the main objectives of EBS developments was therefore to ensure better braking balance between tractor and trailer vehicle even in the aforementioned instance. Compatibility is improved through the adoption of the following measures:

Compatibility between tractor and trailer vehicles

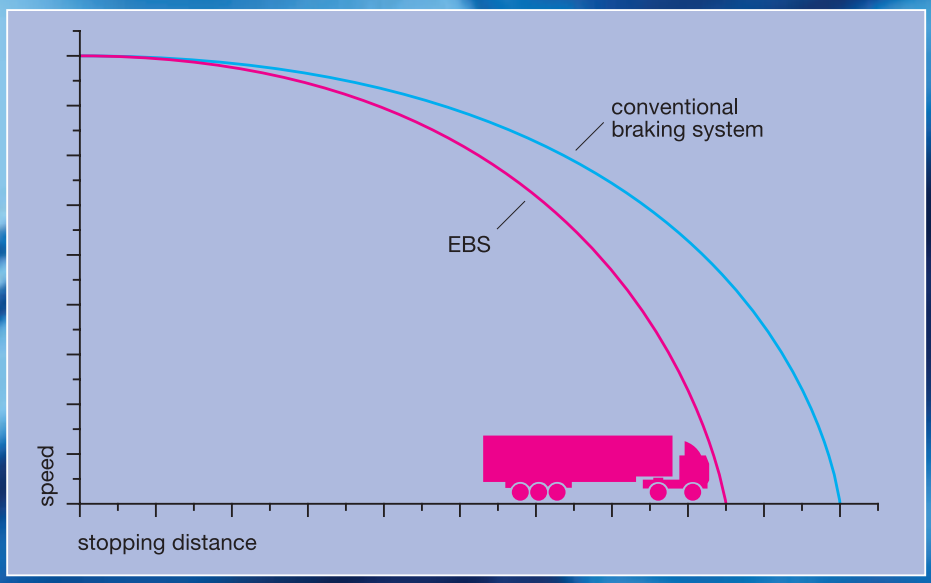


Figure 15

- The basic layout of EBS tractor vehicles corresponds to the mean band position of laden vehicles over the entire deceleration range. Retardation feedback control therefore allows the assignment of vehicle retardation to the coupling head pressure to be re-compared again and again during travel.
- The basic layout of EBS trailer vehicles with WABCO EBS has also been designed for the mean band position as was standard in previous trailer vehicles. The starting point in the EC Band, i.e. the activation pressure, is therefore defined as 0.7 bar.
- As a result of fitting automatic compatibility control function in the tractor vehicle EBS, differences in the braking characteristics of tractor and trailer vehicles are automatically learnt and minimised. If the differences in braking characteristics are compensated for, all wheel brakes of the vehicle combination should make contact at the start of braking. The predominance function of the standard trailer control valve is therefore substituted by an electropneumatic adaptation function which is automatically activa ted when trailers are changed.

The best results are of course achieved when both tractor vehicle and trailer vehicle have WABCO EBS. By transferring additional data through the standardised electrical connection, it is then possible for the ideal tractor-trailer balance to be established.

A combination of these measures results in the retardation characteristics of both vehicles of the combination being virtually identical in the range of lower braking pressure levels and highly synchronous wear characteristics are achieved between the two parts of a tractor-trailer unit.

Compatibility between tractor and trailer vehicles

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

In addition to this, overall wear levels are reduced because the average temperature level of the wheel brakes is reduced as a result of the better distribution of braking force. New tractor vehicles with EBS usually have a greater braking force than previous vehicles. However, this is not achieved by a steeper characteristics curve in the EC band, but by increasing the permanently available supply pressure with the aid of introduced constant pressure systems. The characteristics curve is therefore extended over the 6.5 bar computed pressure to 8.5 bar. All trailer vehicles, even older ones which are operated behind these new tractor vehicles, also provide more braking force because they are supplied with 8.5 bar of constant pressure and around 8 bar is available when the brakes are fully actuated.

The present standard design of trailer braking systems where z = 0.55 ... 0.6 at pm = 6.5 bar should therefore be retained in principle.

Therefore, it generally makes no difference whether the trailer vehicles are fitted with drum- or disc-type brakes.

If you would like more information about WABCO Truck EBS, have any further questions or are interested in individual advice, please contact your WABCO field service staff directly at one of our Service Centers or call WABCO at +49 (0)511-922-0.

WABCO, the vehicle control systems business of American Standard Companies, is the world's leading producer of electronic braking, stability, suspension and transmission control systems for heavy duty commercial vehicles. WABCO products are also increasingly used in luxury cars and sport utility vehicles (SUVs). Customers include the world's leading commercial truck, trailer, bus and passenger car manufacturers. Founded in the US 135 years ago as Westinghouse Air Brake Company, WABCO was acquired by American Standard in 1968. Headquartered in Brussels, Belgium, the business today employs nearly 6500 people in 29 office and production facilities worldwide. In 2003, WABCO contributed US$ 1.358 billion to American Standard's total sales of US$ 8.568 billion.

Website: www.wabco-auto.com

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Vehicle Control Systems
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