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Type : TailGUARD  
Manufacturer : WABCO Vehicle Control Systems, D-30453 Hannover

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## TEST REPORT

### No. EB181.2E

on the regularity of the braking system of a vehicle in accordance  
with the regulations of the EC Directive 71/320/EEC or the UN-ECE Regulation no. 13  
when installing a rear monitoring system with brake intervention

Type / Abbreviated designation : TailGUARD

Manufacturer : WABCO Vehicle Control Systems  
Am Lindener Hafen 21  
D-30453 Hannover

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## 0. General

The company WABCO Vehicle Control Systems, also called manufacturer in the following, has developed a driver assistance system that monitors the area to the rear of the vehicle using ultrasonic sensors, indicating objects visually and acoustically. If the distance to the object falls below the defined minimum distance, an automatically commanded braking is triggered.

The objective of this report is an evaluation of whether the braking system of a vehicle still complies with the legal requirements after this system has been installed.

For this purpose the system was subjected to a verification of the special requirements for the safety aspects of complex electronic vehicle control systems according to ECE regulation no. 13, annex 18.

With regard to the previous Test Report EB181.1E this report covers the following amendments:

- Extension of the scope of application to vehicles with WABCO EBS braking systems and initiating the brake application via the truck EBS by requesting the halt brake function.
- Extension of the ABS application to vehicles with a relay valve instead of a load sensing valve (LSV).

## 1. Identification

Manufacturer : WABCO Vehicle Control System  
Am Lindener Hafen 21  
D - 30453 Hannover

System designation : TailGUARD

Variant : For Truck and Bus Application

Version : Option Brake Application

Application : ABS-Application (via valve package)  
EBS-Application (via valve package)  
brake-by-truck EBS-Application (via EBS interface)

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See sections 3.3.1 and 3.3.5.1 of this test report on the identification of the hard- and software.

The version covered by this test report will hereinafter be called TailGUARD or the system.

The information document

TailGUARD  
For Truck and Bus Application  
Option Brake Application

with the description of the system will hereinafter be called ID\_TG.

## 2. Scope of application and notes

### 2.1 Scope of application

TailGUARD is intended for application in vehicles of categories M3, N2 and N3 with compressed air braking systems in accordance with the prescriptions in 71/320/EEC or ECE-R13.

On vehicles with an anti-lock braking system (pneumatic control line only) with relay valve or an automatic load sensing device the ABS-Application of TailGUARD according to 3.3.2 of ID\_TG shall be utilised.

On vehicles with a WABCO EBS braking system (one pneumatic and one electric control line) according to specification 815 020 015 3 or WABCO EBS3 the EBS-Application according to 3.3.3 of ID\_TG has to be utilised.

On vehicles with a WABCO EBS and an interface according to 3.2.2 the brake-by-truck EBS-Application according to 3.3.4 of ID\_TG may be utilised.

Vehicles designed to tow a trailer must be equipped with a control unit for permanent deactivation of the system.

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## 2.2 Assembly and operation

The system must be installed according to the manufacturer's installation instructions (WABCO system description, see section 3.0 of this test report). Prior to start-up of the system, the positions of the ultrasonic sensors must be learned and several vehicle and system parameters need to be defined (end-of-line programming, WABCO system description, chapter "Start-up"). The WABCO Diagnostic Interface and a personal access code, which is only granted to trained / instructed persons, is required for this purpose. Instructions for the driver on safe operation of the system and restrictions in applicability are included in the WABCO system description, chapters "Operation" and "Workshop instructions" (see also section 2.3 of this test report and ID\_TG, section 3.3.10)

## 2.3 Safety information

TailGUARD is a driver assistance system.

The system does not relieve the driver of his special responsibility when reversing in accordance with §9(5) of the German Road Traffic Act (StVO). The driver is responsible for ensuring that any hazard to other road users is ruled out. If necessary, he must be guided or directed by another person, despite the system being installed.

Depending on environmental conditions, object properties and system configuration, the ability of the system to detect objects is restricted due to the physical properties of the ultrasonic sensors.

The automatically commanded braking does not ensure that a collision can be avoided under all boundary conditions. The driver remains fully responsible for ensuring that the vehicle comes to a stop before reaching the object by appropriate speed and service brake application in good time.

## 2.4 Operation on a roller test stand

For operation on a roller test stand with less than 9 km/h the system must be switched off before engaging the reverse gear.

For operation on a roller test stand with more than 9 km/h the system must be disconnected from the power supply.  
(see also ID\_TG, section 3.3.10)

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### 3. Safety aspects of complex electronic vehicle control systems

3.0 The manufacturer's documentation comprises two parts

Part A

Document	As of
Information Document TailGUARD - For Truck and Bus Application - Option Brake Application	Rev. D 13.01.2016
WABCO system description *) TailGUARD - For Truck and Bus Application Product Number 815 020 211 3	3. edition Version 1
Product specifications of the components *)	--

\*) current version can be accessed at <http://inform.wabco-auto.com/intl/de/>

Part B

Additional material and analysis data that was disclosed for the inspection and is retained by the manufacturer (in accordance with ECE R13, Annex 18, 3.4.4)

The documentation according to part A contains the following information:

3.1 Periodic technical inspections

TailGUARD is equipped with a remote control and indication unit (TRC - Trailer Remote Control). This is used to indicate visually and acoustically the readiness of the system, current status and, if applicable, a fault warning. This indication unit is also used to check the current operational status for the purpose of periodic technical inspections (see also ID\_TG, section 4.2.3).

On the brake-by-truck EBS-Application these information is displayed by an instrument cluster at the dashboard (distance indication, warning lamp) (see also ID\_TG section 3.4.5).

3.2 Functional description of the system

TailGUARD in the version dealt with here is a rear monitoring system with automatically commanded braking. The function of the system is described in section 3.4 of the ID\_TG. The numbers placed in [ ] denote components in the system diagram in section 3.3.2, 3.3.3 and 3.3.4 of the ID\_TG.

To monitor the area to the rear of the vehicle, the system can be equipped with 2 to 6 ultrasonic sensors [2] ... [5]. Depending on the number of sensors, different requirements relating to the quality of object detection and the monitored area are met (see also section 4.1 of this test report).

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To inform the driver about

- the status of the system
- objects in the monitored area
- fault messages

an indication unit is installed in the driver's cabin (TRC - Trailer Remote Control [6] / Instrument cluster Display). The information is transmitted visually by means of LEDs or display and acoustically by means of an audio signal, in case of TRC with changing frequency and duration (see ID\_TG, section 3.4.5 and 3.4.8.3 and WABCO system description chapter "Functional description").

Optionally this indication unit can be replaced by visually (auxiliary lights) and acoustically (buzzer) acting equipment in the driver's cabin which is functionally identical.

If the distance to the object falls below an adjustable minimum distance, an automatically commanded brake application is triggered.

On vehicles with ABS- or EBS-Application and valve package the actuation is implemented by means of two solenoid valves connected in series [10]. At the ABS-Application these direct pressure from the braking system's rear axle circuit to the rear axle wheel brakes via a "select high" valve [12] and the automatic load sensing device or relay valve. At the EBS-Application pressure is directed via a relay valve [28] and two "select high" valves [12] to the brake chambers of the rear axle(s). An upstream pressure safety valve [8] secures the required minimum pressure in the service brake system. This valve may be omitted if, in case of EBS-Application, compressed air is not released from one of the brake circuit reservoirs.

A pressure limiting valve [9] is used to adjust the pressure controlled by the automatic brake application. On settings for the pressure safety and pressure limiting valve see also ID\_TG, section 4.3.1 and WABCO system description chapter "Components". A pressure sensor [11] monitors the function of the valves. The driver can always override the automatically commanded brake application by means of the "select high" valves. On vehicles with the brake-by-truck EBS-Application a request for activation of the halt brake is sent to the EBS control unit. The brake actuation is carried out by the vehicle only if the vehicle speed is less than 15 km/h and the reverse gear is engaged. Brake reservoirs and valves are monitored by the EBS. The status of the brake application is confirmed to the TailGUARD control unit. The triggered brake pressure can always be overridden by the driver.

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### 3.2.1 List of input variables and their operating range

Input variables are (see also ID\_TG, sections 4.3 and 4.4)

- terminals 15, 30
- RMS off switch
- stop light signal
- speed signal (C3 or CAN)
- braking pressure sensor
- CAN interface
- brake status
- actuation of reversing light / gear information
- signals from the ultrasonic sensors
- diagnostic port

For operating ranges see the corresponding sections of the ID\_TG and the product specifications of the respective component.

### 3.2.2 List of output variables and their operating range

Output variables are (see also ID\_TG, sections 4.3 and 4.4)

- stop light signal
- solenoid valves (brake actuation)
- CAN interface
- Brake relay
- Warning / status lamp
- TRC control / obstacle distance
- diagnostic port

For operating ranges see the corresponding sections of the ID\_TG and the product specifications of the respective component.

### 3.2.3 System limits

The system has been designed for an working range of:

Temperature:	-40 to +65 °C
Supply voltage:	19 to 32 V ("24V"-systems) 11,5 to 16 V ("12V"-systems)
Supply pressure:	7.3 to 13 bar
Speed:	0 to 12 km/h

The manufacturer has demonstrated that appropriate measures were implemented during the development process to take into account environmental conditions relevant to use of the system.

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Apart from a changed voltage transformer, all components of the system are carry-over parts from a rear monitoring system for trailers that has been used as a standard application for several years now. Examinations and measures with respect to resistance to environmental influences are summarised in the Product Verification Report ELEX ECU, 446 122 170 2 (A), Doc.-Code 066 (part B of the documentation) and can be applied to the current system.

More information can be found in the product specifications for the respective component.

### 3.2.4 Electromagnetic compatibility

The components of the system have been tested with respect to electromagnetic compatibility as required by regulation ECE-R10, and they meet the requirements stated therein.

Name	Type	Approval no.	Remark
Control unit / ECU	ELEX	E1-10R-035979, ext. 1	tested incl. ultrasonic sensors
Indication and remote control unit	TRC	E1-10R-036230, ext. 1	

### 3.3 System diagram and circuit diagrams

#### 3.3.1 List of components

A list of components is found in section 3.3.1 of the ID\_TG.

#### 3.3.2 Function of the units

The function of the units is described in section 3.4 of the ID\_TG.

#### 3.3.3 Connections

The connections within the system and to the vehicle are shown in the schematic system diagram in section 3.3.2 to 3.3.4 of the ID\_TG. Details on the electrical connections are found sections 3.3.5 and 3.3.6 of the ID\_TG. Examples of pneumatic and electrical circuit diagrams are available under the drawings listed in section 2.3.1 of the ID\_TG.



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### 3.3.4 Signal flow and priorities

The signal flows correspond with the connection diagram. Since only one signal is assigned to each port, no priorities are defined. Only the diagnosis operates with a CAN interface and multiple messages.

In the brake-by-truck EBS-Application the priorities of the CAN interface confirm to ISO 11992-3 (see ID\_TG, section 3.3.11).

### 3.3.5 Identification of units

#### 3.3.5.1 Identification of the hardware

The hardware can be identified by the part number attached to the respective components. The current hardware versions at the time of testing are listed in ID\_TG, section 3.3.1.

#### 3.3.5.2 Identification of the software

The software is identified by an alphanumeric code that can be read out via the WABCO Diagnostic Interface (see ID\_TG, section 4.1.2).

The code is structured as follows: EXaabbcc

The software code positions signify:

Item	current version	Content
EX	EX	Identifies software for the Electronic Extension Module (ELEX)
aa	01	Identifies changes relating to ECE-R13
bb	04	Identifies the level of the "For Truck and Bus Application"
cc	04	Identifies changes that do not have any effect on the functions dealt with here

For ABS-Application the minimum required SW level is **EX010314**.

For EBS-Application the minimum required SW level is **EX010404**.

For brake-by-truck EBS-Application the minimum required SW level is **EX010451**.

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### 3.4 Safety concept

The safety concept of the TailGuard system in the version considered here is summarised in ID\_TG, section 3.4.8.

The safety concept was evaluated in cooperation with experts for functional safety from the Electronics & IT department at the Institute for Vehicle Technology and Mobility of the TÜV NORD Mobility.

As part of the assessment, the applied basic architecture, the procedures and resources applied for their development as well as the measures for ensuring safe operation in the event of a fault were explained on the basis of additional documents (see section 3.4.4, part B of the documentation).

The following concepts for protection against faults and maintaining safe operation are implemented in the system:

- monitoring functions for fault detection within the ECU and outside of it (sensors, actuators, cabling etc.)
- warning signals for the driver in the event of a fault
- deactivation of the system functions (reverse monitoring and brake interventions)

All electrical components inside and outside the ECU are monitored for short circuits and line interruptions. The supply voltage is also monitored. Detected faults trigger a corresponding fault message and a deactivation of the system. Only the diagnostic function will continue to be supported where possible. The pneumatic actuation of the wheel brakes can also be monitored (supply pressure, braking pressure, leaks) by means of two solenoid valves and one pressure sensor. Even in the event of a short-circuit to supply voltage of a solenoid valve the system can still be deactivated by means of the second solenoid valve, so that the system brought into a safe state.

Depending on the fault type, the fault message occurs permanently or with activation of the system (engaging the reverse gear) or by absence of the indication of system readiness to appear when the system is activated (see ID\_TG, section 3.4.8.3).

#### 3.4.1 Confirmation of the manufacturer

The manufacturer confirms that the strategy chosen to achieve the system objectives will not, under non-fault conditions, prejudice the safe operation of the braking system (see ID\_TG, section 3.3.9).

The driver can always override the triggered pressure ("select high" valve or truck EBS). In the ABS- and EBS-Application the pressure safety valve prevents pressure being removed from the system if this would cause the pressure to fall below the safety pressure for the corresponding circuit. This valve may be omitted if, in case of EBS-Application, compressed air is not released from one of the brake circuit reservoirs

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#### 3.4.2 Development process (basic architecture, applied procedures and resources)

The manufacturer has a quality management system that is certified according to ISO/TS 16949 and ISO 9001. Development was carried out in accordance with the WABCO process instructions DP-PD-01 "Common Development Process".

The manufacturer explained the procedures and resources applied during development for implementing the system logic, e.g.:

- software development according to the V model (7 phases)
- software architecture according to CESAR
- code analysis according to MISRA guidelines
- software review and release for each phase
- staged approval procedures
- module test using Tessy (test tool)
- configuration management using MKS tool
- change management

#### 3.4.3 Design provisions to generate safe operation under fault conditions

##### 3.4.3.1 Fallback to a partial system

TailGUARD is an assistance system whose presence is not required. In the event of a fault the system is, depending on the fault type, switched off completely (fail safe) or the system function is cancelled and only the diagnostic port supported. The function of the braking system is not impaired by this. There is no fallback to a partial system.

##### 3.4.3.2 Change over to a separate backup system

There is no separate backup system.

##### 3.4.3.3 Removal off the high level function

When the system functions are deactivated in the event of a fault, all output signals of the system are blocked except communication via the diagnostic port.

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### 3.4.4 Safety analysis

The manufacturer has carried out a safety analysis that demonstrates the behaviour of the system in the event of defined faults with an impact on the vehicle function or safety. The safety analysis is based, among other things, on the following documents:

Document	Identification	Doc. code	As of
System FMEA	100 080 003 0	059	21.05.2013/ 19.06.2013/ 03.03.2015/ 12.11.2015
Technical Safety Concept Overview	100 080 003 0, Rev. 2.1	--	27.11.2015
Product Verification Report ELEX stand-alone system	100 080 003 0 Rev. F Rev. H	066	22.04.2013/ 20.09.2013/ 26.03.2015/ 23.11.2015
ELEX stand-alone vehicle test description	TR-6171-2013-0004	030	24.04.2013
Functional testing of failure monitoring of ELEX stand-alone function.	TR-6171-2013-0010 TR-6171-2015-0009	030	09.08.2013 17.03.2015
TG Truck EBS system conformance Overview	TR-6171-2014-0004	030	12.02.2015
Vehicle Integration and Requirements Testing	TR-6171-2015-0024	030	23.11.2015

Based on the evidence supplied in the documentation and the results of the subsequent evaluation of possible failures it is evident that the safety concept described is systematic and complete.

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#### 3.4.4.1 Monitored parameters and warning signals

The monitored parameters are described in ID\_TG, section 3.4.8.1. Fault indication is implemented according to sections 3.4.8.3 and 3.4.8.5.

The fault indication at the ABS- and EBS-Application differentiates between "Standard failures" and "Severe failures".

"Standard failures" are indicated via LEDs and a warning tone when the system is activated (engaging the reverse gear). In the case of deactivation (corresponds to a reset), the "second indication" occurs for a period of 60 sec. If the fault is still present after reactivation, this is indicated by the absence of the readiness check.

"Severe failures" are indicated by a warning tone and a permanent warning indication via the LEDs even without the system being activated (e.g. with the activation check after "ignition on".) In this case a reset only occurs after ignition change.

At the brake-by-truck EBS-Application all failures are indicated by the warning lamp at the dashboard instrument cluster.

A line interruption of the speed signal can not be distinguished from a stationary vehicle with the ignition turned on. In this case a time condition (5 min after "ignition on", 30 min for the subsequent ignition cycle) is used to identify an unavailable speed signal as a fault. Additionally, a memory bit is set for this fault. This memory bit is only deleted once a plausible speed signal is detected.

A line interruption of the reverse gear signal (fault) can not be distinguished from disengaging the reverse gear (normal function). In both cases the system does not output an indication of readiness (i.e. system not available). If this fault only occurs after activation of the system above a limit speed, the driver is alerted by an additional fault message.

## 4 Verification and testing

### 4.1 Operating mode of the system

The functional operation of the system, as described in ID\_TG, section 3.4 was verified as follows.

A separate test report no. EB175.0E was prepared for reverse monitoring in accordance with ISO/TR 12155 1994-10-00 "Commercial vehicles - Obstacle detection device during reversing - Requirements and tests". This report applies to the system configuration TailGUARDMAX with 6 ultrasonic sensors.

Depending on the number and arrangement of the ultrasonic sensors, the monitoring area according to ISO/TR 12155 may not be covered completely.

A test using a test object (plastic tube, length 1320 mm, Ø 75 mm) demonstrated that with the use of two ultrasonic sensors object detection was not, or only partially, achieved in the corner areas of the monitoring area according to test 1 of ISO/TR 12155.

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The test of the automatically controlled brake application was carried out on the following test vehicle:

Vehicle type	MAN 12.225 LLC	MAN TGM 26.340	MB Actros	MB Econic
Braking system	WABCO ABS E4	WABCO EBS2	WABCO EBS3	WABCO EBS3
Arrangement of USS	Two sensors in the area of the rear underride protection (see ID_TG, section 3.4.4, TailGUARD 3x, without centre sensor)			
ELEX ECU	HW	446 122 070 0		
	Ser. No.	0015 000 36048	0015 000 41333	0015 000 36018 0015 000 46894
	SW	2_EX010310	EX010404	EX010451
		3_EX310_RL Y1 <sup>1)</sup>		

<sup>1)</sup> (additional test with software update, development stage)

#### 4.1.1 Verification of the system's operating mode

Tests were carried out with the vehicle mentioned above to verify the system's ability to perform in a fault-free state. The system's mode of operation was examined while reversing at different speeds, with and without an object in the monitoring area and with and without additional brake actuation. The behaviour of the system and the information transmitted via the TRC matched the manufacturer's specifications. An impermissible impact on the braking system with respect to legal requirements was not identified.

#### 4.1.2 Verification of the safety concept

Several internal and external faults were simulated to verify the safety concept of the system. The fault codes were recorded and the response of the system and the impact on the braking system were observed. The following faults (amongst others) were induced:

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- Defined system pressure was not reached / was exceeded
- Solenoid valve line interruption / Short circuit to battery voltage
- Pressure sensor line interruption / Signal offset
- Ultrasonic sensor line interruption / Short circuit to ground
- Reverse gear signal failure / Signal permanently present
- Speedometer signal line interruption / Short circuit to ground
- Undervoltage ECU (9V / 19V)
- Relay contacts for stop light actuation short circuit to ground
- Simulated leakage at relay valve
- Disruption of PLC communication
- Faulty CAN signal (reverse gear, speed signal)
- Brake relay short circuit

#### 4.1.2.1 Results of the verification

The saved fault codes matched the specifications in the safety concept.  
The fault responses of the system and the fault messages and system information to the driver matched the documented specifications of the manufacturer in ID\_TG, sections 3.4.5, 3.4.8.3 and 3.4.8.5.

#### 5. Place and date of the test

as before and  
Hannover, 15.11.2015  
Jeversen, 25.11.2015

#### 6. Attachments

1. Information document 13.01.2016  
TailGUARD  
For Truck and Bus Application  
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## 7. Summary

On the basis of the provided documentation and explanations in combination with the tests carried out for verification, it is confirmed that the safety concept of the manufacturer and its execution can be considered as adequate according to the special regulations for safety aspects of complex electronic vehicle control systems.

The installation of the system in accordance with the manufacturer's specifications does not have a negative impact on the function of the vehicle's braking system, which continues to meet the legal requirements. Safe operation of the vehicle is ensured in the event of a fault occurring.

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This test report comprises pages 1 to 16.

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Akkreditiert nach / *accredited* DIN EN ISO/IEC 17025: D-PL-11109-01-00  
Benannt als Technischer Dienst / *designated as Technical Service*  
Vom Kraftfahrt Bundesamt / *by Kraftfahrt-Bundesamt: KBA – P 00004-96*

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