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Type of device : **CTU**  
Manufacturer : **WABCO**

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## Technical Report

Nr. **EB138.1E**

on a measurement and simulation device  
to check compliance with the provisions of  
the ECE-Regulation No. 13

### 1 General

This Technical Report serves as a verification of the conformity to regulations of the measuring and simulation device described (hereinafter called CTU) for the officially authorised expert or examiner in the assessment of motor vehicles and trailers according to §§ 20 and 21 StVZO or Directive 71/320/EEC in the version of 1<sup>st</sup> October 2002 (2002/78/EEC) and ECE Regulation No. 13 / 11 (Supplement 8).

With respect to the previous Technical Report No EB138.0E this report covers the following additions:

- Amendment to the standard ISO 11992:2003 including ISO 11992-2:2003/ Amd. 1:2007
- Compatibility test procedure of the motor vehicle and the trailer according to ECE-R13, Annex 17 amended
- Test procedure for capacity of energy storage devices for motor vehicles and trailers added (ECE-R13, Annex 7, Part A, Paragraph 1)

#### 1.1 Manufacturer:

**WABCO Vehicle Control Systems**

Am Lindener Hafen 21  
D - 30453 Hannover

#### 1.2 Applicant:

see 1.1

#### 1.3 Type:

**Conformity Test Unit**

#### 1.4 Type of device:

**CTU**

### 2 Scope of application

#### 2.1 Vehicle categories:

With the CTU it is possible to check compliance with the relevant provisions of Annexes 6,7 (Part A paragraph 1) 16 and 17 of the ECE Regulation No. 13 with respect to vehicles of the categories M, N and O.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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### 3 Technical Data

#### 3.1 General:

The CTU is a testing device which satisfies the requirements for the functions of the sample simulators described as laid down in ECE R13 Annexes 6 and 17.

The test programme for the CTU assessed in this report relates to the status of the standard ISO 11992:2003 incl. ISO 11992-2:2003 / Amd 1:2007 (according to the requirements of the ECE Regulation No. 13, Supplement 8 to the 11 series of amendments).

The control of the CTU and user guidance are by means of the PC program included with the CTU. Together with the CTU hardware, this is used to conduct the conformity check. The user surface is currently installed by WABCO on a PC with Windows operating systems. Data exchange with the CTU hardware is conducted according to the PDU protocol\* (in accordance with internal WABCO specification).

A detailed description is given in Annex 1 (CTU System Description 815 010 190 3).

\* PDU = Protocol Data Unit

#### 3.2 Components:

The CTU consists of the modules listed below. The WABCO part numbers of the individual components are listed in section 4.4 of Annex 1.

**Note:** The PC needed for the test is not a part of the CTU.

##### General instruction of component marking:

The components listed in section 4.4 of Annex 1 are identified by the following data on a nameplate:

- Manufacturer's logo "WABCO"
- Week and year of production
- Part number
- Place of production (number code)
- Serial No. SN # .... (for components which have to be calibrated)\*

\* These components must be given a calibration sticker.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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3.2.1 Basic package:

WABCO part number 446 310 010 0

**The basic package includes:**

- central control unit CTU (446 310 000 0)
- ISO 7638-Adapterset (7 polig)
- one pressure sensor
- test hose supply pressure ( $l = 2.5 \text{ m}^*$  /  
 $d_{\text{inside}} = 13 \text{ mm}$ )
- USB-RS232 Adapter
- USB-Stick for the installation and test software

\*Note: The total volume of 385 cm<sup>3</sup> demanded in Annex 6 of ECE-R13 is obtained by including the coupling head belonging to the test hose.

3.2.2 Motor vehicle extension:

WABCO part number 446 310 013 0

**The motor vehicle extension includes:**

- Step plate with double contact maker
- two pressure sensors
- test hose control pressure ( $l = 2.5 \text{ m}^*$  /  
 $d_{\text{inside}} = 13 \text{ mm}$ )
- test volume 0,5 dm<sup>3</sup>

\*Note: see para. 3.2.1

3.2.3 Trailer extension:

WABCO part number 446 310 011 0

**The trailer extension includes:**

- simulator 446 310 025 2 (pneumatic control)
- test hose control pressure ( $l = 2,44 \text{ m}^*$  /  
 $d_{\text{inside}} = 13 \text{ mm}$ )

\*Note: The total volume of 385 cm<sup>3</sup> demanded by Annex 6, para. 3.3.1 of ECE-R13 is obtained by including the volume between the orifice and connection of the test hose to the simulator and of the test hose volume.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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- 3.3 Power supply for the CTU:** For details see Annex 1, para. 5.5 "Power supply"
- 3.3.1 Motor vehicle with ISO 7638 connector.: by the motor vehicle through the ISO 7638 adapter
- 3.3.2 Motor vehicle without ISO 7638 connector.: through a 24V power supply unit
- 3.3.3 Trailer with ISO 7638 connector: For time measurement: according to Annex 6 of ECE-R13:  
- by the motor vehicle through the ISO 7638 adapter  
or  
- through a 24V power supply unit  
For the test according to Annex 7 and 17 of ECE-R13:  
- through a power pack with **controllable** power supply (rated voltage at least 24 V)
- 3.3.4 Trailer without ISO 7638 connector: through a 24V power supply unit

## 4 Tests performed

### 4.1 General:

With the CTU the following test procedures of the main programme module (menu start screen)(to check compliance with the provisions of Annexes 6, 16 and 17 of ECE-R13) and of other programme modules (menu command bar) were performed.

In addition the other tests listed in section 4.4 were performed.

The hardware components are unchanged compared to the version tested in November 2001 except for the pressure sensors. The previous pressure sensor 441 040 014 0 was replaced by a functionally equivalent device with the identification 441 044 104 0. The product specification of both pressure sensors are identical (see section 4.4).

The parts of the software of the CTU controlling and evaluating the response time measurement according to ECE-R13, Annex 6 are unchanged compared to the version tested in November 2001. The test results of the previous Technical Report regarding paragraphs 4.2.1, 4.2.3 and 4.2.4 are valid unchanged and are listed again here below.

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Gerätetyp : **CTU**  
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## 4.2 Main programme modules

### 4.2.1 Test of response time for trailer vehicles:

With the CTU the tests for trailers both with pneumatic and electric braking line were conducted on a 3-axle semi-trailer in accordance with section 3 of Annex 6 of ECE-R13.

For the trailer presented the times of 0.36 s (pneumatic control) and 0.31 s (electric control) were measured between the moment when the pressure of 0.65 bar introduced into the control line by the simulator (or the equivalent bit value 3328 introduced) was reached and the moment when the pressure in the brake cylinder of the trailer reached 75% of the asymptotic value. The accuracy of the measurement was verified with a control measurement using an oscillograph.

### 4.2.2 Test of the compatibility of a trailer with an electric control line:

A check was made of all requirements of section 4 of Annex 17 of ECE-R13 which relate to trailers with electric and pneumatic control line.

During the verification of the function of the service brake system (ECE-R13, Annex 17, 4.2.2.1) all required messages were transmitted correctly by the simulator and the pressure at the brake chambers of the trailer complied with the required values.

Given the current legal situation, trailers with purely electric control (without pneumatic control line) are not yet permissible and there are therefore no corresponding electronic braking systems available as yet. The test procedures according to para. 4.2.2.1.2 of Annex 17 of ECE-R13 which are included in the CTU program have therefore not yet been checked.

In Annex 17 of ECE-R13 the reaction of the test vehicle with respect to the red and yellow warning signal is required for various test procedures.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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When the yellow warning signal (pin 5) of the trailer is switched via the ISO 7638 connector, this is recognised by the CTU program and indicated (an illuminated symbol lights up in the status bar of the start window). The signal at pin 5 was verified using an oscilloscope additionally.

The request for the red warning signal is clearly identified and output by the CTU by means of the message EBS 22, byte 2 bits 3-4 (red warning signal request) via the electrical connection between the motor vehicle and trailer according to ISO 11992 (in short CAN bus). An additional check of the accuracy of the program indication was made using an additional CAN monitor.

The chronological sequence of the red warning signal request when the electrical part of the braking system is first energised is recorded by the CTU. Because different start-up sequences are permitted the CTU performs no evaluation of the result.

The correct transmission of the messages of automatically commanded braking (EBS 22, byte 4, bits 5-6) and intervention of the vehicle stability function (EBS 21, byte 2, bits 1-2) were verified by a CAN simulator. The messages sent by the simulator were received correspondingly either using the CTU or an additional CAN viewer.

#### 4.2.3 Test of response time for motor vehicles with and without trailer control:

With the CTU the tests according to section 2 of Annex 6 of ECE-R13 were conducted on a 2-axle semi-trailer tractor (brake air reservoir volume 50 dm<sup>3</sup>, flexible pipe length 4.5 m, inside diameter 9 mm).

With the actuation time of 0.2 seconds the time between the start of actuation of the brake pedal and the moment when the pressure at the inlet of the least favourably placed brake cylinder (rear right) had reached 75% of its asymptotic value was 0.47 seconds.

The times between the start of the actuation of the brake pedal and the moment when the pressure measured at the yellow coupling head of the control line or the digital deceleration value in the electrical control line had reached x% of its asymptotic value were:

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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	response time up to attainment of 10% of asymptotic value	threshold time up to attainment of 75% of asymptotic value
coupling head of control line	0.16 s	0.35 s
digital deceleration value of electrical control line	0.07 s	0.15 s

#### 4.2.4 Breakaway test (automatic braking):

In the breakaway test according to para. 2.7 of Annex 6 (or para. 5.2.1.18.4.1) of ECE-R13 conducted on the semi-trailer tractor mentioned above the pressure in the supply line fell within 1.32 seconds to a value of 1.5 bar with an actuation time of 0.2 s. The accuracy of the measurement was verified with a control measurement using an oscillograph.

Slow actuation of the brake pedal in this test was recognised by the CTU program and given as a fault message.

#### 4.2.5 Compatibility check of a motor vehicle with electrical trailer control:

A check was made of all requirements of section 3 of Annex 17 of ECE-R13 which relate to motor vehicles with electric and pneumatic control line.

The messages transmitted from the towing vehicle regarding the control line signaling (EBS 12, byte 3) and the service and secondary braking demand (EBS 11, byte 3-4) are correctly received and displayed by the CTU.

The CTU is able to simulate a permanent failure in the communication line (short circuit at pin 6 or pin 7 of the ISO 7638 connector) The yellow warning signal according to ECE-R13, 5.2.1.29.1.2 is transmitted correctly via pin 5 of the ISO 7638 connector. The voltage level at Pin5, 6 and 7 was monitored with an oscilloscope.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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At the motor vehicle used for the verification of the CTU a failure warning at pin 5 of the ISO 7638 connector at standstill of the vehicle does not illuminate the yellow warning lamp according to ECE-R13, 5.2.1.29.1.2 at the control panel of the vehicle. Not until the vehicle speed exceeds 18 km/h the warning lamp illuminates and extinguishes again when the vehicle speed falls below this value. The function of the CTU complies with the requirements of ECE-R13, Annex 17, 3.2.2.3. An evaluation of the test vehicle is not part of this Technical Report. Because of this reaction of the test vehicle the result "warning lamp does not illuminate" is a valid result of the test and the CTU program refers to additional testing of the vehicle in motion.

The error simulation required in paras. 3.2.2.3.1 and 3.2.2.3.2 of Annex 17 of the ECE-R13 (single-wire capability of data communication) is generated by short circuit of pins 6 and 7 of the electrical control line against earth of the CTU program. The actual failure of the respective data lines (pin 6 and pin 7 of the ISO 7638 connector) was verified by control measurements using an oscillograph.

Given the current legal situation, motor vehicles with purely electrical control (without pneumatic control line) are not yet permissible. At present therefore there are no corresponding electronically controlled braking systems available. Recognition of the parameter "**00<sub>b</sub>**" of the message EBS 12 byte 3 - bits 5-6 ("Towing vehicle without pneumatic control line"), see para. 3.2.2.1.1 of Annex 17 of ECE-R13, was tested indirectly by simulation of the messages. In response to the input that the test vehicle is equipped with a purely electrical control line, the CTU program correctly gave the assessment "Error".

The messages of the trailer "vehicle service brake active/passive" (EBS 22, byte 4, bits 5-6) and "vehicle directional control active/passive" (EBS 21, byte 2, bits 1-2) can be simulated by the CTU and release the required reaction at the towing vehicle.



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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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### 4.3 Special program modules

#### 4.3.1 ISO 11992:

This program module consists of the following menu items:

- Display CAN messages
- Display data contents
- Timing of the messages
- Bus utilization

Every message transmitted at the data communication interface between the motor vehicle and the trailer is displayed. For messages with known CAN-identifier, the message names are displayed. For messages according to ISO 11992-2:2003/Amd 1:2007 data content will be displayed and repetition time can be measured. This was verified with a CAN viewer within the compatibility checks of a motor vehicle and a trailer with electric control line respectively.

#### 4.3.2 EXTRAS:

This program module consists of the following menu items:

- Test of the CTU hardware
- Calibration of simulator's pressure sensors
- Pneumatic test of the simulator
- Settings

The calibration of the pressure sensors and the verification of the step plate with double contact maker were carried out within the compatibility checks of a motor vehicle and a trailer with electric control line respectively. The response time of the simulator during the examination of the pneumatic characteristics according to ECE-R13, Annex 6, 3.3.3 was verified with an oscilloscope. The requirements are fulfilled.

#### 4.3.3 Trailer:

This program module consists of the following menu items:

- Test of the response time of trailers with pneumatic control line (see above para. 4.2.1)
- Test of the response time of trailers with pneumatic and electric control line (see above para. 4.2.1)
- Test of the capacity of the energy storage devices for trailers (ECE-R13, Annex 7, Part A, Paragraph 1.3)
- Test of the compatibility of a trailer with electric control line(see above para. 4.2.2)

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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- Test acc. to ISO 11992
- Towing vehicle simulation

From this program module it is possible to start the main program modules for time measurement and compatibility test already mentioned above (see paras. 4.2.1 and 4.2.2).

The test of the capacity of the energy storage devices was conducted on a 3-axle semi-trailer with air suspension and a volume of the energy reservoir of 80 dm<sup>3</sup>. The test was done with electric and pneumatic control line and with purely pneumatic control line as well. The automatic load sensing device was set to laden condition by simulating an equivalent bellow pressure in the air suspension. At the start of the test, the pressure in the energy reservoir equated the required 850 kPa with a tolerance of 10 kPa. During the test the energy reservoir was isolated from supply line and reservoirs for auxiliary equipment. The pressure in the pneumatic control line at each brake application was 750 kPa. During the test with electric control line the digital demand value corresponded to 750 kPa. The values for pressure and digital demand value were verified with external devices.

	pneu. contr. line.	pn. u. el. contr. line.
Reservoir pressure prior to brake application	840 kPa	841 kPa
Reservoir pressure during the first brake application	750 kPa	734 kPa
Required reservoir pressure after 8 brake applications	375 kPa	367 kPa
Measured reservoir pressure after 8 brake applications	445 kPa	447 kPa

In the menu item "Test acc. to ISO 11992" it is possible to show the messages of the ISO 11992 interface, the bus load and the repetition rate of the messages. The trailer messages are decoded and displayed as text.

In the menu item "Towing vehicle simulation" it is possible to transmit the messages of the motor vehicle for test purposes.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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#### 4.3.4 Towing vehicle:

This program module consists of the following menu items:

- Test of the response time of towing vehicle without trailer control (see above para. 4.2.3)
- Test of the response time of towing vehicle with pneumatic trailer control (see above para. 4.2.3)
- Test of the response time of towing vehicle with pneumatic and electric trailer control (see above para. 4.2.3)
- Breakaway test (automatic braking) (see above para. 4.2.4)
- Test of the capacity of the energy storage devices for motor vehicles (ECE-R13, Annex 7, Part A, Paragraph 1.2)
- Test of the compatibility of a towing vehicle with electric trailer control(see above para. 4.2.5)
- Test acc. to ISO 11992
- Trailer simulation

From this program module it is possible to start the main program modules for time measurement, break-away test and compatibility test already mentioned above (see para. 4.2.3, 4.2.4 and 4.2.5).

The test of the capacity of the energy storage devices was conducted on a 2-axle semi-trailer tractor with a volume of the energy reservoir of 2 x 25 dm<sup>3</sup> (Circuit 1 and 2) and 30 dm<sup>3</sup> (Circuit 3). The test was done for a solo vehicle as well as for a towing vehicle with pneumatic control line. In the second case an additional volume of 500 cm<sup>3</sup> was connected to the coupling head of the pneumatic control line. The reservoirs were charged up to the energy level specified by the manufacturer and isolated from supply line and reservoirs for auxiliary equipment. During the test with a pneumatic control line for a trailer the supply line was isolated and the pressure in the reservoir for the pneumatic control line was measured.

Gerätetyp : **CTU**  
 Hersteller : **WABCO**

Solo vehicle	Circuit 1 / 2	Trailer conr. line
Reservoir pressure according to manufacturer	1000/1000 kPa	--
Reservoir pressure prior to brake application	1037/1039 kPa	--
Reservoir pressure during the first brake application	956/957 kPa	--
Required reservoir pressure after 8 brake applications	500/500 kPa	--
Measured reservoir pressure after 8 brake applications	619/619 kPa	--

Towing vehicle with pneumatic control line	Circuit 1 / 2	Trailer con. line
Reservoir pressure according to manufacturer	1000/1000 kPa	950 kPa
Reservoir pressure prior to brake application	1014/1016 kPa	952 kPa
Reservoir pressure during the first brake application	928/928 kPa	902 kPa
Required reservoir pressure after 8 brake applications	500/500 kPa	451 kPa
Measured reservoir pressure after 8 brake applications	536/538 kPa	647 kPa

In the menu item "Test acc. to ISO 11992" it is possible to show the messages of the ISO 11992 interface, the bus load and the repetition rate of the messages. The towing vehicle messages are decoded and displayed as text.

In the menu item "Trailer simulation" it is possible to transmit the messages of the trailer for test purposes.

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Gerätetyp : **CTU**  
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#### **4.4 Further tests**

Because of the unchanged components of the CTU and the identical specifications of the pressure sensors the results of the component type approval of November 2001 remain valid unchanged. The results are listed again here below.

##### 4.4.1 Component type approval:

A component type approval was conducted with reference to the "Guideline on the application, design and testing of time measuring devices for determining the response time of certain service braking systems of motor vehicles and trailers"\* BMW/StV7-36.25.25.-05 of 03.03.1976 (VkBl P. 284), where this is still applicable given the present state of the art.

\*Note: Hereinafter called "Guideline".

##### 4.4.1.1 Application in acc. with para. 1 of the Guideline:

The CTU serves to determine, among other things, the response time as a function of the actuation time of the control device. Further testing possibilities going beyond the scope of the aforementioned Guideline are given in section 3 of the present report.

##### 4.4.1.2 Types

The CTU serves to test compressed air braking systems in motor vehicles and trailers

##### 4.4.1.3 Design

With the use of mechanically adequately dimensioned components, microcontroller-based control of the test sequences and of continuous-operation pressure sensors it is ensured that there is ease of handling under the usual operating conditions when testing motor vehicles and trailers.

The CTU fulfils the general requirements for testing devices. The regulations used by the manufacturer are listed in the EC certificate of conformity for the device type CTU 3 HW Version 3 (Article No. 446 310 000 0).

The air reservoir used (LS Ident. No. 132 408) has a CE mark and satisfies EN 286-2, the dimensions satisfy DIN 74 281.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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The CTU is operated using the software supplied. The calibration is supported by the software. The calibration values are stored and safeguarded against unintentional changes.

The mechanically adjustable components (incl. step plate with double contact maker) are safeguarded against unintentional readjustment, provided the operating instructions are followed.

The CTU consists of the components listed in section 3.

The test hoses used (WABCO Product ID No. 893 600 -021 and -022) are made to DIN 74310 .

The use of CTU components makes it possible for the measuring and simulation device to have a practice-based, modular structure.

The interfaces present and the user and evaluation software facilitate easy measurement and evaluation. Connection of additional sensory and measuring instruments (pressure gauge, oscillograph etc.) is possible if needed.

The CTU has an internal voltage stabilisation which allows operation at an unbalanced direct voltage source (e.g. vehicle battery in the range 15 V to 34 V. The operational readiness is signalled by a pilot light (green LED).

To implement other functions (such as undervoltage test) it may be necessary to have a controllable direct voltage source according to WABCO specifications.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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4.4.1.4 Time measuring device, components and requirement:

The CTU is an electronic timer in the meaning of the Guideline.

The time resolution of the internal counter is greater than the 20 ms required by the Guideline. According to function, it is a maximum of 1 ms.

The CTU saves the measuring signals with adequate scanning frequency ( $> 1$  kHz) in electronic memories. The evaluation graphics are displayed on a monitor. The stored signals or evaluated measurements are printed out where necessary on an external printer.

The simulator air reservoir has an air capacity of 30 l (LS Ident. No. 132 408). The necessary valves are all together in a valve block. Other major parts are the pressure sensors DS-4 and DS-5 (WABCO Part No. 441 040 014 0 or 441 044 104 0) used instead of pressure switches and the orifice to determine time characteristics with a bore diameter as determined of 4 mm.

The solenoid valves are controlled and the pressure sensor signals evaluated by the CTU control electronics.

In combination with the specified hoses adherence to the threshold time  $t_{sB}$  of 0.2 s was checked (see para. 4.2 of the Guideline).

In the case of pneumatic control the function of pressure switches (see para. 4.3 of the Guideline) is realised by the pressure sensors mentioned above. After successful calibration following the WABCO calibration instructions it is possible to specify/set the pressure values, i.e. the switching points 0.65 bar or the 10 % and 75 % values of the asymptotic end values are achievable.

The pressure sensors according to the product specification 441 040 014 0 or 441 044 104 0 satisfy after calibration the requirements laid down in the Guideline (see paras. 4.3/4.4) with respect to linearity and limit frequency.

With digital control according to ISO 11992 a corresponding pressure control is realised in accordance with Annex 6, para. 3.4.3 of ECE-R13.

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Gerätetyp : **CTU**  
Hersteller : **WABCO**

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With the use of the electronic pressure sensors the requirement in para. 4.5 of the Guideline for a pressure gauge no longer applies.

The setting of the "pressure limiting valves and pressure controllers" (see para. 4.6 of the Guideline) is possible continuously and is conducted by means of software.

#### 4.4.1.5 Guarantee error limits:

The temperature limits are given in the operating instructions and in the WABCO product specification and cover the required temperature range of  $-10^{\circ}\text{C}$  to  $+35^{\circ}\text{C}$ .

The time measurement is conducted by means of an electronic measurement controlled by a quartz time basis. This ensure reliable adherence to the error limit of 30 ms required by the Guideline.

This high limit frequency of the pressure sensors of 800 Hz ensures adequate response time for measurement at various pressures.

The error limits specified in para. 5.4 of the Guideline for the pressure sensors are observed by regular calibration according to the specifications in the calibration instructions examined.

The stopwatches and pressure switches mentioned in the Guideline are not used in the CTU. This means that the determination of the standard deviations according to para. 5.5 of this Guideline does not apply.

The total error in relation to the sensing of variables which change over time is substantially less, thanks to the use of electronic components, than the total error limit of 40 ms required by the Guideline.



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Gerätetyp : **CTU**  
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#### 4.4.1.6 Component type approval

The component type approval was conducted on specimens presented in November 2001. The components listed in section 3 were available. In addition normal devices (calibrated reference devices) were used for the pressure measurement and to display signals changing over time.

The vehicle-related measurements were conducted on a semi-trailer tractor and a semi-trailer.

The error limits of the individual components were taken from the manufacturer's product specifications and satisfy by a wide margin the values required by the Guideline.

This was demonstrated by manufacturer's test reports.

The maximum possible total error of the CTU is far below the values required by para. 6.3 of the Guideline with the use of sensors and parts with very narrow tolerances.

This was demonstrated by reference measurements with calibrated measuring devices (oscillograph, pressure sensors etc.).

With the CTU the same step plates are used as underwent and passed an RWTÜV component type approval in 1976 and 1989 respectively. A new check was therefore not conducted.

#### 4.4.1.7 Unit test:

Reference is made to conduct of a unit test/ calibration in the operating instructions (see section 3.2 of Annex 1)

Gerätetyp : **CTU**  
Hersteller : **WABCO**

#### 4.5 Electromagnetic compatibility (EMC):

To satisfy the statutory requirements regarding EMC the electronic control unit of the CTU has been tested in accordance with the European Council Directive 2004/108/EC (see section 7.2 in Appendix 1 to this technical report).

#### 5 Annex

1 CTU System Description 815 010 190 3, Version 1 / 06.2012

#### 6 Concluding certification

It is confirmed that the measuring and simulation device described in this technical report satisfies the requirements of the ECE Regulation No. 13, Supplement 8 to the 11 series of amendments (especially Annexes 6 and 17) and the Guideline mentioned in section 4.4.1 of this report.

The "Guideline on the application, design and testing of time measuring devices for determining the response time of certain service braking systems of motor vehicles and trailers" of 03.03.1976 (VkBl P. 284) was taken as a basis for assessing the CTU, to the extent that it still represented the state of the art.

### PRÜFLABORATORIUM / TEST LABORATORY

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A handwritten signature in black ink, appearing to read 'Harder'.

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