



# Economic and Social Council

Distr.: General  
9 December 2013

Original: English

---

## Economic Commission for Europe

Inland Transport Committee

World Forum for Harmonization of Vehicle Regulations

Working Party on Brakes and Running Gear

Seventy-sixth session

Geneva, 17–21 February 2014

Item 10(b) of the provisional agenda

**International Whole Vehicle Approval (IWVTA) –  
Regulation No. 13-H**

### **Proposal for a new Regulation on Brake Assist Systems (BAS)**

**Submitted by the experts from the European Association of Automotive  
Suppliers and the International Organization of Motor Vehicle  
Manufacturers \***

The text reproduced below was prepared by the experts from the European Association of Automotive Suppliers (CLEPA) and the International Organization of Motor Vehicle Manufacturers (OICA).

---

\* In accordance with the programme of work of the Inland Transport Committee for 2010–2014 (ECE/TRANS/208, para. 106, ECE/TRANS/2010/8, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

# I. Proposal

## Regulation No. YY

### Uniform provisions concerning the approval of passenger cars with regard to brake assist systems

#### Contents

*Page*

#### Regulation

1.	Scope.....	
2.	Definitions.....	
3.	Application for approval .....	
4.	Approval .....	
5.	General requirements .....	
6.	Functional requirements .....	
7.	General test requirements .....	
8.	Assessment of the presence of a category "A" BAS .....	
9.	Assessment of the presence of a category "B" BAS.....	
10.	Modification of vehicle type or braking system and extension of approval.....	
11.	Conformity of production.....	
12.	Penalties for non-conformity of production .....	
13.	Production definitely discontinued.....	
14.	Names and addresses of Technical Services responsible for conducting approval tests, and of Administrative Departments .....	

#### Annexes

1	Communication.....	
2	Arrangements of approval marks .....	
3	Method for determination of $F_{ABS}$ and $a_{ABS}$ .....	
4	Data processing for the BAS .....	
[5	Special requirements to be applied to the safety aspects of complex electronic vehicle control systems .....	]

## 1. Scope

- 1.1. This Regulation applies to the approval of vehicles of category M<sub>1</sub> and N<sub>1</sub><sup>1</sup> with regard to their brake assist system.
- 1.2. This Regulation does not cover:
  - 1.2.1. Vehicles with a design speed not exceeding 25 km/h;
  - 1.2.2. Vehicles fitted for invalid drivers.

## 2. Definitions

For the purposes of this Regulation,

- 2.1. "*Approval of a vehicle*" means the approval of a vehicle type with regard to brake assist system.
- 2.2. "*Vehicle type*" means a category of vehicles which do not differ in such essential respects as:
  - 2.2.1. The manufacturer's trade name or mark;
  - 2.2.2. Vehicle features which significantly influence the performances of the Brake Assist System;
  - 2.2.3. The type and design of the Brake Assist System.
- 2.8. "*Maximum mass*" means the maximum mass stated by the vehicle manufacturer to be technically permissible (this mass may be higher than the "permissible maximum mass" laid down by the national administration).
- 2.9. "*The distribution of mass among the axles*" means the distribution of the effect of the gravity on the mass of the vehicle and/or its contents among the axles.
- 2.10. "*Wheel/axle load*" means the vertical static reaction (force) of the road surface in the contact area on the wheel/wheels of the axle.
- 2.12. "*Brake Assist System (BAS)*" means a function of the braking system that deduces an emergency braking event from a characteristic of the driver's brake demand and, under such conditions:
  - (a) Assists the driver to deliver the maximum achievable braking rate; or
  - (b) Is sufficient to cause full cycling of the Anti-lock Braking System.
- 2.12.1. "*Category A Brake Assist System*" means a system which detects an emergency braking condition based primarily<sup>2</sup> on the brake pedal force applied by the driver;
- 2.12.2. "*Category B Brake Assist System*" means a system which detects an emergency braking condition based primarily<sup>2</sup> on the brake pedal speed applied by the driver;

<sup>1</sup> M<sub>1</sub> and N<sub>1</sub> categories of vehicles are defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.2, para. 2

<sup>2</sup> As declared by the vehicle manufacturer.

### **3. Application for approval**

- 3.1. The application for approval of a vehicle type with regard to BAS shall be submitted by the vehicle manufacturer or by their duly accredited representative.
- 3.2. It shall be accompanied by the under-mentioned documents in triplicate and by the following particulars:
  - 3.2.1. A description of the vehicle type with regard to the items specified in paragraph 2.2. above. The numbers and/or symbols identifying the vehicle type and the engine type shall be specified;
  - 3.2.2. A list of the components, duly identified, constituting the BAS system;
  - 3.2.3. A diagram of the assembled BAS system and an indication of the position of its components on the vehicle;
  - 3.2.4. Detailed drawings of each component to enable it to be easily located and identified.
- 3.3. A vehicle, representative of the vehicle type to be approved, shall be submitted to the Technical Service conducting the approval tests.

### **4. Approval**

- 4.1. If the vehicle type submitted for approval pursuant to this Regulation meets the requirements of paragraphs 5. and 6. below, approval of that vehicle type shall be granted.
- 4.2. An approval number shall be assigned to each type approved, its first two digits shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party shall not assign the same number to the same vehicle type equipped with another type of BAS system, or to another vehicle type.
- 4.3. Notice of approval or of refusal of approval of a vehicle type pursuant to this Regulation shall be communicated to the Contracting Parties to the Agreement which apply this Regulation by means of a form conforming to the model in Annex 1 to this Regulation and of a summary of the information contained in the documents referred to in paragraphs 3.2.1. to 3.2.4. above, the drawings supplied by the applicant for approval being in a format not exceeding A4 (210 x 297 mm), or folded to that format, and on an appropriate scale.
- 4.4. There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every vehicle conforming to a vehicle type approved under this Regulation, an international approval mark consisting of:
  - 4.4.1. A circle surrounding the letter "E" followed by the distinguishing number of the country which has granted approval<sup>3</sup>, and of

---

<sup>3</sup> The distinguish numbers of the Contracting Parties to the 1958 Agreement are reproduced in Annex 3 to Consolidated Resolution on the Construction of Vehicles (R.E.3), ECE/TRANS/WP.29/78/Rev.2.

- 4.4.2. The number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle prescribed in paragraph 4.4.1. above.
- 4.5. If the vehicle conforms to a vehicle type approved under one or more other Regulations, annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 4.4.1. above, need not be repeated; in such a case, the Regulation and approval numbers and the additional symbols of all the regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 4.4.1. above.
- 4.6. The approval mark shall be clearly legible and be indelible.
- 4.7. The approval mark shall be placed close to or on the vehicle data plate.
- 4.8. Annex 2 to this Regulation gives examples of arrangements of approval marks.

## **5. General requirements**

- 5.1. Vehicles equipped with a brake assist system shall meet the functional requirements specified in paragraph 6. of this Regulation. Compliance with these requirements shall be demonstrated by meeting the provisions of paragraphs 8. or 9. of this Regulation under the test requirements specified in paragraph 7. of this Regulation. In addition to the requirements of this Regulation, vehicles equipped with a brake assist system shall also be equipped with ABS in accordance with technical requirements of Regulation 13-H.
- 5.2. The BAS shall be so designed, constructed and fitted as to enable the vehicle in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.
- 5.3. In particular, the BAS shall be so designed, constructed and fitted as to be able to resist the corroding and ageing phenomena to which it is exposed.
- 5.4. The effectiveness of the ESC shall not be adversely affected by magnetic or electrical fields. This shall be demonstrated by fulfilling the technical requirements and transitional provisions of Regulation No. 10 by applying:
- (a) the 03 series of amendments for vehicles without a coupling system for charging the REESS (traction batteries).
  - (b) the 04 series of amendments for vehicles with a coupling system for charging the REESS (traction batteries).
- [5.5. The requirements of Annex 6 shall be applied to the safety aspects of electronic brake assist systems.]
- 5.6. Provisions for the periodic technical inspection of brake assist systems
- 5.6.1. It shall be possible at a periodic technical inspection to confirm the correct operational status by visual observation of the warning signals following a power-on.
- 5.6.2. At the time of type approval, the means implemented to protect against simple unauthorized modification of the operation of the warning signals

shall be confidentially outlined. Alternatively, this protection requirement is fulfilled when a secondary means of checking the correct operational status is available.

## **6. Functional requirements**

### **6.1. General performance characteristics for category "A" BAS systems**

When an emergency condition has been sensed by a relative high pedal force, the additional pedal force to cause full cycling of the ABS shall be reduced compared to the pedal force required without the BAS system in operation.

Compliance with this requirement is demonstrated if the provisions of paragraphs 8.1. to 8.3. of this Regulation are met.

### **6.2. General performance characteristics for category "B" BAS systems**

When an emergency condition has been sensed, at least by a very fast application of the pedal, the BAS system shall raise the pressure to deliver the maximum achievable braking rate or cause full cycling of the ABS.

Compliance with this requirement is demonstrated if the provisions of paragraphs 9.1. to 9.3. of this Regulation are met.

## **7. General test requirements**

### **7.1. Variables**

While performing the tests described in this Regulation, the following variables shall be measured:

7.1.1. Brake pedal force,  $F_p$  ;

7.1.2. Vehicle velocity,  $v_x$  ;

7.1.3. Vehicle deceleration,  $a_x$  ;

7.1.4. Brake temperature,  $T_d$  ;

7.1.5. Brake pressure,  $P$ , where applicable;

7.1.6. Brake pedal speed,  $v_p$ , measured at the centre of the pedal plate or at a position on the pedal mechanism where the displacement is proportional to the displacement at the centre of the pedal plate allowing simple calibration of the measurement.

### **7.2. Measuring equipment**

7.2.1. The variables listed in paragraph 7.1. above shall be measured by means of appropriate transducers. Accuracy, operating ranges, filtering techniques, data processing and other requirements are described in ISO Standard 15037-1: 2006.

7.2.2. Accuracy of pedal force and disc temperature measurements shall be as follows:

<i>Variable range system</i>	<i>Typical operating range of the transducers</i>	<i>Recommended maximum recording errors</i>
Pedal force	0 to 2,000 N	±10 N
Brake temperature	0 – 1,000 °C	±5 °C
Brake pressure*	0 – 20 MPa*	±100 kPa*

\* Applicable as specified in paragraph 8.2.5.

7.2.3. Details on analogue and digital data processing of the BAS test procedures are described in Annex 4 to this Regulation. A sampling rate for data acquisition of at least 500 Hz is required.

7.2.4. Alternative measuring methods to those referred to in paragraph 7.2.3. may be allowed, provided they demonstrate at least an equivalent level of precision.

7.3. Test conditions

7.3.1. Test vehicle loading condition: The vehicle shall be unladen. There may be, in addition to the driver, a second person on the front seat who is responsible for noting the results of the tests.

7.3.2. Braking tests shall be carried out on a dry surface affording good adhesion.

7.4. Test method

7.4.1. The tests as described in paragraphs 8. and 9. of this section shall be carried out from a test speed of  $100 \pm 2$  km/h. The vehicle shall be driven at the test speed in a straight line.

7.4.2. The average temperature of the service brakes on the hottest axle of the vehicle, measured inside the brake linings or on the braking path of the disc or drum, shall be between 65 and 100°C prior to any brake application.

7.4.3. For the tests the reference time,  $t_0$ , is defined as the moment when the brake pedal force reaches 20 N.

*Note:* For vehicles equipped with a brake system assisted by an energy source, the applied pedal force necessary depends on the energy level that exists in the energy storage device. Therefore, sufficient energy level shall be ensured at the beginning of the test.

## 8. Assessment of the presence of a category "A" BAS

A category "A" BAS shall meet the test requirements contained in paragraphs 8.1. and 8.2.

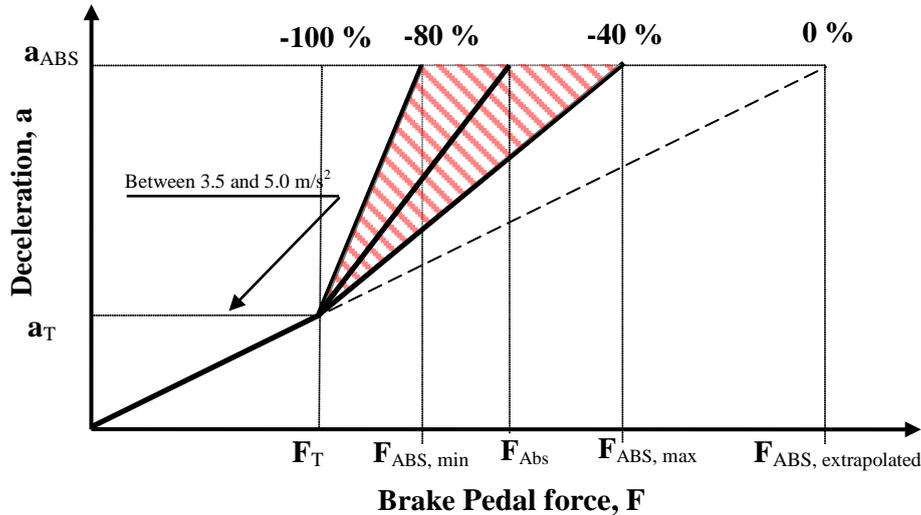
8.1. Test 1: Reference test to determine  $F_{ABS}$  and  $a_{ABS}$ .

8.1.1. The reference values  $F_{ABS}$  and  $a_{ABS}$  shall be determined in accordance with the procedure described in Annex 3 to this Regulation.

8.2. Test 2: For activation of BAS

- 8.2.1. Once an emergency braking condition has been detected, systems sensitive to pedal force shall show a significant increase in the ratio of:
- (a) Brake line pressure to brake pedal force, where permitted by paragraph 8.2.5.; or
  - (b) Vehicle deceleration to brake pedal force.
- 8.2.2. The performance requirements for a category "A" BAS are met if a specific brake application characteristic can be defined that exhibits a decrease of between 40 per cent and 80 per cent in required brake pedal force for  $(F_{ABS} - F_T)$  compared to  $(F_{ABS, extrapolated} - F_T)$ .
- 8.2.3.  $F_T$  and  $a_T$  are threshold force and threshold deceleration as shown in Figure 1. The values of  $F_T$  and  $a_T$  shall be supplied to the Technical Service at the time of submission of the type-approval application. The value of  $a_T$  shall be between  $3.5 \text{ m/s}^2$  and  $5.0 \text{ m/s}^2$ .

Figure 1a  
**Pedal force characteristic needed in order to achieve maximum deceleration with category "A" BAS**



- 8.2.4. A straight line is drawn from the origin through the point  $F_T, a_T$  (as shown in Figure 1a). The value of brake pedal force "F", at the point of intersection between this line and a horizontal line defined by  $a=a_{ABS}$ , is defined as  $F_{ABS, extrapolated}$ :

$$F_{ABS, extrapolated} = \frac{F_T \cdot a_{ABS}}{a_T}$$

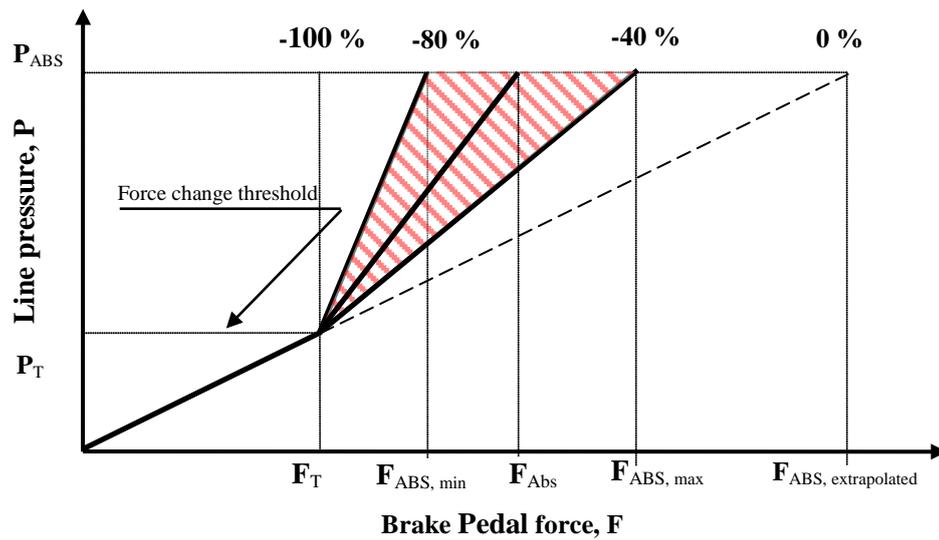
- 8.2.5. As an alternative, which can be selected by the manufacturer, in the case of vehicles of category  $N_1$ , or  $M_1$  derived from those  $N_1$  vehicles, with a gross vehicle mass  $GVM > 2,500 \text{ kg}$ , the pedal force figures for  $F_T, F_{ABS, min}, F_{ABS, max}$  and  $F_{AB, extrapolated}$  may be derived from the brake line pressure response characteristic instead of the vehicle deceleration characteristic. This shall be measured as the brake pedal force is increasing.
- 8.2.5.1. The pressure, at which ABS cycling commences, shall be determined by making five tests from  $100 \pm 2 \text{ km/h}$  in which the brake pedal is applied up to the level which produces ABS operation and the five pressures at which this

occurs as determined from front wheel pressure records, shall be recorded and the mean value obtained as  $P_{ABS}$ .

- 8.2.5.2. The threshold pressure  $P_T$  shall be stated by the manufacturer and correspond to a deceleration in the range of 2.5 - 4.5 m/s<sup>2</sup>.
- 8.2.5.3. Figure 1b shall be constructed in the manner set out in paragraph 8.2.4., but using line pressure measurements to define the parameters set out in paragraph 8.2.5. of this Regulation where:

$$F_{ABS, \text{extrapolated}} = \frac{F_T \cdot P_{ABS}}{P_T}$$

Figure 1b  
Pedal force characteristic needed in order to achieve maximum deceleration with category "A" BAS



- 8.3. Data evaluation  
The presence of a category "A" BAS is proven if

$$F_{ABS, \text{min}} \leq F_{ABS} \leq F_{ABS, \text{max}}$$

where:

$$F_{ABS, \text{max}} - F_T \leq (F_{ABS, \text{extrapolated}} - F_T) \cdot 0.6$$

and

$$F_{ABS, \text{min}} - F_T \geq (F_{ABS, \text{extrapolated}} - F_T) \cdot 0.2$$

## 9. Assessment of the presence of a category "B" BAS

A category "B" BAS shall meet the test requirements contained within paragraphs 9.1. and 9.2. of this section.

- 9.1. Test 1: Reference test to determine  $F_{ABS}$  and  $a_{ABS}$ .
- 9.1.1. The reference values  $F_{ABS}$  and  $a_{ABS}$  shall be determined in accordance with the procedure described in Annex 3 to this Regulation.

9.2. Test 2: For activation of BAS

The vehicle shall be driven in a straight line at the test speed specified in paragraph 7.4. of this Regulation. The driver shall apply the brake pedal quickly according to Figure 2, simulating emergency braking so that BAS is activated and ABS is fully cycling.

In order to activate BAS the brake pedal shall be applied as specified by the car manufacturer. The manufacturer shall notify the Technical Service of the required brake pedal input at the time of submission of the application for type-approval. It shall be demonstrated to the satisfaction of the Technical Service that the BAS activates under the conditions specified by the manufacturer in accordance with paragraph 16.1.1. or 16.1.2 of Annex 1.

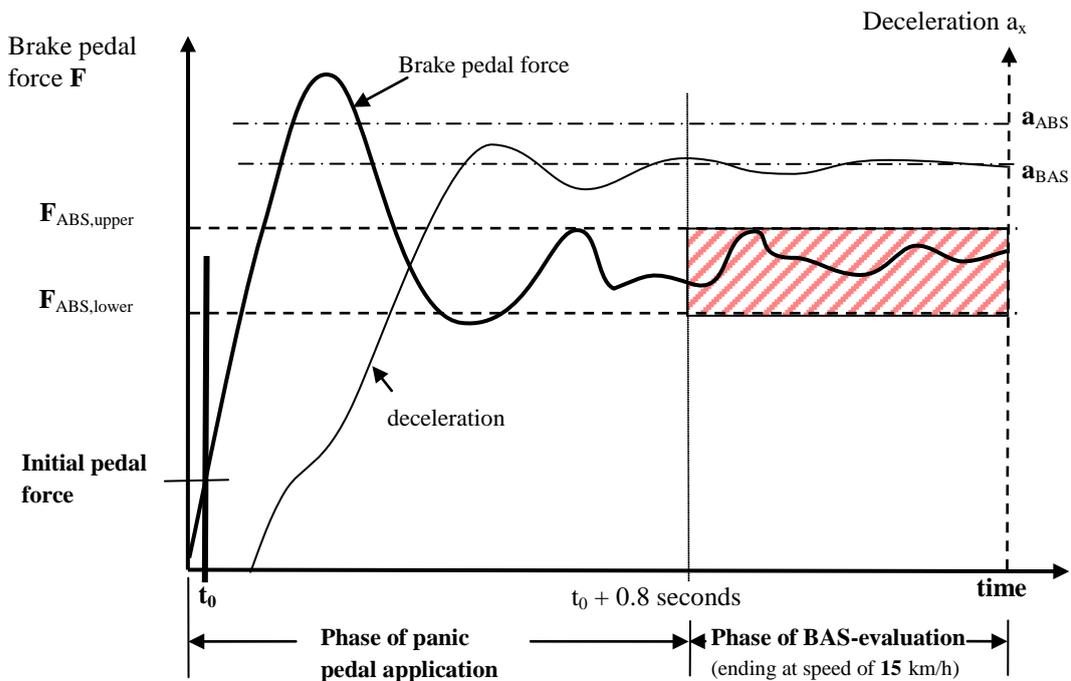
After  $t = t_0 + 0.8$  s and until the vehicle has slowed down to a speed of 15 km/h, the brake pedal force shall be maintained in a corridor between  $F_{ABS, upper}$  and  $F_{ABS, lower}$ , where  $F_{ABS, upper}$  is  $0.7 F_{ABS}$  and  $F_{ABS, lower}$  is  $0.5 F_{ABS}$ .

The requirements are also considered to be met if, after  $t = t_0 + 0.8$  s, the pedal force falls below  $F_{ABS, lower}$  provided the requirement of paragraph 9.3. is fulfilled.

9.3. Data evaluation

The presence of BAS 'B' is demonstrated if a mean deceleration ( $a_{BAS}$ ) of at least  $0.85 \cdot a_{ABS}$  is maintained from the time when  $t = t_0 + 0.8$  s to the time when the vehicle speed has been reduced to 15 km/h.

Figure 2  
Example of test 2 of a category "B" BAS system



## **10. Modification of vehicle type or BAS and extension of approval**

10.1. Every modification to an existing vehicle type shall be notified to the administrative department which approved the vehicle type.

The department shall then either:

- (a) decide, in consultation with the manufacturer, that a new type-approval is to be granted; or
- (b) apply the procedure contained in paragraph 10.1.1. (Revision) and, if applicable, the procedure contained in paragraph 10.1.2. (Extension).

10.1.1. Revision

When particulars recorded in the information documents have changed and the administrative department considers that the modifications made are unlikely to have appreciable adverse effects and that in any case the foot controls still meet the requirements, the modification shall be designated a "revision".

In such a case, the administrative department shall issue the revised pages of the information documents as necessary, marking each revised page to show clearly the nature of the modification and the date of re-issue. A consolidated, updated version of the information documents, accompanied by a detailed description of the modification, shall be deemed to meet this requirement.

10.1.2. Extension

The modification shall be designated an "extension" if, in addition to the change of the particulars recorded in the information documents,

- (a) further inspections or tests are required, or
- (b) any information on the communication document (with the exception of its attachments) has changed, or
- (c) approval to a later series of amendments is requested after its entry into force.

10.2. Confirmation or refusal of approval, specifying the alteration, shall be communicated by the procedure specified in paragraph 4.3. above to the Contracting Parties to the Agreement applying this Regulation. In addition, the index to the information documents and to the test reports, attached to the communication document of Annex 1, shall be amended accordingly to show the date of the most recent revision or extension.

10.3. The competent authority issuing the extension of approval shall assign a serial number to each communication form drawn up for such an extension."

## **11. Conformity of production**

The conformity of production procedures shall comply with those set out in the Agreement, Appendix 2 (E/ECE/324-E/ECE/TRANS/505/Rev.2) with the following requirements:

11.1. A vehicle approved to this Regulation shall be so manufactured as to conform to the type approved by meeting the requirements set forth in paragraphs 5. and 6. above.

- 11.2. The authority which has granted type approval may at any time verify the conformity control methods applied in each production facility. The normal frequency of these verifications shall be once every two years.

## **12. Penalties for non-conformity of production**

- 12.1. The approval granted in respect of a vehicle type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 11.1. above are not complied with.
- 12.2. If a Contracting Party to the Agreement which applies this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation by means of a copy of the communication form conforming to the model in Annex 1 to this Regulation.

## **13. Production definitely discontinued**

If the holder of the approval completely ceases to manufacture a type of vehicle approved in accordance with this Regulation, they shall so inform the authority which granted the approval. Upon receiving the relevant communication, that authority shall inform thereof the other Contracting Parties to the Agreement applying this Regulation by means of copies of a communication form conforming to the model in Annex 1 to this Regulation.

## **14. Names and addresses of the Technical Services conducting approval tests, and of administrative departments**

The Contracting Parties to the Agreement applying this Regulation shall communicate to the United Nations secretariat the names and addresses of the Technical Services responsible for conducting approval tests and of the Administrative Departments which grant approval and to which forms, certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

# Annex 1

## Communication

(Maximum format: A4 (210 x 297 mm))



issued by :

Name of administration:

.....  
 .....  
 .....

- concerning<sup>2</sup>:
- APPROVAL GRANTED
  - APPROVAL EXTENDED
  - APPROVAL REFUSED
  - APPROVAL WITHDRAWN
  - PRODUCTION DEFINITELY DISCONTINUED

of a vehicle type with regard to BAS, pursuant to Regulation No. YY

Approval No. . . . . Extension No. . . . .

1. Trade name or mark of the vehicle .....
2. Vehicle type .....
3. Manufacturer's name and address .....
4. If applicable, name and address of manufacturer's representative .....
5. Mass of vehicle .....
- 5.1. Maximum mass of vehicle .....
- 5.2. Minimum mass of vehicle .....
6. Distribution of mass of each axle (maximum value) .....
8. Engine type .....
9. Number and ratios of gears .....
10. Final drive ratio(s) .....
11. If applicable, maximum mass of trailer which may be coupled .....
- 11.1. Unbraked trailer .....

<sup>1</sup> Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see provisions in the Regulation).

<sup>2</sup> Strike out what does not apply.

- 12. Tyre dimension .....
- 13. Maximum design speed .....
- 14. Brief description of braking equipment .....
- 15. Mass of vehicle when tested: .....

	<b>Load</b> (kg)
Axle No. 1	
Axle No. 2	
Total	

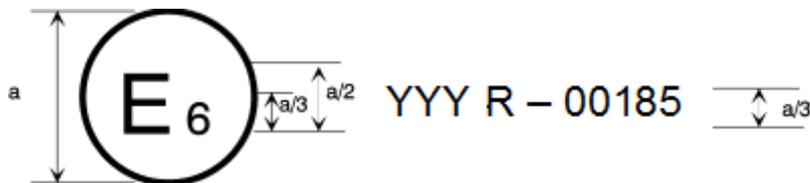
- 16.1. Category of Brake Assist System A / B<sup>2</sup>
- 16.1.1. For category A systems, define the force threshold at which the ratio between pedal force and brake pressure increases<sup>2</sup>; .....
- 16.1.2. For category B systems, define the brake pedal speed which must be achieved in order to activate the Brake Assist System (e.g. pedal stroke speed (mm/s) during a given time interval)<sup>2</sup>; .....
- [17. Adequate documentation according to Annex 6 was supplied in respect of the BAS system(s): ..... Yes / No / Not applicable<sup>2</sup>]
- 18. Vehicle is equipped with ABS in accordance with technical requirements of Regulation No.13-H ..... Yes / No<sup>2</sup>
- 19. Vehicle submitted for approval on .....
- 20. Technical Service responsible for conducting approval .....
- 21. Date of report issued by that Service .....
- 22. Number of report issued by that Service .....
- 23. Approval granted / refused / extended / withdrawn<sup>2</sup>
- 24. Position of approval mark on the vehicle.....
- 25. Place.....
- 26. Date.....
- 27. Signature .....
- 28. The summary referred to in paragraph 4.3. of this Regulation is annexed to this communication

## Annex 2

### Arrangements of approval marks

Model A

(See paragraph 4.4. of this Regulation)

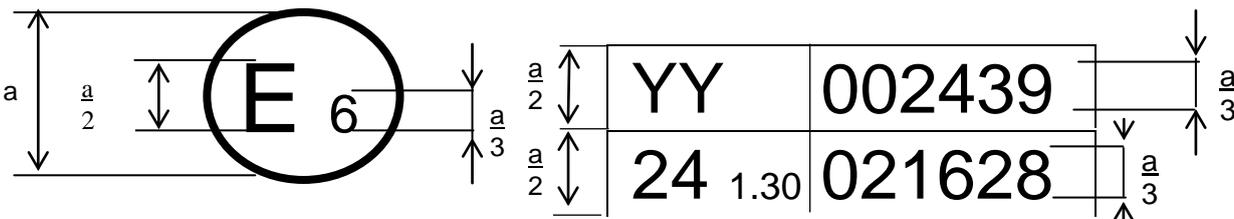


$a = 8 \text{ mm min.}$

The above approval mark affixed to a vehicle shows that the vehicle type concerned has been approved in Belgium (E 6) with regard to the Brake Assist System pursuant to Regulation No. YYY. The first two digits of the approval number indicate that the approval was granted in accordance with the requirements of Regulation No. YYY in its original form.

Model B

(See paragraph 4.5. of this Regulation)



$a = 8 \text{ mm min.}$

The above approval mark affixed to a vehicle shows that the vehicle type concerned has been approved in Belgium (E 6) pursuant to Regulations Nos. YY and 241. (In the case of the latter Regulation the corrected absorption coefficient is 1.30 m<sup>-1</sup>). The approval numbers indicate that, at the dates when the respective approvals were given, Regulation No. YY was in its original form and Regulation No. 24 included the 02 series of amendments.

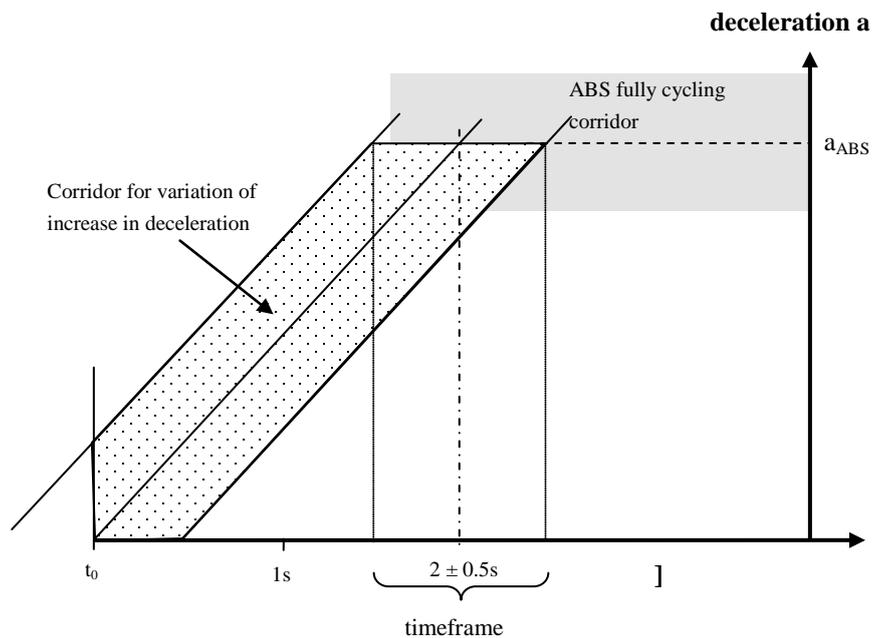
<sup>1</sup> This number is given merely as an example.

### Annex 3

#### Method for determination of $F_{ABS}$ and $a_{ABS}$

- 1.1. The brake pedal force  $F_{ABS}$  is the minimum pedal force that has to be applied for a given vehicle in order to achieve maximum deceleration which indicates that ABS is fully cycling.  $a_{ABS}$  is the deceleration for a given vehicle during ABS deceleration as defined in paragraph 1.8.
- 1.2. The brake pedal shall be applied slowly (without activating the BAS in the case of category B systems) providing a constant increase of deceleration until ABS is fully cycling (Figure 3).
- 1.3. The full deceleration must be reached within the timeframe of  $2.0 \pm 0.5$  s. The deceleration curve, recorded against time, must be within a corridor of  $\pm 0.5$  s around the centre line of the deceleration curve corridor. The example in Figure 3 has its origin at the time  $t_0$  crossing the  $a_{ABS}$  line 2 seconds. Once full deceleration has been achieved, the brake pedal shall be operated so that the ABS continues fully cycling. The time of full activation of the ABS system is defined as the time when pedal force  $F_{ABS}$  is achieved. The measurement shall be within the corridor for variation of increase in deceleration (see Figure 3).

Figure 3  
Deceleration corridor for determination of  $F_{ABS}$  and  $a_{ABS}$



- 1.4. Five tests meeting the requirements of paragraph 1.3. shall be carried out. For each of these valid tests the vehicle deceleration shall be plotted as a function of the recorded brake pedal force. Only data recorded at speeds above 15 km/h shall be taken for the calculations described in the following paragraphs.
- 1.5. For the determination of  $a_{ABS}$  and  $F_{ABS}$ , a low pass filter of 2 Hz for vehicle deceleration as well as pedal force shall be applied.
- 1.6. The five individual "deceleration versus brake pedal force" curves are averaged by calculating the mean deceleration of the five individual "deceleration vs. brake pedal force" curves at increments of 1 N pedal force. The result is the mean deceleration versus brake pedal force curve, which will be referred to as the "maF curve" in this annex.
- 1.7. The maximum value for the vehicle deceleration is determined from the "maF curve" and is named as " $a_{max}$ ".
- 1.8. All values of the "maF curve" that are above 90 per cent of this deceleration value " $a_{max}$ " are averaged. This value of "a" is the deceleration " $a_{ABS}$ " referred to in this Regulation.
- 1.9. The minimum force on the pedal ( $F_{ABS}$ ) sufficient to achieve the deceleration  $a_{ABS}$  is defined as the value of F corresponding to  $a = a_{ABS}$  on the maF curve.

## Annex 4

### Data processing for the BAS

(see paragraph 7.2.3. of this Regulation)

1. Analogue data processing

The bandwidth of the entire, combined transducer/recording system shall be no less than 30 Hz.

In order to execute the necessary filtering of signals, low-pass filters with order 4 or higher shall be employed. The width of the pass band (from 0 Hz to frequency  $f_0$  at -3 dB) shall not be less than 30 Hz. Amplitude errors shall be less than  $\pm 0.5$  per cent in the relevant frequency range of 0 Hz to 30 Hz. All analogue signals shall be processed with filters having sufficiently similar phase characteristics to ensure that time delay differences due to filtering lie within the required accuracy for time measurement.

*Note:* During analogue filtering of signals with different frequency contents, phase shifts can occur. Therefore, a data processing method, as described in paragraph 2. of this appendix, is preferable.

2. Digital data processing

2.1. General consideration

Preparation of analogue signals includes consideration of filter amplitude attenuation and sampling rate to avoid aliasing errors, and filter phase lags and time delays. Sampling and digitizing considerations include pre-sampling amplification of signals to minimize digitizing errors; number of bits per sample; number of samples per cycle; sample and hold amplifiers; and time-wise spacing of samples. Considerations for additional phaseless digital filtering include selection of pass bands and stop bands and the attenuation and allowable ripple in each; and correction of filter phase lags. Each of these factors shall be considered in order to achieve a relative overall data acquisition accuracy of  $\pm 0.5$  per cent.

2.2. Aliasing errors

In order to avoid uncorrectable aliasing errors, the analogue signals shall be appropriately filtered before sampling and digitizing. The order of the filters used and their pass band shall be chosen according to both the required flatness in the relevant frequency range and the sampling rate.

The minimum filter characteristics and sampling rate shall be such that:

- (a) Within the relevant frequency range of 0 Hz to  $f_{\max} = 30$  Hz the attenuation is less than the resolution of the data acquisition system; and
- (b) At one-half the sampling rate (i.e. the Nyquist or "folding" frequency) the magnitudes of all frequency components of signal and noise are reduced to less than the system resolution.

For 0.05 per cent resolution the filter attenuation shall be less than 0.05 per cent in the frequency range between 0 and 30 Hz, and the attenuation shall be

greater than 99.95 per cent at all frequencies greater than one-half the sampling frequency.

*Note:* For a Butterworth filter the attenuation is given by:

$$A^2 = \frac{1}{1 + \left(\frac{f_{\max}}{f_0}\right)^{2n}} \quad \text{and} \quad A^2 = \frac{1}{1 + \left(\frac{f_N}{f_0}\right)^{2n}}$$

where:

n is the order to filter;

$f_{\max}$  is the relevant frequency range (30 Hz);

$f_0$  is the filter cut-off frequency;

$f_N$  is the Nyquist or "folding" frequency.

For a fourth order filter

for  $A = 0.9995$ :  $f_0 = 2.37 \cdot f_{\max}$

for  $A = 0.0005$ :  $f_s = 2 \cdot (6.69 \cdot f_0)$ , where  $f_s$  is the sampling frequency  $= 2 \cdot f_N$ .

### 2.3. Filter phase shifts and time delays for anti-aliasing filtering

Excessive analogue filtering shall be avoided, and all filters shall have sufficiently similar phase characteristics to ensure that time delay differences are within the required accuracy for the time measurement. Phase shifts are especially significant when measured variables are multiplied together to form new variables, because while amplitudes multiply, phase shifts and associated time delays add. Phase shifts and time delays are reduced by increasing  $f_0$ . Whenever equations describing the pre-sampling filters are known, it is practical to remove their phase shifts and time delays by simple algorithms performed in the frequency domain.

*Note:* In the frequency range in which the filter amplitude characteristics remain flat, the phase shift  $\Phi$  of a Butterworth filter can be approximated by

$$\Phi = 81 \cdot (f/f_0) \text{ degrees for second order}$$

$$\Phi = 150 \cdot (f/f_0) \text{ degrees for fourth order}$$

$$\Phi = 294 \cdot (f/f_0) \text{ degrees for eighth order}$$

The time delay for all filter orders is:  $t = (\Phi/360) \cdot (1/f_0)$

### 2.4. Data sampling and digitizing

At 30 Hz the signal amplitude changes by up to 18 per cent per millisecond. To limit dynamic errors caused by changing analogue inputs to 0.1 per cent, sampling or digitizing time shall be less than 32  $\mu$ s. All pairs or sets of data samples to be compared shall be taken simultaneously or over a sufficiently short time period.

### 2.5. System requirements

The data system shall have a resolution of 12 bits ( $\pm 0.05$  per cent) or more and an accuracy of  $\pm 0.1$  per cent (2 lbs). Anti-aliasing filters shall be of order 4 or higher and the relevant data range  $f_{\max}$  shall be 0 Hz to 30 Hz.

For fourth order filters the pass-band frequency  $f_o$  (from 0 Hz to frequency  $f_o$ ) shall be greater than  $2.37 \cdot f_{\max}$  if phase errors are subsequently adjusted in digital data processing, and greater than  $5 \cdot f_{\max}$  otherwise. For fourth order filters the data sampling frequency  $f_s$  shall be greater than  $13.4 \cdot f_o$ .

## [Annex 6

## Special requirements to be applied to the safety aspects of complex electronic vehicle control systems

### 1. General

This annex defines the special requirements for documentation, fault strategy and verification with respect to the safety aspects of Complex Electronic Vehicle Control Systems (definition 2.3. below) as far as this Regulation is concerned.

This annex may also be called, by special paragraphs in this Regulation, for safety related functions which are controlled by electronic system(s).

This annex does not specify the performance criteria for "The System" but covers the methodology applied to the design process and the information which must be disclosed to the Technical Service, for type approval purposes.

This information shall show that "The System" respects, under normal and fault conditions, all the appropriate performance requirements specified elsewhere in this Regulation.

### 2. Definitions

For the purposes of this annex,

- 2.1. "*Safety concept*" is a description of the measures designed into the system, for example within the electronic units, so as to address system integrity and thereby ensure safe operation even in the event of an electrical failure.

The possibility of a fall-back to partial operation or even to a back-up system for vital vehicle functions may be a part of the safety concept.

- 2.2. "*Electronic control system*" means a combination of units, designed to cooperate in the production of the stated vehicle control function by electronic data processing.

Such systems, often controlled by software, are built from discrete functional components such as sensors, electronic control units and actuators and connected by transmission links. They may include mechanical, electro-pneumatic or electro-hydraulic elements.

"*The System*", referred to herein, is the one for which type approval is being sought.

- 2.3. "*Complex electronic vehicle control systems*" are those electronic control systems which are subject to a hierarchy of control in which a controlled function may be over-ridden by a higher level electronic control system/function.

A function which is over-ridden becomes part of the complex system.

- 2.4. "*Higher-level control*" systems/functions are those which employ additional processing and/or sensing provisions to modify vehicle behaviour by commanding variations in the normal function(s) of the vehicle control system.

This allows complex systems to automatically change their objectives with a priority which depends on the sensed circumstances.

- 2.5. "Units" are the smallest divisions of system components which will be considered in this annex, since these combinations of components will be treated as single entities for purposes of identification, analysis or replacement.
- "Transmission links" are the means used for inter-connecting distributed units for the purpose of conveying signals, operating data or an energy supply.
- This equipment is generally electrical but may, in some part, be mechanical, pneumatic, hydraulic or optical.
- 2.7. "Range of control" refers to an output variable and defines the range over which the system is likely to exercise control.
- 2.8. "Boundary of functional operation" defines the boundaries of the external physical limits within which the system is able to maintain control.
3. Documentation
- 3.1. Requirements
- The manufacturer shall provide a documentation package which gives access to the basic design of "The System" and the means by which it is linked to other vehicle systems or by which it directly controls output variables.
- The function(s) of "The System" and the safety concept, as laid down by the manufacturer, shall be explained.
- Documentation shall be brief, yet provide evidence that the design and development has had the benefit of expertise from all the system fields which are involved.
- For periodic technical inspections, the documentation shall describe how the current operational status of "The System" can be checked.
- 3.1.1. Documentation shall be made available in 2 parts:
- (a) The formal documentation package for the approval, containing the material listed in Section 3 (with the exception of that of paragraph 3.4.4.) which shall be supplied to the technical service at the time of submission of the type approval application. This will be taken as the basic reference for the verification process set out in paragraph 4. of this annex;
- (b) Additional material and analysis data of paragraph 3.4.4., which shall be retained by the manufacturer, but made open for inspection at the time of type approval.
- 3.2. Description of the functions of "The System"
- A description shall be provided which gives a simple explanation of all the control functions of "The System" and the methods employed to achieve the objectives, including a statement of the mechanism(s) by which control is exercised.
- 3.2.1. A list of all input and sensed variables shall be provided and the working range of these defined.
- 3.2.2. A list of all output variables which are controlled by "The System" shall be provided and an indication given, in each case, of whether the control is direct or via another vehicle system. The range of control (paragraph 2.7.) exercised on each such variable shall be defined.

- 3.2.3. Limits defining the boundaries of functional operation (paragraph 2.8.) shall be stated where appropriate to system performance.
- 3.3. System layout and schematics
- 3.3.1. Inventory of components
- A list shall be provided, collating all the units of "The System" and mentioning the other vehicle systems which are needed to achieve the control function in question.
- An outline schematic showing these units in combination, shall be provided with both the equipment distribution and the interconnections made clear.
- 3.3.2. Functions of the units
- The function of each unit of "The System" shall be outlined and the signals linking it with other Units or with other vehicle systems shall be shown. This may be provided by a labelled block diagram or other schematic, or by a description aided by such a diagram.
- 3.3.3. Interconnections
- Interconnections within "The System" shall be shown by a circuit diagram for the electrical transmission links, by an optical-fiber diagram for optical links, by a piping diagram for pneumatic or hydraulic transmission equipment and by a simplified diagrammatic layout for mechanical linkages.
- 3.3.4. Signal flow and priorities
- There shall be a clear correspondence between these transmission links and the signals carried between units.
- Priorities of signals on multiplexed data paths shall be stated, wherever priority may be an issue affecting performance or safety as far as this Regulation is concerned.
- 3.3.5. Identification of units
- Each unit shall be clearly and unambiguously identifiable (e.g. by marking for hardware and marking or software output for software content) to provide corresponding hardware and documentation association.
- Where functions are combined within a single Unit or indeed within a single computer, but shown in multiple blocks in the block diagram for clarity and ease of explanation, only a single hardware identification marking shall be used.
- The manufacturer shall, by the use of this identification, affirm that the equipment supplied conforms to the corresponding document.
- 3.3.5.1. The identification defines the hardware and software version and, where the latter changes such as to alter the function of the unit as far as this Regulation is concerned, this identification shall also be changed.

- 3.4. Safety concept of the manufacturer
- 3.4.1. The manufacturer shall provide a statement which affirms that the strategy chosen to achieve "The System" objectives will not, under non-fault conditions, prejudice the safe operation of systems which are subject to the prescriptions of this Regulation.
- 3.4.2. In respect of software employed in "The System", the outline architecture shall be explained and the design methods and tools used shall be identified. The manufacturer shall be prepared, if required, to show some evidence of the means by which they determined the realisation of the system logic, during the design and development process.
- 3.4.3. The Manufacturer shall provide the technical authorities with an explanation of the design provisions built into "The System" so as to generate safe operation under fault conditions. Possible design provisions for failure in "The System" are for example:
- (a) Fall-back to operation using a partial system;
  - (b) Change-over to a separate back-up system;
  - (c) Removal of the high level function.
- In case of a failure, the driver shall be warned for example by warning signal or message display. When the system is not deactivated by the driver, e.g. by turning the Ignition (run) switch to "off", or by switching off that particular function if a special switch is provided for that purpose, the warning shall be present as long as the fault condition persists.
- 3.4.3.1. If the chosen provision selects a partial performance mode of operation under certain fault conditions, then these conditions shall be stated and the resulting limits of effectiveness defined.
- 3.4.3.2. If the chosen provision selects a second (back-up) means to realise the vehicle control system objective, the principles of the change-over mechanism, the logic and level of redundancy and any built in back-up checking features shall be explained and the resulting limits of back-up effectiveness defined.
- 3.4.3.3. If the chosen provision selects the removal of the higher level function, all the corresponding output control signals associated with this function shall be inhibited, and in such a manner as to limit the transition disturbance.
- 3.4.4. The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any one of those specified faults which will have a bearing on vehicle control performance or safety.
- This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety considerations.
- The chosen analytical approach(es) shall be established and maintained by the manufacturer and shall be made open for inspection by the technical service at the time of the type approval.

- 3.4.4.1. This documentation shall itemise the parameters being monitored and shall set out, for each fault condition of the type defined in paragraph 3.4.4. above, the warning signal to be given to the driver and/or to service/technical inspection personnel.
4. Verification and test
- 4.1. The functional operation of "The System", as laid out in the documents required in paragraph 3., shall be tested as follows:
- 4.1.1. Verification of the function of "The System"
- As the means of establishing the normal operational levels, verification of the performance of the vehicle system under non-fault conditions shall be conducted against the manufacturer's basic benchmark specification unless this is subject to a specified performance test as part of the approval procedure of this or another Regulation.
- 4.1.2. Verification of the safety concept of paragraph 3.4.
- The reaction of "The System" shall, at the discretion of the type approval authority, be checked under the influence of a failure in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal faults within the unit.
- The verification results shall correspond with the documented summary of the failure analysis, to a level of overall effect such that the safety concept and execution are confirmed as being adequate.]

## II. Justification

The secretariat distributes GRRF-75-14 with an official symbol

---