Transmitted by the expert from
the European Commission (EC)

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Introduction of Brake Assist Systems to Regulation No. 13-H

The text proposed below modifies ECE Regulation No. 13-H to introduce specifications for Brake Assist Systems where fitted.

A. Proposed Amendments to ECE Regulation No. 13-H

Insert new item 5.2.10

5.2.10 In the event of failure in any part of the Brake Assist System (as defined in Annex 6) the prescribed service brake performance and brake distribution shall be guaranteed

After Paragraph 2.23 insert a new paragraph 2.24 as follows

'2.24**.** "Brake Assist System (BAS)" means a system which supports the driver in building up vehicle deceleration when the brake pedal is operated with an emergency characteristic. There are three categories of Brake Assist System:

2.24.1 "Category A Brake Assist System" means a system which detects an emergency braking condition based on the brake pedal force applied by the driver.

2.24.2 "Category B Brake Assist System" means a system which detects an emergency braking condition based on the rate at which the brake pedal is applied.

2.24.3 "Category C Brake Assist System" means a system which detects an emergency braking condition based on multiple criteria, one of which must be the rate at which the brake pedal is applied.'

Annex 1

Insert a new item 22 to read

'22. The vehicle is/is not fitted with a Brake Assist System meeting the requirements of Annex 10. 2/

22.1 category of Brake Assist System A/B/C 2/

22.1.1 for category A systems, define the force threshold at which the ratio between pedal force and brake pressure increases

22.1.2 for category B systems, define the brake pedal speed which must be achieved in order to activate the Brake Assist System (e.g. pedal speed during a given time interval)

22.1.3 For category C systems define the input variables affecting the decision to activate the Brake Assist System, the relationship between them and the pedal application required to activate the Brake Assist System for the tests described in Annex 9. 2/'

Items 22 to 31 (former), renumber as items 22 to 32.

Insert a new Annex 10 as follows:

‘**Annex 10**

SPECIAL REQUIREMENTS TO BE APPLIED TO BRAKE ASSIST SYSTEMS, WHERE FITTED

1. GENERAL

This Annex specifies test requirements for Brake Assist Systems, as defined in Paragraph 2.24 of this Regulation where fitted. [to a vehicle within the scope of this Regulation.]

In addition to the requirements of this Annex, Brake Assist Systems shall also be subject to any relevant requirements contained elsewhere within this Regulation.

1.1 GENERAL PERFORMANCE CHARACTERISTICS FOR CATEGORY 'A' BAS SYSTEMS

When an emergency condition has been sensed, the required braking force to achieve a specific vehicle deceleration shall be reduced by between 40 % and 80% compared to the braking force required without the BAS system in operation.

Compliance with this requirement is demonstrated if the provisions of paragraphs 3.1 to 3.3 of this annex are met.

1.2 GENERAL PERFORMANCE CHARACTERISTICS FOR CATEGORY 'B' AND CATEGORY 'C ' BAS SYSTEMS

When an emergency condition has been sensed, a vehicle deceleration of at least 85% of the maximum ABS braking deceleration shall be maintained under constant pedal force during the period from 0.8 seconds after the initial application of the pedal force until the vehicle speed reduces to 10km/h .

Compliance with this requirement is demonstrated if the provisions of paragraphs 4.1 to 4.3 of this annex are met.

2. GENERAL TEST REQUIREMENTS

2.1. VARIABLES

Whilst performing the tests described in this Annex, the following variables shall be measured:

2.1.1. brake pedal force, F_p, applied at the centre of the brake pedal plate following a tangential arc to the brake pedal pivot.

2.1.2. vehicle longitudinal velocity, v_x (ISO Standard 8855:1991).

2.1.3. vehicle longitudinal acceleration, a_x (ISO Standard 8855:1991)

2.1.4. brake temperature, T_d, measured on the braking path of the disc or drum of the front brakes.

2.1.5 brake pedal travel, [S_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.

2.2. MEASURING EQUIPMENT

2.2.1. The variables listed in paragraph 2.1 of this Annex shall be measured by means of appropriate transducers. Accuracy, operating ranges, filtering techniques, data processing and other requirements are described in ISO Standard 15037-1:1998.

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

Variable range system	**Typical operating range of the transducers**	**Recommended maximum recording errors**
Pedal force	0 to 2,000 N	± 10 N
Brake disc temperature	0 – 1,000°C	± 5°C

2.2.3. A sampling rate for data acquisition of at least 500Hz is required.

2.2.4 Further details on analogue and digital data processing of the BAS test procedures are described in Appendix 2 to this Annex.

2.3. TEST CONDITIONS

2.3.1. Test track: The requirements for test track and weather conditions are described in ISO Standard 15037-1:1998.The test track surface should have a nominal coefficient of friction of 0.8.

2.3.2. Test vehicle tyres: The specification of test tyres and their warm up are described in ISO Standard 15037-1:1998.

2.3.3. Test vehicle loading condition: The loading conditions of the vehicle are described in ISO Standard 15037-1:1998.

2.4. TEST METHOD

2.4.1. The tests as described in paragraphs 3 and 4 below shall be carried out from a test speed of 100 ± 2 km/h. The vehicle shall be driven at the test speed in a straight line.

2.4.2. The average temperature of the front brakes shall be measured, in accordance with paragraph 2.1.4., and recorded before each test and shall lie between 65°C and 100°C prior to any test.

2.4.3. The braking tests shall be performed on a dry asphalt test track in accordance with ISO Standard 15037-1:1998.

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

Note: For vehicles equipped with a vacuum booster the applied brake pedal force necessary depends on the vacuum level that exists in the vacuum brake booster. Therefore, a sufficient vacuum shall be ensured at the beginning of a braking test.

3. ASSESSMENT OF THE PRESENCE OF A CATEGORY ‘A’ BAS

A Category 'A' BAS shall meet the test requirements contained in paragraphs 3.1 and 3.2.

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

3.1.1. The reference values F_{ABS} and a_{ABS} shall be determined in accordance with the procedure described in Appendix 1 to this Annex.

3.2. Test 2: For activation of BAS

3.2.1. Systems sensitive to pedal force shall show a significant increase in the ratio of brake pedal force to vehicle deceleration once an emergency braking condition has been detected.

3.2.2. 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% and [80%] in required brake pedal force for ($F_{ABS\ extrapolated}$ - F_T) compared to (F_{ABS} - F_T).

3.2.3 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 3.5m/s² and 5.0m/s².

3.2.4 A straight line is drawn from the origin through the point F_T, a_T (as shown in Figure 1).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 $F_{ABS,\ extrapolated}$:

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

3.3. Data evaluation

The presence of a Category 'A' BAS is proven if

$$F_{ABS,min} \le F_{ABS} \le F_{ABS,max}$$

Where,

$$F_{ABS,max} - F_T \le \left(F_{ABS,extrapolated} - F_T\right) \times 0.6$$

and

$$F_{ABS,min} - F_T \ge \left(F_{ABS,extrapolated} - F_T\right) \times [0.2]$$

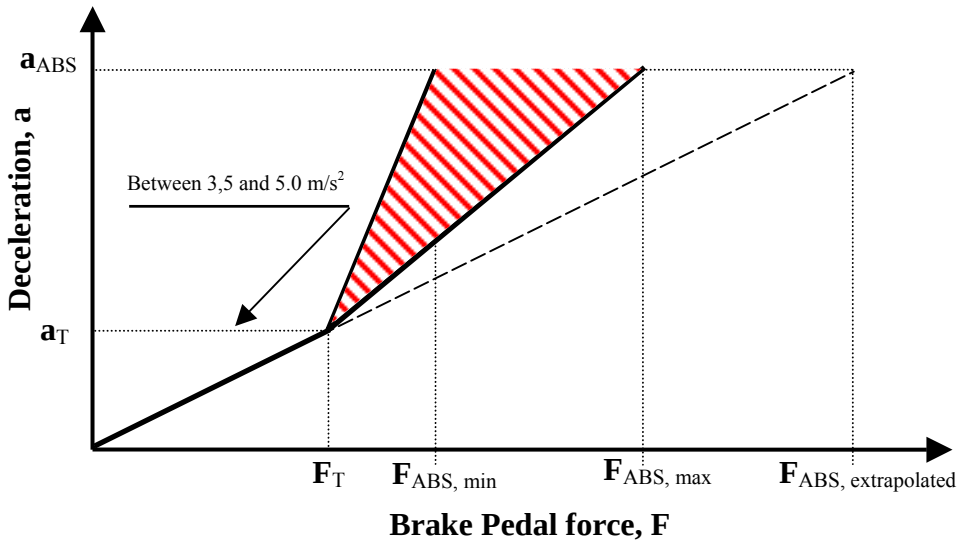

Figure 1: Pedal force characteristic needed in order to achieve maximum deceleration with Category 'A' BAS

4. ASSESSMENT OF THE PRESENCE OF A CATEGORY ‘B’ BAS

A Category 'B' BAS shall meet the test requirements contained within paragraphs 4.1 and 4.2 of this Annex.

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

4.1.1. The reference values F_{ABS} and a_{ABS} shall be determined in accordance with the procedure described in Appendix 1 to this Annex.

4.2. Test 2: For activation of BAS

The vehicle shall be driven in a straight line at the test speed specified in 2.4 above. 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 that the BAS activates under the conditions specified by the manufacturer in accordance with paragraphs 22.1.2 or 22.1.3.

After $t = t_0 + 0.8$ s and until the vehicle has slowed down to a speed of 10 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 also are 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 4.3 is fulfilled.

4.3. Data evaluation

The presence of BAS 'B' is proven if a mean deceleration of at least 0.85 x 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 10 km/h.

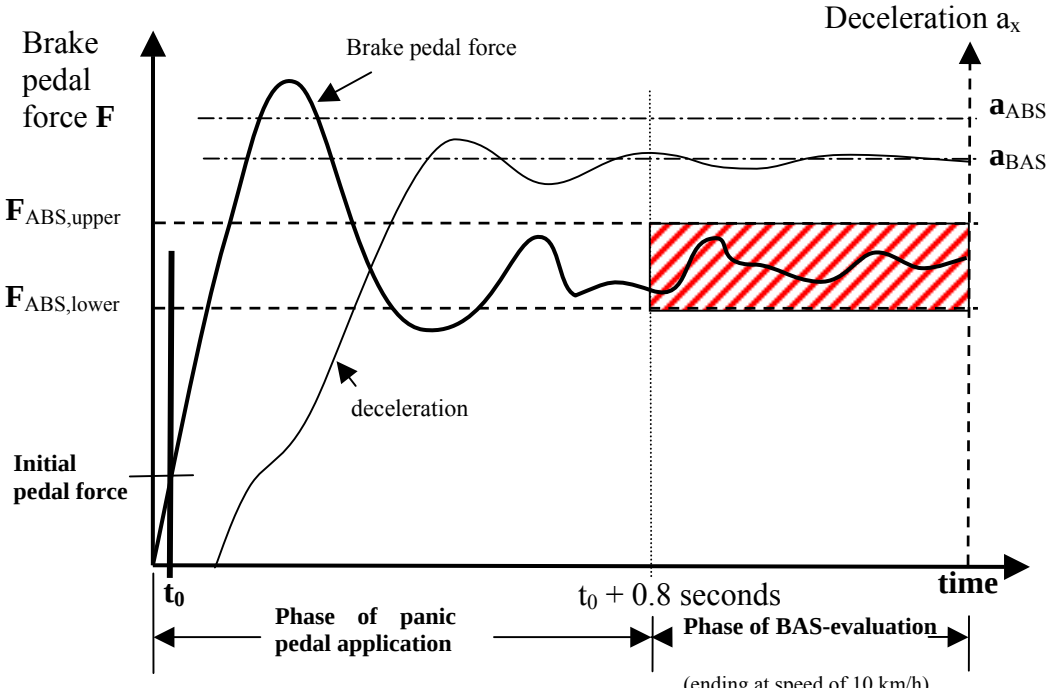

Figure 2: Test 2 of a Category 'B' BAS system.

5. ASSESSMENT OF THE PRESENCE OF A CATEGORY 'C' BAS

5.1 A Category 'C' BAS shall meet the test requirements of paragraphs 4.1 and 4.2 of this Annex.

5.2 Data evaluation

A Category 'C' BAS shall meet the requirements of paragraph 4.3 of this Annex.

Annex 10, Appendix 1

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 1.7..

1.2 The brake pedal shall be applied slowly (without activating the Brake Assist System) providing a constant increase of deceleration until ABS is fully cycling (Figure 3). A brake pedal force of at least 600 N shall be achieved during the test.

1.3 The full deceleration must be reached within the timeframe of 2.0 ± 0.5 s. The deceleration curve, recorded against time, must be within a corridor of ±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 at 2 seconds. Once full deceleration has been achieved the pedal travel [S_p] shall not be decreased for at least 1 s. 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 variance of deceleration increase (see Figure 3).

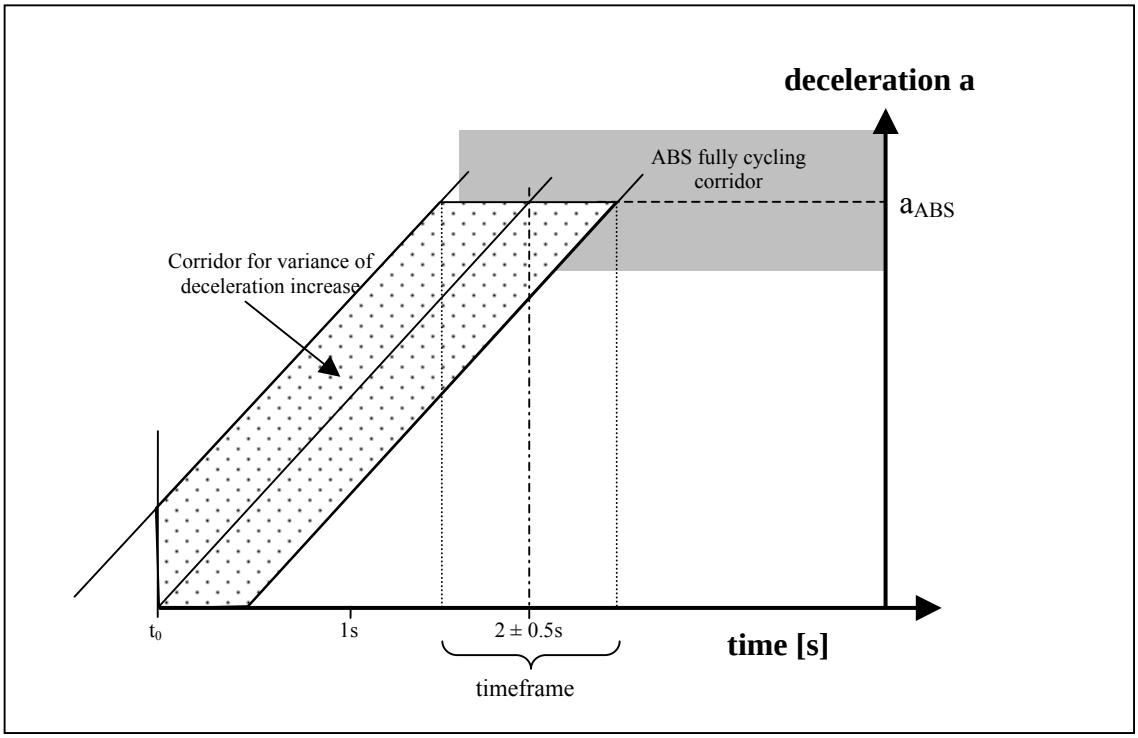

Figure 3: Deceleration corridor for determination of F_{ABS} and a_{ABS}

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.

1.5 The maximum individual value for the vehicle deceleration is determined from each of the five individual curves. The mean value (a_{max}) of these five maximum values represents the upper limit of the deceleration achieved.

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 1N pedal force. The result is the mean deceleration versus brake pedal force curve (Figure 4), which will be referred to as the "maF curve" in this Appendix.

1.7 The ABS deceleration (a_{ABS}) referred to in this appendix is the average value of the vehicle deceleration 'a' on the "maF" curve between the left and right hand border of Window I.

1.7.1 Window I on the "maF" is defined as follows:

- the upper border is a line where a = a_{max}.
- the lower border is a line where a = 0.9*a_{max}.
- the left border is a line where F corresponds to 0.9*a_{max} on the maF curve.
- the width of the window is 200N.

1.8 The minimum force on the pedal (F_{min}) sufficient to achieve the deceleration a_{ABS} calculated in 1.7 is defined as the value of F corresponding to a= a_{ABS} on the maF curve.

1.9 Using linear regression, a straight line is drawn through all maF curve values below the pedal force F_{min} and above the ABS deceleration value (0.7 * a_{ABS}). The value of the brake pedal force 'F' at the point of intersection between this line and the horizontal line where a= a_{ABS} is defined as F_{ABS} (diamond in figure 4).

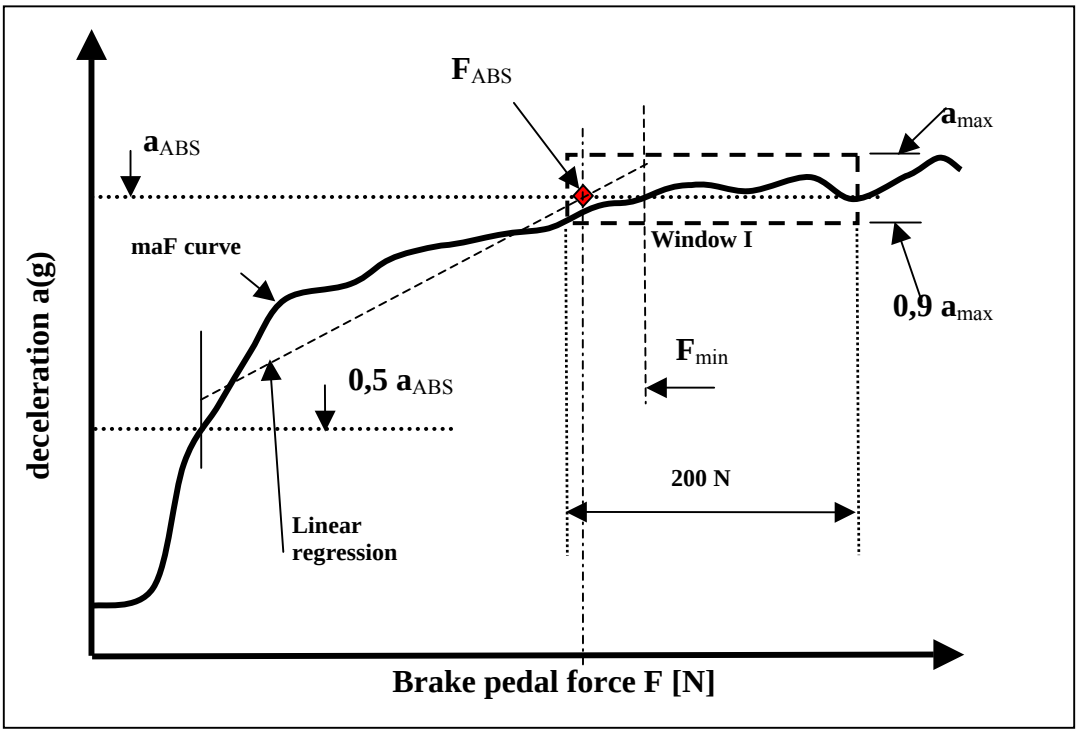

Figure 4: Determination of the value of F_{ABS}'

Annex 10, Appendix 2

DATA PROCESSING FOR THE BAS

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_o at - 3 dB) shall not be less than 30 Hz. Amplitude errors shall be less than ± 0,5 % 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 digitising considerations include pre-sampling amplification of signals to minimize digitising 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 ± 0.5 %.

2.2 Aliasing errors

In order to avoid uncorrectable aliasing errors, the analogue signals shall be appropriately filtered before sampling and digitising. 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

- 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

- 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 % resolution the filter attenuation shall be less than 0.05 % to 30 Hz, and the attenuation shall be greater than 99.95 % at all frequencies greater than one-half the sampling frequency.

NOTE: For a Butterworth filter the attenuation is given by:

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

where:

n is the order to filter;
f_{max} is the relevant frequency range (30 Hz);
f_o is the filter cut-off frequency;
f_N is the Nyquist or "folding" frequency.

For a fourth order filter

for A = 0.9995: $f_o = 2{,}37 * f_{max}$
for A = 0.0005: f_s, = 2 * (6.69 * f_o), where f_s, is the sampling frequency = 2 * fN.

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_o. 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 @ of a Butterworth filter can be approximated by

$\Phi = 81 \times (f/f_0)$ degrees for second order

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

2.4 Data sampling and digitising

At 30 Hz the signal amplitude changes by up to 18 % per millisecond. To limit dynamic errors caused by changing analogue inputs to 0.1 %, sampling or digitising time shall be less than 32 µs. 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 (± 0.05 %) or more and an accuracy of 2 LSB (± 0.1 %). 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 * f_{max} if phase errors are subsequently adjusted in digital data processing, and greater

than 5 * f_{max} otherwise. For fourth order filters the data sampling frequency f_s shall be greater than 13.4 * f_o.

B. JUSTIFICATION

This document introduces provisions for brake-assist systems to enable manufacturers to declare, and for contracting parties to confirm, the presence of a brake assist system on a vehicle covered by this Regulation. It is not intended that this Regulation should mandate the installation of brake assist systems. However, it is envisaged that Contracting Parties wishing to encourage or mandate the use of such systems within their territories (for example, as part of a package of measures to improve the protection of pedestrians) could specify that vehicles are fitted with systems meeting the technical specifications proposed in this document.

The specifications contained within this document reflect systems that are currently available on the market. However, the tests and specifications cannot discriminate between a category B and a category C system. The tests also rely on a declaration from the manufacturer on how the pedal should be pressed to activate their particular BAS. It has, therefore, been requested that information regarding the brake pedal application required to activate BAS (all categories) and all of the input variables to category C systems and their relationships and threshold values be supplied to the Technical Service to monitor the way in which BAS is implemented and to help determine whether further requirements are necessary for these types of system. It is envisaged that in the future the requirements could be further developed to enhance the current performance requirements and allow alternative methods of identifying emergency situations (for example, by using radar technology)

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