84 Brake assist systems

Refer to: R139 00

84.1 Effective date and Scope:

84.1.1 Effective date from 2018/1/1, the new vehicle type of category symbols M1 and N1, and from 2022/1/1, the all vehicle types of category symbols M1 and N1, shall comply with this regulation.

84.1.1.1 Category symbols M1 and N1 that conformed to “42-3 Dynamic braking” of “Directions”, regard as has conformed to this regulation.

84.1.2 This regulation does not suitable for:

84.1.2.1 Vehicles with a design speed not exceeding 25km/hr.

84.1.3 The same applicant applying for low volume safety approval and the amounts of vehicle not exceed 3 at same year and the category symbols M1 or N1 of same type and specification, could exempt from regulation of “Brake assist systems”.

84.1.4 The same applicant applying for vehicle-by-vehicle low volume safety approval and the amounts of vehicle not exceed 20 at same year and small passenger vehicle of same type and specification, could exempt from regulation of “Brake assist systems”.

84.2 Definitions:

84.2.1 "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).

84.2.2 "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.

84.2.3 "Wheel/axle load" means the vertical static reaction (force) of the road surface in the contact area on the wheel/wheels of the axle.

84.2.4 "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.

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

84.2.4.2 "Category B Brake Assist System" means a system which detects an emergency braking condition based primarily on the brake pedal speed applied by the driver;

84.2.5 Vehicles of category M1' derived from N1' means those vehicles of M1 category which, forward of the A pillars, have the same general structure and shape as a pre-existing N1 category vehicle.

84.3 Brake assist systems shall according to suitable type and range of principle：

84.3.1 The same brand and vehicle type.

84.3.2 Vehicle features which significantly influence the performances of the Brake Assist System (e.g. design of the braking system);

84.3.3 The design of the Brake Assist System.

84.4 General requirements

84.4.1 Applicants apply for certification test shall provide at least one representative vehicle (or the essential part of vehicle for test) and submit the documents as below:

Applicants applying for low volume safety approval which could exempt from regulation of paragraph 84.4.1.1.2, 84.4.1.1.3 and paragraph 84.4.1.1.4.

84.4.1.1 Vehicle specification documents, drawings and / or photographs described in paragraph 84.3.

84.4.1.1.1 The numbers and/or symbols identifying the vehicle type and the engine type shall be specified;

84.4.1.1.2 A list of the components, duly identified, constituting the BAS system;

84.4.1.1.3 A diagram of the assembled BAS system and an indication of the position of its components on the vehicle;

84.4.1.1.4 Detailed drawings of each component to enable it to be easily located and identified.

84.4.1.1.5 Mass of vehicle.

84.4.1.1.5.1 Maximum mass of vehicle

84.4.1.1.5.2 Minimum mass of vehicle

84.4.1.1.6 Distribution of mass of each axle (maximum value)

84.4.1.1.7 Engine type

84.4.1.1.8 Number and ratios of gears

84.4.1.1.9 Final drive ratio(s)

84.4.1.1.10 If applicable, maximum mass of trailer which may be coupled

84.4.1.1.10.1 Unbraked trailer

84.4.1.1.11 Tyre dimension

84.4.1.1.12 Maximum design speed

84.4.1.1.13 Brief description of braking equipment

84.4.1.1.14 Mass of vehicle when tested:

	Load *(kg)*
Axle No. 1	
Axle No. 2	
Total	

84.4.1.1.15 Category of Brake Assist System A / B

84.4.1.1.15.1 For category A systems, define the force threshold at which the ratio between pedal force and brake pressure increases;

84.4.1.1.15.2 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);

84.4.1.1.16 Description of Vehicle has conformed to ” Anti-lock braking system (ABS)” of “VSTD”.

84.5 General

84.5.1 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 84.7.1 to 84.7.3 are met.

84.5.2 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 84.8.1 to 84.8.3 are met.

84.6 General test requirements

84.6.1 Variables

Whilst performing the tests described in part B of this annex, the following variables shall be measured:

84.6.1.1 Brake pedal force, Fp ;

84.6.1.2 Vehicle velocity, vx ;

84.6.1.3 Vehicle deceleration, ax ;

84.6.1.4 Brake temperature, Td ;

84.6.1.5 Brake pressure, P, where applicable;

84.6.1.6 Brake pedal speed, vp, 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.

84.6.2 Measuring equipment

84.6.2.1 The variables listed in paragraph 84.6.1 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.

84.6.2.2 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 temperature	0 - 1,000 deg. C	+/- 5 deg. C
Brake pressure*	0 - 20 MPa*	+/- 100 kPa*

∗:Applicable as specified in paragraph84.7.2.5

84.6.2.3 Details on analogue and digital data processing of the BAS test procedures are described in paragraph 84.10. A sampling rate for data acquisition of at least 500 Hz is required.

84.6.2.4 Alternative measuring methods to those referred to in paragraph 84.6.2.3 may be allowed, provided they demonstrate at

least an equivalent level of precision.

84.6.3 Test conditions

84.6.3.1 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.

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

84.6.4 Test method

84.6.4.1 The tests as described in paragraphs 84.7 and 84.8 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.

84.6.4.2 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 deg. C prior to any brake application.

84.6.4.3 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.

84.7 Assessment of the presence of a category "A" BAS

A category "A" BAS shall meet the test requirements contained in paragraphs 84.7.1 and 84.7.2.

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

84.7.1.1 The reference values F_{ABS} and a_{ABS} shall be determined in accordance with the procedure described in paragraph 84.9.

84.7.2 Test 2: For activation of BAS

84.7.2.1 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 84.7.2.5; or

(b) Vehicle deceleration to brake pedal force.

84.7.2.2 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).

84.7.2.3 F_T and a_T are threshold force and threshold deceleration as shown in Figure 1a. 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 m/s2 and 5.0 m/s^2.

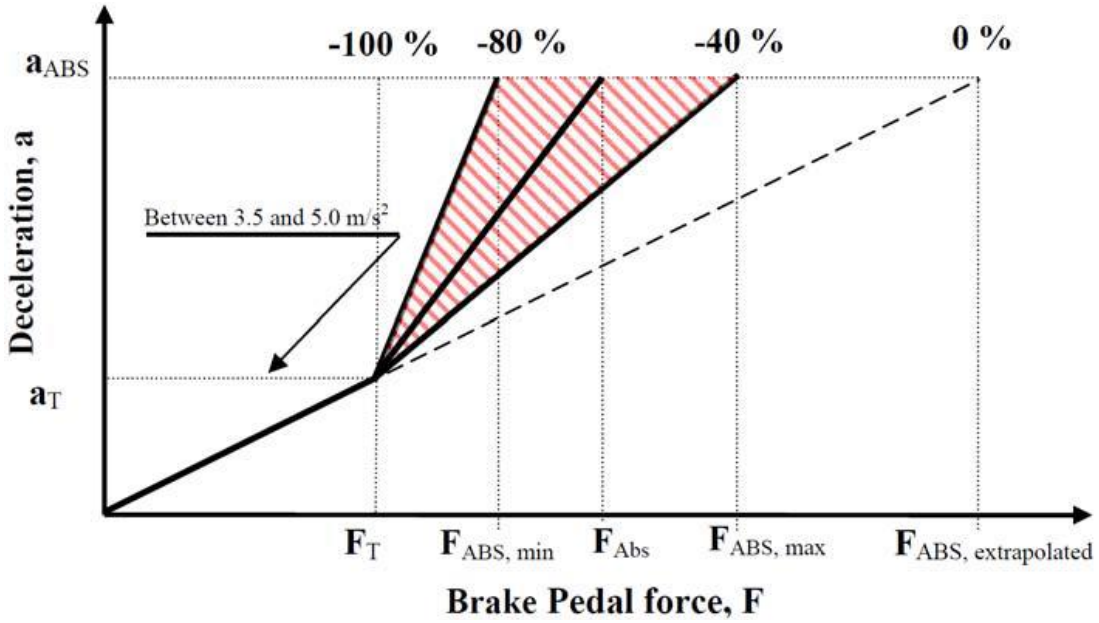

Figure 1a: Pedal force characteristic needed in order to achieve maximum deceleration with category “A” BAS

84.7.2.4 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 $F_{ABS,\ extrapolated}$:

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

84.7.2.5 As an alternative, which can be selected by the manufacturer, in the case of vehicles of category N1, or M1 derived from those N1 vehicles, with a gross vehicle mass GVM > 2,500 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.

84.7.2.5.1 The pressure, at which ABS cycling commences, shall be determined by making five tests from 100 +/- 2 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}.

84.7.2.5.2 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^2.

84.7.2.5.3 Figure 8b shall be constructed in the manner set out in paragraph 84.7.2.4, but using line pressure measurements to define the parameters set out in paragraph 84.7.2.5 of this section where:

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

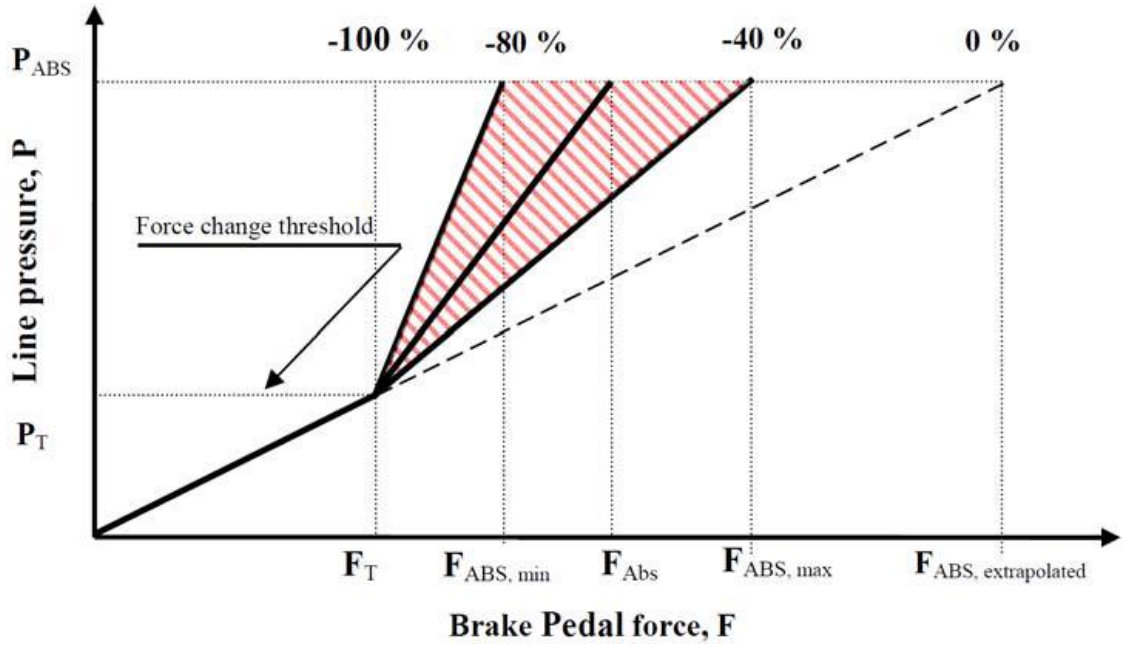

Figure 1b: Pedal force characteristic needed in order to achieve maximum deceleration with category "A" BAS

84.7.3 Data evaluation

The presence of a category "A" BAS is proven if

$F_{ABS,min} < F_{ABS} < F_{ABS,max}$

where:

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

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

84.8 Assessment of the presence of a category "B" BAS

A category "B" BAS shall meet the test requirements contained within paragraphs 84.8.1 and 84.8.2.

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

84.8.1.1 The reference values F_{ABS} and a_{ABS} shall be determined in accordance with the procedure described in paragraph 84.9.

84.8.2 Test 2: For activation of BAS

The vehicle shall be driven in a straight line at the test speed specified in paragraph 84.6.4. 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.

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 = t0 + 0.8 s, the pedal force falls below FABS, lower provided the requirement of paragraph 84.8.3 is fulfilled.

84.8.3 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 = t0 + 0.8 s to the time when the vehicle speed has been reduced to 15 km/h.

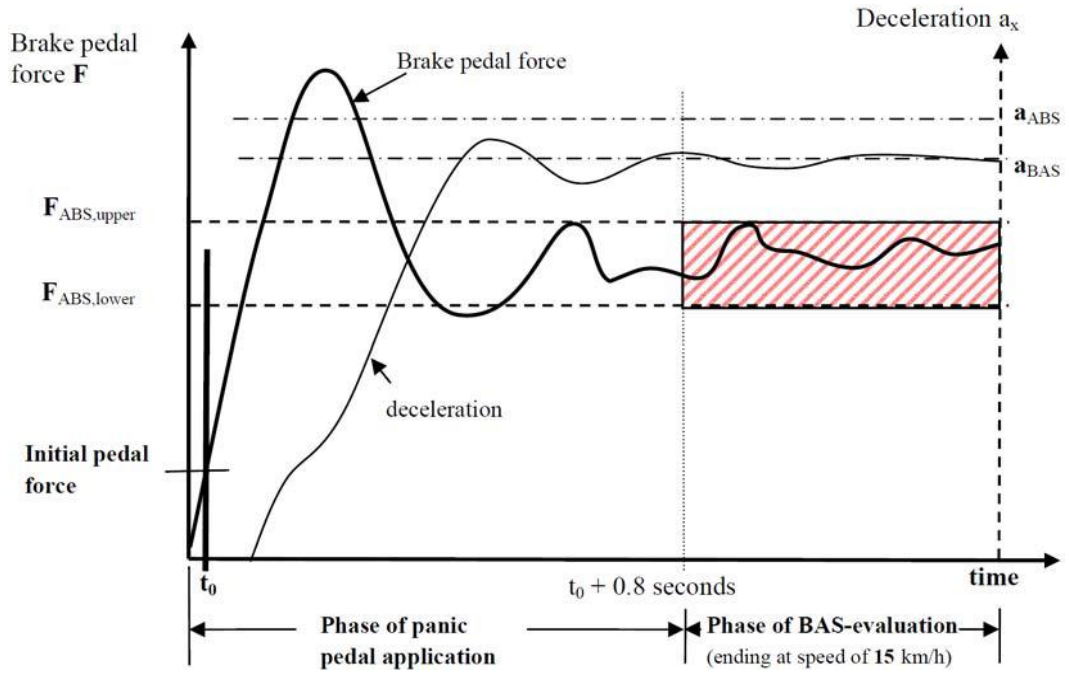

Figure 3: Example of test 2 of a category "B" BAS system

84.9 Method for determination of F_{ABS} and a_{ABS}

84.9.1 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 84.9.7.

84.9.2 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).

84.9.3 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 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).

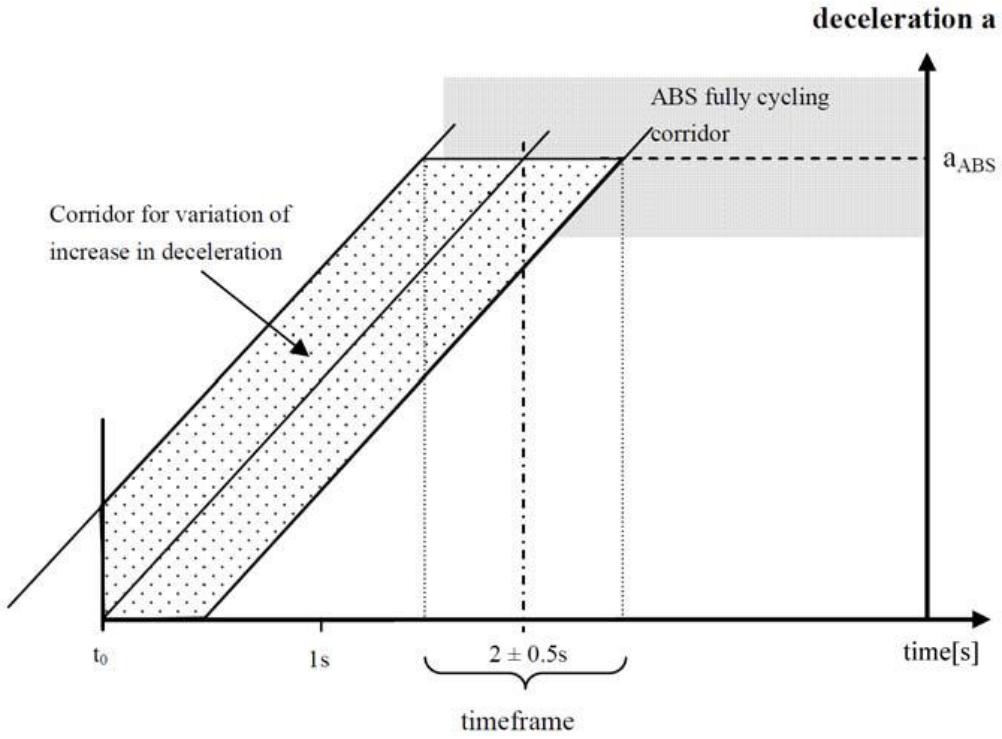

Figure 3: Deceleration corridor for determination of F_{ABS} and a_{ABS}

84.9.4 Five tests meeting the requirements of paragraph 84.9.3 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.

84.9.5 For the determination of aABS and FABS, a low pass filter of 2 Hz for vehicle deceleration as well as pedal force shall be applied.

84.9.6 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".

84.9.7 The maximum value for the vehicle deceleration is determined from the "maF curve" and is named as "a_{max}".

84.9.8 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}".

84.9.9 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.

84.10 Data processing for the BAS

84.10.1 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 fo at -3 dB) shall not be less than 30 Hz. Amplitude errors shall be less than +/-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 content s, phase shifts can occur. Therefore, a data processing

method, as described in paragraph 84.10.2, is preferable.

84.10.2 Digital data processing

84.10.2.1 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 per cent.

84.10.2.2 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:

(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 by:

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

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

for $A = 0.0005$: $f_{S,} = 2 \cdot (6.69 \cdot f_o)$, where $f_{S,}$ is the sampling frequency $= 2 \cdot f_N$.

84.10.2.3 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 phi of a Butterworth filter can be approximated by

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

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

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

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

84.10.2.4 Data sampling and digitising

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 digitising time shall be less than 32 microseconds. All pairs or sets of data samples to be compared shall be taken simultaneously or over a sufficiently short time period.

84.10.2.5 System requirements

The data system shall have a resolution of 12 bits (+/-0.05 per cent) or more and an accuracy of +/-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 fo (from 0 Hz to frequency fo) 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 fs shall be greater than $13.4 \cdot f_o$.