INTERNATIONAL STANDARD

ISO 12021-1

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Road vehicles — Sensitivity to lateral wind —

Part 1:
Open-loop test method using wind generator input

Véhicules routiers — Sensibilité au vent latéral —

Partie 1: Méthode en boucle ouverte avec génération de vent

Reference number
ISO 12021-1:1996(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 12021-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 9, *Vehicle dynamics and road-holding ability*.

ISO 12021 will consist of the following parts, under the general title *Road vehicles — Sensitivity to lateral wind*:

— *Part 1: Open-loop test method using wind generator input*

— *Part 2: Semi open-loop test method using natural wind input*

Annexes A and B form an integral part of this part of ISO 12021.

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Introduction

The dynamic behaviour of road vehicles is a most important part of active vehicle safety. Any given vehicle, together with its driver and the prevailing environment, forms a unique closed-loop system. The task of evaluating dynamic behaviour is therefore very difficult because of the significant interaction of the driver, vehicle and road elements, each of which is in itself complex. A complete and accurate description of the behaviour of the road vehicle must necessarily involve information obtained from a number of tests of different types.

The results of the test described in this part of ISO 12021 quantify only a small part of the whole handling field. Hence, the results of a test can be considered significant only for a correspondingly small part of the overall dynamic behaviour.

Moreover, insufficient knowledge is available concerning the relationship between accident risk and the dynamic characteristics evaluated by the test described in this part of ISO 12021. A substantial amount of effort is necessary to acquire sufficient and reliable data on the correlation between accident risk and the characteristics of vehicle dynamics in general and the results of this test in particular.

Therefore, it is not possible to use this method and test results for regulation purposes at present. The best that can be expected is that the sensitivity to lateral wind test is used as one among many other mostly transient tests, which together cover the field of vehicle dynamic behaviour.

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Road vehicles — Sensitivity to lateral wind —

Part 1:
Open-loop test method using wind generator input

1 Scope

This part of ISO 12021 specifies an open-loop test method to determine the sensitivity to lateral wind of a vehicle by means of a wind generator. It applies to passenger cars as defined in ISO 3833, passenger car–trailer combinations and light trucks. Its applicability to motorcycles is yet to be investigated.

The test conditions specified in this test method are not representative of real driving conditions but are useful to obtain measures of vehicle dynamic response to lateral wind.

NOTE 1 The test conditions in this test method do not simulate natural wind conditions. However, the wind velocity proposed here is representative of fairly severe wind conditions occurring naturally.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 12021. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 12021 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1176:1990, *Road vehicles — Masses — Vocabulary and codes.*

ISO 3833:1977, *Road vehicles — Types — Terms and definitions.*

ISO 8855:1991, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary.*

3 Principle

The purpose of this test method is to determine vehicle sensitivity to lateral wind by which the vehicle motion is disturbed.

This method requires the measurement of vehicle behaviour under a lateral wind condition. The vehicle behaviour can be characterized by several measures.

In this test method the vehicle is initially driven along a straight path and its response to a crosswind input of a wind generator is then measured. The steering-wheel is held fixed during most of the test.

Two methods for finding the lateral deviation are proposed

— a direct method by means of direct measurement or with a dye-trail left on the road surface, and

— an indirect method by means of a computation from on-board-measured vehicle motions.

4 Reference system

The variables of motion used to describe the effect of lateral wind on course holding and directional behaviour of the vehicle relate to the intermediate axis system (X, Y, Z) as defined in ISO 8855.

5 Variables

The following variables corresponding to the terms and definitions of ISO 8855 shall be measured:

— yaw velocity, $\dot{\psi}$;

— lateral acceleration, a_Y;

— steering-wheel angle, δ_H;

— longitudinal velocity, v_X;

It is optional to measure the additional variables:

— lateral deviation, y;

— roll angle, φ;

— sideslip angle, β;

— lateral velocity, v_Y.

The variables listed in this clause are not intended to comprise a complete list.

6 Measuring equipment

6.1 Description

The variables selected from those listed in clause 5 shall be measured by means of appropriate transducers. Their time histories shall be recorded on a multi-channel recorder having a time base. This is not obligatory for lateral deviation, which can be measured directly after the test has been completed.

The typical operating ranges of the variables and recommended maximum errors of the combined transducers and the recording system are shown in table 1.

6.2 Transducer installation

The transducers shall be installed according to the manufacturer's instructions, where such instructions exist, so that the variables corresponding to the terms and definitions of ISO 8855 can be determined.

If the transducer does not measure the variable directly, appropriate transformations into the reference system shall be carried out.

6.2.1 Lateral deviation

The lateral deviation may be measured either by direct measurement using appropriate instrumentation or by means of a dye-trail, or by means of a computational method (see 10.5). The dye-trail shall be made on the test track by means of a water jet. The water outlet should be 0,02 m above the track surface. Elastic tube may be used to extend this outlet.

The water jet should be positioned as close as possible to the z-axis of the intermediate axis system. If this is not the case, a correction can be applied to achieve values within the tolerance for lateral acceleration.

6.3 Data processing

The frequency range relevant to this test is between 0 Hz and the maximum utilized frequency f_{max} = 5 Hz. According to the chosen data processing method, analog or digital data processing, the stipulations given in 6.3.1 or 6.3.2 shall be observed.

Table 1 —Typical operating ranges of the variables and recommended maximum errors of transducers and recording system

Variable	Range of variable	Recommended maximum error of the combined transducers and recording system
Yaw velocity	– 10°/s to + 10°/s	± 0,1°/s
Lateral acceleration	– 5 m/s² to + 5 m/s²	± 0,05 m/s²
Steering-wheel angle	– 30° to + 30° *)	± 1°, but resolution < 0,3°
Longitudinal velocity	0 m/s to 40 m/s	± 0,4 m/s
Lateral deviation	5 m	± 0,02 m
Roll angle	– 10° to + 10°	± 0,1°
Sideslip angle	– 5° to + 5°	± 0,2°
Lateral velocity	– 10 m/s to + 10 m/s	± 0,4 m/s

NOTES

1 These values are tentative and provisional until more data are available.

2 Transducers for some of the listed variables are not widely available and are not in general use. Many such instruments are developed by users. If any system error exceeds the recommended maximum value, this and the actual maximum error shall be stated in the test report (see annex A).

*) Assuming a conventional steering system

6.3.1 Analog data processing

The bandwidth of the entire combined transducer/recording system shall be no less than 8 Hz.

Low-pass filters with order four or higher shall be employed to filter the signals. The width of the passband frequency f_0 at – 3 dB shall not be less than 8 Hz. Amplitude errors shall be less than ± 0,5 % in the relevant frequency range of 0 Hz to 5 Hz. All analog signals shall be processed with filters having sufficiently similar phase characteristics to ensure that time delay differences due to filtering shall lie within the required accuracy for time measurement.

NOTE 2 During analog filtering of signals with different frequency contents, phase shifts can occur. Therefore a data processing method, as described in 6.3.2, is preferable.

6.3.2 Digital data processing

6.3.2.1 Preparation of analog signals

In order to avoid aliasing, the analog signals shall be filtered correspondingly before digitizing. In this case low-pass filters with order four or higher shall be employed. The width of passband frequency (f_0 at – 3 dB) shall be:

$f_0 \geqslant 5 f_{max}$

The amplitude error of the anti-aliasing filter shall not exceed ± 0,5 % in the usable frequency range. All analog signals shall be processed with anti-aliasing filters having sufficient similar phase characteristics to ensure that time delay differences lie within the required accuracy for time measurements.

Additional filtering shall be avoided in the data acquisition string.

Amplification of the signal shall be such that, in relation to the digitizing process, the additional error is less than 0,2 %.

6.3.2.2 Digitizing

The sampling rate f_s shall be at least twice the highest frequency after filtering. In practice the sample frequency is usually chosen to be appropriate to the order of the filters used and to the resolution of the digitizing process (see note 3).

NOTE 3 As examples, $f_s \geqslant 9 f_0$ for four pole butterworth filters and $f_s \geqslant 3{,}8 f_0$ for eight pole butterworth filters, both at 12 bits resolution.

6.3.2.3 Digital filtering

For the filtering of sampled data in the data evaluation, phaseless (zero phase shift) digital filters shall be used with the following characteristics (see figure 1):

— passband range, ⩾ 0 Hz to ⩾ 5 Hz;

— start of stopband, ⩾ 10 Hz and ⩽ 15 Hz;

— filter gain in the passband, 1 ± 0,005 (100 % ± 0,5 %);

— filter gain in the stopband, ⩽ 0,01 (⩽ 1 %).

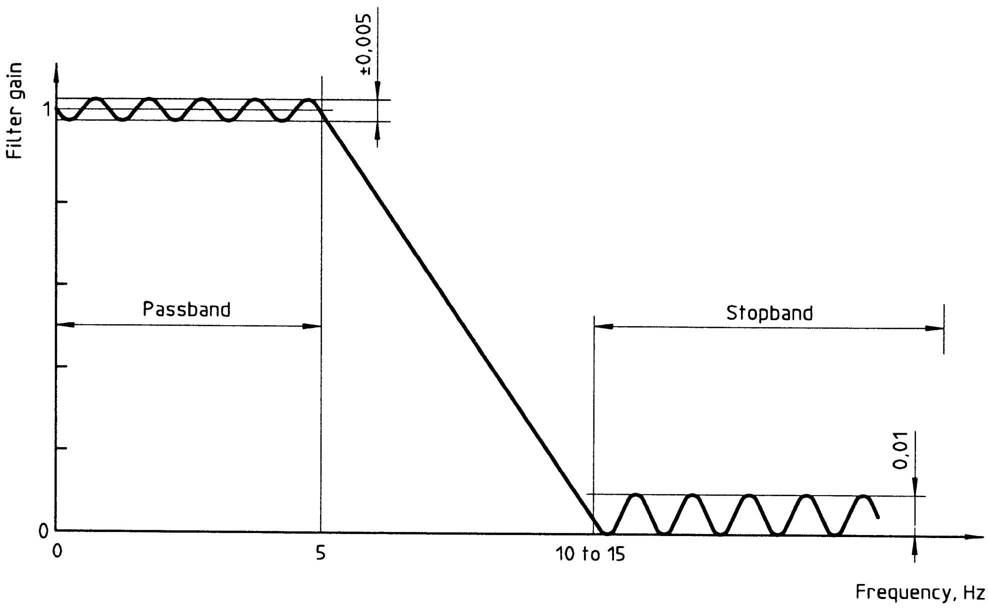


Figure 1 — Required characteristics of phaseless digital filters

7 Test conditions

Limits and specifications for the ambient wind and vehicle test conditions are established in 7.1 to 7.3, and shall be maintained during the test. Any deviations shall be specified in the test report (see annex A), including individual diagrams for the presentation of results (see annex B).

7.1 Test track

All tests shall be carried out on a uniform hard road surface which is free of contaminants. The gradient, as measured over the full width of the track in the lateral direction and over a distance of at least 50 m in the longitudinal direction, shall be < 2,5 %.

It is recommended that the track has either a smooth surface (asphalt or concrete) or a high friction surface.

The test surface shall be at least 5 m wide, from at least 100 m before to 100 m after the wind zone (see figure 2). The width of the track after the wind zone shall be at least 7 m.

Increased run-off area should be provided in addition to the specified test surface.

7.2 Weather conditions

During the time frame of the experiment, ambient wind velocity should be as low as possible, and shall not exceed 3 m/s regardless of the wind direction. The standard test condition of a dry road surface should be used. However, a wet road with no measurable water depth may be used.

Weather conditions shall be recorded in the test report (see annex A).

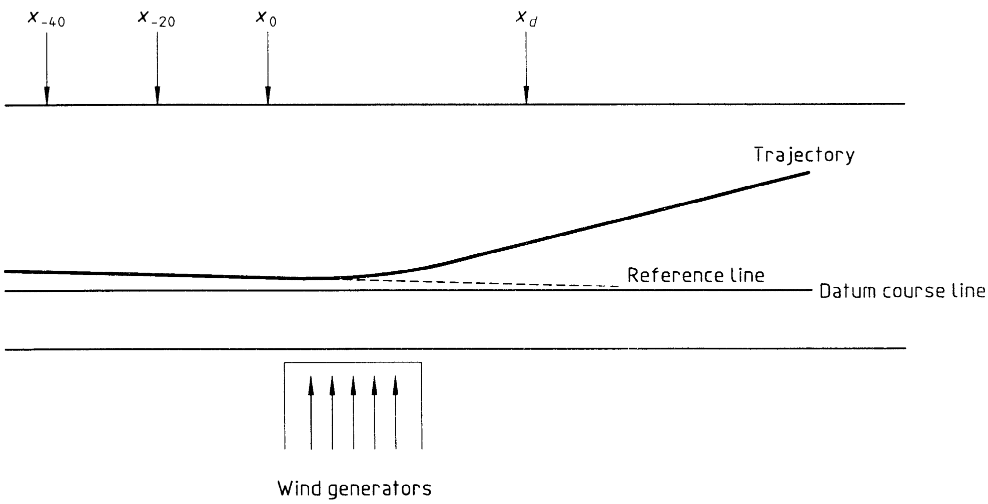
7.3 Test vehicle

7.3.1 Tyres

It is recommended that new tyres are fitted on the test vehicle in the approriate position. They shall be run in for at least 150 km on the test vehicle without excessively harsh use, for example braking, accelerating, cornering, hitting the kerb, etc. They shall have a tread depth of at least 90 % of the original value and shall have been manufactured not more than one year before the tests.

The tests may also be performed with tyres in any state of wear providing that at the end of the tests they retain a minimum of 1,5 mm of tread depth across the whole tread breadth and around the whole circumference of the tyre.

NOTE 4 Tread breadth is the width of that part of the tread which, with the tyre correctly inflated, contacts the road in normal straight line driving.



x_0 is the start of the wind zone, defined as the intersection of the leading edge of the wind generator and the datum course line

x_d is the distance corresponding to 2 s of travel at the test speed after the start of the wind zone x_0

Figure 2 — Test track layout

Tyres shall be inflated to the pressure as specified by the vehicle manufacturer for the test vehicle configuration. The tolerance for setting the cold inflation pressure is ± 5 kPa [1)] for pressures up to 250 kPa and ± 2 % for pressures above 250 kPa.

NOTE 5 In certain cases the tread depth has a significant influence on test results and it should be taken into account when making comparisons between vehicles or between tyres.

7.3.2 Operating components

All operating components likely to influence the results of this test (for example shock absorbers, springs and other suspension components) shall be inspected to ensure that they meet the manufacturer's specifications and shall be properly adjusted and secured. The results of these inspections and measurements shall be recorded and any deviation from the manufacturer's specifications shall be noted in the test report (see annex A).

7.3.3 Vehicle loading conditions

Tests shall be carried out at the minimum loading condition and at the maximum loading condition defined below. Tests may be carried out at other loading conditions of interest.

The maximum authorized total mass (Code: ISO-M08) and the maximum authorized axle load (Code: ISO-M13), both defined by ISO 1176:1990, items 4.8 and 4.13, shall not be exceeded.

Care shall be taken to generate the minimum deviation in the location of the centre of gravity and in the values of the moments of inertia as compared to the loading conditions of the vehicle in normal use. The resulting wheel loads shall be determined and recorded in the test report (see annex A).

7.3.3.1 Minimum loading condition

For the minimum loading condition, the total vehicle mass shall consist of the complete vehicle kerb mass (Code: ISO-M06) plus the masses of the driver and the instrumentation. The complete vehicle kerb mass is defined by ISO 1176:1990, item 4.6. The mass of the driver and the instrumentation should not exceed 150 kg.

7.3.3.2 Maximum loading condition

For the maximum loading condition the total mass shall be equal to the maximum authorized total mass (Code: ISO-M08).

8 Wind generators

Lateral wind shall be generated by wind generators which produce an average wind velocity of 20 m/s ± 3 m/s (for an ambient wind condition of < 1 m/s). The average shall be calculated over the length of the wind zone on the datum course line (see figure 2) and over the height of the test vehicle. As a further specification of the wind input, the nominal wind angle relative to the datum course line and graphs of the wind velocity profiles over the length and over the height of the wind zone shall be presented in the test report (see annex A). The nominal length of the wind zone, usually composed of a series of wind generators, shall not be less than 15 m and should preferably be more than 25 m. The nominal length of the wind zone shall be noted in the test report (see annex A).

9 Test procedure

9.1 Tyre warm-up

Prior to the tests, the tyres shall be warmed by driving at the test speed over a distance of at least 10 km.

9.2 Test speed

The test speed is defined as the nominal value of the longitudinal velocity. The standard test speed is 100 km/h. Other test speeds of interest may be used (preferably in 20 km/h steps).

For each test run, the longitudinal velocity shall be within a tolerance of ± 2 km/h before the start of the wind zone x_0. After that point the accelerator pedal shall be held fixed.

9.3 Steering

Test runs shall be made by driving the vehicle at the test speed along a straight path, the datum course line. When approaching the wind zone, steering corrections are permitted to enable the vehicle to maintain the datum course line but the steering-wheel shall be held fixed from 40 m before the start of the wind zone (see figure 2) to at least a distance corresponding to 2 s of travel at the test speed after the start of the wind zone (x_d).

The maximum deviation of the steering-wheel angle from its average value shall be less than 2°, until the vehicle has passed point x_d.

1) 1 kPa = 10^{-2} bar = 10^3 N/m^2