BS ISO 9816:2018

BSI Standards Publication

Passenger cars — Power-off reaction of a vehicle in a turn — Open-loop test method

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National foreword

This British Standard is the UK implementation of ISO 9816:2018. It supersedes BS ISO 9816:2006, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AUE/15, Safety related to vehicles.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Passenger cars — Power-off reaction of a vehicle in a turn — Open-loop test method

Voitures particulières — Réponse d'un véhicule à un lever de pied en virage — Méthode d'essai en boucle ouverte

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives.

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles,* Subcommittee SC 33, *Vehicle dynamics and chassis components*.

This third edition of ISO 9816 cancels and replaces the second edition (ISO 9816:2006) which has been technically revised. The main changes compared to the previous edition are as follows:

— an update was made regarding alternative powertrain systems.

Introduction

The main purpose of this document is to provide repeatable and discriminatory test results.

The dynamic behaviour of a road vehicle is a very important aspect of active vehicle safety. Any given vehicle, together with its driver and the prevailing environment, constitutes a closed-loop system that is unique. The task of evaluating the dynamic behaviour is therefore very difficult since the significant interaction of these driver-vehicle-environment elements are each complex in themselves. A complete and accurate description of the behaviour of the road vehicle must necessarily involve information obtained from a number of different tests.

Since this test method quantifies only one small part of the complete vehicle handling characteristics, the results of these tests can only be considered significant for a correspondingly small part of the overall dynamic behaviour.

Moreover, insufficient knowledge is available concerning the relationship between overall vehicle dynamic properties and accident avoidance. A substantial amount of work is necessary to acquire sufficient and reliable data on the correlation between accident avoidance and vehicle dynamic properties in general and the results of these tests in particular. If this test method is used for regulation purposes, the correlation between test results and accident statistics should be checked.

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Passenger cars — Power-off reaction of a vehicle in a turn — Open-loop test method

1 Scope

This document specifies open-loop test methods to determine the reactions of a vehicle in a turn to a sudden drop in motive power resulting from release of the accelerator pedal. It applies to passenger cars as defined in ISO 3833.

The open-loop manoeuvre specified in this test method is not representative of real driving conditions, but is useful to obtain measures of a vehicle's power-off behaviour resulting from specific types of control inputs under closely controlled test conditions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 15037-1:2018[1)], *Road vehicles — Vehicle dynamics test methods — Part 1: General conditions for passenger cars*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855, ISO 15037-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

For the purposes of this document, the terms and definitions given in the general conditions given in, and the following terms and definitions shall apply.

3.1
power-off
vehicle operating condition where the vehicle is in gear and the accelerator pedal is fully released, especially when initiated by a sudden release of the accelerator pedal

3.2
instant of power-off initiation
t_0
moment in time when a rapid release of the accelerator pedal is initiated

1) Under preparation. Stage at time of publication: ISO/DIS.

— lateral acceleration; a_Y;

— sideslip angle, β, or lateral velocity, v_Y.

In addition, the following variables may be determined:

— longitudinal acceleration, a_X.

The variables are defined in ISO 8855, except the instant of accelerator pedal release t_0, which is the instant at which the accelerator pedal is released (see 8.3). The variables are not intended to comprise a complete list.

6 Measuring equipment

6.1 Description

The variables selected for test purposes shall be measured by means of appropriate transducers. Their time histories shall be recorded by a multi-channel recording system having a time base. Typical operating ranges and recommended maximum errors of the transducer and recording system are as specified in ISO 15037-1:2006 and Table 1. In the context of this document, these values should be considered as provisional until more experience and data are available.

6.2 Transducers installations

The requirements of ISO 15037-1 shall apply.

6.3 Data processing

The requirements and specifications of ISO 15037-1 shall be followed.

7 Test conditions

Limits and specifications for the ambient and the vehicle test conditions established in ISO 15037-1 shall be followed.

In addition, for standard test conditions, the adjustment and condition of the engine and drive train (especially the differentials, clutches, locks, free-wheel shifts, engine idle-calibration) shall correspond to the vehicle manufacturer's specifications.

Table 1 — Typical operating ranges and recommended maximum errors for recorded variables — Additions and exceptions to ISO 15037-1

Variable	Typical operating range	Recommended maximum error of the combined transducer and recorder system
Instant of power-off initiation	—	0,05 s
Yaw angle	−180° to 180°	±2°
NOTE Increased measuring accuracy be desirable for computation of some of the characteristic values given in Clause 9.		

8 Test method

8.1 Warm-up

The procedure specified in ISO 15037-1 shall be followed to warm up the tyres and other vehicle components prior to the test.

8.2 Initial driving condition

8.2.1 General

For both the constant-radius and the constant-speed test methods, the initial driving condition is a steady-state circular run as defined in ISO 15037-1.

For either test method, the initial runs shall be conducted from a steady-state circular condition in which a lateral acceleration of about 4 $m/s^2$is achieved. In successive runs, the steady-state lateral acceleration of the initial turn shall be increased incrementally from run to run in steps of not more than 1 m/s^2. It is recommended that increments of 0,5 m/s^2 or less be used when the power-off response changes significantly between runs at the larger increment (1 m/s^2).

For vehicles with manual transmission, the test shall be performed in the lowest gear possible, but not in first gear. The engine speed shall not be higher than 80 % of the engine speed at the maximum power point, as specified by the vehicle manufacturer. If the increase in vehicle speed during a constant-radius test requires a gear change, the previous speed shall be run in both gears.

For vehicles with automatic transmission, the standard drive mode shall be used. The position of the transmission lever and the selected driving programme shall be recorded in the test report (see Annex A).

Cars with adaptive gear selection or CVT may use different gears or ratios at a given speed. For such cars, engine speed shall be recorded for the purpose of determining gear ratio. It shall be recorded in the test report.

For vehicles with regenerative braking capabilities the specific vehicle configuration may alter the dynamic vehicle behaviour while releasing the accelerator pedal and/or while pressing the brake pedal. Also, the different dynamic vehicle behaviour with or without active regenerative braking shall be considered while performing the tests. The selected level of regenerative braking capability and the transmission lever position shall be documented in the test report.

8.2.2 Initial driving condition — Constant-radius method

During the initial driving condition, the vehicle shall be steered in such a manner that the reference point of the vehicle moves on a circular path of the desired radius. As it is known that the significance of the results and the ability to discriminate between different vehicles increase with increasing test speed, the standard radius of this path shall be 100 m. Smaller radii may be used. The minimum permissible radius is 30 m, but the recommended minimum radius is 40 m.

From run to run, the initial driving speeds shall be those which establish the required steady-state lateral accelerations as described in 8.2.1.

8.2.3 Initial driving condition — Constant-speed method

The standard speed for the initial driving condition is 100 km/h. If higher or lower test speeds are selected, they shall be in 20 km/h increments.

From run to run, the steady-state lateral accelerations as required in 8.2.1 shall be established by either of the following two methods.

— The test runs are performed using a series of discrete turn radii, consisting of a number of marked circles or circular segments with different radii chosen to establish the required initial lateral accelerations at the selected test speed.

— The test runs are performed using a series of discrete, constant steer angles (with no constraint on initial vehicle path) chosen to establish the required initial lateral accelerations at the selected test speed. The use of an adjustable steering stop is recommended for maintaining constant steer angles.

8.3 Power-off procedure

The position of the steering wheel and the accelerator pedal shall be kept as constant as possible during the initial driving condition. The initial condition is considered to be sufficiently constant if the conditions defined in ISO 15037-1 are fulfilled.

For the constant-radius method, the radius in the initial driving condition may not deviate by more than ±2 % of the desired value or ±2 m, whichever is smaller, during the time interval of 1,3 s to 0,3 s before power-off initiation.

For the constant-speed method, the longitudinal velocity in the initial driving condition may not deviate by more than ±1 km/h of the desired value during the time interval of 1,3 s to 0,3 s before power-off initiation.

When the initial steady-state driving condition has been established, the steering wheel shall be held fixed by a mechanical device or, alternatively, shall be firmly held by the driver.

The accelerator pedal shall be released as quickly as possible. On vehicles with manual transmission, the clutch shall be kept engaged. On vehicles with automatic transmission, the shift lever shall remain in the initial position.

The data signal indicating the instant of power-off initiation, t_0, shall be generated when the foot force on the acceleration pedal is lower than 10 N (contact switch).

The transducer signals shall be recorded from at least 1,3 s before to at least 2 s after the instant of power-off initiation. This recording period shall be extended by the settling time of all filters used during recording (0,2 s to 1 s, depending on the type of filter used).

During the recording period, the steering-wheel angle shall not deviate more than ±3 % from the steady-state value. To improve accuracy, it is recommended that at least three valid test runs be performed for each lateral acceleration level (see 8.2.1).

Tests shall be carried out for both left and right turns.

9 Data evaluation and presentation of results

9.1 General

General data shall be presented in the test report as referred to in Annex A and Annex B. For every change in equipment of the vehicle (e.g. load), the general data shall be documented again.

At the present level of knowledge, it is not yet known which variables best represent the subjective feeling of the driver and which variables (i.e. which characteristic values) best describe the dynamic reaction of vehicles. The following specified variables therefore represent only examples for the evaluation of results.

9.2 Time histories

For every test run, time histories of the variables listed in Clause 5 shall be presented. Apart from their evaluation purposes, the time histories serve to monitor correct test performance and functioning of the transducers (see Figure B.1).

9.3 Initial point in time t_0

The initial point in time t_0 for the following characteristic values is the instant of the power-off initiation.

9.4 Characteristic values

9.4.1 General

The characteristic values should be determined and presented as functions of the initial steady-state lateral acceleration (see Annex B). The characteristic values in the steady-state condition are defined as mean values during the time interval 1,3 s to 0,3 s before power-off initiation t_0. The other characteristic values are determined during an observation period beginning at t_0 and ending 2 s later. The representative values at t_n shall be calculated by taking the mean values during the time interval from t_n − 0,1 s to t_n + 0,1 s. For standard evaluation the actual time is $t_n = t_0 + 1$ s, but t_n may also assume additional values.

For each set of initial conditions, calculate and plot the characteristic values listed below. The reference values of yaw velocity and lateral acceleration used in some of the formulas that follow are those values which would have occurred at time t, had the initial turn radius been maintained while the vehicle proceeded at its actual longitudinal velocity $v_{X,\,t}$, if the initial radius were maintained by the vehicle. They are defined as follows:

Reference yaw velocity:

$$\dot{\psi}_{\mathrm{Ref},t} = \frac{v_{X,t}}{R_0}$$

Reference lateral acceleration:

$$a_{Y,\mathrm{Ref},t} = \frac{v_{X,t}^2}{R_0}$$

NOTE The throttle-off behaviour of passenger cars is normally designed in a way that the vehicle slightly decreases the radius of curvature of the driving path after the initiation of throttle-off. Therefore, the reference course that would be followed, if the vehicle were to maintain the exact same turn radius after throttle-off is not necessarily the ideal course. This should be kept in mind for the assessment of the following evaluation metrics.

9.4.2 The mean longitudinal acceleration during the time interval t_0 to t_n (see Figure B.2):

$$-\bar{a}_{X,t_n} = \frac{v_{X,0} - v_{X,t_n}}{t_n - t_0} = f_1\left(a_{Y,0}\right)$$

9.4.3 The ratio of the value of the yaw velocity at time t_n to the value of the reference yaw velocity at time t_n (see Figure B.3):

$$\frac{\dot{\psi}_{t_n}}{\dot{\psi}_{\mathrm{Ref},t_n}} = f_2\left(a_{Y,0}\right)$$

9.4.4 The ratio of the maximum value attained by the yaw velocity to the corresponding reference value of the yaw velocity (see Figure B.4):

$$\frac{\dot{\psi}_{\max}}{\dot{\psi}_{\mathrm{Ref},t_{\max}}} = f_3\left(a_{Y,0}\right)$$

where $t_{\max}$ is the instant when the maximum value of the yaw velocity is reached.

9.4.5 The difference between the values of the instantaneous yaw velocity at time t_n and the reference yaw velocity at time t_n (see Figure B.5):

$$\Delta\dot{\psi}_{t_n} = \dot{\psi}_{t_n} - \dot{\psi}_{\text{Ref},t_n} = \dot{\psi}_{t_n} - \frac{v_{X,t_n}}{R_0} = f_4(a_{Y,0})$$

9.4.6 The maximum value of the difference between the yaw velocity during power-off and the affiliated reference yaw velocity (see Figure B.6):

$$\Delta\dot{\psi}_{\max} = \left(\dot{\psi}_t - \dot{\psi}_{\text{Ref},t}\right)_{\max} = \left(\dot{\psi}_t - \frac{v_{X,t}}{R_0}\right)_{\max} = f_5(a_{Y,0})$$

9.4.7 The instantaneous value of yaw acceleration evaluated at time t_n. Time t_n would typically be one second after throttle release, expressed as $t_n = t_0 + 1$ s. Yaw acceleration may be computed by differentiating yaw velocity (see Figure B.7):

$$\ddot{\psi}_{t_n} = \left.\frac{\mathrm{d}\dot{\psi}}{\mathrm{d}t}\right|_{t_n} = f_6(a_{Y,0})$$

9.4.8 The ratio of the value of the lateral acceleration at time t_n to the reference value of the lateral acceleration at time t_n (see Figure B.8):

$$\frac{a_{Y,t_n}}{a_{Y,\text{Ref},t_n}} = \frac{R_0}{R_{t_n}} = f_7(a_{Y,0})$$

9.4.9 The maximum value of the sideslip angle during the observation period and the time t_{bm} (Beta-Max) expressing the time passed after t_0 until the maximum was reached (see Figure B.9):

$$\beta_{\max} = f_{8-1}(a_{Y,0}) \qquad t_{\text{bm}} = f_{8-2}(a_{Y,0})$$

9.4.10 The difference between the values of the sideslip angle at time t_n and the initial steady-state value of the sideslip angle (see Figure B.10):

$$\beta_{t_n} - \beta_0 = f_9(a_{Y,0})$$

9.4.11 The difference between the maximum value of the sideslip angle during the observation period and the initial steady-state value of the sideslip angle (see Figure B.11):

$$\beta_{\max} - \beta_0 = f_{10}(a_{Y,0})$$

9.4.12 The difference between the values of the instantaneous yaw velocity at time t_n and the calculated yaw velocity at time t_n (see Figure B.12):

$$\dot{\beta}'_{t_n} = \dot{\psi}_{t_n} - \frac{a_{Y,t_n}}{v_{X,t_n}} = f_{11}(a_{Y,0})$$

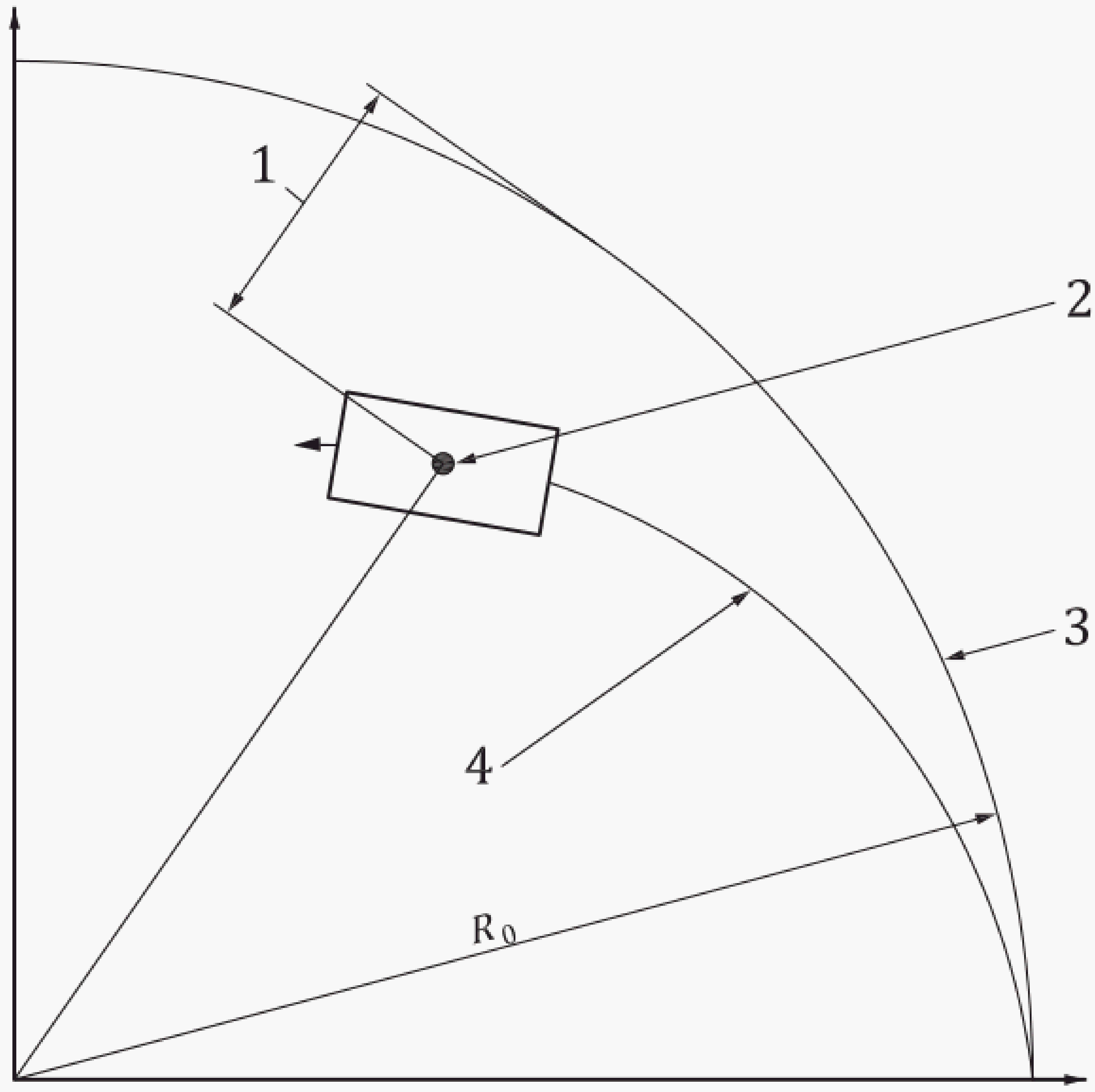
where $\dot{\beta}'$ is the sideslip-angle velocity uncorrected for the effects of the sideslip angle itself and the deceleration.

This metric provides information on the vehicle's yaw stability.

9.4.13 The path deviation at time t_n defined as the radial distance of the reference point and its initial circular path (see Figure B.13):

$$\Delta s_{Y,t_n} = f_{12}\left(a_{Y,0}\right)$$

where $t_n = t_0 + 2$ s.



Key

1 path deviation

2 vehicle reference point

3 initial circuit path

4 path of reference point

R_0 initial radius

Figure 1 — Definition of path deviation

The path deviation is calculated by the path of the reference point in the earth fixed axis system (see Figure 1). The coordinates of the reference point can be determined for example by transforming the vehicle fixed velocity vectors $\vec{v}_X$ and $\vec{v}_Y$ into the earth fixed system and subsequent integration.

Annex A
(normative)

Test report — General data

The documentation of general data and test conditions shall be in compliance with ISO 15037-1:2018[2], Annex A and Annex B.

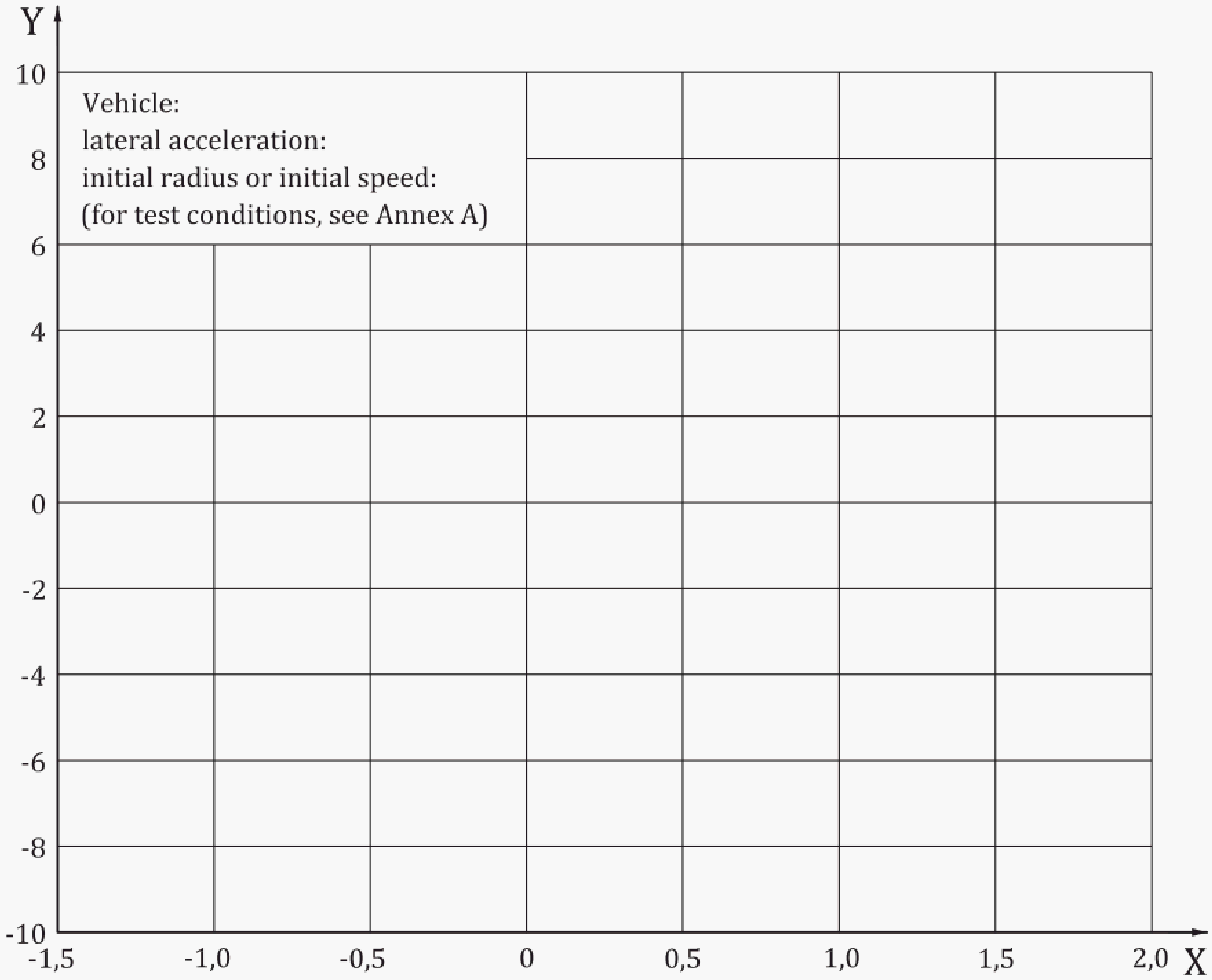
2) Under preparation. Stage at time of publication: ISO/DIS.

Annex B
(normative)

Presentation of results

Figure B.1 shows the time histories of variables.

The characteristic values of the vehicle dynamic reaction shall be presented as functions of the initial steady-state lateral acceleration or initial radius, as shown in Figures B.2 to B.13.

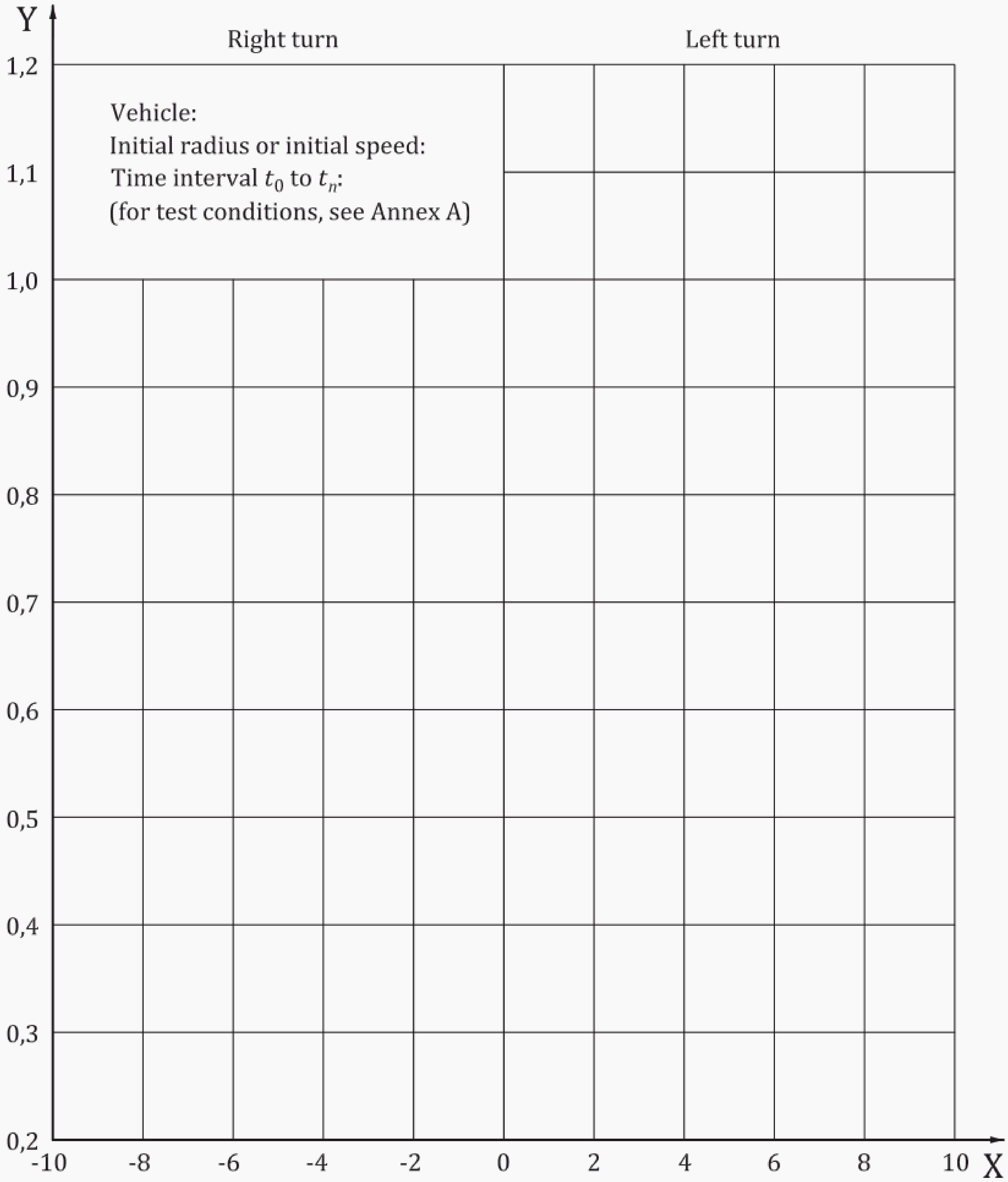


Key

X time (s)

Y longitudinal velocity (m/s), lateral acceleration (m/s²), steering wheel angle (°), sideslip angle (°), yaw velocity (°/s)

Figure B.1 — Time histories of variables during the time interval −1,5 s **before and** 2,0 s **after power-off initiation (scaling depends on variables and test conditions)**

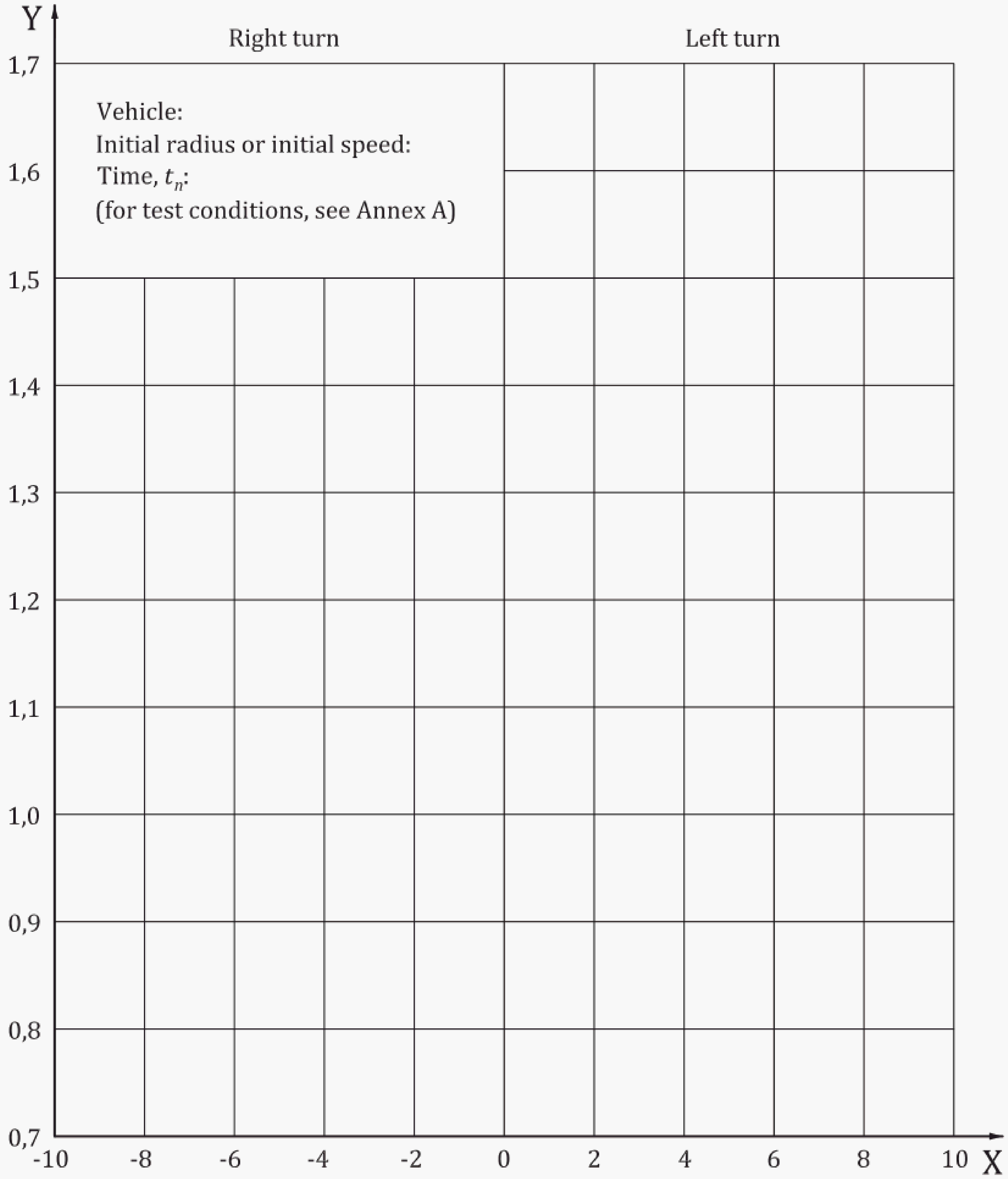


Key

X initial lateral acceleration $a_{Y,0}$ (m/s²)

Y $-\bar{a}_{X,t_n}$ (m/s²)

Figure B.2 — Mean longitudinal acceleration $-\bar{a}_{X,t_n}$ during the time interval t_0 to t_n as a function of the initial lateral acceleration $a_{Y,0}$

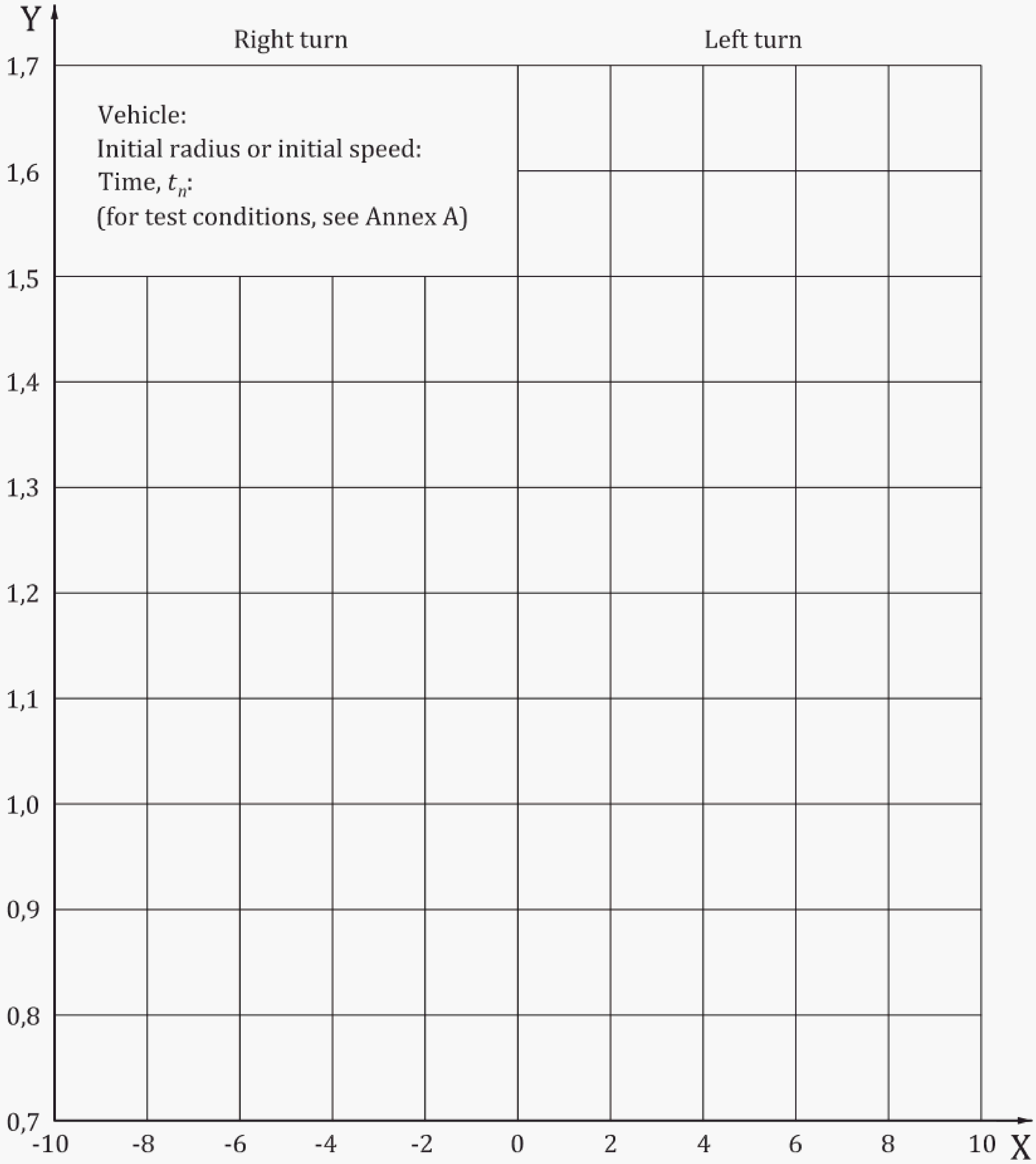


Key

X initial lateral acceleration $a_{Y,0}$ (m/s²)

Y $\frac{\dot{\psi}_{t_n}}{\dot{\psi}_{\mathrm{Ref},t_n}}$ (−)

Figure B.3 — The ratio of the value of the yaw velocity at time t_n to the value of the reference yaw velocity at time t_n as a function of the initial lateral acceleration $a_{Y,0}$

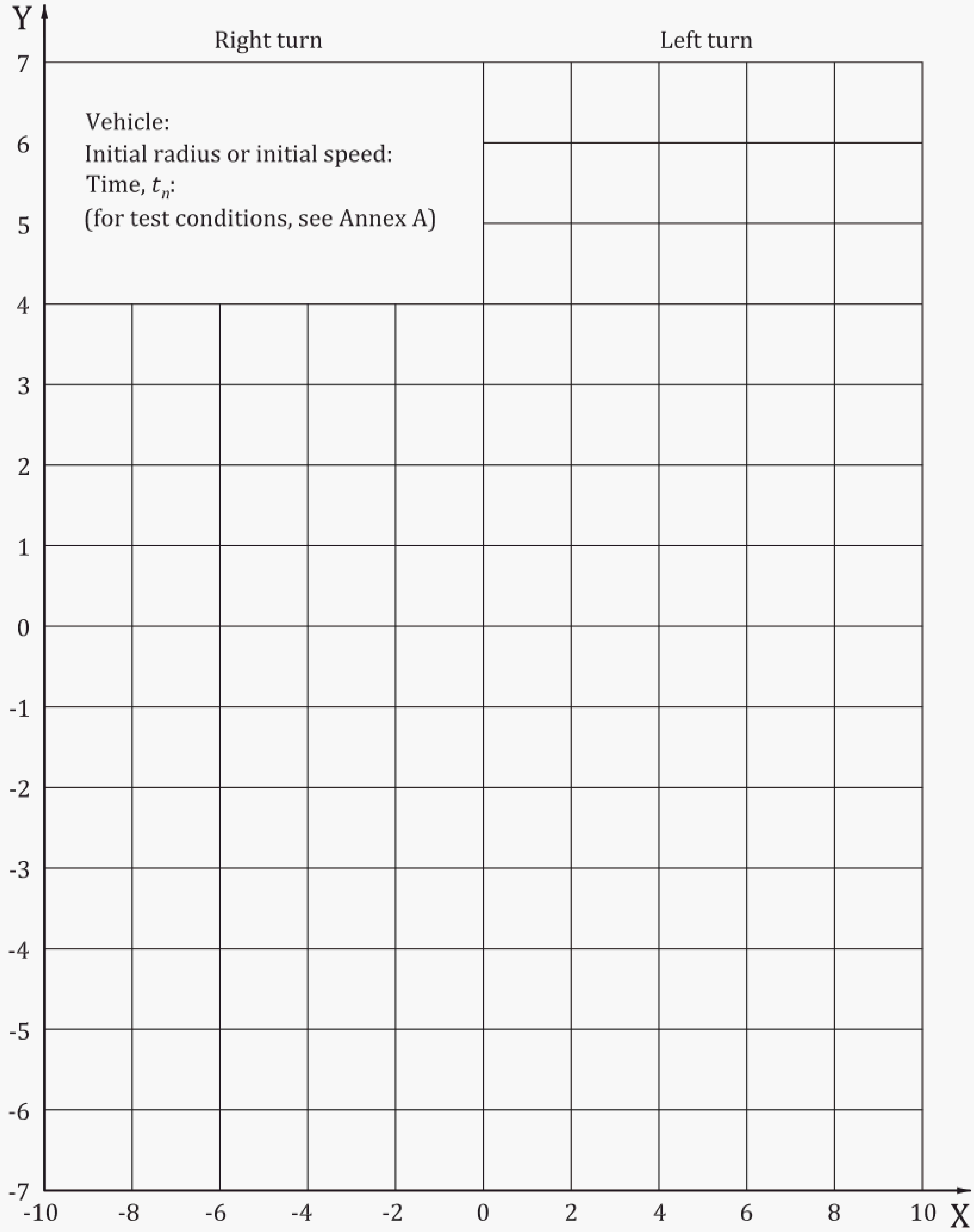


Key

X initial lateral acceleration $a_{Y,0}$ (m/s²)

Y $\dfrac{\dot{\psi}_{max}}{\dot{\psi}_{Ref,\,t_{max}}}$ (−)

Figure B.4 — The ratio of the maximum value attained by the yaw velocity $\dot{\psi}_{max}$ to the corresponding reference value of the yaw velocity $\dot{\psi}_{Ref,\,t_{max}}$ as a function of the initial lateral acceleration $a_{Y,0}$

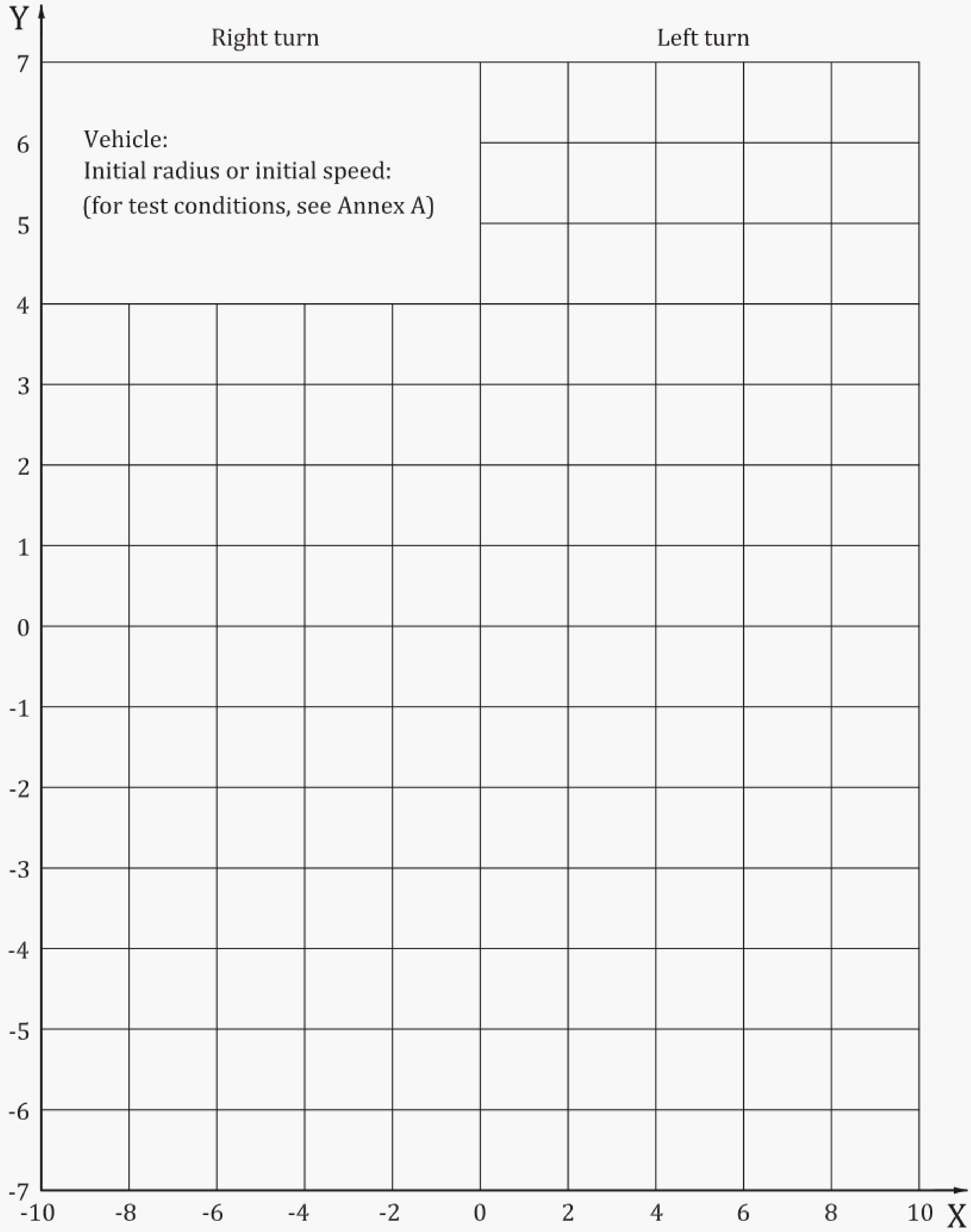


Key

X initial lateral acceleration $a_{Y,0}$ (m/s²)

Y $\dot{\psi}_{t_n} - \dot{\psi}_{\text{Ref},t_n}$ (°/s)

Figure B.5 — Difference between the value of the yaw velocity at time t_n and the value of the reference yaw velocity at time t_n as a function of the initial lateral acceleration $a_{Y,0}$

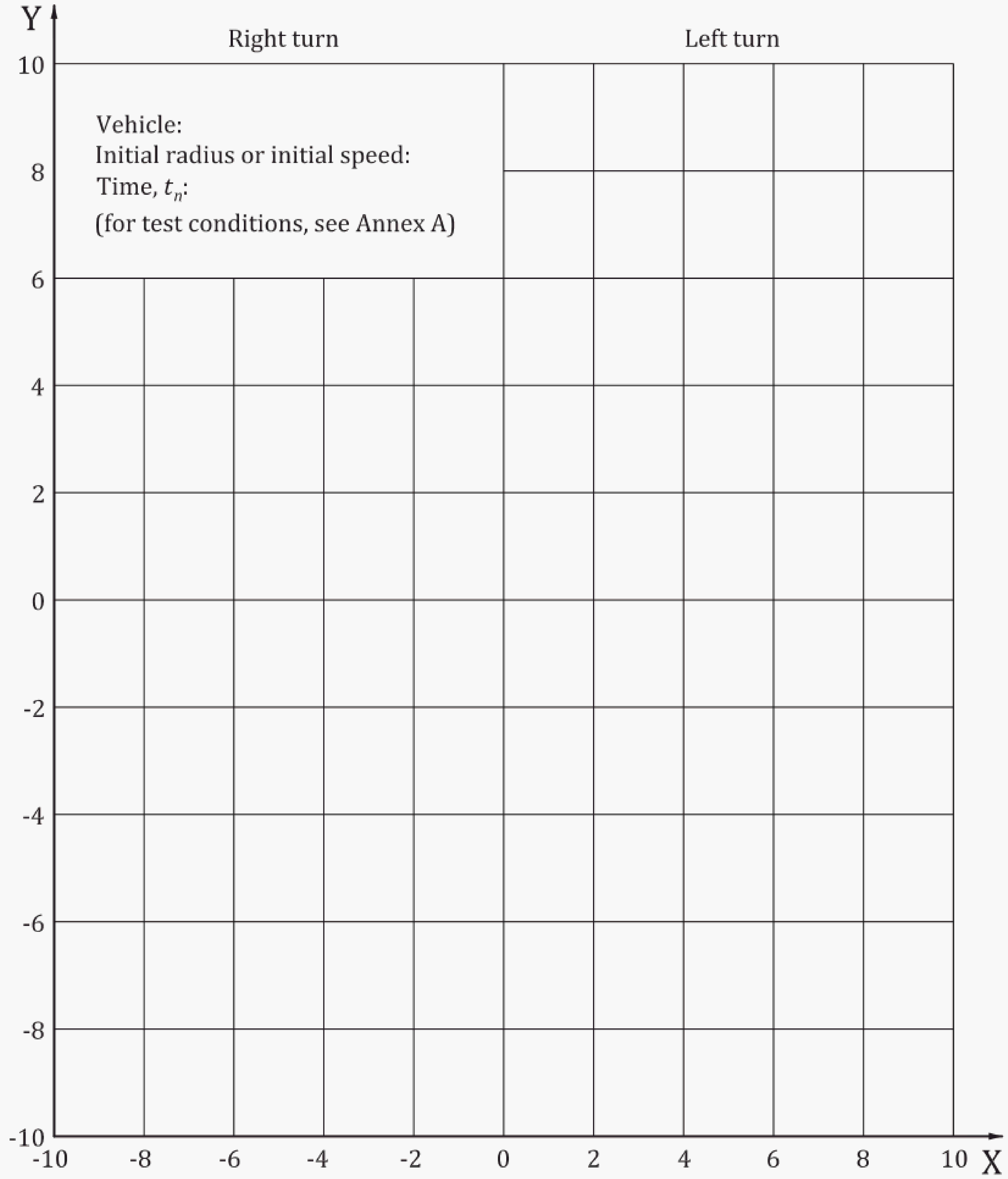


Key

X initial lateral acceleration $a_{Y,0}$ (m/s^2)

Y $\left(\dot{\psi}_t - \dot{\psi}_{\text{Ref},t}\right)$ max (°/s)

Figure B.6 — The maximum value of the difference between the yaw velocity during power-off $\dot{\psi}_t$ and the affiliated reference yaw velocity $\dot{\psi}_{\text{Ref},t}$ as a function of the initial lateral acceleration $a_{Y,0}$

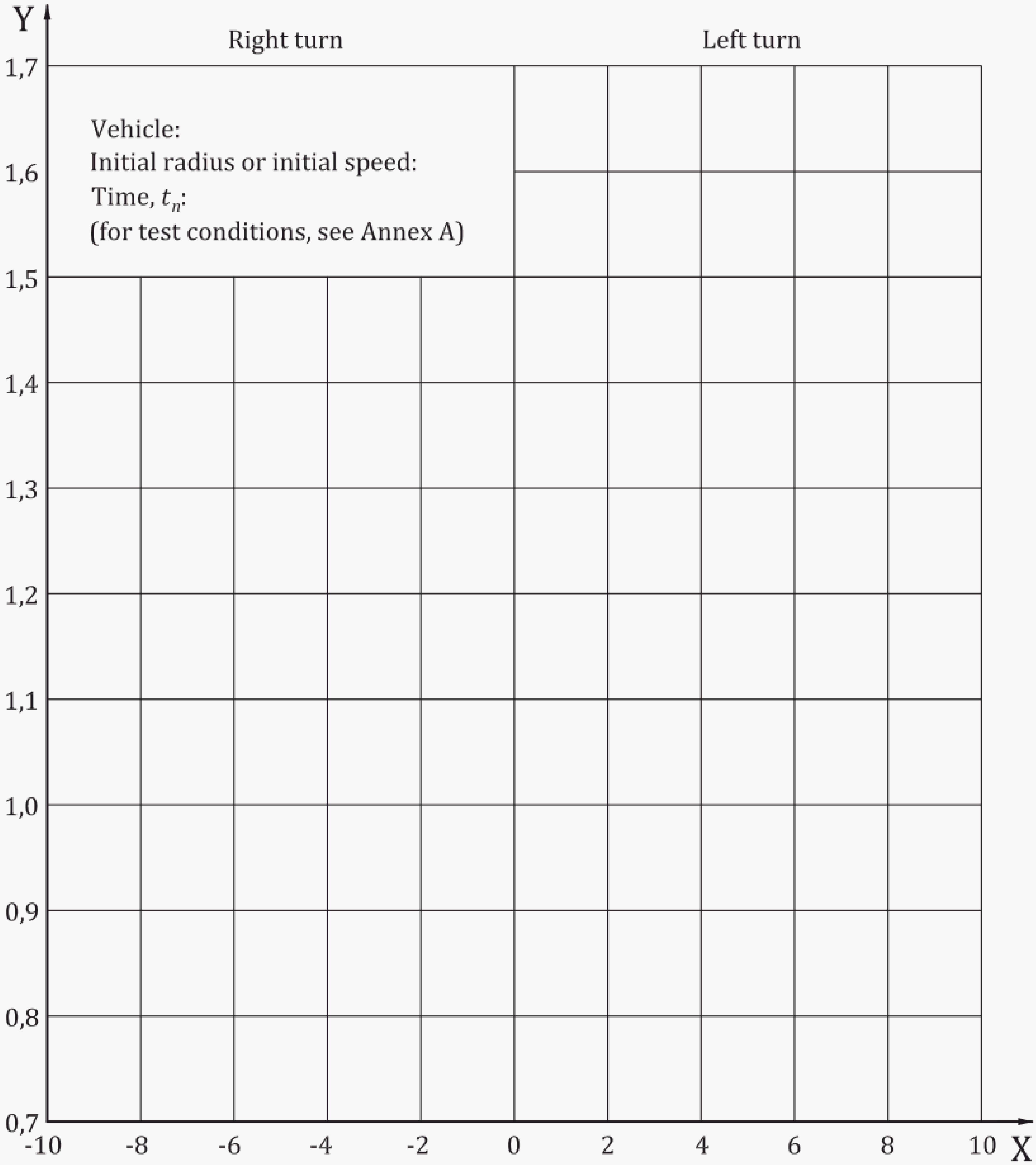


Key

X initial lateral acceleration $a_{Y,0}$ (m/s²)

Y $\ddot{\psi}_{t_n}$ (°/s²)

Figure B.7 — The instantaneous value of yaw acceleration at time t_n as a function of the initial lateral acceleration $a_{Y,0}$

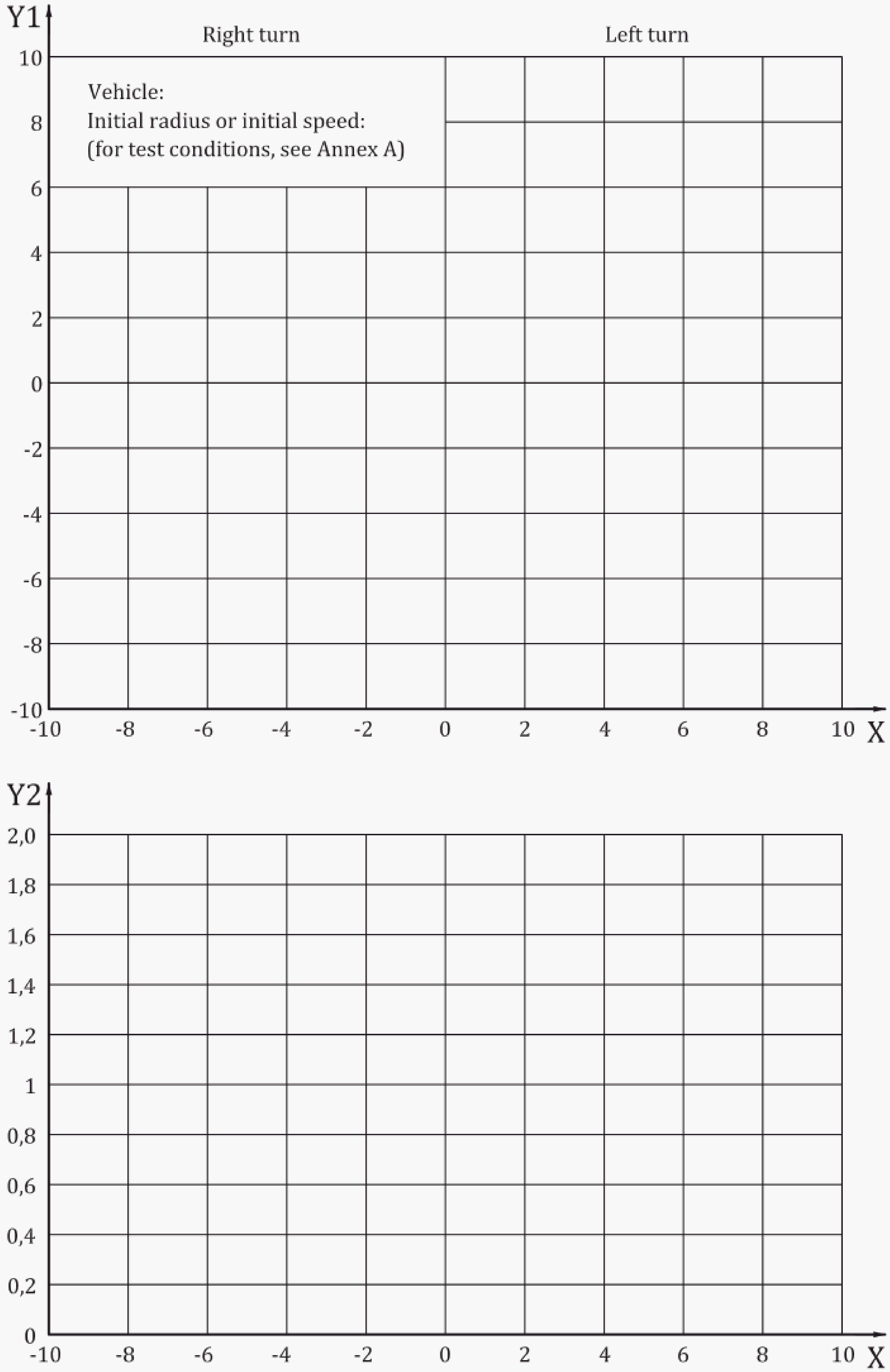


Key

X initial lateral acceleration $a_{Y,0}$ (m/s²)

Y $\frac{a_{Y,t_n}}{a_{Y,\mathrm{Ref},t_n}}$ (−)

Figure B.8 — The ratio of the value of the lateral acceleration at time t_n to the value of the reference lateral acceleration at time t_n as a function of the initial lateral acceleration $a_{Y,0}$



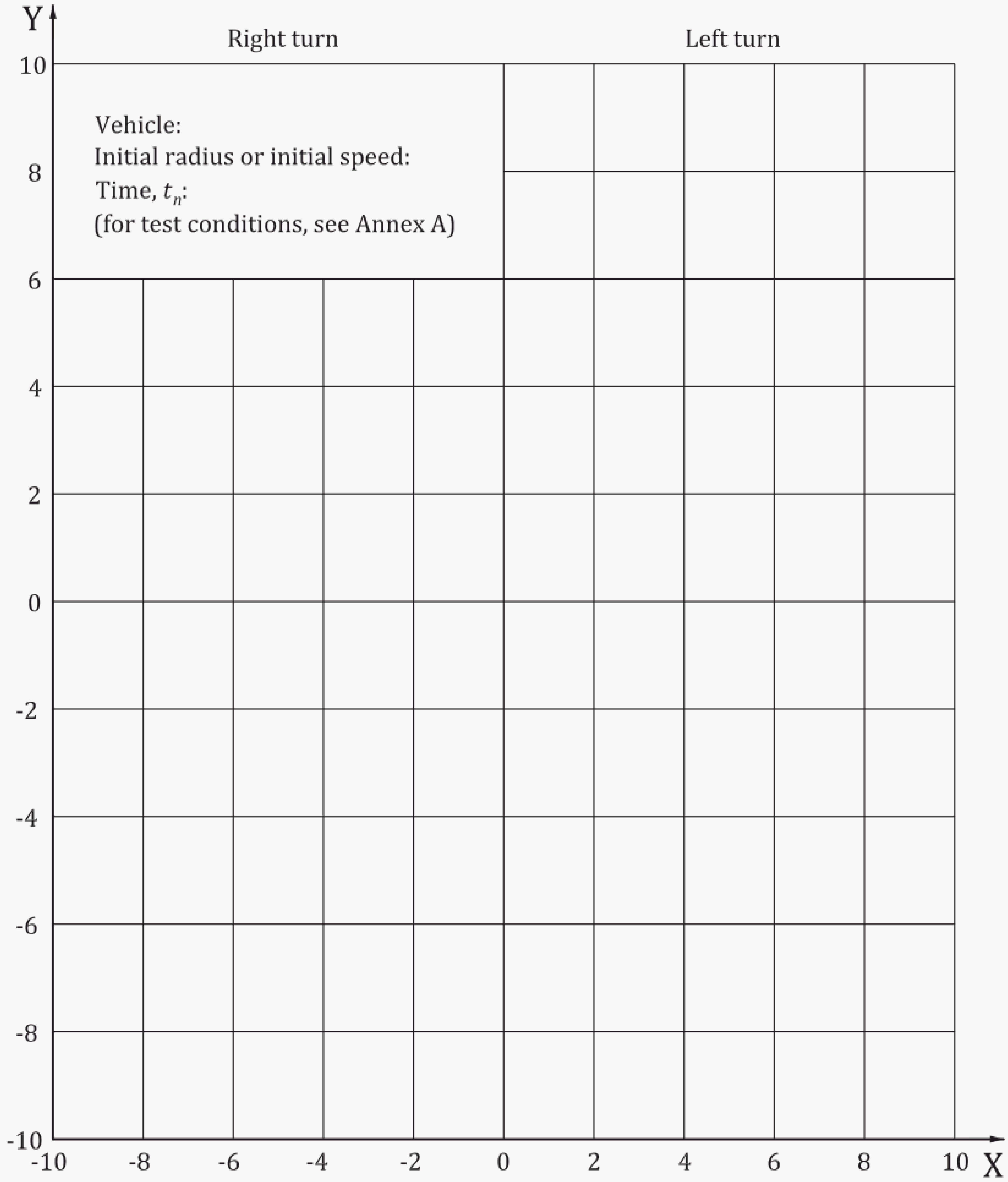
Key

X initial lateral acceleration $a_{Y,0}$ (m/s^2)

Y1 β_{max} (°)

Y2 t_{bm} (s)

Figure B.9 — Maximum value of the sideslip angle β_{max} during the observation period from 0 s to 2 s and the affiliated time t_{bm}, β_{max} as a function of the initial lateral acceleration $a_{Y,0}$

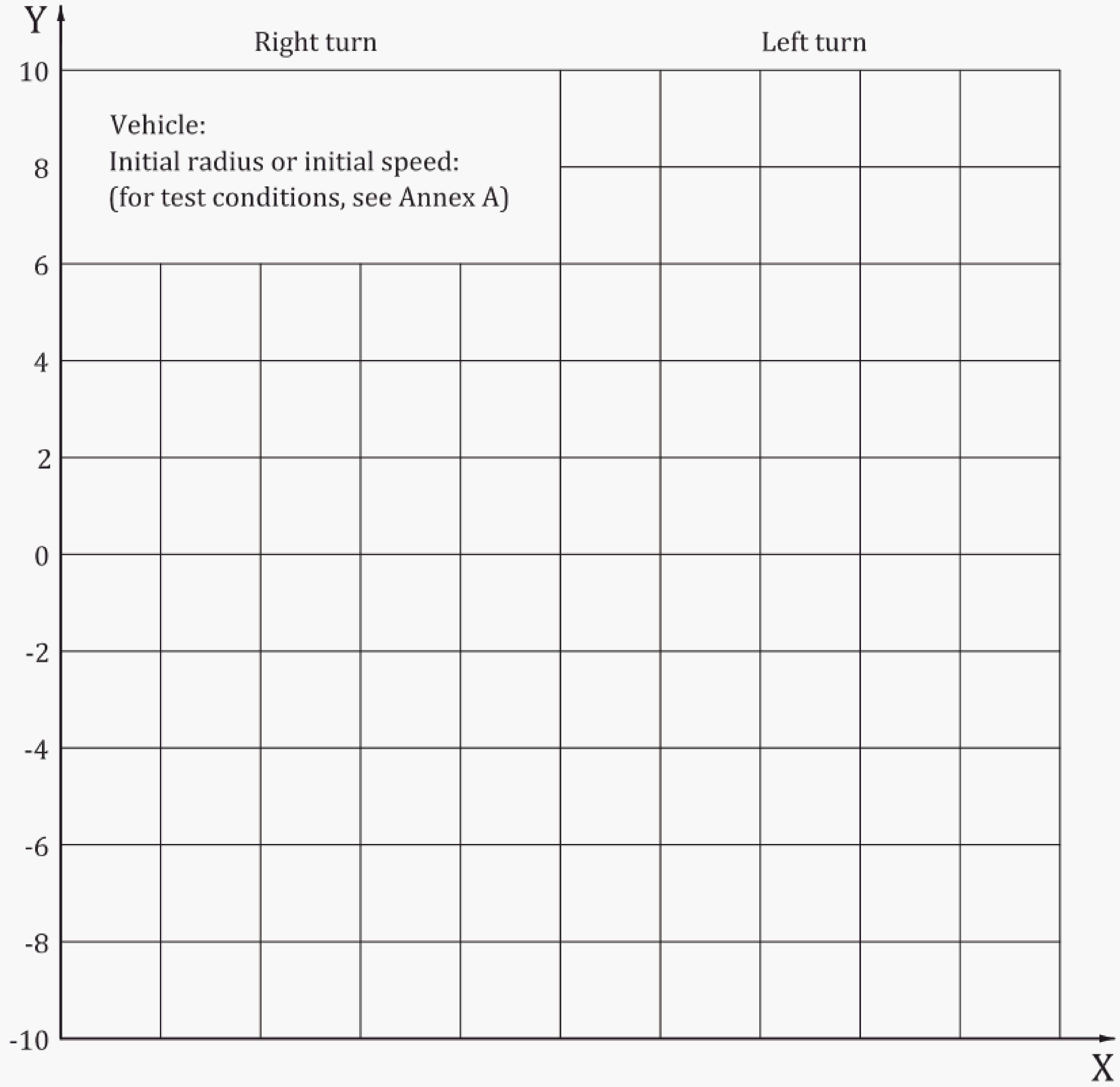


Key

X initial lateral acceleration $a_{Y,0}$ (m/s^2)

Y $\beta_{t_n} - \beta_0$ (°)

Figure B.10 — Difference between the value of the sideslip angle at time t_n and the initial value of the sideslip angle β_0 as a function of the initial lateral acceleration $a_{Y,0}$

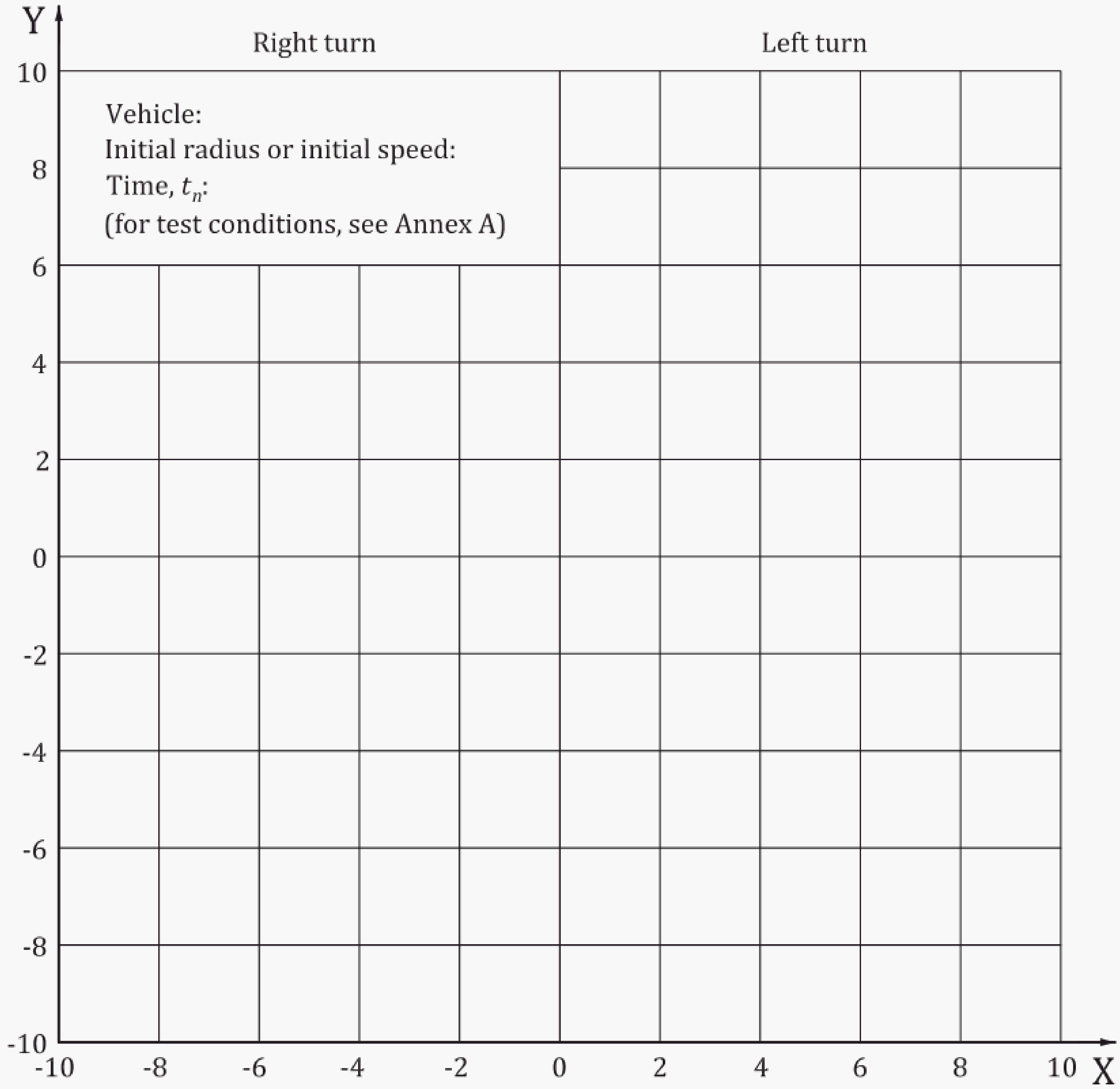


Key

X initial lateral acceleration $a_{Y,0}$ (m/s^2)

Y $\beta_{max} - \beta_0$(°)

Figure B.11 — Difference between the maximum value of the sideslip angle during the observation period from t_0 to t_n and the initial value of the sideslip angle β_0 as a function of the initial lateral acceleration $a_{Y,0}$

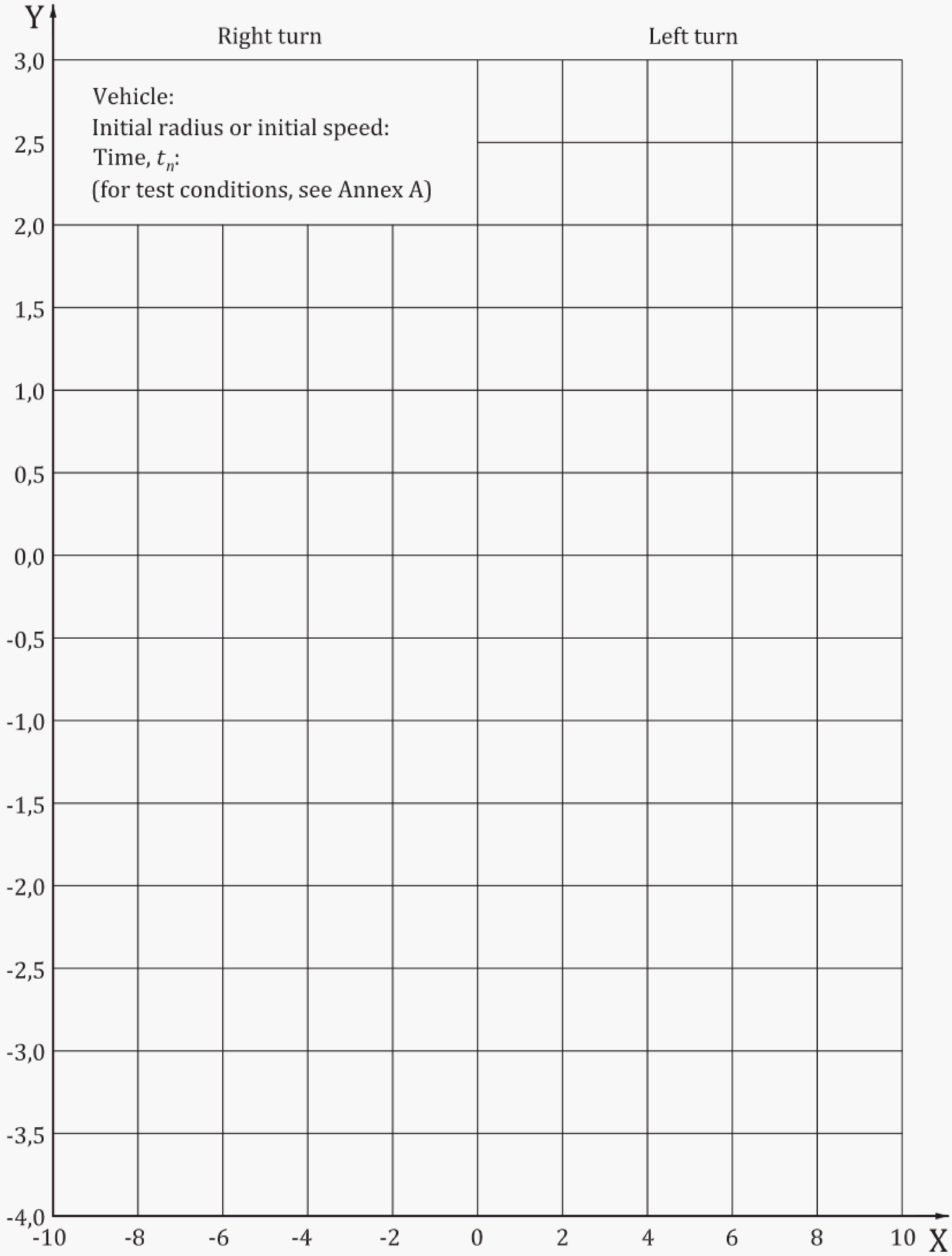


Key

X initial lateral acceleration $\boldsymbol{a}_{\boldsymbol{Y},\,\mathbf{0}}$ (m/s^2)

Y $\dot{\beta}'_{t_n}$ (°/s)

Figure B.12 — Difference between the values of the instantaneous yaw velocity at time t_n and the calculated yaw velocity at time t_n as a function of the initial lateral acceleration $a_{Y,\,0}$



Key

X initial lateral acceleration $a_{Y,0}$ (m/s^2)

Y $\Delta s_{Y,t_n}$ (m)

Figure B.13 — Path deviation of the reference point $\Delta s_{Y,t_n}$ at time $t_n = t_0 + 2$ s as a function of the initial lateral acceleration $a_{Y,0}$

Bibliography

[1] ISO 1176:1990, *Road vehicles — Masses — Vocabulary and codes*

[2] ISO 2416:1992, *Passenger cars — Mass distribution*

[3] ISO 4138, *Passenger cars — Steady-state circular driving behaviour — Open-loop test methods*

[4] ISO 3833, *Road vehicles — Types — Terms and definitions*

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