GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 43.040.50

CCS T 23

GB/T 41600-2022

Straight-line Driving Stability Test Procedure for Automobile

汽车直线行驶稳定性试验方法

Issued on: July 11, 2022 **Implemented on: November 1, 2022**

Issued by: State Administration for Market Regulation;

Standardization Administration of the People's Republic of China.

Table of Contents

Straight-line Driving Stability Test Procedure for Automobile

1 Scope

This document specifies the straight-line driving stability test procedure for automobile.

This document is applicable to Type-M and Type-N automobiles defined in GB/T 15089. The other types of automobile may take this as a reference.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in this text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 3730.2 Road Vehicle - Masses - Vocabulary and Codes

GB/T 12534-1990 Motor Vehicles - General Rules of Road Test Method

GB/T 12549 Terms and Definitions for Vehicle Controllability and Stability

GB/T 15089 Classification of Power-driven Vehicles and Trailers

3 Terms and Definitions

What is defined in GB/T 3730.2, GB/T 12534-1990, GB/T 12549 and GB/T 15089, and the following terms and definitions are applicable to this document.

3.1 Straight-line Driving Stability

Straight-line driving stability refers to the characteristic of maintaining or recovering to the original driving state after being subjected to external disturbances when a vehicle is driving in a straight line. It is characterized by the steering wheel correction amount during the process of straight-line driving in a limited straight-through lane.

4 Measurement Parameters

The following parameters need to be measured in the test:

shall comply with the exit-factory technical conditions of the vehicle. Before the test, the vehicle shall be subjected to running-in of at least 150 km of normal driving. If old tyres are used, after the test, the depth of the residual tyre tread pattern shall be not less than 1.6 mm.

6.2 Test Road Conditions

The test site shall be a flat, clean, dry and evenly paved road; the slope of the test road shall not exceed 2% (preferably 1.5%) in any direction. The length of the road section in the recommended test interval is 500 m ~ 1,000 m. For each test, the road conditions, slopes and paving materials shall all be recorded in Appendix A.

6.3 Test Environment

During the test, the ambient wind velocity is measured at a height of 1 m from the road surface; the maximum ambient wind velocity should not exceed 3 m/s. Under ideal conditions, the ambient wind velocity shall not exceed 1.5 m/s. If the wind velocity exceeds 1.5 m/s during the test, the influence of crosswind shall be avoided. When the atmospheric temperature is within the range of 0 °C ~ 40 °C, the environmental conditions for each test shall be recorded, as it is shown in Appendix A.

7 Test Process

7.1 Pre-heating

Before the formal test, the driver shall pre-heat the vehicle at the test speed; the driving distance shall not be lower than 50 km. Meanwhile, the driver shall be familiar with the test requirements and test site.

The test is a closed-loop test, and the test results with different drivers will be different. Therefore, the test shall adopt the same equipment and be completed by the same driver.

7.2 Straight-line Driving Process

The vehicle maintains a stable driving speed during the test. The test speed is 80% of the maximum speed of the sample vehicle, and rounded up to an integer multiple of 10. Alternatively, the vehicle speed may be used as a benchmark to increase or decrease the test speed (the speed interval is 20 km/h); the maximum test speed shall not exceed the safe speed of the test site. During the whole test process, it shall be ensured that the deviation of the vehicle speed does not exceed 3% of the specified vehicle speed in the test; the test vehicle shall be recorded in detail in the test report. If necessary, the test may add the operating condition of acceleration or deceleration.

In the straight-line driving test area, stakes shall be set up, or lane markings shall be drawn on the ground; the width of the lane shall be increased by 0.4 m on the basis of the width of the test vehicle. Before entering the test area, the vehicle shall achieve a straight-line driving state in advance and maintain for at least 100 m or a duration of 3 s. During the test, the driver shall

control the steering wheel in accordance with the normal driving habits, so as to ensure that the test vehicle runs straight through in the lane. During the test, if the stakes are knocked down, or the lane markings are crossed, then, the current test is invalid.

In the whole test area, the time history of each sensor signal needs to be recorded. The valid test data in both forward and reverse directions shall not be less than 3 sets. The total mileage of the valid data finally obtained shall not be less than 4 km. Meanwhile, record the test sequence.

8 Test Data Processing

8.1 Test Data Pre-processing

In order to maintain the vehicle running in the test lane, the driver needs to operate the steering wheel. The angle and the angular velocity of the steering wheel during this process are collected as indicators of evaluating the straight-line driving performance of the vehicle. The data pre-processing should adopt the following parameters:

a) cut-off frequency: f_c not less than 30 Hz;

b) data filtering: using anti-aliasing filter;

c) sampling time interval is determined in accordance with the performance index of the anti-aliasing filter used in the data acquisition process on the basis of satisfying the cut-off frequency.

The test data pre-processing method shall comply with the requirements of Appendix B.

8.2 Calculation of Test Evaluation Indexes

The standard deviation of steering wheel angle in the k^{th} test shall be calculated in accordance with Formula (1):

$$\sigma_{\delta swk} = \sqrt{\frac{\sum_{i=1}^{n} (\delta_{swki} - \overline{\delta_{swk}})^2}{n}} \qquad \cdots\cdots(1)$$

Where,

$\sigma_{\delta swk}$---the standard deviation of the steering wheel angle, expressed in (°);

δ_{swki}---the instantaneous value of steering wheel angle of the i^{th} sampling point of the k^{th} test, expressed in (°);

$\overline{\delta_{swk}}$ ---the average value of the steering wheel angle of the k^{th} test, expressed in (°).

Appendix B

(normative)

Requirements for Data Pre-processing

B.1 Overview

The frequency range of the test and evaluation is 0 Hz ~ 5 Hz.

B.2 Analog Signal Debugging

B.2.1 Bandwidth requirements for sensors and acquisition systems

The bandwidth shall be greater than or equal to 8 Hz.

B.2.2 Requirements for filters

Signal filtering shall adopt a low-pass filter. The passband bandwidth (frequency f_0 of 0 Hz ~ −3 dB) shall not be less than 9 Hz. Within the frequency range of 0 Hz ~ 5 Hz, the amplitude error shall be less than ± 0.5%. All analog signals shall be processed by filters with the same phase characteristics, so as to ensure that the time delay caused by filtering is the same.

In order to preserve low-frequency signals, the signals shall be DC-coupled. Since the filtering of analog signals containing different frequency components will cause phase shifts, the digital signal processing method described in B.3 should be adopted.

B.3 Aliasing Errors and Anti-aliasing Filters

B.3.1 Analog signal processing

Preparation for analog signal processing includes: selecting the sampling frequency and filter amplitude attenuation characteristics, filter phase lag and time delay characteristics that avoid aliasing errors.

B.3.2 General requirements for sampling and digitization

The contents that need to be considered in sampling and digitization: pre-sampling magnification, bits per sampling, sampling size per cycle, sample and hold amplifier, and sample space to minimize digitization error. For other digital filters without phase shifts, the selection of passband, stopband, attenuation and allowable ripple, as well as the correction of filter phase lag need to be considered.

In order to achieve the acquisition accuracy of ± 0.5% of the overall data, the above-mentioned factors are of great importance.

Adopt the attenuation and phase shift information of the Butterworth filter to avoid uncorrectable aliasing errors. Before sampling and digitization, the analog signals shall be correctly filtered. The selection of filter order and its passband shall be determined in accordance with the frequency range of interest and the requirements for signal flatness at the corresponding sampling frequency. The minimum filtering characteristics and minimum sampling frequency shall satisfy:

a) within the frequency range of 0 Hz ~ 5 Hz, the maximum attenuation of the analog signals shall be less than the resolution of the signal digitization;

b) at 1/2 sampling frequency (i.e., the Nyquist frequency or folding frequency), the magnitude of all frequency components of the signal and noise is reduced to less than the digitization resolution.

Example: for a resolution of 0.05%, within the 5 Hz range, the amplitude attenuation of the filter is less than 0.05%. For all frequencies above 1/2 sampling frequency, the amplitude attenuation is greater than 99.95%.

B.3.3 Requirements for filter order

In order to ensure the effect of data processing, the recommended anti-aliasing filter is forth-order or higher.

Adopt anti-aliasing filtering and avoid excessive analog signal filter. In addition, all filters shall have the same phase characteristics, so as to ensure that the time delay difference between the signals satisfies the accuracy requirements of time domain measurement.

NOTE: since the phase shift and the corresponding time delay will increase when the amplitudes of the measured variables are multiplied, when the measured variables are multiplied to form a new variable, the phase shift shall be paid special attention to. By increasing the cut-off frequency f_0 of the filter, the phase shift and time delay can be reduced.

B.4 Sampling and Digitization

The dynamic errors caused by the analog input variation exceeding 0.1% shall be limited; the sampling or digitization time shall be less than 32 μs. Each pair or set of sample data to be compared shall be collected simultaneously or within a sufficiently short period of time.

Digitization shall adopt 14-bit or a higher resolution (± 0.05%), 2 LSB (± 0.1%) precision system. The amplification of the analog signal before digitization shall ensure that in the process of digitization, the comprehensive error caused by limited resolution and inaccuracy of digitization shall be less than 0.25%.

B.5 Digital Filter without Phase Shift

For filtering used for data evaluation, the digital filter without phase shift (zero-phase-shift) shall have the following characteristics (see Figure B.1):

This is an excerpt of the PDF (Some pages are marked off intentionally)

------ The End ------