Road vehicles – Steering efforts (in cornering) test procedure

1. Scope

This standard stipulates the methods for testing steering effort when vehicles are cornering. It does not apply to motorcycles or special-purpose vehicles.

2. Normative reference

The following standards are quoted in this standard, and thus comprise part of the stipulations in this standard. The quoted standards are the latest issues (including supplements).

JIS D 0102: Road vehicles — Types — Terms and definitions

JASO Z117-1: Road vehicles — Steering and stability test procedure — Part 1: Passenger car standard test conditions

JASO Z117-2: Road vehicles — Steering and stability test procedure — Part 2: Truck and bus standard test conditions

JASO Z208: Steering and stability terminology

3. Definitions

The definitions of the main terms used within this standard are as described in **JIS D 0102** and **JASO Z208**. Other terms are defined below.

a) Steering wheel effective radius

Extends from the center of the wheel to the midpoint between the indentations of the steering wheel grip and the outer circumference of the wheel.

b) Steering effort

The steering wheel operating force required in the direction of rotation. This value is the steering torque measured around the steering wheel axis divided by the steering wheel effective radius.

c) Steering effort when cornering

The steering effort for a vehicle cornering in a constant circle when the radius of the course of the front axle centerline is 30 m and the centripetal acceleration is 2.5 m/s^2 (V = 31 km/h). This effort is indicated by the symbol F_{25}.

d) Steering effort at extremely low speed

The steering effort for a vehicle cornering in a constant circle when the centripetal force is extremely small. This is expressed by the value when the radius of the trajectory of the front axle centerline is 30 m. This effort is indicated by the symbol F_0.

e) Steering effort centripetal acceleration coefficient of influence

The ratio at which steering effort increases with respect to centripetal acceleration. This is indicated by the symbol *C*. The range of centripetal acceleration for calculating the steering effort increase ratio will vary depending on the vehicle type.

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4. Test conditions

4.1 Test vehicle configuration

4.1.1 Tires

The tires are to be as stipulated in **5.4.2** (Tires) in **JASO Z117-1** and in **6.3.2** (Tires) in **JASO Z117-2**.

4.1.2 Load conditions

The test vehicle is to be tested under the following load conditions.

a) For passenger cars, loads equivalent to the full complement of passengers are to be securely added with load ratios over the front and rear axles as specified in the specifications manual. The centers of gravity of the loads should ideally be as close as possible to the centers of gravity of seated passengers.

b) For trucks and buses, load the vehicle to the maximum loads indicated in the specifications manual for the front and rear axles. There are no particular stipulations on the centers of gravity of the loads added.

4.1.3 Front wheel alignment

The front wheels of the test vehicle should be aligned as indicated in the specifications manual.

4.2 Test road and course configuration

4.2.1 Test road

The test road is to be as stipulated in **5.2** (Test road) in **JASO Z117-1** and in **6.1** (Test road) in **JASO Z117-2.**

4.2.2 Cornering course configuration

The course should normally be a circular arc with a radius of 30 m and a cornering angle of at least 90 degrees, as shown in **Attached Figure 1**. The ends of the course should ideally have straight approach sections tangent to the corner.

4.3 Measuring equipment

The measuring equipment is to be as follows.

4.3.1 Steering effort measuring device

A device capable of recording the steering effort continuously while **cornering.**

4.3.2 Centripetal acceleration measuring device

A device for measuring the centripetal acceleration of a vehicle while cornering.

5. Test method

5.1 Measurement preparations

Mount the steering effort measuring device in the test vehicle, and install the device for measuring centripetal acceleration.

5.2 Test vehicle driving method

Drive the test vehicle around the course illustrated in **Attached Figure 1** at a constant speed V_i. The constant speed V_i is arbitrary, but ideally should be approximately one-tenth of the difference between the maximum speed at which the course can be safely negotiated, V_{max} and the extremely low speed V_0. For each circuit, the hands should be released from the steering wheel before entering the course to record the exact steering effort zero point.

5.3 Measurement data and recording

The maximum value of the steering effort, F_i, recorded when driving at speed V_i is to be measured with the mean centripetal acceleration A_i over the cornering course, and entered in **Attached Table 1**.

5.4 Test categories

Testing is to be conducted for left and right cornering at the load conditions stipulated in **4.1.2**.

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6. Organizing test results and records

6.1 Data processing

The following correlation graphs and characteristics are calculated from the data obtained in **5.3** using the methods described in **6.1.1** to **6.1.5**.

a) Correlation graph for centripetal acceleration and steering effort

b) Steering effort when cornering

c) Steering effort at extremely low speed

d) Steering effort centripetal acceleration coefficient of influence

6.1.1 Correlation graph for centripetal acceleration and steering effort

Plot the centripetal acceleration A_i and the corresponding steering effort F_i shown in **Attached Table 1** in **Attached Table 2** with A_i along the horizontal axis and F_i on the vertical axis.

6.1.2 Linear approximation using least square approximation

The correlation between A_i and F_i is approximated linearly using least square approximation to increase objectivity in the assessment of steering effort when cornering, steering effort at extremely low speed, and the steering effort centripetal acceleration coefficient of influence.

The straight line is determined separately for left and right cornering, and is expressed by the following equation.

$$F = F_0(\text{right}) + C(\text{right})A$$

$$F = F_0(\text{left}) + C(\text{left})A \qquad (A \le N) \quad \text{.....} (1)$$

F_0(right) and F_0(left) in equation (1) are the steering effort values at extremely low speed when cornering to the right and left, respectively. C(right) and C(left) represent values for the steering effort centripetal acceleration coefficient of influence when cornering to the right and left, respectively.

The linear approximation determined using the least square approximation is to be entered in **Attached Table 2.**

6.1.3 N value

When calculating the linear approximation using the least square approximation in **6.1.2**, the data used for the least square approximation must be $0 < A_i \le N$ (m/s^2), and data in the range $A_i > N$ (m/s^2) should be ignored. N is normally set as follows.

1) Passenger cars: 3.5

2) Trucks and buses: 2.5

6.1.4 Steering effort when cornering

F_{25}(right) and F_{25}(left) are read from the straight line in **Attached Table 2** and used in the following equation to calculate the steering effort when cornering, F_{25}.

$$F_{25} = \frac{1}{2}\left[F_{25}(right) + F_{25}(left)\right] \quad \text{.....} (2)$$

6.1.5 Steering effort at extremely low speed

F_0(right) and F_0(left) in **Attached Table 2** are used in the following equation to calculate the steering effort at extremely low speed, F_0.

$$F_0 = \frac{1}{2}\left[F_0(right) + F_0(left)\right] \quad \text{.....} (3)$$

6.1.6 Steering effort centripetal acceleration coefficient of influence

C(right) and C(left) in **Attached Table 2** are used in the following equation to calculate the steering effort

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