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**Performance requirements and testing methods for
continuously variable transmission**

无级变速器（CVT）性能要求及试验方法

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Table of Contents

Foreword	7
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	9
4 Testing requirements and performance requirements	10
5 Testing methods.....	13

Performance requirements and testing methods for continuously variable transmission

1 Scope

This Standard specifies the performance requirements and testing methods for continuously variable transmissions (CVTs) for M₁ vehicles.

This Standard applies to the M₁ vehicles equipped with CVTs, while N₁ vehicles equipped with CVTs and M₂ vehicles under 3,500kg may be implemented in accordance with this Standard.

2 Normative references

The following documents are essential for the application of this Standard. For dated references, only the dated editions apply to this Standard. For undated references, the latest editions (including all amendments) apply to this Standard.

GB 15089 *Classification of power-driven vehicle and trailers*

GB 18352.5-2013 *Limits and measurement methods for emissions from light-duty vehicles (CHINA 5)*

GB 19233 *Measurement methods of fuel consumption for light-duty vehicles*

QC/T 465 *Automotive mechanical transmission terminology and definition*

ECE R10 Rev. 3 *Uniform provisions concerning the approval of: vehicles with regard to electromagnetic compatibility*

ISO 11451-2 *Road vehicles - Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 2: Off-vehicle radiation sources*

ISO 11452-4 *Road vehicles - Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 4: Bulk current injection (BCI)*

3.11 Starting device

A device that is coupled between the engine and the transmission to transfer engine torque to the transmission, such as a torque converter, a friction clutch, etc.

3.12 Lock up

A connection state where the speed difference between input and output of the starting device is 0.

3.13 Optimal fuel consumption curve

A curve connecting the lowest effective fuel consumption rate under different operating conditions of the engine.

4 Testing requirements and performance requirements

4.1 Testing requirements

4.1.1 Testing conditions

4.1.1.1 Environment

During the test, the temperature in the test chamber shall be 288K to 308K (15°C to 35°C), the relative humidity shall be 20% to 60%, and the altitude shall not exceed 1,000m.

4.1.1.2 Transmission oil

The transmission oil specified by the transmission manufacturer may be used, and the fuel quantity is allowed to be adjusted in a manner specified by the manufacturer.

4.1.1.3 Bench test run-in

Before performing the measurement test of the actual gear ratio and gear ratio spread, transmission torque capacity, and steady-state efficiency, the test samples shall be run-in according to the following specifications:

- a) The speed of the drive motor is set to 1,000r/min to 2,000r/min, and the torque is set to 50% of the rated torque.
- b) RUN-IN 1h in the states of the largest transmission ratio, the smallest transmission ratio, and the middle transmission ratio, respectively.

connecting shaft of the CVT.

5.1.1.1.3 The CVT oil cooler and piping shall be the same as when the vehicle is running normally, and the rigid pipe cannot be bent.

5.1.1.1.4 The joint shall be effectively sealed and shall not leak oil.

5.1.1.2 Run-in

The test equipment and samples shall be run-in in accordance with the requirements of 4.1.3.

5.1.2 Test procedure

5.1.2.1 SET the drive motor to the speed control mode.

5.1.2.2 SET the load motor to the no-load state.

5.1.2.3 SET the CVT to the D-gear position.

5.1.2.4 SET the starting device to the lock-up state.

5.1.2.5 INCREASE the speed of the drive motor so that the transmission is able to achieve the lowest oil pressure to maintain normal operation.

5.1.2.6 ADJUST the CVT controller so that the transmission reaches the oil pressure design value at the largest transmission ratio or the smallest transmission ratio, respectively, and operates stably.

5.1.2.7 MEASURE the drive motor speed, N_1 , and N_2 and N_3 of the load motor at different gear ratios. The measurement time is not less than 10s, and the sampling interval is no more than 10ms.

5.1.2.8 REPEAT steps 5.1.2.3 to 5.1.2.7 for 3 tests.

5.1.3 Treatment of test results

5.1.3.1 CALCULATE the gear ratio according to the following formula:

$$I = \frac{1}{3} \times \sum_{i=1}^3 \frac{2 \times N_{1i}}{N_{2i} + N_{3i}}$$

Where:

I - Gear ratio;

N_{1i} - The average speed of the drive motor in the i^{th} test;

During the test, the difference between the theoretical speed and the actual speed of the transmission load motor shall not exceed 5%, and the input torque at this time is the transmission torque capacity.

It shall be corrected according to the following formula:

$$T_c = T_{in} - T_{din}$$

Where:

T_c - Transmission torque capacity;

T_{in} - Input torque;

T_{din} - Loss of torque at the input of the device.

5.3 Optimal fuel economy tracking performance of the engine

5.3.1 Test preparation

Pre-test preparation shall be carried out in accordance with the requirements of 4.1.5.

5.3.2 Test cycle

The test cycle, as described in Annex CA of Appendix C of GB 18352.5-2013, consists of two parts of Part 1 (urban driving) and Part 2 (suburban driving). If the vehicle does not reach the acceleration and maximum speed values required by the test cycle, the accelerator pedal shall be stepped through until the required operating curve is returned. Deviation from the test cycle shall be documented in the test report.

5.3.3 Dynamometer settings

The load and inertia of the dynamometer shall be set according to the provisions of Appendix C of GB 18352.5-2013.

5.3.4 Test procedure

5.3.4.1 OBTAIN the engine optimal fuel consumption rate curve map.

5.3.4.2 RUN the test according to the provisions of Appendix C of GB 18352.5-2013.

5.3.4.3 MEASURE the engine speed and torque.

5.3.4.4 The data acquisition frequency is 1Hz.

Where:

L - Lock-up ratio;

t_{lock} - Lock-up duration;

t - Total duration of the test (excluding the idle time).

5.5 Transmission efficiency

5.5.1 Test preparation

Pre-test preparation shall be carried out in accordance with the requirements of 5.1.1.

5.5.2 Test procedure

5.5.2.1 SET the drive motor to the speed control mode.

5.5.2.2 SET the load motor to the torque control mode.

5.5.2.3 SET the CVT to the D-gear position.

5.5.2.4 SET the starting device to the lock-up state.

5.5.2.5 SET the drive motor speed to 1,000r/min.

5.5.2.6 ADJUST the CVT controller so that the transmission reaches the oil pressure design value at the largest transmission ratio, and operates stably.

5.5.2.7 ADJUST the torque of the drive motor to 25%, 50%, and 75% of the rated torque load, respectively, and MEASURE the torque of the load motor; after the value is stable, the measurement time is not less than 10s.

5.5.2.8 The load motor speed is increased by an increment of 1,000r/min (the maximum speed does not exceed the speed corresponding to the vehicle speed of 120km/h). MAINTAIN the gear ratio and the drive motor torque unchanged. MEASURE the speed and torque of the load motor.

5.5.2.9 INCREASE the drive motor torque as specified in Table 3, and REPEAT the test procedure 5.5.2.8.

5.5.2.10 ADJUST the CVT controller to make the transmission reach the oil pressure design value at the middle ratio and operate stably. REPEAT the test procedures 5.2.2.7 to 5.2.2.9.

5.5.2.11 ADJUST the CVT controller to make the transmission reach the oil pressure design value at the smallest transmission ratio and operate stably. REPEAT the test procedures 5.2.2.7 to 5.2.2.9.

5.6.1.2 Speed, torque and temperature measuring devices.

5.6.1.3 Calibrator, microphone and wind ball.

5.6.1.4 Noise data acquisition and processing system.

5.6.2 Test requirements

5.6.2.1 The test shall be carried out in a semi-anechoic chamber with a background noise of less than 25dB(A); and the difference between the final measurement and the background noise shall not be less than 10dB(A).

5.6.2.2 The installation state of the CVT on the bench is the same as the installation state on the complete vehicle. The shaft axis of the CVT input shaft is not less than 400mm from the ground.

5.6.2.3 The CVT output shaft shall use the drive shaft and hub (if any) of the original vehicle.

5.6.2.4 The cooling capacity of the oil cooling unit of the test bench is equivalent to the original vehicle, and the CVT is guaranteed to operate normally.

5.6.2.5 During the noise measurement process, the fan cannot be used. The CVT lubricating oil temperature is maintained at $(80\pm 5)^{\circ}\text{C}$, and the individual extreme conditions may relax the temperature limit, but shall not exceed 100°C .

5.6.2.6 The run-in specification shall be carried out in accordance with 4.1.3.

5.6.2.7 The frequency range of noise measurement is from 200Hz to 8,000Hz.

5.6.2.8 The installation positions of the microphone are at the top, left, right and front of the CVT center, and the distance between the microphone and the outer envelope surface of the CVT (corresponding to the microphone installation side) is 1m. For different layouts of CVT, when the test bench interferes with the position of a certain measuring point, the measuring point may be canceled, but at most one measuring point may be canceled.

5.6.3 Test procedure

5.6.3.1 TURN off all devices of the test bench, and MEASURE the background noise of the test chamber.

5.6.3.2 MEASURE the background noise of the test bench before the transmission under test is installed on the bench. ARRANGE the

In the case of canceling a measuring point, the above formula is changed to:

$$L_{pA} = 10 \times \lg \left(\frac{\sum_{i=3}^{L_{d10}} 10^{\frac{L_{d10}}{10}}}{3} \right)$$

5.7 Electromagnetic compatibility

5.7.1 Narrowband electromagnetic radiation test

Narrowband electromagnetic radiation testing shall be carried out in accordance with the provisions of Annex 8 of ECE R10 Rev. 3 *Uniform provisions concerning the approval of: vehicles with regard to electromagnetic compatibility*. The test object is a TCU of the CVT and is tested under power-on conditions.

For testing of other electrical components in the CVT assembly, REFER to ECE R10 Rev. 3 *Uniform provisions concerning the approval of: vehicles with regard to electromagnetic compatibility*.

5.7.2 Electromagnetic radiation immunity test

It shall be tested in accordance with the provisions of Annex 6 of ECE R10 Rev. 3 *Uniform provisions concerning the approval of: vehicles with regard to electromagnetic compatibility*.

- a) ESTABLISH a test field strength using the “alternative method” as specified in ISO 11451-2 *Road vehicles - Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 2: Off-vehicle radiation sources*.
- b) STABILIZE the speed at 50km/h±2km/h, CONNECT the monitoring device, and RECORD the I/O signal when the CVT is operating normally.
- c) APPLY interference under CW and AM/PM modulated signals, PERFORM the electromagnetic radiation immunity tests, respectively, and MONITOR the operating state of CVT in real time.

If the off-vehicle radiation source method cannot be used for testing due to the conditions, the test may be carried out according to the method specified in ISO 11452-4 *Road vehicles - Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 4: Bulk current injection (BCI)* with a testing level of 60mA.

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