

JASO

Technical Paper

Investigation of performance criteria for
electrical inertia chassis dynamometer

JASO TP 06001:2011

2nd Edition
2011-3-31

Japanese Automobile Standards Organization

Society of Automotive Engineers of Japan, Inc.

Index

1. Need for the evaluation method for electrical inertia chassis dynamometer	2
1) Purpose	2
2) Target	2
3) Major tasks to establish the performance criteria for electrical inertia CHDY	2
4) Principles of the evaluation method	2
2. Summary	3
1) About using electrical inertia CHDY in the type approval of emissions/fuel consumption	3
2) Results of the verification test	5
3. Background of the investigation	6
1) Introduction of the linear regression formula	6
2) Judgment criteria	7
3) Standardization of the judgment	8
4. Summary of the investigation results to use the linear regression formula	9
5. Overview of the detection/measurement processing method of roller linear velocity	13
6. What is the electrical inertia CHDY?	16
7. Calculation method of the linear regression evaluation method	19
8. Explanation of minor revision	20

1. Need for the evaluation method for electrical inertia chassis dynamometer

At present, electrical inertia chassis dynamometer (hereinafter referred to as CHDY) are not formally adopted in Japan. However, advantages in cost and other aspects are expected with the Note electrical inertia CHDY. Therefore an investigation was conducted to see if it satisfies performance requirements to substitute for the mechanical inertia (flywheel) CHDY in the future and its evaluation method.

(Note) What is the electrical inertia CHDY?

Instead of using the mechanical inertia of flywheel etc., the inertia load is calculated by detecting/computing acceleration/deceleration electrically. The force is applied as an electrical load automatically from the dynamometer to exert the inertia effect equivalent of the flywheel. This control method to compensate for the inertia electrically without using a mechanical inertia disk (flywheel) is the electrical inertia control. (See “7. What is the electrical inertia CHDY?” for details.)

Prior to the investigation of the evaluation method, National Traffic Safety and Environment Laboratory (hereinafter referred to as NTSEL), 3 CHDY manufacturing companies (Ono Sokki Co., Ltd., Horiba, Ltd., Meidensha Corporation), Japan Automobile Manufacturers Association, Inc. (hereinafter referred to as JAMA) and Japan Automobile Research Institute, Inc. established the WG, then the WG studied about the performance criteria for electrical inertia CHDY.

1) Purpose

- Establishment and standardization of the verification method for inertia load in using the electrical inertia CHDY in the type approval emissions/fuel consumption

2) Target

- To present a method to verify equivalence with the mechanical inertia CHDY and the numeric values to serve as the performance criteria

3) Major tasks of the performance criteria for the electrical inertia CHDY

- Unification of the conditions and the evaluation method to properly conduct performance evaluation of the electrical inertia CHDY that has already been installed at NTSEL and auto manufacturers
- Setting of a performance evaluation method and the criteria values for the electrical inertia CHDY
- Specific verification method at the official testing

4) Principles of the evaluation method

- It shall be possible to evaluate a vehicle in running condition on the CHDY.

- It shall be possible to evaluate the electrical inertia dynamic characteristics and the load accuracy.
- It shall be also applicable to the mechanical inertia CHDY or other various CHDYs.
- It shall be the theoretical evaluation.
- The evidence of the evaluation shall be left after the test on the CHDY.
- It shall be an advanced method.

5) Scope

- This paper is applicable to electrical inertia CHDYs that only use a single-axis.

2. Summary

1) About using electrical inertia CHDY in the type approval emissions/fuel consumption

In recent years, improvement of the control performance of the electrical inertia CHDY is remarkable. And the response delay of the electric inertia force is recognized not to effect to the emissions/fuel consumption and it was confirmed that the required accuracy was satisfied. And also, regarding the inertia weight at the emissions/fuel consumption test, the proper evaluation method, that is verified the accurate of the load inertia, is established. This led to a conclusion that the electric inertia CHDY can be used for the certification test of emissions/fuel consumption under the conditions mentioned below.

(1) Requirements of the electrical inertia CHDY

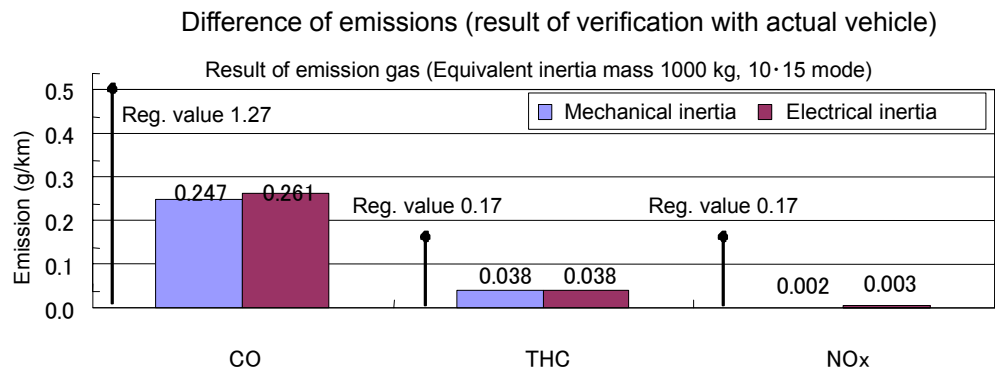
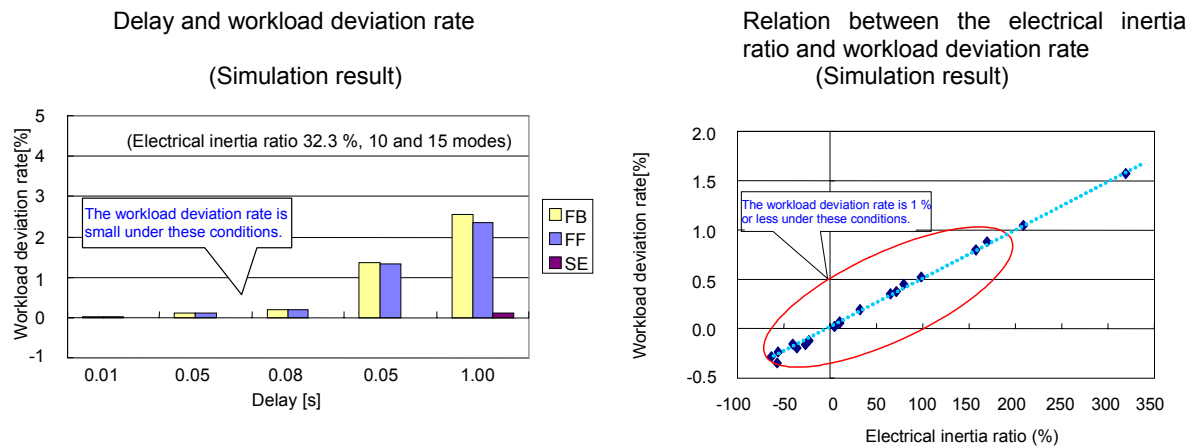
An investigation of effect on the emissions/fuel consumption was carried out by both the computer simulation and comparing the emissions with mechanical inertia type CHDY. In case of the computer simulation, the control response and the electric inertia ratio are analyzed with the workload deviation percent. As a result, it is possible to use the electrical inertia CHDY that satisfies the following performance requirements for an emissions/fuel consumption test.

A) Electrical inertia ratio: -60 to +200 %

Electrical inertia ratio (%) =
$$\frac{\text{Equivalent inertia mass} - \text{Mechanical fixed inertia mass}}{\text{Mechanical fixed inertia mass}} \times 100$$

B) Delay in control response: 0.10 s max. (90 % response time)

Use the evaluation method recommended by the CHDY manufacturers.



Chujo et al.; Applicability of Electric Inertia Chassis dynamometer to exhaust Emission and Fuel Economy Tests, Transactions of Society of Automotive Engineers of Japan, 20054752, Vol. 36 No. 5 (2005)

C) Description of terms of the electrical inertia CHDY control method

FB: differential feedback method

FF: Driving force observer torque control method

SE: Driving force observer torque control method + Simulation error (SE) correction method

* From the electrical inertia control method adopted by M company in Japan

(2) Evaluation items and judgment criteria for the evaluation test

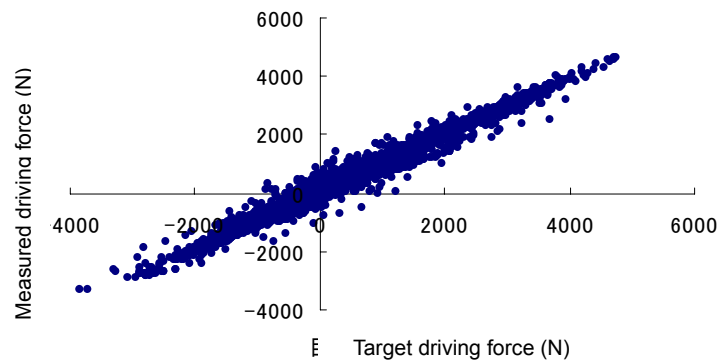
In a vehicle mode running condition, obtain the relation between a target driving force (X) per 50 ms and measured driving force (Y) obtained from the detected torque value of CHDY by a linear regression formula and use it as a statistical evaluation index.

A) Driving force deviation rate 5 % or less

$$\text{Driving force deviation rate} = \frac{\text{Standard deviation}}{\text{Average driving force} + 3\sigma} \times 100$$

B) Correlation coefficient 0.98 or more

- C) Tilt of the regression line 1.00 ± 0.02
D) Intercept of the regression line ± 20 N

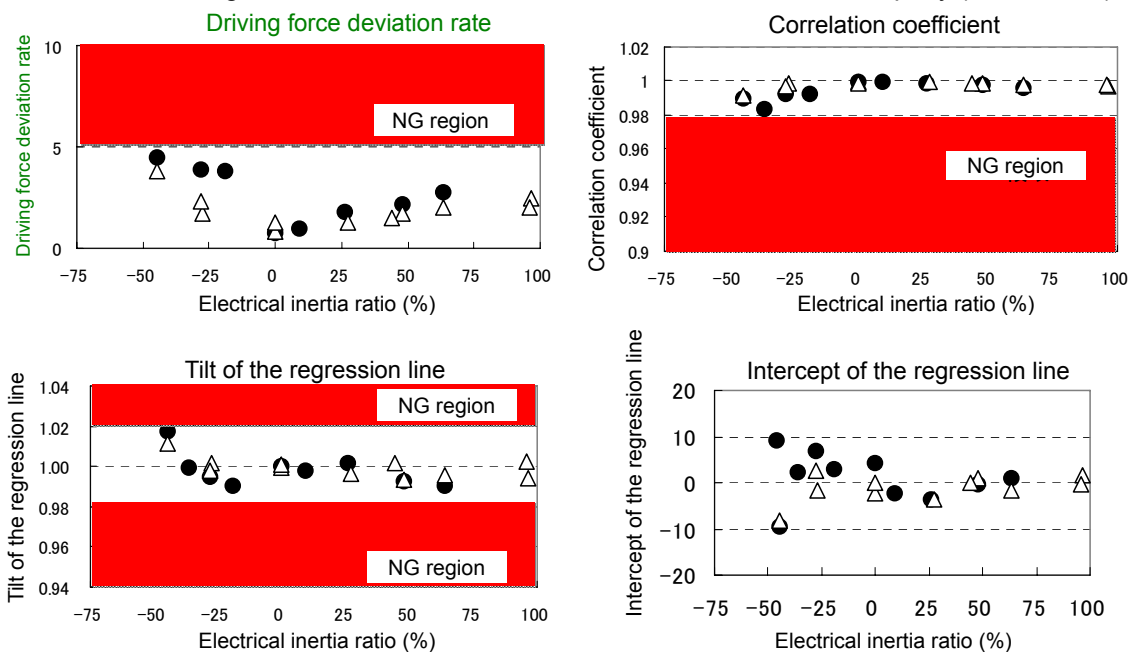


2) Results of the verification test

The electrical inertia CHDY owned by each JAMA member companies was tested based on the linear regression formula using different transmissions and distributing an electrical inertia ratio in the requirement ranges. The result showed that with exception of a few CHDYs, most CHDYs satisfied the newly established performance criteria.

At the region of the negative inertia where the performance of the response time is regarded as important, the test results of a few CHDYs strayed from the preset criteria. However, the verification test method and the standard values are evaluated as appropriate and it was agreed upon to use the values as the performance standard values of the electrical inertia CHDY.

1. Test result using the electrical inertia CHDY of each JAMA member company (JC08 mode)



3. Background of the investigation

1) Introduction of the linear regression formula

In order to evaluate the correct control of the electrical inertia amount of CHDY during the test, the detected torque value of CHDY during the mode running is measured and evaluated a statistical analysis based on the linear regression formula as against the target value of driving force calculated from the vehicle speed etc. An experiment was conducted as to this method and performance was verified for the evaluation method.

Definition of the X and Y axes of linear regression formula

X axis: Target driving force = Target running resistance + Equivalent inertia mass $\times$ Differential of CHDY vehicle speed detection (acceleration/deceleration speed by 7-point approximation method)

Y axis: CHDY detection driving force = CHDY torque at detection roller surface + Mechanical loss + Mechanical fixed inertia mass $\times$ Differential of CHDY vehicle speed detection (acceleration/deceleration speed by 7-point approximation method)

Test condition

Driving mode	: 10•15 mode, JC08 mode
Electrical inertia ratio	: -46.0 to +96.4 %
Test vehicle, CHDY	: 11 types of vehicles (incl. 6 types of manual transmission vehicles), 3 types of CHDYs
Data sampling rate	: 50 ms
Measurement item	: Vehicle speed pulse, driving force, etc.

Contents of the investigation

A) Differential method of the vehicle speed to obtain the driving force value and sampling rate

In order to obtain acceleration suitable for the calculation of driving force value, it is necessary to determine a differential method that has no phase delay with high efficiency in noise reduction and clarify an algorithm.

Considering the fact that the pulse number varies by CHDY manufacturer and the condition that the CHDY control response and transient phenomena, the linear differential 7-point approximation method that requires less calculation work was adopted.

The sampling period was set to 50 ms (20Hz) because the required response frequency for the CHDY is 3 Hz or more and it is possible to confirm if there is a signal of 10 Hz or more based on the theorem of sampling, taking the vehicle behavior and calculation workload into consideration.

B) Regression range

The experiment result showed that it is necessary to exclude the following ranges from