CHAPTER 5 : VERIFICATION OF INERTIA OTHER THAN MECHANICAL

1 Scope :

1.1 This Chapter describes the method to check that the simulated total inertia of the dynamometer is carried out satisfactorily in the running phases of the operating cycle.

2 Principle :

2.1 Drawing up working equations :

2.1.1 Since the chassis dynamometer is subjected to variations in the rotating speed of the roller(s), the force at the surface of the roller(s) can be expressed by the formula:

$F = I * \gamma = I_M * \gamma + F_I$

Where
F = force at the surface of the roller(s)

I = total inertia of the chassis dynamometer (equivalent inertia of the vehicle as in Table III of Chapter 3 of this Part).

I_M = inertia of the mechanical masses of the chassis dynamometer

γ = tangential acceleration at roller surface

F_I = inertia force

2.1.2 The total inertia is expressed as follows :

$$I = I_M + \frac{F_1}{\gamma}$$

where
I_M can be calculated or measured by traditional methods
F_I can be measured on the bench
γ can be calculated from the peripheral speed of the rollers

2.1.3 The total inertia "I" will be determined during an acceleration or deceleration test with values higher than or equal to those obtained on an operating cycle.

2.2 Specification for the calculation of total inertia :

The test and calculation methods must make it possible to determine total inertia I with a relative error (ΔI / I) of less than 2 %.

3 Specification :

3.1 The mass of the simulated total inertia I must remain the same as the theoretical value of the equivalent inertia (paragraph 5.1 of Chapter 3 of this Part) within the following limits:

3.1.1 ± 5 % of the theoretical value for each instantaneous value.

3.1.2 ± 2 % of the theoretical value for the average value calculated for each sequence of the cycle.

3.2 The limit given in paragraph 3.1.1 is brought to ± 50 percent for one second when starting and, for vehicles with manual transmission, for two seconds during gear changes.

4 Verification Procedure :

4.1 Verification is carried out during each test throughout the cycle defined in paragraph 2.1 of chapter 3 of this part.

4.2 However, if the provisions of paragraph 3 above are met, with instantaneous accelerations which are at least three times greater or smaller than the values obtained in the sequences of the theoretical cycle, the verification described above will not be necessary.

5 Technical Note :

Explanation of drawing up working equations:

5.1 Equilibrium of the forces on the road,

$$CR = k_1 Jr_1 \frac{d\theta_1}{dt} + k_2 Jr_2 \frac{d\theta_2}{dt} + k_3 M\gamma r_1 + k_3 F_s r_1$$

5.2 Equilibrium of the forces on dynamometer with mechanical simulated inertias

$$C_m = k_1 Jr_1 \frac{d\theta 1}{dt} + k_3 \frac{JR_m \frac{dW_m}{dt}}{R_m} r_1 + k_3 F_s r_1$$

$$= k_1 Jr_1 \frac{d\theta 1}{dt} + k_3 I\gamma r_1 + k_3 F_s r_1$$

5.3 Equilibrium of the forces of dynamometer with non-mechanically simulated inertias

$$C_e = k_1 Jr_1 \frac{d\theta_1}{dt} + \left(k_3 \frac{JR_e \frac{dW_e}{dt}}{R_e} r_1 + \frac{C_1}{R_e} r_1 \right) + k_3 F_s r_1$$

$$= k_1 Jr_1 \frac{d\theta_1}{dt} + k_3 (I_M \gamma + F_1) r_1 + k_3 F_s r_1$$

In these formulae :

CR = engine torque on the road

C_m = engine torque on the chassis dynamometer with mechanically simulated inertias

C_e = engine torque on the chassis dynamometer with electrically simulated inertias

Jr_1 = Moment of inertia of the vehicle transmission brought back to the driving wheels

Jr_2 = Moment of inertia of the non-driving wheels

JR_m = Moment of inertia of the bench with mechanically simulated inertias

JR_e = Moment of mechanical inertia of the chassis dynamometer with electrically simulated inertias

M = Mass of the vehicle on the road

I = Equivalent inertia of the chassis dynamometer with electrically simulated inertias

IM= Mechanical Inertia of the chassis dynamometer with electrically simulated inertia.

F_s = Resultant force at stabilized speed.

C_1 = Resultant torque from electrically simulated inertias

F_1 = Resultant force from electrically simulated inertias

$\frac{d\theta_1}{dt}$ = Angular acceleration of the driving wheels

$\frac{d\theta_2}{dt}$ = Angular acceleration of the non-driving wheels

$\frac{dW_m}{dt}$ = Angular acceleration of the mechanical chassis dynamometer

$\frac{dW_e}{dt}$ = Angular acceleration of the electrical chassis dynamometer

γ = Linear acceleration

r_1 = Radius under load of the driving wheels

r_2 = Radius under load of the non-driving wheels

R_m = Radius of the rollers of the mechanical chassis dynamometer

R_e = Radius of the rollers of the electrical chassis dynamometer

k_1 = Coefficient dependent on the gear reduction ratio and the various inertias of transmission and "efficiency"

k_2 = Ratio transmission * (r_1/r_2) * "efficiency"

k_3 = Ratio transmission * "efficiency"

5.4 Supposing the two types of bench (Paragraphs 5.2 and 5.3 above) are made equal and simplified, one obtains :

$$k_3 * (I_M * \gamma + F_1) * r_1 = k_3 * I * \gamma * r_1$$

where -

$$I = I_M + (F_1 / \gamma)$$