

## **Chapter 4**

### **CHASSIS DYNAMOMETER**

#### **Section I**

#### **1. Definition of a Chassis Dynamometer with Fixed Load Curve**

1.1. Introduction : In the event that total resistance to progress on the road is not reproduced on the chassis dynamometer between speeds of 10 and 120 km/h, it is recommended to use a chassis dynamometer having the characteristics defined below.

##### **1.2. Definition**

1.2.1. The chassis dynamometer may have one or two rollers. The front roller drives, directly or indirectly, the inertia masses and the power absorption device.

1.2.2. The load absorbed by the brake and the chassis dynamometer internal frictional effects from the speed of 0 to 120 km/h is as follows:

$$F = (a + b * V^2) \pm 0.1 * F_{80} \text{ (without being negative)}$$

where:

F = total load absorbed by the chassis dynamometer (N)

a = value equivalent to rolling resistance (N)

b = value equivalent to coefficient of air resistance (N/(km/h)<sup>2</sup>)

V = speed (km/h)

F<sub>80</sub> = load at the speed of 80 km/h (N)

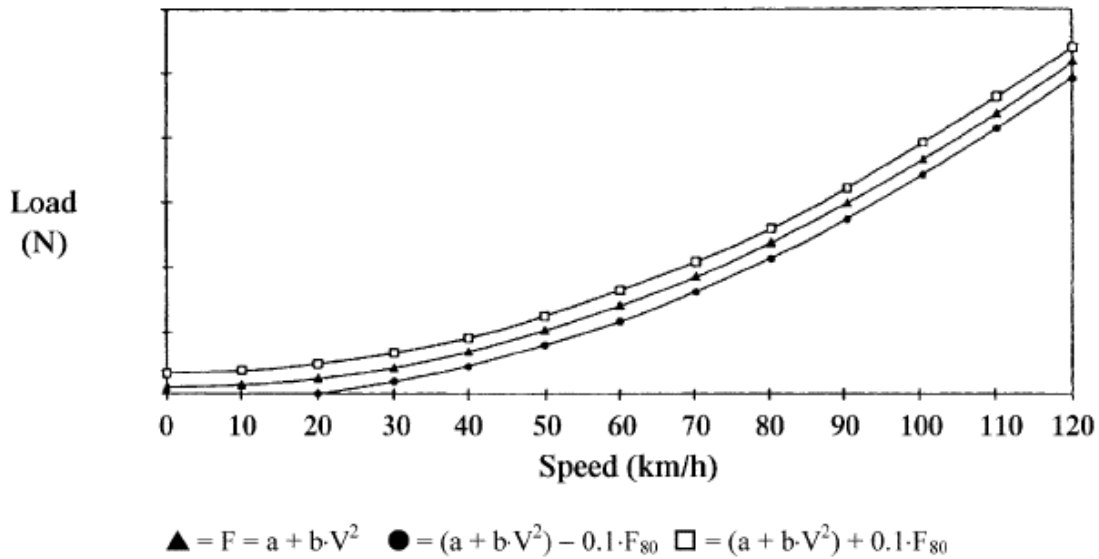
#### **2. Method of Calibrating the Dynamometer**

2.1. Introduction: This section describes the method to be used to determine the load absorbed by a dynamometer brake. The load absorbed comprises the load absorbed by frictional effects and the load absorbed by the power-absorption device. The dynamometer is brought into operation beyond the range of test speeds. The device used for starting up the dynamometer is then disconnected: the rotational speed of the driven roller decreases. The kinetic energy of rollers is dissipated by the power-absorption unit and by the frictional effects. This method disregards variations in the roller's internal frictional effects caused by rollers with or without the vehicle. The frictional effects of the rear roller shall be disregarded when this is free.

2.2. Calibrating the load indicator to 80 km/h as a function of the load absorbed. The following procedure is used (see also Figure 4).

2.2.1. Measure the rotational speed of the roller if this has not already been done. A fifth wheel, a revolution counter or some other method may be used.

**Figure 4. Diagram illustrating the load of the chassis dynamometer**



- 2.2.2. Place the vehicle on the dynamometer or devise some other method of starting up the dynamometer.
- 2.2.3. Use the fly-wheel or any other system of inertia simulation for the particular inertia class to be used.
- 2.2.4. Bring the dynamometer to a speed of 80 km/h.
- 2.2.5. Note the load indicated  $F_i$  (N).
- 2.2.6. Bring the dynamometer to a speed of 90 km/h.
- 2.2.7. Disconnect the device used to start up the dynamometer.
- 2.2.8. Note the time taken by the dynamometer to pass from a speed of 85 km/h to a speed of 75 km/h.
- 2.2.9. Set the power-absorption device at a different level.
- 2.2.10. The requirements of 2.2.4 to 2.2.9 must be repeated sufficiently often to cover the range of load used.
- 2.2.11. Calculate the power absorbed, using the formula:

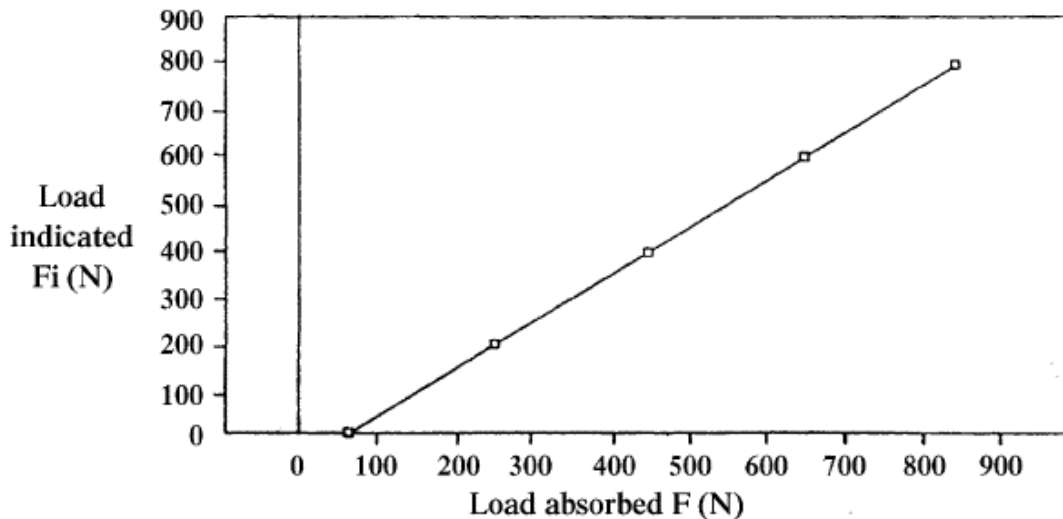
$$F = \frac{M_i \cdot \Delta V}{t}$$

where:

- $F$  = load absorbed in N
- $M_i$  = equivalent inertia in kg (excluding the inertial effects of free rear roller)
- $\Delta V$  = speed deviation in m/s (10 km/h = 2.775 m/s)
- $t$  = time taken by the roller to pass from 85 to 75 km/h.

2.2.12. Figure 5 shows the load indicated at 80 km/h in terms of the load absorbed at 80 km/h.

**Figure 5. Load indicated at 80 km/h in terms of load absorbed at 80 km/h**



2.2.13. The operation described in 2.2.3 to 2.2.12 must be repeated for all inertia classes to be used.

2.3. Calibration of the load indicator as a function of the absorbed load for other speeds. The procedures described in 2.2 must be repeated as often as necessary for the chosen speeds.

2.4. Verification of the load-absorption curve of the dynamometer from a reference setting at a speed of 80 km/h

2.4.1. Place the vehicle on the dynamometer or devise some other method of starting up the dynamometer.

2.4.2. Adjust the dynamometer to the absorbed load at 80 km/h.

2.4.3. Note the load absorbed at 100, 80, 60, 40 and 20 km/h.

2.4.4. Draw the curve  $F(v)$  and verify that it corresponds to the requirements of 1.2.2.

- 2.4.5. Repeat the procedure set out in 2.4.1 to 2.4.4 for other values of load F at 80 km/h and for other values of inertia.
- 2.5. The same procedure must be used for force or torque calibration.
3. Setting of the Dynamometer
- 3.1. Setting methods: The dynamometer setting may be carried out at a constant speed of 80 km/h in accordance with the requirements of Annexure II of this chapter.
- 3.1.1. Introduction: This method is not a preferred method and must be used only with fixed load curve shape dynamometers for determination of load setting at 80 km/h and cannot be used for vehicles with compression-ignition engines.
- 3.1.2. Test instrumentation: The vacuum (or absolute pressure) in the intake manifold vehicle is measured to an accuracy of  $\pm 0.25$  kPa. It must be possible to record this reading continuously or at intervals of no more than one second. The speed must be recorded continuously with a precision of  $\pm 0.4$  km/h.
- 3.1.3. Road test
- 3.1.3.1. Ensure that the requirements of clause 4 of Annexure II of this chapter are met.
- 3.1.3.2. Drive the vehicle at steady speed of 80 km/h recording speed and vacuum (or absolute pressure) in accordance with the requirements of 3.1.2.
- 3.1.3.3. Repeat procedure set out in 3.1.3.2 three times in each direction. All six runs must be completed within four hours.
- 3.1.4. Data reduction and acceptance criteria
- 3.1.4.1. Review results obtained in accordance with 3.1.3.2 and 3.1.3.3 (speed must not be lower than 79.5 km/h or greater than 80.5 km/h for more than one second). For each run, read vacuum level at one-second intervals, calculate mean vacuum ( $\bar{v}$ ) and standard deviation(s). This calculation must consist of no less than 10 readings of vacuum.
- 3.1.4.2. The standard deviation must not exceed 10% of mean ( $\bar{v}$ ) for each run.
- 3.1.4.3. Calculate the mean value ( $\bar{v}$ ) for the six runs (three runs in each direction).

### 3.1.5. Dynamometer setting

3.1.5.1.Preparation: Perform the operations specified in 5.1.2.2.1 to 5.1.2.2.4 of Section II of this chapter.

3.1.5.2.Setting: After warm-up, drive the vehicle at a steady speed of 80 km/h and adjust dynamometer load to reproduce the vacuum reading (v) obtained in accordance with 3.1.4.3. Deviation from this reading must be no greater than 0.25 kPa. The same instruments are used for this exercise as were used during the road test.

3.2. Alternative method: With the manufacturer's agreement the following method may be used:

3.2.1. The brake is adjusted so as to absorb the load exerted at the driving wheels at a constant speed of 80 km/h in accordance with the following table:

**TABLE: Setting of the Dynamometer (Alternative Method)**

Reference Mass of Vehicles		Equivalent Inertia	Power and load absorbed by dynamometer at 80 km/h		Coefficients	
					A	B
					N	N/(km/h) <sup>2</sup>
RW (kg)		Kg	KW	N	N	N/(km/h) <sup>2</sup>
Exceeding	Upto					
----	480	455	3.8	171	3.8	0.0261
480	540	510	4.1	185	4.2	0.0282
540	595	570	4.3	194	4.4	0.0296
595	650	625	4.5	203	4.6	0.0309
650	710	680	4.7	212	4.8	0.0323
710	765	740	4.9	221	5.0	0.0337
765	850	800	5.1	230	5.2	0.0351
850	965	910	5.6	252	5.7	0.0385
965	1080	1020	6.0	270	6.1	0.0412
1080	1190	1130	6.3	284	6.4	0.0433
1190	1305	1250	6.7	302	6.8	0.0460
1305	1420	1360	7.0	315	7.1	0.0481
1420	1530	1470	7.3	329	7.4	0.0502
1530	1640	1590	7.5	338	7.6	0.0515
1640	1760	1700	7.8	351	7.9	0.0536
1760	1870	1810	8.1	365	8.2	0.0557
1870	1980	1930	8.4	378	8.5	0.0577
1980	2100	2040	8.6	387	8.7	0.0591
2100	2210	2150	8.8	396	8.9	0.0605
2210	2380	2270	9.0	405	9.1	0.0619
2380	2610	2270	9.4	423	9.5	0.0646
2610	----	2270	9.8	441	9.9	0.0674

3.2.2. In case of vehicles, other than passenger cars, with a reference mass of more than 1700 kg, or vehicles with a permanent all wheel drive, the power values given above are multiplied by the factor 1.3 as per table given below. However at the manufacturer's request, the factor of 1.3 need not be applied for measurement of fuel consumption.

<b>Sr.No.</b>	<b>Vehicle Type</b>	<b>4 Wheel Drive Mode</b>	<b>Reference Mass</b>	<b>Use of 1.3 factor</b>
1	M1, Passenger Vehicle	Selectable	< 1700 Kg	No
2	M1, Passenger Vehicle	Selectable	> 1700 Kg	No
3	M1, Passenger Vehicle	Permanent	> 1700 Kg	Yes
4	N1, Other than passenger veh	Selectable	> 1700 Kg	Yes
5	N1, Other than passenger veh	Selectable	< 1700 Kg	No

## Chapter 4

### Section II

#### **RESISTANCE TO PROGRESS OF A VEHICLE - MEASUREMENT METHOD ON THE ROAD -SIMULATION ON A CHASSIS DYNAMOMETER**

1. Scope: This section describes the methods to measure the resistance to the progress of a vehicle at stabilised speeds on the road and to simulate this resistance on a chassis dynamometer in accordance with paragraph 4.1.7 of Chapter 3 of this part.
2. Definition of the road:
  - 2.1. The road shall be level and sufficiently long to enable the measurements specified below to be made. The longitudinal slope shall not exceed 1.5% and shall be constant within  $\pm 0.1$  % over the measuring strip.
3. Atmospheric Conditions:
  - 3.1. Wind: Testing must be limited to wind speeds averaging less than 3 m/s with peak speeds less than 5 m/s. In addition, the vector component of the wind speed across the test road must be less than 2 m/s. Wind velocity should be measured 0.7 m above the road surface.
  - 3.2. Humidity: The road shall be dry.
  - 3.3. Pressure - Temperature: Air density at the time of the test shall not deviate by more than  $\pm 7.5$  percent from the reference conditions:  $P = 100 \text{ kPa}$  &  $T = 293.2 \text{ K}$
4. Vehicle Preparation:
  - 4.1. Selection of the vehicle: If not all variants of a vehicle type are measured the following criteria for the selection of the test vehicle shall be used.
    - 4.1.1. Body: If there are different types of body, the worst one in terms of aerodynamics shall be chosen. The manufacturer shall provide data for the selection.
    - 4.1.2. Tyres: The widest tyres shall be chosen. If there are more than three tyres sizes, the widest minus one shall be chosen.
    - 4.1.3. Testing mass: The testing mass shall be the reference mass of the vehicle with the highest inertia range.

- 4.1.4. Engine: The test vehicle shall have the largest heat exchanger(s).
- 4.1.5. Transmission: A test shall be carried out with each type of the following transmissions:
- front wheel drive
  - rear wheel drive
  - full time 4 x 4
  - part time 4 x 4
  - automatic gear box
  - manual gear box
- 4.2. Running in: The vehicle shall be in normal running order and adjusted after having been run-in as per manufacturer's specifications. The tyres shall be run in at the same time as the vehicle or shall have a tread depth within 90 and 50 percent of the initial tread depth.
- 4.3. Verifications: The following verifications shall be made in accordance with the manufacturer's specifications for the use considered:
- wheel, wheel trims, tyres (make, type, pressure),
  - front axle geometry,
  - brake adjustment (elimination of parasitic drag)
  - lubrication of front and rear axles,
  - adjustment of the suspension and vehicle level, etc.
- 4.4. Preparation for the test: The vehicle shall be loaded to its reference mass. The level of the vehicle shall be that obtained when the centre of gravity of the load is situated midway between the "R" points of the front outer seats and on a straight line passing through those points.
- 4.4.1. In case of road tests, the windows of the vehicle shall be closed. Any covers of air climatization systems, headlamps, etc., shall be in the non-operating position.
- 4.4.2. The vehicle shall be clean.
- 4.4.3. Immediately prior to the test the vehicle shall be brought to normal running temperature in an appropriate manner.
5. Methods for chassis dynamometer with adjustable load curve
- 5.1. Energy variation during coast-down method
- 5.1.1. On the road



5.1.1.1.Accuracies of test equipment: Time shall be measured accurate to within 0.1 second. Speed shall be measured accurate to within 2 percent.

#### 5.1.1.2.Test procedure

5.1.1.2.1. Accelerate the vehicle to a speed of 10 km/h greater than the chosen test speed, V.

5.1.1.2.2. Place the gear box in “neutral” position.

5.1.1.2.3. Measure the time taken ( $t_1$ ) for the vehicle to decelerate from  $V_2 = V + \Delta V$  km/h to  $V_1 = V - \Delta V$  km/h: with  $\Delta V \leq 5$  km/h

5.1.1.2.4. Perform the same test in the opposite direction:  $t_2$

5.1.1.2.5. Take the average  $T$ , of the two times  $t_1$  and  $t_2$ .

5.1.1.2.6. Repeat these tests several times such that the statistical accuracy (p) of the average

$$T = \frac{1}{n} \sum_{i=1}^n T_i \text{ is not more than } 2 \% (p \leq 2 \%)$$

The statistical accuracy (p) is defined by :

$$p = \frac{t * s}{\sqrt{n}} * \frac{100}{T}$$

where:

t = coefficient given by the table below,

s = standard deviation,

$$s = \sqrt{\sum_{i=1}^n \frac{(T_i - \bar{T})^2}{n-1}}$$

n = number of tests,

**TABLE : Method of Energy Variation during coast-down**

N	4	5	6	7	8	9	10	11	12	13	14	15
T	3.2	2.8	2.6	2.5	2.4	2.3	2.3	2.2	2.2	2.2	2.2	2.2
$\frac{t}{\sqrt{n}}$	1.6	1.25	1.06	0.94	0.85	0.77	0.73	0.66	0.64	0.61	0.59	0.57

5.1.1.2.7 Calculate the power by the formula :

$$P = \frac{m * V * \Delta V}{500 * T}$$

where,

P is expressed in kW

V = speed of the test in m/s

$\Delta V$ = speed deviation from speed V, in m/s

m = reference mass in kg

T = time in seconds

Alternatively, the coast down shall be carried out as per IS 14785-2000 to establish “a” and “b” coefficients for setting on chassis dynamometer.

**The power (P) determined on the track shall be corrected to the reference ambient conditions as follows:**

**P corrected = K . P measured**

$$K = \frac{R_R}{R_T} \left[ 1 + K_R (t - t_0) \right] + \frac{R_{AERO}}{R_T} \cdot \frac{(p_0)}{p}$$

Where

$R_R$  = rolling resistance at speed V

$R_{AERO}$  = aerodynamic drag at speed V

$R_T$  = total driving resistance =  $R_R + R_{AERO}$

$K_R$  = temperature correction factor of rolling resistance, taken to be equal to:  $8.64 \times 10^{-3}$  / degrees C or the manufacturer’s correction factor that is approved by the authority.

t = road test ambient temperature in degrees C

$t_0$  = reference ambient temperature = 20 degrees C

rho = air density at the test conditions

$\rho_0$  = air density at the reference conditions (20 degrees C, 100 kPa)

The ratios  $R_R / R_T$  and  $R_{AERO} / R_T$  shall be specified by the vehicle manufacturer on the basis of the data normally available to the company.

If these values are not available, subject to the agreement of the manufacturer and the technical service concerned, the figures for the rolling/ total resistance ratio given by the following formula may be used:

Where:

M= vehicle mass in kg

And for each speed the coefficients a and b are shown in the following table:

V (km /h)	a	b
20	$7.24 \times 10^{-5}$	0.82
40	$1.59 \times 10^{-4}$	0.54
60	$1.96 \times 10^{-4}$	0.33
80	$1.85 \times 10^{-4}$	0.23
100	$1.63 \times 10^{-4}$	0.18
120	$1.57 \times 10^{-4}$	0.14

5.1.2. On the chassis dynamometer:

5.1.2.1.Measurement equipment and accuracy: The equipment shall be identical to that used on the road.

5.1.2.2.Test procedure:

5.1.2.2.1. Install the vehicle on the test dynamometer.

5.1.2.2.2. Adjust the tyre pressure (cold) of the driving wheels as required by the chassis dynamometer.

5.1.2.2.3. Adjust the equivalent inertia of the chassis dynamometer.

5.1.2.2.4. Bring the vehicle and chassis dynamometer to operating temperature in a suitable manner.

5.1.2.2.5. Carry out the following operations specified in paragraph 5.1.1.2 with the exception of paragraphs 5.1.1.2.4 and 5.1.1.2.5 and with changing  $m$  by  $I$  in the formula of paragraph 5.1.1.2.7 above.

5.1.2.2.6. Adjust the brake to reproduce the corrected power (Section 5.1.1.2.8) and to take into account the difference between the vehicle mass ( $M$ ) on the track and the equivalent inertia test mass ( $I$ ) to be used. This may be done by calculating the mean corrected road coast down time from  $V_2$  to  $V_1$  and reproducing the same time on the dynamometer by the following relationship:

$$T_{\text{corrected}} = \frac{T_{\text{measured}}}{K} \cdot \frac{I}{M}$$

$K$  = specified in 5.1.1.2.8.

5.1.2.2.7. The power  $P_a$  to be absorbed by the bench should be determined in order to enable the same power (clause 5.1.1.2.8) to be reproduced for the same vehicle on different days.

5.2. Torque measurements method at constant speed:

5.2.1. On the road:

5.2.1.1.Measurement equipment and error: Torque measurement shall be carried out with an appropriate measuring device, accurate to within 2 %. Speed measurement shall be accurate to within 2 %.

### 5.2.1.2 Test procedure

5.2.1.2.1 Bring the vehicle to the chosen stabilised speed, V.

5.2.1.2.2 Record the torque  $C_{(t)}$  and speed over a period of at least 20 s. The accuracy of the data recording system shall be at least  $\pm 1$  Nm for the torque and  $\pm 0.2$  km/h for the speed.

5.2.1.2.3 Differences in torque  $C_{(t)}$ , and speed relative to time shall not exceed 5% for each second of the measurement period.

5.2.1.2.4 The torque C is the average torque derived from the following formula

$$C_n = \frac{1}{\Delta t} \int_t^{t+\Delta t} C(t) dt$$

5.2.1.2.5 The test shall be carried out three times in each direction. Determine the average torque from these six measurements for the reference speed. If the average speed deviates by more than 1 km/h from the reference speed, a linear regression shall be used for calculating the average torque.

5.2.1.2.6 Determine the average of these torques  $C_{t1}$  and  $C_{t2}$  i.e  $C_t$ .

5.2.1.2.7 The average torque  $C_{(t)}$  determined on the track shall be corrected to the reference ambient conditions as follows:

$$C_{T \text{ corrected}} = K * C_{T \text{ measured}}$$

Where K is defined in 5.1.1.2.8 of this annexure.

### 5.2.2 On the chassis dynamometer

#### 5.2.2.1 Measurement equipment and error

The equipment shall be identical to that used on the road.

#### 5.2.2.2 Test procedure

5.2.2.2.1 Perform the operations specified in paragraphs 5.1.2.2.1 to 5.1.2.2.4 above.

5.2.2.2.2 Perform the operations specified in paragraphs 5.2.1.2.1 to 5.2.1.2.4 above.

5.2.2.2.3 Adjust the power absorption unit to reproduce the corrected total track torque of 5.2.1.2.7.

5.2.2.2.4 Proceed with the same operations as in 5.1.2.2.7 for the same purpose.

### 5.3 Integrated torque over vehicle driving pattern:

5.3.1 This method is a non-obligatory complement to the constant speed method described in paragraph 5.2 above.

5.3.2 In this dynamic procedure the mean torque value  $\overline{M}$  is determined.

This is accomplished by integrating the actual torque values,  $M(t)$ , with respect to time during operation of the test vehicle with a defined driving cycle. The integrated torque is then divided by the time difference  $t_2 - t_1$ ,

The result is:

$$\overline{M} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} M(t) * dt \text{ (with } M(t) > 0 \text{)}$$

$\overline{M}$  is calculated from six sets of results.

It is recommended that the sampling rate of  $\overline{M}$  be not less than two samples per second.

5.3.3 Dynamometer setting: The dynamometer load is set by the method described in paragraph 5.2 above. If  $\overline{M}$  (dynamometer) does not match  $M$  (road) then the inertia setting shall be adjusted until the values are equal within  $\pm 5$  percent.

Note: This method can only be used for dynamometers with electrical inertia simulation or fine adjustment.

5.3.3.1 Acceptance criteria:

Standard deviation of six measurements must be less than or equal to 2 % of the mean value.

5.4 Method by deceleration measurement by gyroscopic platform:

5.4.1 On the road:

5.4.1.1 Measurement equipment and accuracy:

- Speed shall be measured with an accuracy better than 2 %.
- Deceleration shall be measured with an accuracy better than 1 %.
- The slope of the road shall be measured with an accuracy better than 1%.
- Time shall be measured with an accuracy better than 0.1 s.
- The level of the vehicle is measured on a reference horizontal ground: as an alternative, it is possible to correct for the slope of the road ( $\alpha$  1).

5.4.1.2 Test procedure:

5.4.1.2.1 Accelerate the vehicle to a speed 5 km/h greater than the chosen test speed V.

5.4.1.2.2 Record the deceleration between V + 0.5 km/h and V - 0.5 km/h.

5.4.1.2.3 Calculate the average deceleration attributed to the speed V by the formula:

$$\bar{\gamma}_1 = \frac{1}{t} \int_0^t \gamma_1(t) dt - (g \cdot \sin \alpha_1)$$

where:

$\bar{\gamma}_1$  = average deceleration value at the speed V in one direction of the road

t = time between V + 0.5 kmph and V - 0.5 kmph

$\gamma_1(t)$  = deceleration recorded with the time

g = 9.81 m/s<sup>2</sup>.

5.4.1.2.4 Perform the same test in the other direction  $\gamma_2$

5.4.1.2.5 Calculate the average deceleration i.e.

$$\gamma_i = \frac{\gamma_1 + \gamma_2}{2} \text{ for test I.}$$

5.4.1.2.6 Perform a sufficient number of tests as specified in paragraph 5.1.1.2.6 above replacing T by  $\gamma$  where

$$\gamma = \frac{1}{n} \sum_{i=1}^n \gamma_i$$

5.4.1.2.7 Calculate the average force absorbed  $F = m * \gamma$ , where m = vehicle reference mass in kg &  $\gamma$  = average deceleration calculated as above.

5.4.2 On the chassis dynamometer:

5.4.2.1 Measuring equipment and accuracy

The measurement instrumentation of the chassis dynamometer itself shall be used as defined in Para 5.1.2.1 of this Part.

5.4.2.2 Test procedure

Adjustment of the force on the rim under steady speed.

On chassis dynamometer, the total resistance is of the type:

$F_{\text{total}} = F_{\text{indicated}} + F_{\text{driving axle rolling}}$  with

$F_{\text{total}} = F_{\text{road}}$

$F_{\text{indicated}} = F_{\text{road}} - F_{\text{driving axle rolling}}$

where:  $F_{\text{indicated}}$  is the force indicated on the force-indicating device of the chassis dynamometer.

$F_{\text{road}}$  is known.

$F_{\text{driving axle rolling}}$  can be measured on chassis dynamometer driving axle rolling able to work as generator.

The test vehicle, gearbox in neutral position, is driven by the chassis dynamometer at the test speed; the rolling resistance,  $R_R$ , of the driving axle is then measured on the force-indicating device of the chassis dynamometer.

Determination on chassis dynamometer unable to work as a generator.

For the two-roller chassis dynamometer, the  $R_R$  value is the one, which is determined before on the road.

For the single-roller chassis dynamometer, the  $R_R$  value is the one which is determined on the road multiplied by a coefficient  $R$  which is equal to the ratio between the driving axle mass and the vehicle total mass.

Note:  $R_R$  is obtained from the curve  $F = f(V)$ .

5.4.2.2.1 Calibrate the force indicator for the chosen speed of the roller bench as defined in Para 2 Chapter 5 of this Part.

5.4.2.2.2 Perform the same operation as in paragraphs 5.1.2.2.1 to 5.1.2.2.4 above.

5.4.2.2.3 Set the force,  $F_A = F - F_R$  on the indicator for the speed chosen.

5.4.2.2.4 Carry out a sufficient number of tests as indicated in paragraph 5.1.1.2.6 above, replacing  $T$  by  $F_A$ .

5.5 Deceleration Method applying coast down techniques:

5.5.1 On the Road

5.5.1.1 Accuracies of the test instrument shall be the same as specified in 5.1.1.1.

5.5.1.2 Drive the vehicle at a constant speed of about 10 km/h more than the chosen test speed,  $V$  km/h, along a straight line.

5.5.1.3 After this speed is held steady for a distance of at-least 100 m, disconnect the engine from the driveline by bringing the gear to neutral or by other means in the case of vehicle where manual shifting to neutral is not possible.

5.5.1.4 Measure the time taken ( $t_1$  sec) for the speed to drop from  $V + \Delta V$  km/h to  $V - \Delta V$  km/h. The value of  $\Delta V$  shall not be less than 1 km/h or more than 5 km/h. However, same value of  $\Delta V$  shall be used for all the tests.

5.5.1.5 Repeat the test in the opposite direction and record the time ( $t_2$  sec.).

5.5.1.6 Repeat the test 10 times such that the statistical error of the time  $t_i$  (arithmetic average of  $t_1$  and  $t_2$ ) is equal to or less than 2%.

5.5.1.7 The statistical error 'p' is calculated as -

$$p = \frac{24.24 * (t_i - t_m)^2}{t_m}$$

where  $t$  = average time for each consecutive set of reading,  $\frac{t_1 + t_2}{2}$   
 $t_m$  = Arithmetic average of 10 such  $t_i$ .

5.5.1.8 The basic equation of motion to calculate the road load resistance force,  $F$ , is

$$F = \frac{(W + W_2) * V}{(3.6 * t_m * g)}$$

where,

$F$  - in N

$W$  - the weight of the test vehicle in N

$W_2$  - equivalent inertia weight of rotating axle (0.035 x mass of the test vehicle for four-wheeled vehicles) in N

$V$  - vehicle speed difference during the coast down, in km/h

$t_m$  - coast down time, in seconds

$g$  - acceleration due to gravity, 9.81 m/s<sup>2</sup>.

5.5.1.9 Using least square curve fitting method and values of  $F$  and  $V$ , the coefficient of aerodynamic and rolling resistance of the vehicle viz.  $a$  and  $b$  respectively are found from the following equation:

$$F = a * V^2 + b$$

5.5.2 Chassis Dynamometer Setting: The values of  $a$  and  $b$  are set on the dynamometer.