

A. Fuel Consumption Tests

I. Level-Road Consumption

The level-road consumption of a motor vehicle is determined under certain definite conditions laid down in a DIN standard. Under ordinary conditions it is hardly possible to achieve level-road consumption since the varying operating conditions resulting from traffic and road conditions, driving habits, weather influences, tire condition, and tire pressure have an unfavorable influence and increase fuel consumption. Nevertheless the level-road consumption figure is of considerable importance since it makes it possible to compare cars of various types under uniform standard conditions.

When determining level-road consumption, the following conditions must be strictly observed:

a) Vehicle

The vehicle and all its parts, including carburetor setting and ignition timing, must be of the standard type.

It must be fully loaded (permissible total weight approx. 1650 kg).

The engine and the vehicle must be run in. Before the actual test the vehicle should be run for a sufficient period of time to allow engine, transmission, and rear axle to reach their normal operating temperatures (cooling water temperature approx. 80° C).

Note: During the cold season test runs should not be made when the outside temperature is below —5° C.

b) Route

Runs should be made on a level freeway stretch (short gradients of max. 1.5%) approx. 20 km long, on a windless day (maximum wind velocity 2—3) in opposite directions. The runs must be made without any intervening time lag.

The exact distance covered should be determined by means of the road mileage signs and the stopping distance of the vehicle should not be taken into consideration.

c) Speed

The speed should be kept constant as far as possible at two thirds of the maximum speed, but should not exceed 80 km/h. The car should be driven in top gear over the whole stretch.

d) Fuel

The car should be run on the fuel prescribed in the operating instructions. For knock-free operating the engine of Model 190 requires commercially sold fuels of a minimum octane rating of 86 according to the research method (ROZ).

e) Fuel Consumption

The amount of fuel consumed during the test run should be determined by means of a fuel-mileage tester which can be switched from the 'run' to the 'test' position from the beginning and to the end of the test route. With a 10% increase for unfavorable conditions the level-road consumption is then determined in accordance with the equation

$$k_n = 110 \frac{K}{W} \text{ (liters/100 km)}$$

where k_n = level-road consumption in liters/100 km

K = fuel consumption in liters

W = test route in km

The level-road consumption of Model 190 has been officially tested as on all our other models. To make allowance for inevitable differences in test conditions, all measuring tests should be based on a + 5% tolerance.

Under these conditions, the measured level-road consumption of Model 190 is 8.9 liters/100 km.

In practice it is almost impossible to fulfill the conditions laid down for measuring level-road consumption.

II. Fuel Consumption According to German Standard DIN 70 030

In order to adapt fuel consumption tests to present conditions and to developments in automotive engineering, a revised edition of the DIN Standard 70 030 was issued in August 1956.

As compared with the previous edition of the Standard for determining level-road consumption of motor vehicles (April 1952), the new edition contains the following changes:

- a) The title was changed from "Kraftstoffnormverbrauch" (level-road consumption) to "Kraftstoffverbrauch nach DIN 70 030" (fuel consumption according to DIN 70 030).
- b) The load during the test run was decreased to half the difference in weight between the permissible total weight and the curb weight (in the case of Model 190 = 225 kg) instead of the permissible total weight.
- c) The test distance was shortened from 20 km to 10 km.
- d) The speed was fixed at $\frac{3}{4}$ instead of $\frac{2}{3}$ of the maximum speed as determined in accordance with DIN 70 030. The maximum permissible test speed was increased from 80 km/h to 110 km/h.

A comparatively large number of test runs is necessary in order to determine accurately the value of fuel consumption according to DIN 70 030. The accurate figure for the fuel consumption according to DIN 70 030 of Model 190 will be announced as soon as the official tests have been concluded.

In practice it is hardly ever possible to fulfill in every detail the conditions laid down for measuring level-road consumption and fuel consumption according to DIN 70 030. It is much more convenient therefore to measure partial load consumption (see Section III) or overall consumption (see Section IV).

III. Fuel Consumption Curve (Partial Load Fuel Consumption)

For obvious reasons, not only the level-road consumption of a car but also its fuel consumption at other speeds is of great interest. For this reason we give in addition to the level-road consumption figure a fuel consumption curve, the so-called partial load consumption curve (Fig. 00 — 4/1). The values plotted in the graph are derived from measurements.

At the various test speeds, fuel consumption is determined by running the vehicle over a 1 km stretch of level freeway in opposite directions. As a rule it is sufficient to take measurements at speed intervals of 20 km/h.

The partial load consumption curve is determined on runs made with two persons in the car and with a full fuel tank. When checking the partial load consumption, which is the most reliable indication of the car's actual consumption, the following conditions must be observed:

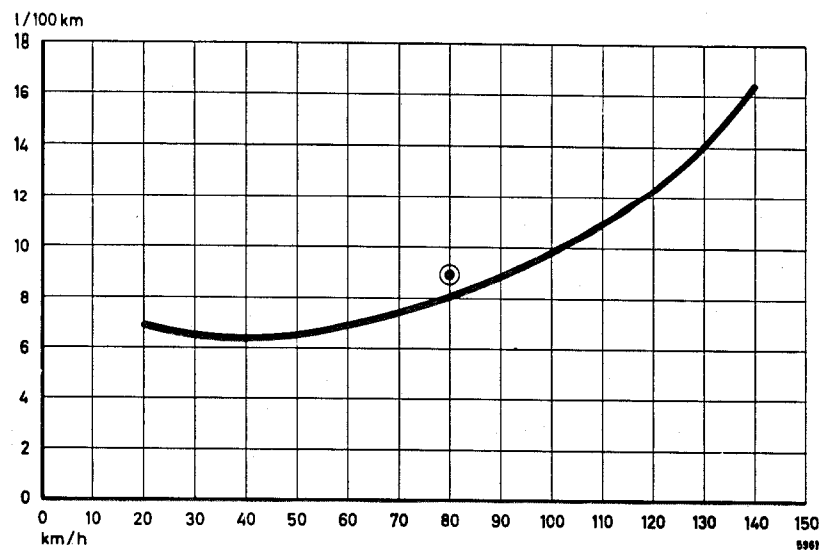


Fig. 00 — 4/1

- a) The test route must have been accurately measured. In selecting the test route it is advisable to contact the competent authorities in order to select a suitable route since the distance between milestones very often is not accurate enough. The best method is to measure the route by means of a measuring tape.
- b) Test runs should only be made on a dry road. On wet roads considerable discrepancies are inevitable.
Test runs should not be made at an outside temperature below -5°C .
- c) Besides the driver a second person is necessary to take the measurements. This must be a reliable and experienced automotive mechanic.
- d) Before carrying out a test run it is advisable to check the compression, the ignition timing, the carburetor setting, and the tappet clearance.
- e) Tire pressure must be in accordance with our specifications (front 1.7 atm., rear 1.8 atm. with tires cold).
- f) At the beginning of the test run the engine must be at operating temperature (water and oil temperature approx. 80°C); transmission and rear axle must have warmed up.
- g) Measurements must be made at all test speeds in 4th gear.
- h) Measurements should be made in such a way that the speed at which fuel consumption is to be determined is reached 200 to 300 meters before the beginning of the test route and should be maintained over the whole stretch (1 km). The speed should be maintained according to the 20, 40, 60, 80, etc. km/h marks on the speedometer dial.

The actual speed of the car is determined by recording the time required to cover the test route (calibration of the speedometer), and fuel consumption is measured by switching on the fuel-mileage tester during the period of the test.

Note: At speeds above 60 km/h, the car should be timed with an accuracy of $\frac{2}{10}$ sec. The consumption curve in Fig. 00 — 4/1 is plotted without a percentage increase for unfavorable conditions. As in the case of level-road consumption a tolerance of $+10\%$ is permissible. The above values can only be obtained if the car is in good working order.

IV. Overall Fuel Consumption

To determine overall fuel consumption, which is the amount of fuel consumed on a fairly long stretch and under normal traffic conditions, it is advisable to select a circuit of approx. 100 km over ordinary roads. Measurements over shorter stretches are useless since traffic conditions, driving habits, and road conditions are bound to have an adverse effect. It goes without saying that the test route must be known to have exactly the required length.

The test route should be covered under normal traffic conditions and at a fairly constant speed, fuel consumption should be measured and the run should be accurately timed.

Overall fuel consumption is determined by means of the equation

$$k_s = \frac{K}{W} \text{ (liters/100 km)}$$

where k_s = overall consumption in liters/100 km

K = fuel consumption in liters

W = test route in km

The average speed is

$$v = 60 \frac{W}{t} \text{ km/h}$$

where v = average speed in km/h

W = test route in km

t = time in minutes required for the test run

In evaluating the measurements, attention should be given to the fact that even on such a long test route, consumption depends to a large extent on traffic conditions and above all on driving habits. For this reason consumption tests should always be made by the same driver, who must be an experienced expert, and the vehicle should always carry two persons or the driver plus 65 kg of weight. After selecting a stretch of accurately known length it is advisable to cover the distance several times in a car in good working order and to measure fuel consumption at different average speeds. These consumption figures can then be used as a basis for measurements carried out with other cars.

At a rough estimate, overall fuel consumption at a given average speed can be assumed to equal partial load consumption at a speed 20—25 km higher.

Example: At a measured average speed of 60 km/h permissible overall fuel consumption can be roughly as much as the partial load consumption at a speed of 80 to 85 km/h (see Fig. 00—4/1). The partial load curve would in this case indicate a permissible overall consumption of 8.1—8.5 liters/100 km.

V. Testers

Various firms manufacturing automobile accessories have brought a number of fuel-mileage testers on the market which are suitable for measuring fuel consumption (partial load consumption). Most of these testers have a capacity of 0.5—1 liter. The tester is connected via a three-way cock to the fuel tank and to the fuel feed pump. With this arrangement it is possible to use fuel from the fuel tank even when the tester is connected so that the car can be driven to the test route with the tester installed.

The tester is filled by switching the cock to the "fill" position. One of these testers which we find very useful for the purpose is the fuel-mileage tester produced by Messrs. V. Löwener of Cologne (Model VLC 1003 A) Fig. 00 — 4/2).

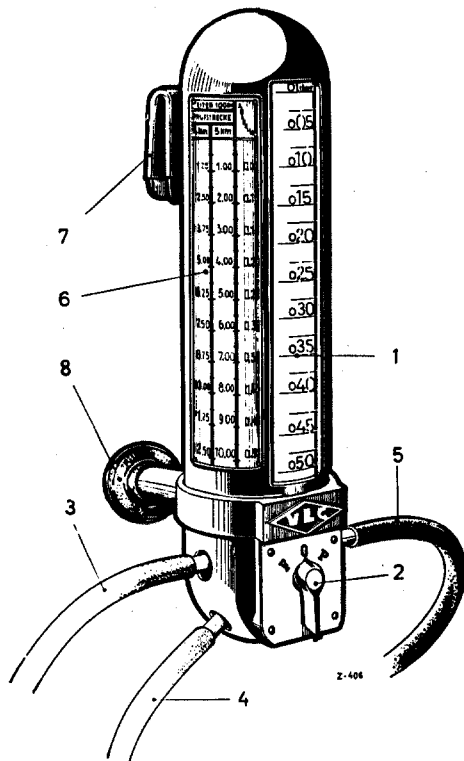


Fig 00 — 4/2

- 1 Graduated glass insert
- 2 Three-way cock
 - F = "Fill" position for filling the tester
 - O = "Run" position with fuel supplied from the fuel tank
 - P = "Test" position with fuel supplied from the tester
- 3 Connecting hose (red)
- 4 Connecting hose (white)
- 5 Connecting hose (black)
- 6 Conversion table
- 7 Hook
- 8 Rubber suction cups

The tester can be hooked over the side window by means of the hook (7) and is held in position by two rubber suction cups (8). Attach tube (3) to the suction side of the fuel feed pump (red tube), tube (4) to the supply line to the fuel tank (white tube) tube (5) to the second connection at the delivery side of the fuel feed pump (black tube).

For details see the instructions for use of the individual testers. By means of this tester the partial load consumption curve can be plotted with sufficient accuracy. However, for measuring overall consumption the capacity of this tester is not large enough. It is advisable therefore to use a gasoline can with a connection for a fuel hose welded into the bottom. An accurate calibrated measuring stick should be made for this can so that the fuel contents can be accurately determined. At the end of the test run, fuel consumption is measured by filling up the can.

The values thus determined should be entered in the data sheet for fuel consumption issued by our firm (see specimen on page 00 — 4/6). Complaints should always be accompanied by a carefully completed data sheet.

The Data Sheets can be obtained from our Untertürkheim factory, Export Service Department.

Data Sheet for Fuel Consumption		Model		Mileage					
Branch/Agent		Chassis No.:							
		Engine No.:							
		First licensed:							
		Owner:							
Measured by:		Date:							
Customer's complaint:									
Type of fuel:		Cooling water temperature C°							
Specific gravity:		Oil temperature: C°							
Weather conditions:		Outside temperature: C°							
Road condition:									
1. Fuel Consumption Under Partial Load Distance run = 1 km Load: 2 persons or driver + 65 kg weight									
Speed indicated by speedometer	km/h	20	40	60	80	100	120	140	160
Time recorded for 1 km	t sec.								
Actual speed $V_{\text{eff}} = \frac{1 \times 3600}{t}$	km/h								
Fuel consumption per km	liters								
Fuel consumption per 100 km	liters								
2. Overall Fuel Consumption Load: 2 persons or driver + 65 kg weight									
Recorded mileage after test run	 km							
Recorded mileage before test run	 km							
Distance run W	 km							
Fuel consumption K	 liters							
Time recorded t	 min.							
Overall fuel consumption $k = 100 \times \frac{K}{W} = 100 \times \text{.....} = \text{..... liters/100 km}$									
Average speed $v = \frac{60 \times W}{t} = 60 \times \text{.....} = \text{..... km/h}$									
<p>In practice it is hardly ever possible to measure level-road consumption and fuel consumption under the conditions laid down in DIN 70030. It is much more convenient to measure partial load consumption or overall consumption.</p> <p>For details on test runs see Workshop Manual Model 190, Job No. 00-4, Section A.</p>									

B. Oil Consumption Test Runs

The oil consumption of an engine can only be determined accurately by an oil consumption test run. Oil dip stick measurements are too inaccurate.

Since oil consumption depends to a large extent on driving habits i. e. engine load and engine speed, a test route should be selected for a circuit of approx. 100 km in order to simulate actual normal operating conditions. This test route should include 30 to 40 km of freeway or similar roads on which an average speed of 110 to 120 km can be maintained.

The whole test route should be covered at a certain average speed and the speeds laid down for the various laps should as far as possible be adhered to on other test runs. It is advisable always to have oil consumption test runs carried out by the same driver. The vehicle should carry 2 persons or the driver plus 65 kg of weight. When these conditions are observed, oil consumption can be determined with sufficient accuracy and the consumption of different engines can be compared.

Before the test run is carried out the engine must be very carefully checked for possible leaks, for instance at the oil filter, at the cylinder head cover, etc. Oil consumption should be determined as follows:

- a) Warm up the engine; oil temperature should be 75—80° C. The oil temperature should be measured with an Electric Distant-Reading Thermometer 000 589 21 27 whose heat feeler is put in the oil pan instead of the dip stick.
- b) Keep a clean vessel in readiness and weigh the empty vessel.
- c) Place the vehicle on a level surface and mark its position in such a way that after the test run the vehicle can be placed in the same position.
- d) Disconnect the main ignition cable from the ignition coil to the distributor at the ignition coil or take off the distributor cap.
- e) Unscrew the drain plug at the oil pan and **run the warm oil into the clean vessel for a period of 30 minutes**. The engine should be turned for about ten seconds by means of the starter motor after 15, 20, and 25 min. of draining.
- f) Screw in the oil pan drain plug and tighten.
- g) Weigh the vessel with the oil on a scale graduated in grams and fill up to the specified **weight of 3520 g** (corresponding to 4 liters).
- h) Carefully fill the weighed amount of oil into the engine, taking care not to spill any.

The vessel must be used again after the test run and should therefore not be cleaned or used for other purposes in the meantime since otherwise weight errors will result.

- i) Drive the vehicle under the above-mentioned conditions for approx. 100 km.
- k) Place the vehicle in the previously marked position immediately after the test run.
- l) Disconnect the main ignition cable from the ignition coil or remove the distributor cap.
- m) Place the vessel previously used for the purpose under the oil pan, unscrew the oil pan drain plug and drain the oil. **Draining time is again 30 min.** Turn the engine by means of the starter motor for about 10 seconds after each 15, 20, and 25 min. draining. Screw in the drain plug and tighten.
- n) Weigh the vessel with the oil.
- o) Determine the oil consumption from the difference in weight between the two measurements before and after the test run.

Oil consumption (b_{oil}) is usually given in liters and computed from the difference in weight as determined above, the specific gravity of the oil, and the distance run in accordance with the following formula

$$b_{oil} = \frac{\text{weight of oil consumed}}{\text{specific gravity of oil (g/cm}^3\text{) x distance run (km)}} \text{ liter/1000 km}$$

The specific gravity of the oil is 0.88 g/cm³

Example:

Weight of oil consumed: 100 g
Distance run: 98 km

Oil consumption is accordingly

$$b_{oil} = \frac{100}{0.88 \times 98} = 1.16 \text{ liters/1000 km}$$

For Model 190 permissible oil consumption is up to 1.5 liters/1000 km = 1320 g/1000 km.

The measurements and all necessary details should be entered in the data sheet issued by our firm (see specimen on page 00 — 4/9). All complaints should be accompanied by a carefully completed data sheet.

The Data Sheets can be obtained from our Untertürkheim factory, Export Service Department.

Data Sheet for Oil Consumption		Model: Mileage: Chassis No.: Engine No.: First licensed: Owner:																	
Branch/Agent																			
Measured by:		Date:																	
Customer's complaint:																			
Distance run:		Weather conditions: Road conditions:																	
Cooling water temperature: °C		Outside temperature: °C																	
Oil temperature: °C Type of oil:		Oil pressure at idling speed: kg/cm ² (with oil temperature measured)																	
<table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">Weight of empty vessel:</td> <td style="width: 20%; text-align: right;">..... g</td> </tr> <tr> <td>Weight of vessel with oil* before test run:</td> <td style="text-align: right;">..... g</td> </tr> <tr> <td>Weight of vessel with oil after test run:</td> <td style="text-align: right;">..... g</td> </tr> <tr> <td style="padding-left: 40px;">Weight of oil consumed:</td> <td style="text-align: right;">..... g</td> </tr> </table> <p>* Specified weight of oil before test run:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">Models 180, 180 D = 3520 g;</td> <td style="width: 50%;">Model 300 Sc⁺ = 8800 g</td> </tr> <tr> <td>Models 190, 190 SL = 3520 g;</td> <td></td> </tr> <tr> <td>Models 219, 220 a, 220 S = 5280 g;</td> <td>Model 300 SL⁺ { = 9700 g, capacity 11 liters</td> </tr> <tr> <td>Models 300, 300 b, 300 c, 300 S = 5720 g;</td> <td> = 13200 g, capacity 15 liters</td> </tr> </table> <p style="text-align: right; margin-right: 50px;">+ In the case of Models 300 Sc and 300 SL also weigh oil container</p>				Weight of empty vessel: g	Weight of vessel with oil* before test run: g	Weight of vessel with oil after test run: g	Weight of oil consumed: g	Models 180, 180 D = 3520 g;	Model 300 Sc ⁺ = 8800 g	Models 190, 190 SL = 3520 g;		Models 219, 220 a, 220 S = 5280 g;	Model 300 SL ⁺ { = 9700 g, capacity 11 liters	Models 300, 300 b, 300 c, 300 S = 5720 g;	= 13200 g, capacity 15 liters
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Recorded mileage after test run km Recorded mileage before test run km <div style="text-align: center;">Distance run km</div>		Remarks:																	
<div style="border: 1px solid black; padding: 10px;"> <p>Oil Consumption</p> $b_{oil} = \frac{\text{weight of oil consumed (g)}}{0.88^{**} \text{ (g/cm}^3\text{)} \times \text{distance run km}} = \frac{0.88 \times \dots}{0.88 \times \dots} = \dots \text{ liters/1000 km}$ <p style="text-align: center;">** Specific gravity of oil = 0.88 g/cm³</p> </div>																			
<p>Measuring instructions (For details see Workshop Manual Model 190, Job No. 00-4, Section B);</p> <ol style="list-style-type: none"> 1. Keep a clean measuring vessel for the oil in readiness and weigh the empty vessel. 2. Warm up the engine to a maximum oil temperature of 80° C (measure the temperature). 3. Place the vehicle on a level surface. 4. Drain the oil into the measuring vessel, draining time 30 min. Turn the engine by means of the starter for about 10 seconds each after 15, 20, and 25 min. For this purpose remove the distributor cap in the case of gasoline engines and cover the intake connections in the case of diesel engines. 5. Weigh the vessel with the drained oil and fill up with oil to the prescribed weight. 6. Fill the weighed amount of oil into the engine without spilling. 7. Make test run according to instructions. 8. Drain the oil as described above and weigh. 																			

C. Acceleration Test and Maximum Speed Test

I. Acceleration Test

In practice it is frequently necessary to check the acceleration values of a car. For this purpose the acceleration values can be taken from the acceleration curves below (Fig. 00 — 4/3).

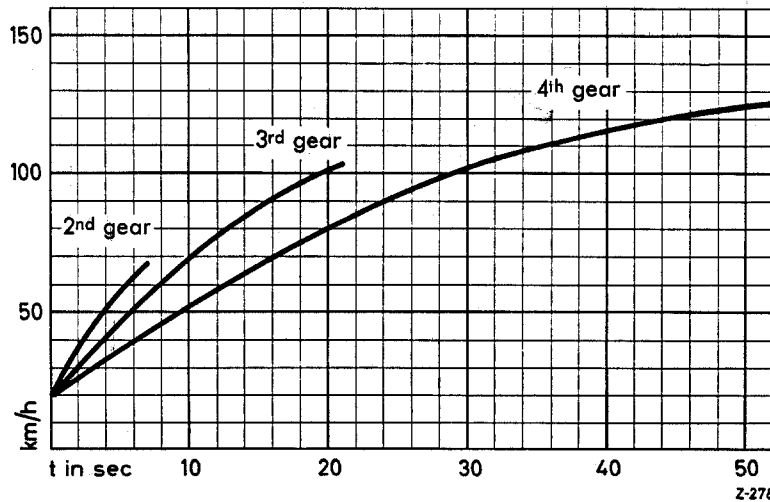


Fig. 00 — 4/3

It is advisable to carry out the acceleration test in 3rd gear. The 2nd gear is unsuitable because the time available is too short with the result that considerable measuring errors may occur. The 4th gear should not be used either because in view of modern traffic density even on freeways the clear stretch required for accurate measurement is hardly available anywhere.

Tests runs should be carried out under the following conditions:

- Use a stop watch to check the time necessary to accelerate the car from 20 km/h to 100 km/h. To do this, open the throttles fully at a speed of approx. 15 km/h and time the car as soon as it reaches an actual speed of 20 km/h. Time it again when the speed has gone up to 100 km/h, thus measuring the acceleration time. The throttles should be fully opened over the whole stretch.
- The speedometer must be calibrated at least for the two measuring speeds of 20 km/h and 100 km/h. **Measurements without a calibrated speedometer are useless.**
- Before measurements are taken, the engine must have reached its operating temperature (water and oil temperature approx. 80° C); transmission and rear axle must have warmed up.
- Test runs should only be made on dry roads.
- Tire pressure should be in accordance with our specifications (front 1.7 atm., rear 1.8 atm. with tires cold).

- f) Before carrying out a test run, it is advisable to check the compression, the ignition timing, the carburetor setting, and the tappet clearance.
- g) The test route must be level without major gradients (maximum 1.5%).
- h) The car must carry two persons.
- i) Make the acceleration test twice in both directions (wind influence) and compute the mean value of these measurements.
- k) The acceleration curves given in Fig. 00 — 4/3 only apply if the vehicle is in good working order. In order to eliminate the effect of unfavorable conditions a tolerance of +5 to +6% is permissible.

II. Maximum Speed Test

In practice the measurement of maximum speed of cars with high terminal speed is almost impossible. Any check carried out under inadequate conditions is bound to produce wrong results. However, to complete this section of tests, we list below the conditions to be observed:

- a) The test route must be exactly 1 km long and must be level (short maximum gradients of 1.5%).
- b) The test route must be covered in opposite directions. There must be no time lag between the two runs. Compute the mean value from the two runs.
- c) Atmospheric pressure may be 745—765 Torr, air temperature 0°—30° C.
- d) The test run must be made on a windless day (maximum wind velocity 2—3).
- e) Engine, transmission, and rear axle must be in run-in condition.
- f) At the beginning of the test run the engine must have reached operating temperature (water and oil temperature approx. 80° C).
- g) The road surface must be dry.
- h) There must be a level approach-stretch of at least 3—4 km which should be covered like the test route with throttles fully opened.
- i) The car must be fully loaded.
- k) Tire pressure must be increased to the values laid down for continuous fast freeway driving (front 1.9 atm., rear 2.0 atm. with tires cold). The tires and their tread must be in good condition.
- l) Window and ventilating system must be closed.