AIS-137 (Part 5)

AUTOMOTIVE INDUSTRY STANDARD

Test Method, Testing Equipment and Related Procedures for Internal Combustion Engines and Electric Drive Trains intended for the Propulsion of Motor Vehicles of Categories L, M and N with regard to the Measurement of Net Power and the Maximum 30 Minutes Power of Electric Drive Trains and Emission of Visible Pollutants of Motor Vehicles of Categories L, M and N equipped with Compression-Ignition Engines

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ON BEHALF OF
AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE

UNDER
CENTRAL MOTOR VEHICLE RULES – TECHNICAL STANDING COMMITTEE

SET-UP BY
MINISTRY OF ROAD TRANSPORT & HIGHWAYS
(DEPARTMENT OF ROAD TRANSPORT & HIGHWAYS)
GOVERNMENT OF INDIA

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Status chart of the standard to be used by the purchaser for updating the record

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INTRODUCTION

In India, the mass emission norms based on Indian Driving Cycle (IDC) were notified under CMVR in 1989. The first mass emission norms for vehicles were enforced from 1st April 1991 for Gasoline vehicles and from 1st April 1992 for Diesel vehicles. Since then, progressively emission norms have been tightened.

Government of India has notified migration to Bharat Stage VI (BS VI) emissions norms for 2, 3 and 4 wheeled vehicles from 1st April 2020. For Agricultural Tractors, Construction Equipment Vehicles and Combine Harvesters (vehicles having power exceeding 37 kW) next stage emission norms Bharat Stage (CEV/TREM) – IV) are notified from 1st October 2020 and Bharat Stage (CEV/TREM) – V) from 1st April 2024. Test procedure for Type Approval and CoP for above emission norms shall be as per various parts of AIS-137, as applicable.

This Part 5 of AIS-137 prescribes Test Method, Testing Equipment and related Procedures for Internal-Combustion Engines and Electric Drive Trains intended for the Propulsion of Motor Vehicles of Categories L, M and N with regard to the Measurement of Net Power and the Maximum 30 Minutes Power of Electric Drive Trains and Emission of Visible Pollutants of Motor Vehicles of Categories L, M and N equipped with Compression-Ignition engines.

While preparing this standard, considerable assistance has been taken from following regulations/documents:

i)	UN Regulation 85 (Supplement 7 to the 00 series of amendments – Date of entry into force: 18-06-16): Uniform provisions concerning the approval of internal combustion engines or electric drive trains intended for the propulsion of motor vehicles of categories M and N with regard to the measurement of net power and the maximum 30 minutes power of electric drive trains.
ii)	UN Regulation 24 (Supplement 3 to the 03 series of amendments - Date of entry into force: 2 February 2007): Uniform provisions concerning: a) The approval of compression ignition (C.I) engines with regard to the emission of visible pollutants b) The approval of motor vehicles with regard to the installation of C.I. engines of an approved type c) The approval of motor vehicles equipped with C.I engines with regard to the emission of visible pollutants by the engine d) The measurement of power of C.I. engine

iii)	Commission delegated Regulation (EU) No. 134/2014 of 16 December 2013 Supplementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to environmental and propulsion unit performance requirements and amending Annex V thereof
iv)	Directive 95/1/EC of the European Parliament and of the Council of 2 February 1995: on the maximum design speed, maximum torque and maximum net engine power of two or three wheel motor vehicles
v)	IS 14599: 1999 (Reaffirmed 2014): Automotive vehicles - Performance requirements (measurement of power, SFC, opacity) of positive and compression-ignition engines - Method of test
vi)	Doc. No.: MoRTH/CMVR/ TAP-115/116: Issue No.: 4: Document on test method, testing equipment and related procedures for testing type approval and conformity of production (CoP) of vehicles for emission as per CMV Rules 115, 116 and 126.
vii)	Government of India, Gazette Notification G.S.R. 889 (E) dated 16th September, 2016 regarding implementation of Bharat Stage VI (BS VI) emission norms for 2, 3 and 4 wheeled vehicles.

The Committee Composition for formulation of this standard is given in Annexure 1

After approval of the standard by SCOE, The Automotive Research Association of India, (ARAI), Pune, being the Secretariat of the AIS Committee, has published this standard. For better dissemination of this information, ARAI may publish this standard on their web site.

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CHAPTER 1

OVERALL REQUIREMENTS

1. SCOPE

1.1. This Part applies to the representation of the curve as a function of engine or motor speed of the power at full load indicated by the manufacturer for internal combustion engines or electric drive trains and the maximum 30 minutes power of electric drive trains intended for the propulsion of motor vehicles of categories L, M and N.

1.2. The internal combustion engines belong to one of the following categories:

Reciprocating piston engines (positive-ignition or compression-ignition), but excluding free piston engines;

Rotary piston engines (positive-ignition or compression-ignition);

Naturally aspirated or supercharged engines.

1.3. The electric drive trains are composed of controllers and motors and are used for propulsion of vehicles as the sole mode of propulsion.

1.4 **This Chapter covers following:**

1.4.1 Method for measuring internal combustion engine net power for M & N category of vehicles fitted with spark ignition engines and compression - ignition engines and L category vehicles fitted with Compression - ignition engines (Refer Appendix 1).

1.4.1.1 Results of tests for measuring net engine power for Appendix 1 (Refer Appendix 1A)

1.4.2 Method for measuring net power and the maximum 30 minutes power of electric drive trains (Refer Appendix 2).

1.4.3 Method for measuring maximum torque and maximum net power for mopeds fitted with spark ignition engine (Refer Appendix 3).

1.4.3.1 Results of tests for measuring maximum torque and maximum net power for Appendix 3 (Refer Appendix 3A)

1.4.4 Method for measuring maximum torque and maximum net power for L category vehicles fitted with spark ignition engine excluding mopeds (Refer Appendix 4).

1.4.4.1 Results of tests for measuring maximum torque and maximum net power for Appendix 4 (Refer Appendix 4A)

1.4.4.2 Measurement of maximum torque and maximum net engine power by means of the engine temperature method (Refer Appendix 4B)

1.4.5 Emission of visible pollutants at steady speeds over the full-load curve (Refer Appendix 5).

1.4.6 Test under free acceleration (Refer Appendix 6).

1.4.7 Opacimeter and their installation (Refer Appendix 7).

1.4.8 Determination of the maximum torque and maximum power of L category vehicles equipped with a hybrid propulsion (Refer Appendix 8).

1.4.8.1 Requirements concerning the methods for measuring the maximum torque and maximum continuous rated power of a hybrid propulsion type (Refer Appendix 8A)

2. DEFINITIONS

2.1 "**Approval of a drive train**" means the approval of a drive train type with regard to its net power measured in accordance with the procedure specified in Appendix 1 or 2 or 3 or 4 or 8 of this Chapter as applicable.

2.2. **"Drive train type"** means a category of an internal combustion engine or an electric drive train for installation in a motor vehicle which does not differ in such essential characteristics as those defined in Chapter 2 or Chapter 3 of this Part..

2.3. **"Net power"** means the power obtained on a test bench at the end of the crankshaft or its equivalent (If power measurement can be carried out only on an engine with the gear box mounted, the efficiency of the gear-box shall be taken into account)at the corresponding engine or motor speed with the auxiliaries listed in Table 1 of Appendix 1 or Appendix 2 or Appendix 3 or Appendix 4 or Appendix 8 of this Chapter, and determined under reference atmospheric condition;

2.4. **"Maximum net power"** means the maximum value of the net power measured at full engine load;

2.5. **"Maximum 30 minutes power"** means the maximum net power of an electric drive train at DC voltage as defined in clause 3.3.1 of this chapter, which a drive train can deliver over a period of 30 minutes as an average;

2.6. **"Hybrid vehicles (HV)":**

2.6.1. **"Hybrid vehicle (HV)"** means a vehicle with at least two different energy converters and two different energy storage systems (on vehicle) for the purpose of vehicle propulsion;

2.6.2. **"Hybrid electric vehicle (HEV)"** means a vehicle that, for the purpose of mechanical propulsion, draws energy from both of the following on-vehicle sources of stored energy/power:

- A consumable fuel;
- An electrical energy/power storage device (e.g.: battery, capacitor, flywheel/generator ...);

2.6.3. For a hybrid electric vehicle the "power train" comprises a combination of two different drive train types:

- An internal combustion engine; and
- One (or several) electric drive train(s);

2.7. **"Standard-production equipment"** means equipment provided by the manufacturer for a particular application;

2.8. **"Dual-fuel engine"** means an engine system type approved according AIS-137 (Part 1) or (Part 2) or (Part 3) or (Part 4) as applicable or mounted on a vehicle type approved with regards to its emissions according to applicable part of AIS-137 and that is designed to simultaneously operate with diesel fuel and a gaseous fuel, both fuels being metered separately, where the consumed amount of one of the fuels relative to the other one may vary depending on the operation;

2.8.1 "**Dedicated Dual-fuel engine**" means an engine system type approved according to AIS-137 or mounted on a vehicle type approved with regards to its emissions according to AIS-137 and that is designed to simultaneously operate with diesel fuel and a gaseous fuel only, both fuels being metered separately, where the consumed amount of one of the fuels relative to the other one may vary depending on the operation; The operation of the engine in diesel only mode will be restricted by reduced power output to cater limp home mode.

2.9. **"Dual-fuel vehicle"** means a vehicle that is powered by a dual-fuel engine and that supplies the fuels used by the engine from separate on-board storage systems;

2.10. **"Dual-fuel mode"** means the normal operating mode of a dual-fuel engine during which the engine simultaneously uses diesel fuel and a gaseous fuel at some engine operating conditions;

2.11. **"Diesel mode"** means the normal operating mode of a dual-fuel engine during which the engine does not use any gaseous fuel for any engine operating condition.

2.12 **"Compression -Ignition Engine"** Means an internal combustion engine in which ignition occurs by the temperature of the cylinder contents resulting solely from their compression

2.13 **"Positive-Ignition Engine"** Means an internal combustion engine in which the combustion of the air/fuel mixture is initiated at given instant by a hot spot, usually an electric spark

2.14 **"Engine Speed"** The number of revolutions of crankshaft in a given period of time.

2.15 **"Engine Torque"** Means torque measured at the end of the crankshaft or its equivalent (if power measurement can be carried out only on an engine with the gear-box mounted as declared by the

manufacturer, the efficiency of the gear-box shall be taken into account) at the corresponding engine speed with the auxiliaries listed in Table 1 of Appendix 1 or 3 or 4 of this Chapter, and determined under reference atmospheric conditions.

2.16 **"Specific Fuel Consumption"** The quantity of fuel consumed by the engine expressed in g/kWh

2.17 **"Intake Air Depression"** The mean pressure head below atmospheric (suction) pressure existing in the intake manifold with an air cleaner fitted expressed in kPa.

2.18 **"Exhaust Back Pressure"** The mean static pressure head existing in the exhaust pipe of an engine test bed installation measured at a point within 150 mm downstream from the outlet flange of the engine manifold/turbo charge outlet expressed in kPa.

2.19 **"Lubricating Oil Pressure"** Oil pressure at given points of the lubricating system (in individual circuits before and after filters, coolers, etc.).

2.20 **"Air Intake Temperature"** The temperature expressed **in** Kelvin (K) measured within 150 mm of the air filter.

2.21 **"Exhaust Gas Temperature"** Temperature of the exhaust gas measured at a point in the exhaust pipe 150 mm downstream from the outlet flange of the exhaust manifold or 150 mm from the outlet flange of the turbo charger expressed in Kelvin (K).

2.22 **"Coolant Temperature"** Temperature(s) at given point(s) such as after the thermostat or of the fluid cooling system(s) expressed in Kelvin (K).

2.23 **"Lubricating Oil Temperature"** Oil temperature(s) at given point(s) of the lubricating system(s) expressed in Kelvin (K).

2.24 **"Fuel Temperature"**

a) In case of positive ignition engines the fuel temperature shall be measured as near as possible to the inlet of the carburetor or fuel injection assembly.

b) In case of compression-ignition engines, the fuel temperature shall be measured at the inlet to the injection pump. At the request of the manufacturer the fuel temperature measurement can be made at another point in the pump representative - the engine operating condition.

2.25 **"Smoke Density"** Means the light absorption coefficient of the exhaust gases emitted by the vehicle expressed in terms of m^{-1} or in other units such as Hartridge, percent opacity

2.26 **"Light Absorption Coefficient"** Means the percentage of light absorption in one meter length of measurement tube of the smoke meter.

2.27 **"Opacimeter"** Means an instrument for continuous measurement of the light absorption coefficient of the exhaust gases emitted by automotive vehicles as specified in Appendix 7 of this Chapter.

2.28 **"Maximum Rated Speed"** Means the maximum speed permitted by governor at full load, unless otherwise declared by the manufacturer**.**

2.29 **Minimum Rated Speed**: Means either the highest of the following three engine speeds:

- 45 percent of maximum net power speed,
- 1 000 rev/min,
- minimum speed permitted by the idling control,

Or such lower speed as the manufacturer may specify

2.30 **Cold Start Device:** Means a device which enriches the fuel-air mixture of the engine temporarily and thus assist in engine start up.

2.31 **Starting Aid**: Means a device which assists the engine start up without enrichment of the fuel mixture such as glow plug, change of injection timing.

2.32 **"Rated net power"** means engine net power as declared by the manufacturer at rated speed.

2.34 **Idle Speed :** Means the engine rate, in revolution per minute, with fuel system controls (accelerator and choke) in the rest position, transmission in neutral and clutch engaged in the case of vehicles with manual or semi-automatic transmission, or with selector in park or neutral position when an automatic transmission is installed, as recommended by the manufacturer

3. SPECIFICATIONS AND TESTS FOR M & N CATEGORIES OF VEHICLE FITTED WITH SPARK IGNITION & COMPRESSION - IGNITION ENGINES. AND L CATEGORIES OF VEHICLE FITTED WITH COMPRESSION - IGNITION ENGINE.

3.1. General

The components liable to affect the power of drive train shall be so designed, constructed and assembled as to enable drive train in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Part

3.2. Description of tests for internal combustion engines

3.2.1. The net power test shall consist of a run at full throttle for positive-ignition engines and at full-load for compression-ignition engines and dual-fuel engines, the engine being equipped as specified in Table 1 of Appendix 1 to this Chapter.

3.2.1.1. In case of a dual-fuel engine that has a diesel mode, the test shall consist of a run on the dual-fuel mode and of a run on the diesel mode of that same engine.

3.2.2. Measurements shall be taken at a sufficient number of engine speeds to define correctly the power curve between the lowest and the highest engine speeds recommended by the manufacturer. This range of speeds shall include the speeds of revolution at which the engine produces its maximum power and its maximum torque. For each speed, the average of at least two stabilized measurements is to be determined.

3.2.3. **The fuel used shall be the following:**

3.2.3.1. For positive-ignition engines fuelled with gasoline:

The test fuel shall be the reference fuel as specified in Gazette Notification. A commercial available fuel may be used.

3.2.3.2. For positive-ignition engines and dual-fuel engines fuelled with LPG:

3.2.3.2.1. In the case of an engine with self-adaptive fuelling:

The test fuel shall be the reference fuel as specified in Gazette Notification. A commercial available fuel may be used.

3.2.3.2.2. In the case of an engine without self-adaptive fuelling:

The fuel used shall be the reference fuel as specified in Gazette Notification with the lowest C3-content, or

3.2.3.2.3. In the case of an engine labelled for one specific fuel composition:

The fuel used shall be the fuel for which the engine is labelled.

3.2.3.2.4. The fuel used shall be specified in the test report.

3.2.3.3. For positive-ignition engines and dual-fuel engines fuelled with natural gas:

3.2.3.3.1. In the case of an engine with self-adaptive fuelling:

The test fuel shall be the reference fuel as specified in Gazette Notification. A commercial available fuel may be used.

3.2.3.3.2. In the case of an engine without self-adaptive fuelling:

The fuel used shall be the one available on the market with a Wobbe index at least 52.6 MJm^{-3} (4 °C, 101.3 kPa). In case of dispute the fuel used shall be the reference fuel G20 specified in Gazette Notification , i.e. the fuel with the highest Wobbe Index, or"

3.2.3.3.3. In the case of an engine labelled for a specific range of fuels:

The fuel used shall be the one available on the market with a Wobbe index at least 52.6 MJm^{-3} (4°C, 101.3 kPa) if the engine is labelled for the H-range of gases, or at least 47.2 MJm^{-3} (4 °C, 101.3 kPa) if the engine is labelled for the L-range of gases. In case of dispute the fuel used shall be the reference fuel G20 specified in Gazette Notification if the engine is labelled for the H-range of gases, or the reference fuel G23 if the engine is labelled for the L-range of gases, i.e. the fuel with the highest Wobbe Index for the relevant range, or

3.2.3.3.4. In the case of an engine labelled for one specific LNG fuel composition:

The fuel used shall be the fuel for which the engine is labelled or the reference fuel G 20 specified in Gazette Notification if the engine is labelled LNG 20.

3.2.3.3.5. In the case of an engine labelled for one specific fuel composition:

The fuel used shall be the fuel for which the engine is labelled.

3.2.3.3.6. The fuel used shall be specified in the test report.

3.2.3.4. For compression - ignition engines and dual-fuel engines:

The test fuel shall be the reference fuel as specified in Gazette Notification. A commercial available fuel may be used.

3.2.3.5. Positive ignition engines of vehicles that can run either on gasoline or on a gaseous fuel, are to be tested with both fuels, in accordance with the provisions in clause 3.2.3.1. to 3.2.3.3 of this Chapter. The vehicles that can be fuelled with both gasoline and a gaseous fuel, but where the gasoline system is fitted for emergency purposes or starting only and of which the gasoline tank cannot contain more than 5 liters (for M and N category vehicles), 3 liters (for L5 category vehicles), 2 liters (for 2 wheelers) of gasoline will be regarded for the test as vehicles that can only run a gaseous fuel.

3.2.3.6. Dual-fuel engines or vehicles that have a diesel mode are to be tested with the fuels appropriate to each mode, in accordance with the provisions set in clause 3.2.3.1 to 3.2.3.4 of this Chapter.

For dedicated dual-fuel vehicles when operated without gaseous fuel the power output will be reduced to 40% for limp home purpose only. In this case the test will carried out in dual-fuel mode only.

3.2.4. Measurements shall be carried out according to the provisions of Appendix 1 of this Chapter.

3.2.5. The test report shall contain the results and all the calculations required to find the net power, as per Appendix 1 of this Chapter.

3.3. Description of tests for measuring the net power and the maximum 30 minutes power of electric drive trains

The electric drive train shall be equipped as specified in Appendix 2 of this Chapter. The electric drive train shall be supplied from a DC voltage source with a maximum voltage drop of 5 per cent depending on time and current (periods of less than 10 seconds excluded). The supply voltage of the test shall be given by the vehicle manufacturer.

Note: If the battery limits the maximum 30 minutes power, the maximum 30 minutes power of an electric vehicle can be less than the maximum 30 minutes power of the drive train of the vehicle according to this test.

3.3.1. Determination of the Net Power

3.3.1.1. The motor and its entire equipment assembly must be conditioned at a temperature of 25 °C ± 5 °C for a minimum of two hours.

3.3.1.2. The net power test shall consist of a run at full setting of the power controller.

3.3.1.3. Just before beginning the test, the motor shall be run on the bench for 3 minutes delivering a power equal to 80 per cent of the maximum power at the speed recommended by the manufacturer.

3.3.1.4. Measurements shall be taken at a sufficient number of motor speeds to define correctly the power curve between zero and the highest motor speed recommended by the manufacturer. The whole test shall be completed within 5 minutes.

3.3.2. Determination of the Maximum 30 Minutes Power

3.3.2.1. The motor and its entire equipment assembly must be conditioned at a temperature of 25 °C ± 5 °C for a minimum of four hours.

3.3.2.2. The electric drive train shall run at the bench at a power which is the best estimate of the manufacturer for the maximum 30 minutes power. The speed must be in a speed range, which the net power is greater than 90 per cent of the maximum power as measured in paragraph 3.3.1 of this Chapter. This speed shall be recommended by the manufacturer.

3.3.2.3 Speed and power shall be recorded. The power must be in a range of ±5 per cent of the power value at the start of the test. The maximum 30 minutes power is the average of the power within the 30 minutes period.

3.4. Interpretation of results for internal combustion engines for M & N Category of vehicles fitted with spark ignition engines & compression-ignition engines and L category vehicles fitted with compression - ignition engines and Electric drive trains

The net power and the maximum 30 minutes power for electric drive trains indicated by the manufacturer for the type of drive train shall be accepted if it does not differ by more than ±2 per cent for maximum power and more than ±4 per cent at the other measurement points on the curve with a tolerance of ±2 per cent for engine or motor speed, or within the engine or motor speed range (X1 min^{-1} + 2 per cent) to (X2 min^{-1} -2 per cent) (X1 < X2) from the values measured by the Test Agency on the drive train submitted for testing.

In case of a dual-fuel engine, the net power indicated by the manufacturer shall be the one measured on the dual-fuel mode of that engine.

CHAPTER 1 - APPENDIX 1

METHOD FOR MEASURING INTERNAL COMBUSTION ENGINE NET POWER FOR M AND N CATEGORY OF VEHICLES FITTED WITH SPARK IGNITION ENGINES AND COMPRESSION - IGNITION ENGINES AND L CATEGORY VEHICLES FITTED WITH COMPRESSION - IGNITION ENGINES

1. These provisions apply to the method for representing the power curve at full load of an internal combustion engine as a function of engine speed.

2. TEST CONDITIONS

2.1. The engine shall have been run-in according to the manufacturer's recommendations.

2.2. If the power measurement can be carried out only on an engine with the gear-box mounted, the efficiency of the gear-box shall be taken into account.

2.3. **Auxiliaries**

2.3.1. Auxiliaries to be fitted

During the test, the auxiliaries necessary for the engine operation in the intended application (as listed in Table 1 of this Appendix) shall be installed on the test bench as far as possible in the same position as in the intended application.

2.3.2. Auxiliaries to be removed

Certain vehicle accessories necessary only for operation of the vehicle and which may be mounted on the engine shall be removed for the test. The following non-exhaustive list is given as a sample:

- Air compressor for brakes
- power steering compressor
- suspension compressor
- Air-conditioning system

Where accessories cannot be removed, the power they absorb in the unloaded condition may be determined and added to the measured engine power.

	Table 1 Auxiliaries to be Fitted for the Test to Determine Net Power of Engine	
1.	**For Vehicle of Categories M & N**	
	("Standard production equipment" means equipment provided by the manufacturer for a particular application)	
No.	**Auxiliaries**	**Fitted for net power test**
1.	Intake system	
	Intake manifold Crankcase emission control system	Yes, standard production equipment
	Air filter Intake silencer Speed limiting device	Yes, standard production equipment (1a)
2	Induction heating device of intake manifold	Yes, standard production equipment. If possible, to be set in the most favourable position.
3	Exhaust system	
	Exhaust purifier Exhaust manifold Supercharging device Connecting pipes(1b) Silencer(1b) Tail pipe(1b) Exhaust brake(2)	Yes, standard production equipment
4	Fuel supply pump(3)	Yes, standard production equipment
5	Carburettor	
	Electronic control system, air flow meter, etc... (if fitted)	Yes, standard production equipment
	Pressure reducer Evaporator Mixer	Equipment for gas engines

No.	Auxiliaries	Fitted for net power test
6	Fuel injection equipment (gasoline and diesel) Prefilter Filter Pump High pressure pipe Injector Air intake valve[4], if fitted Electronic control system air, flow meter, etc... if fitted Governor/control system. Automatic full-load stop for the control rack depending on atmospheric conditions	Yes, standard production equipment
7	Liquid cooling equipment Engine bonnet Bonnet air outlet	No
	Radiator Fan[5],[6] Fan & Fan cowl Water pump Thermostat [7]	Yes[5], standard production equipment
8	Air cooling Cowl Blower [5],[6]	Yes, standard production equipment
	Temperature regulating device	Yes, standard production equipment
9	Electrical equipment	Yes [8], standard production equipment
10	Supercharging equipment (if fitted) Compressor driven either directly by the engine, and/or by the exhaust gases Charge air cooler [9] Coolant pump or fan (engine driven) (if fitted)	Yes, standard production equipment
11	Auxiliary test bench fan	Yes, if necessary
12	Anti-pollution devices [10]	Yes, standard production equipment

Notes

(la) The complete intake system shall be fitted as provided for the intended application:

Where there is a risk of an appreciable effect on the engine power;

In the case of two-stroke and positive-ignition engines;

When the manufacturer requests that this should be done.

In other cases, an equivalent system may be used and a check should be made to ascertain that the intake pressure does not differ by more than 100 Pa from the limit specified by the manufacturer for a clean air filter.

(1b) The complete exhaust system shall be fitted as provided for the intended application:

Where there is a risk of an appreciable effect on the engine power;

In the case of two-stroke and positive-ignition engines;

When the manufacturer requests that this should be done.

In other cases, an equivalent system may be installed provided the pressure measured at the exit of the engine exhaust system does not differ by more than 1,000 Pa from that specified by the manufacturer.

The exit from the engine exhaust system is defined as a point 150 mm downstream from the termination of the part of the exhaust system mounted on the engine.

(2) If an exhaust brake is incorporated in the engine, the throttle valve must be fixed in a fully open position.

(3) The fuel feed pressure may be adjusted, if necessary, to reproduce the pressures existing in the particular engine application (particularly when a "fuel return" system is used).

(4) The air intake valve is the control valve for the pneumatic governor of the injection pump.

The governor of the fuel injection equipment may contain other devices which may affect the amount of injected fuel

(5) The radiator, the fan, the fan cowl, the water pump and the thermostat shall be located on the test bench in the same relative positions as on the vehicle. The cooling liquid circulation shall be operated by the engine water pump only.

Cooling of the liquid may be produced either by the engine radiator or by an external circuit, provided that the pressure loss of this circuit and the pressure at the pump inlet remain substantially the same as those of the engine cooling system. The radiator shutter, if incorporated, shall be in the open position.

Where the fan, radiator and cowl system cannot conveniently be fitted to the engine, the power absorbed by the fan when separately mounted in its correct position in relation to the radiator and cowl (if used), must be determined at the speeds corresponding to the engine speeds used for measurement of the engine power either by calculation from standard characteristics or by practical tests. This power, corrected to the standard atmospheric conditions (293 K (20 °C) and 101.3 kPa), should be deducted from the corrected power.

(6) Where a disconnectable or progressive fan or blower is incorporated, the test shall be made with the disconnectable fan (or blower) disconnected or with the progressive fan or blower running at maximum slip.

(7) The thermostat may be fixed in the fully open position.

(8) Minimum power of the generator: the power of the generator shall be limited to that necessary for the operation of accessories which are indispensable for the operation of the engine. If the connection of a battery is necessary, a fully charged battery in good order must be used

(9) Charge air cooled engines shall be tested with charge air cooling, whether liquid or air cooled, but if the engine manufacturer prefers, a test bench system may replace the air cooled cooler. In either case, the measurement of power at each speed shall be made with the same pressure drop and temperature drop of the engine air across the charge air cooler on the test bench system as those specified by the manufacturer for the system on the complete vehicle.

(10) They may include, for example, EGR (Exhaust Gas Recirculation) system, catalytic convertor, thermal reactor, secondary air supply system and fuel evaporation protecting system.

2.	For Vehicle of Categories L	
No.	**Auxiliaries**	**Fitted for net power test**
1.	**Air intake system** - Induction manifold - Air filter (1) - Induction silencer - Crankcase emission-control system - Electrical control device, where fitted	If series-mounted: yes
2.	**Induction manifold heater**	If series-mounted: yes (if possible, it shall be set in the most favourable position)
3.	**Exhaust system** - Exhaust purifier - Exhaust manifold - Pipe work (2) - Silencer (2) - Exhaust pipe (2) - Exhaust brake (3) - Electrical control device, where fitted	If series-mounted: yes
4.	**Fuel injection system** - Upstream filter - Filter - Fuel supply pump (4) and high pressure pump if applicable - High-pressure lines - Injector - Air intake valve (5), where fitted - Fuel pressure / flow regulator, where fitted	If series-mounted: yes
5.	**Maximum rotational speed-or power governors (1)**	If series-mounted: yes

6.	**Liquid-cooling equipment** - Engine bonnet - Bonnet air outlet - Radiator - Fan (3) - Fan cowl - Water pump - Thermostat (4)	If series-mounted: yes(5)
7.	**Air cooling** - Cowl - Blower (6) (7) - Cooling temperature-regulating device(s) - Auxiliary bench blower	If series-mounted: yes
8.	**Electrical equipment**	If series-mounted: yes (8)
9.	**Super-charger or turbocharger, where fitted** - Compressor driven directly by the engine or by the exhaust gases - Charge air cooler (2) - Coolant pump or fan (engine driven) - Coolant flow control device, where fitted.	If series-mounted: yes
10.	**Pollution-control devices (7)**	If series-mounted: yes
11.	**Lubrication system** - Oil feeder - Oil cooler, where fitted.	If series-mounted: yes

Notes: -

(1) The complete air intake system shall be fitted as provided for the intended application:

- where there is a risk of an appreciable effect on the engine power,
- in the case of two-stroke engines,
- when the manufacturer requests that this should be done. In other cases, an equivalent system may be used and a check should be made to ascertain that the intake pressure does not differ by more than 100 Pa from the limit specified by the manufacturer for a clean air filter.

(2) The complete exhaust system shall be fitted as provided for the intended application:

- where there is a risk of an appreciable effect on the engine power,
- in the case of two-stroke engines,
- when the manufacturer requests that this should be done. In other cases, an equivalent system may be installed provided the pressure measured at the exit of the engine exhaust system does not differ by more than 1 000 Pa from that specified by the manufacturer. The exit of the engine exhaust system is defined as a point 150 mm downstream from the termination of the part of the exhaust system mounted on the engine.

(3) If an exhaust brake is incorporated in the engine, the throttle valve shall be held in the fully open position.

(4) The fuel-feed pressure may be adjusted, if necessary, to reproduce the pressures existing in the particular engine application (particularly when a 'fuel-return' system is used).

(5) The air-intake valve is the control valve for the pneumatic governor of the injection pump. The governor or the fuel- injection equipment may contain devices which can affect the amount of injected fuel.

(6) The radiator, fan, fan nozzle, water pump and thermostat shall, on the test bench, occupy as far as possible the same position relative to each other as if they were on the vehicle. If any of them have a position on the test bench which is different from that on the vehicle, this shall be described and noted in the test report. The cooling-liquid circulation shall be operated by the engine water pump only. Cooling of the liquid may be produced either by the engine radiator or by an external circuit, provided that the pressure loss of this circuit and the pressure at the pump inlet remain substantially the same as those of the engine cooling system. The radiator shutter, if incorporated, shall be in the open position. Where the fan, radiator and cowl system cannot conveniently be fitted to the engine, the power absorbed by the fan when separately mounted in its correct position in relation to the radiator and cowl (if used) shall be determined at the speeds corresponding to the engine speeds used for measurement of the engine power either by calculation from standard characteristics or by practical tests. This power, corrected to the standard atmospheric conditions defined in clause 5.2 of this Appendix, shall be deducted from the corrected power.

(7) Where a disconnectable or progressive fan or blower is incorporated, the test shall be carried out with the disconnectable fan (or blower) disconnected or with the progressive fan or blower running at maximum slip.

(8) Minimum power of the generator: the power of the generator shall be no more than that required to operate accessories which are indispensable for the operation of the engine. If the connection of a battery is necessary, a fully-charged battery in good order shall be used.

2.3.3. Compression-Ignition Engine Starting Auxiliaries

For the auxiliaries used in starting compression-ignition engines, the two following cases shall be considered:

(a) Electric starting : A generator is fitted and supplies, where necessary, the auxiliaries essential for engine operation;

(b) Starting other than by electrical means if there are any electrically operated accessories essential for engine operation for which a generator is fitted. Otherwise, it is removed.

In either case, the system for producing and storing the energy necessary for starting is fitted and operates in the unloaded condition.

2.4. Setting conditions

The setting conditions for the test to determine the net power are indicated in Table 2 of this Appendix

Table 2
Setting Conditions

1.	Setting of carburettor(s)	In accordance with the manufacturer's production specifications and used without further alteration for the particular application
2.	Setting of injection pump delivery system	
3.	Ignition or injection timing (timing curve)	
4.	Governor setting	
5.	Emission control devices	

3. DATA TO BE RECORDED

3.1. The net power test shall consist of a run at full throttle for positive-ignition engines and at fixed full load fuel-injection-pump setting for compression-ignition engines, the engine being equipped as specified in Table 1 of this Appendix.

3.2. Data to be recorded are those indicated in clause 4. of the Appendix 1A of this Chapter. Performance data shall be obtained under stabilized operating conditions with an adequate fresh air supply to the engine. Combustion chambers may contain deposits, but in limited quantity.

Test conditions, such as inlet air temperature, shall be selected as near to reference conditions (see clause 5.2 of this Appendix) as possible in order to minimize the magnitude of the correction factor.

3.3. The temperature of the inlet air to the engine (ambient air) shall be measured within 0.15 m upstream of the point of entry to the air cleaner, or, if no air cleaner is used, within 0.15 m of the air inlet horn. The thermometer or thermocouple shall be shielded from radiant heat and placed directly in the air stream. It shall also be shielded from fuel spray-back. A sufficient number of locations shall be used to give a representative average inlet temperature.

3.4. No data shall be taken until torque, speed and temperatures have been maintained substantially constant for at least one minute.

3.5. The engine speed during a run or reading shall not deviate from the selected speed by more than ±1 per cent or ±10 min^{-1}, whichever is greater.

3.6. Observed brake load, fuel consumption and inlet air temperature data shall be taken simultaneously and shall be the average of two stabilized consecutive values which do not vary more than 2 per cent for the brake load and fuel consumption.

3.7. The temperature of the coolant at the outlet from the engine shall be kept at the value specified by the manufacturer. If no temperature is specified by the manufacturer, the temperature shall be 353 K ± 5 K. For air-cooled engines, the temperature at a point indicated by the manufacturer shall be kept within +0/-20 K of the maximum value specified by the manufacturer in the reference conditions.

3.8. The fuel temperature shall be measured at the inlet to the carburettor or at the fuel injection system and maintained within the limits established by the engine manufacturer.

3.9. The temperature of the lubricating oil measured in the oil pump or within the oil sump or at the outlet from the oil cooler, if fitted shall be maintained within the limits established by the engine manufacturer.

3.10. An auxiliary regulating system may be used if necessary to maintain the temperature within the limits specified in clause 3.7., 3.8. and 3.9. of this Appendix.

4. ACCURACY OF MEASUREMENTS

4.1. Torque: ±1 per cent of measured torque

The torque measuring system shall be calibrated to take friction losses into account. The accuracy in the lower half of the measuring range of the dynamometer bench may be ±2 per cent of measured torque

4.2. Engine speed: The measurement shall be accurate to within ± 0.5 per cent. Engine speed shall be measured preferably with an automatically synchronized revolution counter and chronometer (or counter-timer).

4.3. Fuel consumption : ±1 per cent of measured consumption.

4.4. Fuel temperature : ±2 K.

4.5. Engine inlet air temperature: ± 1 K.

4.6. Barometric pressure : ±100 Pa.

4.7. Pressure in intake-duct : ±50 Pa.

4.8. Pressure in exhaust duct : ±200 Pa.

5. POWER CORRECTION FACTORS

5.1. Definition

The power correction factor is the coefficient to determine the engine power under the reference atmospheric conditions specified in paragraph 5.2. below of this Appendix.

$P_o = \alpha P$

Where

P_o is the corrected power (i.e. power under reference atmospheric conditions)

α is the correction factor (α_a or α_d)

P is the measured power (test power)

5.2. Reference atmospheric conditions

5.2.1. Temperature (T_o): 298 K (25 °C)

5.2.2. Dry pressure (P_{so}): 99 kPa

Note: The dry pressure is based on a total pressure of 100 kPa and a water vapour pressure of 1 kPa.

5.3. Test atmospheric conditions

The atmospheric conditions during the test shall be the following:

5.3.1. Temperature (T)

For positive-ignition engines : $288\ K \leq T \leq 308\ K$

For compression-ignition engines : $283\ K \leq T \leq 313\ K$

5.3.2. Pressure (P_s)

$80\ kPa \leq P_s \leq 110\ kPa$

5.4. Determination of correction factor α_a and α_d[1]

5.4.1. Naturally aspirated or pressure-charged positive-ignition engine factor α_a

The correction factor α_a is obtained by applying the formula:[2]

$$\alpha_a = \left(\frac{99}{P_s}\right)^{1.2} \cdot \left(\frac{T}{298}\right)^{0.6}$$

Where

P_s is the total dry atmospheric pressure in kilopascals (kPa); that is to say, the total barometric pressure minus water vapour pressure

T is the absolute temperature in kelvins (K) of the air drawn in by the engine.

Conditions to be complied with in the laboratory

For a test to be valid, the correction factor α_a must be such that $0.93 \leq \alpha_a \leq 1.07$

If these limits are exceeded, the corrected value obtained shall be given and the test conditions (temperature and pressure) precisely stated in the test report.

5.4.2. Compression -Ignition Engines - Factor α_d

The power correction factor (α_d) for compression- ignition engines at constant fuel rate is obtained by applying the formula:

Where $\alpha_d = (f_a)^{fm}$

f_a is the atmospheric factor

f_m is the characteristic parameter for each type of engine and adjustment

5.4.2.1. Atmospheric factor f_a

This factor indicates the effects of environmental conditions (pressure, temperature and humidity) on the air drawn in by the engine. The atmospheric factor formula differs according to the type of engine.

(1) The test may be carried out in air-conditioned test room where the atmospheric conditions may be controlled

(2) In the case of engines fitted with automatic air temperature control, if the device is such that at full load at 25 °C no heated air is added, the test shall be carried out with the device fully closed. If the device is still operating at 25 °C then the test is made with the device operating normally and the exponent of the temperature term in the correction factor shall be taken as zero (no temperature correction).

5.4.2.1.1. Naturally aspirated and mechanically supercharged engines

$$f_a = \left(\frac{99}{P_s}\right) \cdot \left(\frac{T}{298}\right)^{0.7}$$

5.4.2.1.2. Turbocharged engines with or without cooling of inlet air

$$f_a = \left(\frac{99}{P_s}\right)^{0.7} \cdot \left(\frac{T}{298}\right)^{1.5}$$

5.4.2.2. Engine factor f_m

f_m is a function of q_c (fuel flow corrected) as follows:

$f_m = 0.036\ q_c - 1.14$

Where: $q_c = q/r$

Where:

q is the fuel flow in milligram per cycle per litre of total swept volume (mg/(l.cycle))

r is the pressure ratio of compressor outlet and compressor inlet (r = 1 for naturally aspirated engines)

This formula is valid for a value interval of q_c included between 40 mg/(l.cycle) and 65 mg/(l.cycle.)

For q_c values lower than 40 mg/(l.cycle), a constant value of f_m equal to 0.3 ($f_m = 0.3$) will be taken.

For q_c values higher than 65 mg/(l.cycle), a constant value of f_m equal to 1.2 ($f_m = 1.2$) will be taken (see Figure 1 of this Appendix):

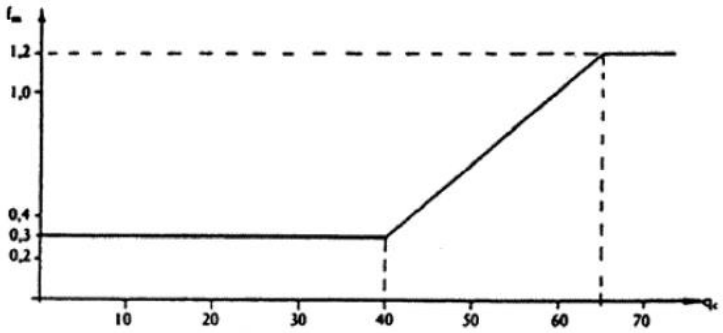

Figure 1

5.4.2.3. Conditions to be complied with in the laboratory

For a test to be valid; the correction factor α_d must be such that $0.90 \leq \alpha_d \leq 1.1$

If these limits are exceeded, the corrected value obtained shall be given and the test conditions (temperature and pressure) precisely stated in the test report.

5.4.3 When turbocharged engine is fitted with a system which allows compensating the ambient conditions temperatures and altitudes, at the request of the manufacturer, the correction factor α_a or α_d shall be set to the value 1.

	CHAPTER 1 – APPENDIX 1A **RESULTS OF TESTS FOR MEASURING NET ENGINE POWER***	
	This form shall be completed by the Test Agency.	
1.	**Test conditions**	
1.1.	Pressures measured at maximum power	
1.1.1.	Total barometric pressure:	Pa
1.1.2.	Water vapour pressure:	Pa
1.1.3.	Exhaust pressure:	Pa
1.2.	Temperatures measured at maximum power	
1.2.1.	Of the intake air:	K
1.2.2.	At the outlet of the engine intercooler:	K
1.2.3.	Of the cooling fluid	
1.2.3.1.	At the engine cooling fluid outlet:	K (1)
1.2.3.2.	At the reference point in the case of air cooling:	K (1)
1.2.4.	Of the lubricating oil:	K (indicate point of measurement)
1.2.5.	Of the fuel	
1.2.6.	Of the exhaust measured at the point adjacent to the outlet flange(s) of the exhaust manifold(s):	°C
1.2.5.1.	At the fuel pump inlet:	K
1.2.5.2.	In the fuel consumption measuring device:	K
1.3.	Engine speed when idling:	min^{-1}
1.4.	Characteristics of the dynamometer	
1.4.1.	Make: …… Model …….	
1.4.2.	Type:	
1.5.	Characteristics of the opacimeter	
1.5.1.	Make:	
1.5.2.	Type:	
	* The characterstic curves of the net power and the net torque shall be drawn as a function of engine speed. (1) Delete as appropriate.	

2.	**Fuel**	
2.1.	For positive-ignition engines operating on liquid fuel	
2.1.1.	Make:	
2.1.2.	Specification:	
2.1.3.	Anti-knock additive (lead, etc.):	
2.1.3.1.	Type:	
2.1.3.2.	Content:gdw100	mg/1
2.1.4.	Octane number RON:	(ASTM D 26 99-70)
2.1.4.1.	Octane number MON No:	
2.1.4.2.	Specific density:	g/cm^3 at 288 K
2.1.4.3.	Lower calorific value:	kJ/kg
2.2.	For positive-ignition engines and dual-fuel engines operating on gaseous fuel	
2.2.1.	Make:	
2.2.2.	Specification:	
2.2.3.	Storage pressure:	bar
2.2.4.	Utilization pressure:	bar
2.2.5.	Lower calorific value:	kJ/kg
2.3.	For compression-ignition engines operating on gaseous fuels	
2.3.1.	Feed system: gas	
2.3.2.	Specification of gas used:	
2.3.3.	Fuel oil/gas proportion:	
2.3.4.	Lower calorific value:	
2.4.	For compression-ignition engines and dual-fuel engines operating on diesel fuel	
2.4.1.	Make:	
2.4.2.	Specification of fuel used:	
2.4.3.	Cetane number (ASTM D 976-71)	
2.4.4.	Specific density:	g/cm^3 at 288 K
2.4.5.	Lower calorific value:	kJ/kg
3.	**Lubricant**	
3.1.	Make:	
3.2.	Specification:	
3.3.	SAE viscosity:	

4. DETAILED RESULTS OF MEASUREMENTS *		
Engine speed, min^{-1}		
Measured torque, Nm		
Measured power, kW		
Measured fuel flow, g/h		
Barometric pressure, kPa		
Water vapour pressure, kPa		
Inlet air temperature, K		
Power to be added for auxiliaries in excess of Table 1 of Appendix 1 of this Chapter, kW No. 1 No. 2 No. 3		
Power correction factor		
Corrected brake power, kW (with/without (1) fan)		
Power of fan, kW (to be subtracted if fan not fitted)		
Net torque, kW		
Net torque, Nm		
Corrected specific fuel consumption g/(kWh) (2)		
Cooling liquid temperature at outlet, K		
Lubricating oil temperature t measuring point, K		
Air temperature after pressure-charger, K (3)		
Fuel temperature at injection pump inlet, K		
Air temperature after charge air cooler, K		
Pressure after pressure-charger, kPa (3)		
Pressure after charge air cooler, kPa		

Notes:

* The characteristic curves of the net power and the net torque shall be drawn as a function of the engine speed.

(1) Delete as appropriate.

(2) Calculated with the net power for compression-ignition and positive-ignition engines, in the latter case multiplied by the power correction factor.

(3) Delete where applicable.

CHAPTER 1 - APPENDIX 2

METHOD FOR MEASURING NET POWER AND THE MAXIMUM 30 MINUTES POWER OF ELECTRIC DRIVE TRAINS OF HYBRID ELECTRIC VEHICLES

1. These requirements apply for measuring the maximum net power and the maximum 30 minutes power of electric drive trains used for propelling Hybrid Electric Vehicle (HEV).

2. TEST CONDITIONS

2.1. The drive train shall have been run-in according to the manufacturer's recommendations.

2.2. If the power measurement can be carried out only on a drive train with the gear-box or a reducer mounted, the efficiency shall be taken into account.

2.3. Auxiliaries

2.3.1. Auxiliaries to be fitted

During the test, the auxiliaries necessary for the drive train operation in the intended application (as listed in Table 1 of this Appendix) shall be installed in the same position as in the vehicle.

2.3.2. Auxiliaries to be removed

The auxiliaries necessary for the proper operation of the vehicle, and which may be mounted on the motor shall be removed when performing the test. The following non-exhaustive list is given as an example:

- Air compressor for brakes;
- Power steering compressor;
- Suspension system compressor;
- Air conditioner system, etc.

Where accessories cannot be removed, the power they absorb in the unloaded condition may be determined and added to the measured power.

	Table 1 **Auxiliaries to be Fitted for the Test to Determine Net Power and the Maximum 30 Minutes Power of Electric Drive Trains** ("Standard-production equipment" means equipment provided by the manufacturer for a particular application).	
No.	**Auxiliaries**	**Fitted for net power and the maximum 30 minutes power test**
1	DC voltage source	Voltage drop during test less than 5 %
2	Speed variator and control device	Yes: Standard-production equipment
3	Liquid-cooling Motor bonnet Bonnet outlet	No
	Radiator (1), (2) Fan Fan cowl Pump Thermostat (3)	Yes: Standard production equipment
	Air cooling Air filter Cowl Blower Temperature adjustment system	Yes: Standard production equipment
4	Electric equipment	Yes: Standard production equipment
5	Bench test auxiliary fan	Yes, if necessary

(1) The radiator, the fan, the fan cowl, the water pump and the thermostat shall be located on the test bench in the same relative position as on the vehicle. The cooling-liquid circulation shall be activated by the drive train water pump only.

Cooling of the liquid may be produced either by the drive train radiator, or by an external circuit, provided that the pressure loss of this circuit and the pressure at the pump inlet remain substantially the same as those of the drive train cooling system. The radiator shutter, if any, shall be in the open position.

Where the fan, radiator and fan cowl cannot conveniently be fitted for the bench test, the power absorbed by the fan when separately mounted in its correct position in relation to the radiator and cowl (if used), shall be determined at the speed corresponding to the motor speeds used for measurement of the motor power either by calculation from standard characteristics or by practical tests. This power,

corrected to the standard atmospheric conditions should be deducted from the correct power.

(2) Where a disconnectable or progressive fan or blower is incorporated, the test should be carried out with the disconnectable fan (or blower) disconnected or at maximum slip condition.

(3) The thermostat may be fixed in the fully open position.

2.4. Setting conditions

The setting conditions shall conform to the manufacturer's specifications for the production motor and be used without further alteration for the particular application.

2.5. Data to be recorded

2.5.1. The test for determining the net power shall be carried out with the accelerator control set at the maximum position.

2.5.2. The motor must have been run-in in accordance with the recommendations of the applicant for the approval.

2.5.3. Torque and speed data shall be recorded simultaneously.

2.5.4. If needed, the cooling liquid temperature recorded at the motor outlet must be maintained at ±5 K of the thermostat temperature setting specified by the manufacturer.

For air cooling drive trains, the temperature at a point indicated by the manufacturer shall be kept within +0/-20 K of the maximum value specified by the manufacturer.

2.5.5. The temperature of the lubricating oil measured in the oil sump or at the outlet from the oil temperature exchanger (if any) shall be maintained within the limits prescribed by the manufacturer.

2.5.6. An auxiliary regulating system may be used, if necessary, to maintain the temperature within the limits specified in clause 2.5.4. and 2.5.5. of this Appendix.

3. ACCURACY OF MEASUREMENTS

3.1. Torque: ±1 per cent of measured torque.

The torque measuring system shall be calibrated to take friction losses into account. The accuracy in the lower half of the measuring range of the dynamometer bench may be ±2 per cent of measured torque.

3.2. Motor speed: 0.5 per cent of measured speed.

3.3. Motor inlet air temperature: ±2 K.

CHAPTER 1 - APPENDIX 3

METHOD FOR MEASURING THE MAXIMUM TORQUE AND MAXIMUM NET POWER FOR MOPEDS FITTED WITH SPARK IGNITION ENGINE

1. TEST CONDITIONS

1.1. The tests to determine maximum torque and maximum net power shall be carried out at full throttle, with the engine equipped as specified in Table 1 of this Appendix.

1.2 The measurements shall be carried out under normal, stable operating conditions and the air supply to the engine shall be adequate. The engine shall have been run in under the conditions recommended by the manufacturer. The combustion chambers may contain deposits, but in limited quantities. The test conditions such as the temperature of the induction air shall be selected as closely as possible to the reference conditions (see clause 4.2 of this Appendix) in order to reduce the correction factor.

1.3. The temperature of the engine induction air (ambient air) shall be measured at the most 0.15 m upstream of the air filter inlet or, if there is no filter, 0.15 m from the inlet air trumpet. The thermometer or thermocouple shall be protected against heat radiation and be placed directly in the airstream. It shall also be protected against vaporized fuel. An adequate number of positions shall be used in order to yield a representative average inlet temperature.

1.4. No measurement shall be taken until the torque, rate of rotation and temperatures have remained substantially constant for at least 30 seconds.

1.5. Once a rate of rotation has been selected for the measurements its value shall not vary by more than ± 2 % .

1.6. Observed brake load and inlet-air temperature data shall be taken simultaneously and shall be the average of two stabilised consecutive values. In the case of the brake load, these values shall not vary by more than 2 %.

1.7. Where an automatically triggered device is used to measure rotational speed and consumption the measurement shall last for at least 10 seconds and if the measuring device is manually controlled that period shall be at least 20 seconds.

1.8. The temperature of the liquid coolant recorded at the engine outlet shall be maintained at ± 5 K of the upper thermostat setting temperature specified by the manufacturer. If the manufacturer does not indicate any values the temperature is 353 K ± 5 K.

In the case of air-cooled engines the temperature at a point specified by the manufacturer shall be maintained at + 0/- 20 K of the maximum temperature intended by the manufacturer under the reference conditions.

1.9. The fuel temperature shall be measured at the carburettor or injection system inlet and kept within the limits laid down by the manufacturer.

1.10. The temperature of the lubricating oil measured in the oil sump or at the outlet from the oil cooler, if fitted, shall be maintained within the limits established by the engine manufacturer.

1.11 The outlet temperature of the exhaust gases shall be measured at right angles to the exhaust flange(s) or manifold(s) or orifices.

1.12 Test Fuel

Test fuel shall be the reference fuel as per Gazette Notification. A commercial available fuel may also be used.

1.13 **Test Procedure:**

Measurements shall be taken at a sufficient number of engine speeds to define correctly the complete power curve between the lowest and the highest governed engine speeds recommended by the manufacturer. This range of speeds shall include the speeds of revolution at which the engine produces its maximum torque and at which it produces its maximum power. For each speed, the average of at least two stabilised measurements is to be determined.

2. ACCURACY OF MAXIMUM TORQUE AND MAXIMUM NET POWER MEASUREMENTS UNDER FULL LOAD

2.1. Torque: ±2% of torque measured .

2.2. Rotational speed: the measurement shall be accurate to ± 1 % of the full scale reading.

2.3. Fuel consumption : ± 2 % for all the devices used .

2.4. Temperature of engine induction air: ± 2K.

2.5. Barometric pressure: ± 100 Pa

2.6. Pressure in the exhaust: ± 200 Pa and

under-pressure of the intake air: ± 50 Pa .

3. TEST FOR THE MEASUREMENT OF MAXIMUM TORQUE AND MAXIMUM NET ENGINE POWER

3.1. **Accessories**

3.1.1. Accessories to be fitted.

During the test the accessories needed for operation of the engine in the application under consideration (as set out in Table 1 of this Appendix) shall be located on the test bench as far as possible in the position they would occupy for the application under consideration.

3.1.2. Accessories not to be fitted

Certain vehicle accessories which are needed only for use of the vehicle itself, but which are likely to be mounted on the engine, shall be removed for the tests. The power absorbed by fixed equipment under no load may be determined and added to the power measured.

3.1.3 The radiator, fan, fan nozzle, water pump and thermostat shall, on the test bench, occupy as far as possible the same position relative to each other as if they were on the vehicle. If the radiator, fan, fan nozzle, water pump or thermostat have a position on the test bench which is different from that on the vehicle, the position on the test bench shall be described and noted in the test report.

	Table 1 **Accessories to be fitted during the Test in order to Determine Torque and Net Engine Power**	
Sr. No.	**Accessories**	**Fitted for the torque and net-power test**
1	**Air Intake System** - Induction manifold - Air filter - Induction silencer - Crankcase emission control system - Electrical control devices, where fitted	If series-mounted : yes
2	**Exhaust system** - Manifold - Pipework ([1]) - Silencer ([1]) - Exhaust pipe [(1)] - Electrical control devices, where fitted	If series-mounted: yes
3	Carburettor	If series-mounted: yes
4	**Fuel injection system** - Upstream filter - Filter - Fuel supply pump and high pressure pump if applicable - Compressed air pump in the case of DI air assist - Pipework	If series-mounted: yes

	- Injector - Where fitted, air inlet flap ([2]) - Fuel pressure/flow regulator, where fitted	
5	**Maximum rotational speed- or power governors**	If series-mounted: yes
6	**Liquid-cooling equipment** - Radiator - Fan ([3]) - Water Pump - Thermostat ([4])	If series-mounted: yes))[(5)]
7	**Air cooling** - Cowl - Blower ([3]) - Cooling temperature regulating device(s) - Auxiliary bench blower	If series-mounted: yes,
8	Electrical equipment	If series-mounted: yes ([6])
9	Pollution control devices [(7)]	If series-mounted: yes
10	Lubrication system Oil feeder	If series-mounted: yes

(1) If it is difficult to use the standard exhaust system an exhaust system causing an equivalent pressure drop may be fitted for the test with the agreement of the manufacturer. In the test laboratory when the engine is in operation the exhaust gas extraction system shall not cause in the extraction flue at the point where it is connected to the vehicle's exhaust system a pressure differing from atmospheric pressure by ± 740 Pa (7.40 mbar), unless, before the test, the manufacturer accepts a higher back pressure.

(2) The air inlet flap shall be that which controls the pneumatic inject pump regulator.

(3) Where a fan or blower may be disengaged the net engine power shall first of all be stated with the fan (or blower) disengaged, followed by the net engine power with the fan (or blower) engaged.

Where a fixed electrically or mechanically-operated fan cannot be fitted on the test bench the power absorbed by that fan shall be determined at the same rotational speeds as those used when the engine power is measured. That power is deducted from the corrected power in order to obtain the net power.

(4) The thermostat may be locked in the fully-open position.

(5) The radiator, fan, fan nozzle, water pump and thermostat must, on the test bench, occupy as far as possible the same position relative to each other as if they were on the vehicle. The liquid coolant shall be circulated solely by the water pump for the engine. The coolant may be cooled either by the engine radiator or by an outside circuit, provided that the pressure drops within that circuit remain substantially the same as those in the engine cooling system. Where fitted the engine blind shall be open

(6) Minimum generator output: the generator supplies the current that is strictly needed to supply the accessories that are essential to the operation of the engine. The battery shall not receive any charge during the test.

(7) Anti-pollution provisions may include, for example, exhaust-gas recirculation (EGR) system, catalytic converter, thermal reactor, secondary air-supply system and fuel-evaporation protecting system.

3.2. Setting conditions:

The conditions applying to settings during the tests to determine maximum torque and maximum net power are set out in Table 2 below of this Appendix.

TABLE 2
Setting Conditions

1.	Setting of carburettor(s)	Setting carried out in accordance with the manufacturer's specifications for series production applied, without any other change, to the use under consideration.
2.	Setting of injector pump flow-rate	
3.	Ignition or injection setting (advance curve)	
4.	(Electronic) Throttle Control	
5.	Any other rotational speed governor setting	
6.	(Noise and tailpipe) emission abatement system settings and devices	

4. POWER AND TORQUE CORRECTION FACTORS

4.1 Definition of factor α_1 and α_2

α_1 and α_2 shall be factors by which the observed torque and power measured are to be multiplied in order to determine the torque and power of an engine under the reference atmospheric conditions specified in clause 4.2 of this Appendix and the mechanical efficiency of the transmission as specified in 4.5 of this Appendix.

The power correction formula is as follows:

$P_0 = \alpha_1 \times \alpha_2 \times P$

where:

P_0 = the corrected power (i.e. the power under the reference conditions at the end of the crank shaft)

α_1 = the correction factor for reference atmospheric conditions

α_2 = the correction factor for the efficiency of the transmission

P = the power measured (power observed).

4.2 Reference atmospheric conditions

4.2.1. Temperature: 25°C (298 K)

4.2.2. Dry reference pressure (p_{so}): 99 kPa (990 mbar)

Note: the dry reference pressure is based on a total pressure of 100 kPa and a water vapour pressure of 1 kPa.

4.2.3 Atmospheric test conditions

4.2.3.1 During the test, the atmospheric conditions shall lie within the following range:

$283 K < T < 318 K$

where T is the test temperature (K).

4.3 Determination of the correction factor α_1

Within the limits defined in 4.4 the correction factor is obtained via the following formula:

$$\alpha_1 = (99/ p_s)^{1.2} * (T/298)^{0.6}$$

where:

T = the absolute temperature in Kelvins of the ingested air

P = the total atmospheric pressure, in kilopascals

PV = the water vapour pressure, in kilopascals

$P_S = P - PV$

Note:- The test may be carried out in temperature-controlled test chambers where the atmospheric conditions can be controlled.

4.4 **Limits to the use of the correction formula**

The correction formula applies only if the correction factor lies between 0.93 and 1.07. If these accepted values are exceeded, the corrected value obtained shall be stated and the test conditions (temperature and pressure) specified exactly in the test report.

4.5 Determination of the correction factor for mechanical efficiency of the transmission α_2

Determination of the factor α_2

— where the measuring point is the output side of the crankshaft, this factor is equal to 1 ,

— where the measuring point is not the output side of the crankshaft, this factor is calculated using the formula:

$$\alpha_2 = 1/n_t$$

where n_t is the efficiency of the transmission located between the crankshaft and measuring point.

This transmission efficiency n_t is determined from the product (multiplication) of efficiency n_j of each of the components of the transmission :

$$n_t = n_1 \times n_2 \ldots\ldots n_j$$

Efficiency n_j of each of the components of the transmission is shown in the following Table 3 of this Appendix:

Table 3
Efficiency n_j of each of the Components of the Transmission

Type		Efficiency
Gear wheel	Spur gear	0.98
	Helical gear	0.97
	Bevel gear	0.96
Chain	Roller	0.95
	Silent	0.98
Belt	Cogged	0.95
	Vee	0.94
Hydraulic coupling or convector	Hydraulic coupling (1) (2)	0.92
	Hydraulic convertor (1)(2)	0.92

(1) The test may be carried out in temperature-controlled test chambers where the atmospheric conditions can be controlled.

(2) If not locked up.

5. MAXIMUM TORQUE AND MAXIMUM NET POWER MEASUREMENT TOLERANCES

5.1. The maximum torque and the maximum net power of the engine as determined by the Test Agency shall have a maximum acceptable tolerance as specified in following Table 4 of this Appendix:

Table 4
Acceptable Measurement Tolerances

Measured power	Acceptable tolerance maximum torque and maximum power
< 1 kW	± 10 %
1 kW ≤ Measured Power ≤ 6 kW	± 5 %
Engine speed tolerance when performing maximum torque and net power measurements: ≤ 3 %	

6. TEST REPORT

The test report shall set out the results and all the calculations needed in order to obtain the maximum torque and the maximum net power.

In addition, the test report shall contain the data as specified in Appendix 3A of this Chapter.

	CHAPTER 1- APPENDIX 3A **RESULTS OF TESTS FOR MEASURING MAXIMUM TORQUE AND MAXIMUM NET POWER FOR MOPEDS FITTED WITH SPARK IGNITION ENGINE**	
	TEST CONDITIONS	
	Pressures measured at maximum power	
	Barometric:.....	kPa
	Steam pressure:…….	kPa
	Exhaust [(1)]: . ……	kPa
	Inlet pressure drop [(1)]: …….	kPa. in the engine
	Induction system:…… .	
	Temperatures measured at maximum engine power of the intake air:……	K
	of the cooling liquid	
	at the engine cooling liquid outlet:…….	K [(2)]
	at the reference point in the case of air cooling:….	K [(2)]
	of the oil:……..	K (indicate the point of measurement)
	of the fuel	
	at the carburettor/injection pump intake [(2)]……	K
	in the fuel-consumption measuring device: …….	K
	of the exhaust, measured at the point adjacent to the outlet flange(s) of the exhaust manifold(s) [(3)]….	K
	Characteristics of the dynamometer	
	Make:…….	
	Type:…….	
	Fuel	
	For spark-ignition engines operating on liquid fuel:	
	Make: ……..	
	Specification:……	
	Anti-knock additive (lead, etc.)	
	Type:……..	
	Content in mg/litre:……..	

	Octane Number:	
	RON:……..	
	MON:……..	
	Relative density.: . . . . . at 15°C. . . . . at 4°C…….	
	Calorific value:……..	kJ/kg
	Lubricant	
	Make:…….	
	Specification:…….	
	SAE viscosissty grade:…….	

(1) To be measured when the original induction systems are not being used.

(2) Delete where inapplicable.

(3) Indicate the position.

DETAILED RESULTS OF MEASUREMENTS

Engine Performance

Engine speed, min^{-1}	
Rotational speed of dynamometer brake, min^{-1}	
Dynamometer brake load, N	
Torque measured at crankshaft, N.m	
Power measured, kW	
Test conditions	Barometric pressure, kPa
	Temperature of ingested air, K
Steam pressure kPa	
Atmospheric correction factor α_1	
Mechanical correction factor α_2	
Corrected torque at crankshaft, N.m	
Corrected power, kW	
Specific fuel consumption (1), g/kW·h	
Engine cooling temperature, K (2)	
Oil temperature at measuring point, K	
Exhaust temperature, K	
Air temperature downstream of supercharger, K	
Pressure downstream of supercharger, kPa	

(1) Without power correction due to the atmospheric factor.

(2) State location of measuring point: the measurement has been carried out (delete where inappropriate):

(a) at the liquid coolant outlet;

(b) at the spark-plug washer;

(c) elsewhere, to be stated.

CHAPTER 1 - APPENDIX 4

METHOD FOR MEASURING MAXIMUM TORQUE AND MAXIMUM NET POWER FOR L CATEGORY VEHICLES FITTED WITH SPARK IGNITION ENGINE EXCLUDING MOPEDS

1. TEST CONDITIONS

1.1. The maximum-torque and net-power tests shall be conducted at full throttle, the engine being equipped as specified in Table 1 of this Appendix.

1.2. The measurements shall be carried out under normal, stabilized operating conditions with an adequate fresh-air supply to the engine. The engine shall have been run in accordance with the manufacturer's recommendations. Combustion chambers may contain deposits, but in limited quantities. Test conditions such as air inlet temperature shall be selected as near to reference conditions (see clause 4.2 of this Appendix) as possible in order to minimize the magnitude of the correction factor.

Where the cooling system on the test bench meets the minimum conditions for proper installation but nevertheless does not enable adequate cooling conditions to be reproduced and thus the measurements to be carried out in normal, stable operating conditions, the method described in Appendix 4B of this Chapter may be used.

The minimum conditions which shall be fulfilled by the test installation and the scope for conducting the tests in accordance with Appendix 4B of this Chapter are laid down as follows:

v_1 is the maximum speed of the vehicle;

v_2 is the maximum velocity of the cooling air flow at the fan delivery side;

Ø is the cross-section of the cooling air flow.

If $v_2 \geq v_1$ and Ø $\geq$ 0.25 m^2 the minimum conditions are fulfilled. If it is not possible to stabilize the operating conditions the method described in Appendix 4B of this Chapter applies.

If $v_2 < v_1$ or Ø < 0.25 m^2:

(a) if it is possible to stabilize the operating conditions the method described in (clause 4.3 of this Appendix - Test Conditions) is applied;

(b) if it is not possible to stabilize the operating conditions:

(i) if $v_2 \geq$ 120 km/h and Ø $\geq$ 0.25 m^2, the installation fulfils the minimum conditions and the method described in Appendix 4B of this Chapter may be applied;

(ii) if $v_2 \geq 120$ km/h and/or $Ø < 0.25$ m^2, the installation does not fulfil the minimum conditions and the test equipment cooling system shall be improved.

However, in this case, the test may be carried out by means of the method described in Appendix 4B of this Chapter, subject to approval by the manufacturer and the Test Agency

1.3. The temperature of the (ambient) inlet air to the engine shall be measured at no more than 0.15 m upstream from the point of entry into the air cleaner or, if no air cleaner is used, within 0.15 m of the air-inlet trumpet. The thermometer or thermocouple shall be shielded from radiant heat and be placed directly in the airstream. It shall also be shielded from fuel spray-back. A sufficient number of locations = shall be used to give a representative average inlet temperature.

1.4. No data shall be taken until torque, speed and temperature have remained substantially constant for at least 30 seconds.

1.5. The engine speed during a run or reading shall not deviate from the selected speed by more than ± 1 % or ± 10 min^{-1} whichever is greater.

1.6. Observed brake load and inlet-air temperature data shall be taken simultaneously and shall be the average of two stabilised consecutive values. In the case of the brake load, these values shall not vary by more than 2 %.

1.7. The temperature of the coolant at the outlet from the engine shall be kept within ±5 K from the upper thermostatically controlled temperature specified by the manufacturer. If no temperature is specified by the manufacturer the temperature shall be 353 K ± 5 K.

For air-cooled engines, the temperature at a point indicated by the manufacturer shall be kept between + 0/- 20 K of the maximum temperature specified by the manufacturer under the reference conditions.

1.8 The fuel temperature shall be measured at the inlet of the carburettor or injection system and be maintained within the limits set by the manufacturer.

1.9. The temperature of the lubricating oil measured in the oil sump or at the outlet from the oil cooler, if fitted, shall be maintained within the limits stipulated by the engine manufacturer.

1.10 The outlet temperature of the exhaust gases shall be measured at right angles to the exhaust flange(s), manifold(s) or orifices.

1.11 Where an automatically-triggered device is used to measure engine speed and consumption the measurement shall last for at least 10 seconds; if the measuring device is manually controlled it shall measure for at least 20 seconds.

1.12 Test Fuel

Test fuel shall be the reference fuel as per Gazette Notification. A commercial available fuel may also be used.

1.13 If it is not possible to use the standard exhaust silencer a device shall be used for the test that is compatible with the engine's normal operating conditions, and specified by the manufacturer.

During the laboratory tests in particular, when the engine is running, the exhaust gas extractor shall not, at the point where the exhaust system is connected to the test bench, give rise in the exhaust-gas extraction duct to a pressure differing from the atmospheric pressure by more than ± 740 Pa (7.4 mbar) unless the manufacturer has deliberately specified the back pressure existing before the test; in this case the lower of the two pressures shall be used.

1.14. **Tests**

Measurements shall be taken at a sufficient number of engine speeds to define correctly the complete power curve between the lowest and the highest engine speeds recommended by the manufacturer. This range of speeds shall include the speeds of revolution at which the engine produces its maximum torque and at which it produces its maximum power. For each speed, the average of at least two stabilised measurements is to be determined.

2. ACCURACY OF THE MEASUREMENTS OF MAXIMUM NET POWER AND MAXIMUM TORQUE AT FULL LOAD

2.1 Torque: ± 1 % of the torque measured [(1).]

2.2. Rotational speed: The measurement shall be accurate to ± 1 % of the full scale reading.

2.3. Fuel consumption: ± 1 % overall for the apparatus used.

2.4. Engine inlet air temperature: ± 1 K

2.5 Barometric pressure: ±100 Pa

2.6. Exhaust pressure: ± 200 Pa and drop in intake air: ± 50 Pa

([1]) The torque measuring device shall be calibrated in order to take account of frictional losses. This accuracy may be ± 2% for the measurements carried out at power levels less than 50% of the maximum value. It will in all cases be ± 1 % for the measurement maximum torque.

3. TESTS TO MEASURE MAXIMUM TORQUE AND MAXIMUM NET ENGINE POWER

3.1. Accessories

3.1.1. Accessories to be fitted

During the test the accessories needed for operation of the engine in the application under consideration (as mentioned in Table 1 of this Appendix) shall be able to be located on the test bench as far as possible in the positions that they would occupy for the application under consideration.

3.1.2. Accessories to be removed

Certain accessories which are necessary only for the operation of the vehicle itself, and which may be mounted on the engine, shall be removed for the test.

Where accessories cannot be removed the power absorbed by them under no load may be determined and added to the engine power measured

	Table 1 **Accessories to be Fitted During the Propulsion Unit Performance Test to in order to Determine Torque and Net Engine Power**	
Sr. No.	**Accessories**	**Fitted for the torque and net-power test**
1	**Air intake system** - Induction manifold - Air filter - Induction silencer - Crankcase emission control system - Electrical control device (where fitted)	If series-mounted : yes
2	**Induction manifold heater**	If series-mounted: yes (if possible, it shall be set in the most favourable position)
3	**Exhaust system** - Exhaust manifold - Exhaust clean-up system (secondary air system) (where fitted) - Pipework (1) - Silencer (1) - Exhaust pipe (1) - Electrical control device - (where fitted)	If series-mounted: yes
4	Carburettor	If series-mounted: yes
5	**Fuel injection system** - Upstream filter - Filter - Fuel supply pump and high pressure pump, if applicable - High pressure lines - Injector - Air inlet flap (2), where fitted - Fuel pressure / flow regulator, where fitted	If series-mounted: yes
6	**Maximum rotational speed or power governors**	If series-mounted: yes
7	**Liquid-cooling equipment** - Engine bonnet - Radiator - Fan (3) - Fan Cowl - Water Pump - Thermostat (4)	If series-mounted: yes(5)

8	**Air cooling** - Cowl - Blower (3) - Cooling temperature-regulating device(s) - Auxiliary bench blower	If series-mounted: yes,
9	Electrical equipment	If series-mounted: yes (6)
10	**Supercharger or turbocharger (where fitted)** - Compressor driven directly by the engine or by exhaust gases - Charge air cooler (7) - Coolant pump or fan (engine driven) - Coolant flow control device (where fitted)	If series-mounted: yes
11	Pollution control device (8)	If series-mounted: yes
12	Lubrication system - oil feeder - Oil cooler (where fitted)	If series-mounted: yes

(1) If it is difficult to use the standard exhaust system an exhaust system causing an equivalent pressure drop may be fitted for the test with the agreement of the manufacturer. In the test laboratory when the engine is in operation the exhaust gas extraction system shall not cause in the extraction flue at the point where it is connected to the vehicle's exhaust system a pressure differing from atmospheric pressure by ±740 Pa (7.40 mbar), unless, before the test, the manufacturer accepts a higher back pressure.

(2) The air inlet flap shall be that which controls the pneumatic inject pump regulator.

(3) Where a fan or blower may be disengaged the net engine power shall first of all be stated with the fan (or blower) disengaged, followed by the net engine power with the fan (or blower) engaged.

Where a fixed electrically or mechanically-operated fan cannot be fitted on the test bench the power absorbed by that fan shall be determined at the same rotational speeds as those used when the engine power is measured. Corrected fan power is deducted from the corrected power in order to obtain the net power

(4) The thermostat may be locked in the fully-open position.

(5) The radiator, fan, fan nozzle, water pump and thermostat shall, on the test bench, occupy as far as possible the same position relative to each other as if they were on the vehicle. The liquid coolant shall be circulated solely by the water pump for the engine. The coolant may be cooled either by the engine radiator or by an outside circuit,

provided that the pressure drops within that circuit remain substantially the same as those in the engine cooling system. Where fitted the engine blind shall be open

(6) Minimum generator output: the generator supplies the current that is strictly needed to supply the accessories that are essential to the operation of the engine. The battery shall not receive any charge during the test.

(7) Charge air-cooled engines shall be tested with charge air cooling, whether liquid or air-cooled, but if the manufacturer prefers, a test bench may replace the air-cooled cooler. In either case, the measurement of power at each speed shall be made with the same pressure drop of the engine air across the charge air cooler on the test-bench system as those specified by the manufacturer for the system on the complete vehicle.

(8) Anti-pollution provisions may include, for example, exhaust-gas recirculation (EGR) system, catalytic converter, thermal reactor, secondary air-supply system and fuel-evaporation protecting system.

3.2 **Setting conditions**

The setting conditions for the test to determine maximum torque and maximum net power are set as in Table 2 of this Appendix.

TABLE 2
Setting Condition

1.	Setting of carburettor(s)	Setting carried out in accordance with the manufacturer's specifications for series production applied, without any other change, to the use under consideration.
2.	Setting of injector pump flow-rate	
3.	Ignition or injection setting (advance curve)	
4.	(Electronic) Throttle Control	
5.	Any other rotational speed governor setting	
6.	(Noise and tailpipe) emission abatement system settings and devices	

4. POWER AND TORQUE CORRECTION FACTORS

4.1. Definition of factors α_1 and α_2

α_1 and $\alpha_{2\ shall}$ be factors by which the torque and power measured are to be multiplied in order to determine the torque and power of an engine, taking account of the efficiency of the transmission (factor α_2) that are possibly used during the tests in order to bring them within the reference atmospheric conditions specified in 4.2.1 of this Appendix (factor α_1).

The power correction formula is as follows:

$$P_0 = \alpha_1 \times \alpha_2 \times P$$

where:

P_0 = the corrected power (i.e. the power under the reference conditions at the end of the crank shaft)

α_1 = the correction factor for reference atmospheric conditions

α_2 = the correction factor for the efficiency of the transmission

P = the power measured (power observed)

4.2. Atmospheric conditions

4.2.1. Reference atmospheric conditions

4.2.1.1. Reference temperature : 298 K (25 °C).

4.2.1.2. Dry reference pressure (p_{so}) : 99 kPa (990 mbar)

Note: the dry reference pressure is based on a total pressure of 100 kPa and a water vapour pressure of 1 kPa.

4.2.2. Atmospheric test conditions

During the test the atmospheric conditions shall lie within the following values.

4.2.2.1. Test temperature (T) : 283 K < T < 318K

4.3. Determination of the correction factors

4.3.1 Determination of factor α_1 (1)

4.3.1.1 Definition of physical magnitudes T, Ps for correction factors α_1

T = the absolute temperature of the ingested air

p_s = the dry atmospheric pressure in kilopascals (kPa) i.e. the total barometric pressure minus the water vapour pressure

(1) The test may be carried out in temperature-controlled test chambers where the atmospheric conditions can be controlled.

4.3.1.2 Factor α_1

Correction factor α_1 is obtained from the following

$\alpha_1 = (99/Ps)^{1.2} * (T/298)^{0.6}$

Above formula only applies if: $0.93 \leq \alpha_1 \leq 1.07$.

If the limit values are exceeded the corrected value obtained = shall be stated and the test conditions (temperature and pressure) stated exactly in the test report.

4.3.2. Determination of the correction factor for mechanical efficiency of the transmission α_2

- Where the measuring point is the output side of the crankshaft this factor is equal to 1.

- Where the measuring point is not the output side of the crankshaft this factor is calculated using the formula :

$$\alpha_2 = 1/n_t$$

where n_t is the efficiency of the transmission located between the crankshaft and measuring point.

This transmission efficiency n_t is determined via the product (multiplication) of efficiency n_j of each of the components of the transmission:

$n_t = n_1 \times n_2 \times ... \times n_j$

Efficiency n_j of each of the components of the transmission is shown in the following Table 3:

Table 3 Efficiency n_j of each of the Components of the Transmission		
Type		**Efficiency**
Gear wheel	Spur gear	0.98
	Helical gear	0.97
	Bevel gear	0.96
Chain	Roller	0.95
	Silent	0.98
Belt	Cogged	0.95
	Vee	0.94
Hydraulic coupling or convector	Hydraulic coupling (1)	0.92
	Hydraulic convertor (1)	0.92
(1) If not locked up.		

5. MAXIMUM TORQUE AND MAXIMUM NET POWER MEASUREMENT TOLERANCES

5.1 The maximum torque and the maximum net power of the engine as determined by the Test Agency shall have a maximum acceptable tolerance as specified in following Table 4 of this Appendix:

Table 4 Acceptable Measurement Tolerances	
Measured power	Acceptable tolerance maximum torque and maximum power
≤ 11 kW	± 5 %
> 11 kW	± 2 %
Engine speed tolerance when performing maximum torque and net power measurements: ≤ 1,5 %.	

6. TEST REPORT

The test report shall contain the results and all the calculations required to obtain the maximum torque and the maximum net power.

In addition, the test report shall contain the data as specified in Appendix 4A of this Chapter.

	CHAPTER 1 – APPENDIX 4A **RESULTS OF TESTS FOR MEASURING MAXIMUM TORQUE AND MAXIMUM NET POWER FOR L CATEGORY VEHICLES FITTED WITH SPARK IGNITION ENGINE EXCLUDING MOPEDS**	
	TEST CONDITINS	
	Pressures measured at maximum power	
	Barometric:……..…….	kPa
	Steam pressure:…….	kPa
	Exhaust [1]: ……..	kPa
	Inlet pressure drop [1]:……	kPa
	Temperatures measured at maximum engine power	
	of the intake air……..	K
	of the cooling liquid	
	at the engine cooling liquid outlet:…….	K [2]
	at the reference point in the case of air cooling…	K [2]
	of the oil:……..	K (indicate the point of measurement)
	of the fuel	
	at the carburettor/injection pump intake [2]….	
	in the fuel-consumption measuring device……	K
	of the exhaust, measured at the point adjacent to the outlet flange(s) of the exhaust manifold(s) [3] …….	K
	Characteristics of the dynamometer	
	Make:…….	
	Type:……..	

	Fuel	
	For spark-ignition engines operating on liquid fuel:	
	Make:……..	
	Specification:…….	
	Anti-knock additive (lead, etc.)	
	Type:……..	
	Content in mg/litre……	
	Octane number:	
	RON:……	
	MON:…….	
	Relative density: ..... at 15 °C…… at 4 °C	g/cm^3
	Lower Calorific value……	kJ/kg
	Lubricant	
	Make:…….	
	Specification: ……..	
	SAE viscosity grade: …….	
	(1) To be measured when the original induction systems are not being used. (2) Delete where inapplicable. (3) Indicate the position.	

DETAILED RESULTS OF MEASUREMENTS

Engine Performance

Engine speed, min^{-1}	
Rotational speed of dynamometer brake, min^{-1}	
Dynamometer brake load, N	
Torque measured at crankshaft, N.m	
Power measured, kW	
Test conditions	Barometric pressure, kPa
	Temperature of ingested air, K
Steam pressure kPa	
Atmospheric correction factor α_1	
Mechanical correction factor α_2	
Corrected torque at crankshaft, N.m	
Corrected power, kW	
Specific fuel consumption (1), g/kW·h	
Engine cooling temperature, K (2)	
Oil temperature at measuring point, K	
Exhaust temperature, K	
Air temperature downstream of supercharger, K	
Pressure downstream of supercharger, kPa	

(1) Without power correction due to the atmospheric factor.

(2) State location of measuring point: the measurement has been carried out (delete where inappropriate):

(a) at the liquid coolant outlet;

(b) at the spark-plug washer;

(c) elsewhere, to be stated.

CHAPTER 1- APPENDIX 4B

MEASUREMENT OF MAXIMUM TORQUE AND MAXIMUM NET ENGINE POWER BY MEANS OF THE ENGINE-TEMPERATURE METHOD

1. TEST CONDITIONS

1.1. The tests intended to determine maximum torque and maximum net power must be carried out at full throttle, the engine being equipped as specified in Table 1 of Appendix 4 of this Chapter

1.2 The measurements must be carried out under normal operating conditions and the supply of induction air to the engine shall be adequate. Engines must have been run in under the conditions recommended by their manufacturer. The combustion chambers of spark-ignition engines may contain deposits, but in limited quantities.

The test conditions, such as the temperature of the induction air, must be selected so as to be as close as possible to the reference conditions (see 4.2.1 of Appendix 4 of this Chapter) in order to reduce the magnitude of the correction factor.

1.3 The temperature of the air ingested into the engine must be measured at a maximum distance of 0.15 m from the air filter inlet or, if there is no filter, 0.15 m from the air inlet trumpet. The thermometer or thermocouple must be protected against radiant heat and placed directly in the air stream. It must also be shielded from fuel spray-back. A sufficient number of locations must be used to give a representative average inlet temperature.

1.4. The engine speed during a measurement run must not deviate from the selected speed while readings are taken by more than ± 1 %.

1.5. The brake load readings for the test engine shall be taken from the dynamometer when the temperature of the engine monitor has reached the set value, the speed of the engine being held virtually constant.

1.6 Brake load, fuel consumption and inlet air-temperature readings must be taken simultaneously, the reading adopted for measurement purposes is the average of two stabilized values. For brake load and fuel consumption these values shall differ by less than 2 %.

1.7. The fuel consumption readings begin when it is certain that the engine has reached a specific speed.

Where an automatically triggered device is used to measure rotational speed and consumption the measurement must last for at least 10 seconds and if the measuring device is manually controlled for at least 20 seconds.

1.8. Where the engine is liquid cooled the temperature of the coolant at the outlet from the engine must be kept within ± 5 K of the upper thermostatically controlled temperature specified by the manufacturer. If no temperature is specified by the manufacturer, the temperature recorded must be 353.2 K ± 5 K.

Where the engine is air cooled, the temperature recorded at the spark-plug washer is the temperature specified by the manufacturer ± 10 K. If the manufacturer has not specified any temperature, that recorded must be 483 K ± 10 K.

1.9 The temperature of the spark-plug washers on air-cooled engines must be measured by a thermometer incorporating a thermocouple and a seal ring.

1.10 The fuel temperature at the inlet of the injection pump or carburetter must be maintained within the limits set by the manufacturer.

1.11 The temperature of the lubricating oil, measured in the oil sump or at the outlet from the oil cooler, if fitted, must be within the limits set by the manufacturer.

1.12 The exhaust gas temperature shall be measured at a point at right angles to the exhaust orifice flange(s) or manifold(s).

1.13 Test Fuel
Test fuel shall be the reference fuel as per Gazette Notification. A commercial available fuel may also be used.

1.14 If it is not possible to use the standard exhaust silencer for the test, a device shall be used for the test that is compatible with the normal speed of the engine as specified by its manufacturer. In particular, when the engine is operating in the test laboratory the exhaust gas extraction system shall not cause a pressure differing from atmospheric pressure by ± 740 Pa (7.4 mbar) in the extraction flue at the point of connection with the vehicle's exhaust system, unless, the manufacturer has deliberately specified the back pressure existing before the test, in which case the lower of the two pressures shall be used.

CHAPTER 1 - APPENDIX 5

EMISSION OF VISIBLE POLLUTANTS AT STEADY SPEEDS OVER THE FULL-LOAD CURVE

1. SCOPE

This Appendix describes the method of determining emissions of visible pollutants at different steady speeds over the full load curve. The test to be carried out either on an engine or on a vehicle.

This appendix is applicable for emission of visible exhaust pollutants from C.I. engines which are intended for fitting to vehicles of categories L, M and N

2. MEASUREMENT PRINCIPLE

2.1 The opacity of the exhaust gases produced by the engine shall be measured with the engine running under full-load and at steady speed.

2.2 A sufficient number of measurements will be carried out ranging between the maximum rated speed and the minimum rated speed. The extreme points of measurement shall be situated at the limits of interval defined above and one point of measurement will coincide with the speed at which the engine develops its maximum power and the speed at which it develops maximum torque.

3. TEST CONDITIONS

3.1 Vehicle or engine:

3.1.1 The engine or the vehicle shall be submitted in good mechanical condition. The engine/vehicle shall have been run in as recommended by the manufacturer.

3.1.2 The engine shall be tested with the equipment prescribed in Table1 of Appendix 1 of this Chapter.

3.1.3 The settings of the engine shall be those prescribed by the manufacturer and shown in Appendix 1 of this Chapter.

3.1.4 In the case of a test on an engine the power of the engine shall be measured in accordance with Appendix 1 of this Chapter and it should meet the requirements of power tolerance given in clause 3.4 of this Chapter. In the case of a test on a vehicle, it should be established that the fuel flow is not less than that declared by the manufacturer.

3.1.5 The exhaust device shall not have any orifice through which the gases emitted by the engine might be diluted. In cases where an engine has several exhaust outlets, these shall be connected to a single outlet in which the opacity measurement shall be made.

3.1.6 The engine shall be in the normal working condition prescribed by the manufacturer. In particular, the cooling water and the oil shall each be at the normal temperature prescribed by the manufacturer.

Table 1

Limit Values Applicable in the Test at Steady Speeds

Nominal Flow G (l/s)	Light Absorption Coefficient K (1/m)	Nominal Flow G (1/s)	Light Absorption Coefficient K (1/m)
<=42	2.26	120	1.37
45	2.19	125	1.345
50	2.08	130	1.32
55	1.985	135	1.30
60	1.90	140	1.27
65	1.84	145	1.25
70	1.775	150	1.205
75	1.72	160	1.19
80	1.665	165	1.17
85	1.62	170	1.155
90	1.575	175	1.14
95	1.535	180	1.125
100	1.495	185	1.11
105	1.465	190	1.095
110	1.425	195	1.08
115	1.395	>200	1.065
The emissions of visible pollutants when tested as detailed in this Appendix shall not exceed the limit values of light absorption coefficient given above for various nominal flows:			

3.2 Fuel: The fuel used shall be the reference fuel as specified in the Gazette Notification.

3.3 **Test Laboratory**

The absolute temperature T of the air (The test may be carried out in air condition test rooms where the atmospheric conditions may be controlled) at the inlet to the engine measured within 0.15 m upstream of the point of entry to the air cleaner, or if no air cleaner is used, within 0.15 m of the air inlet manifold expressed in degrees Kelvin, and the atmospheric pressure Ps, expressed in Kilopascals, shall be measured, and the atmospheric factor fa shall be determined as give below:

Naturally aspirated and mechanically super charged engines :-

$$fa = (99/Ps) * (T/298)^{0.7}$$

Turbo super charge engines with or without cooling of inlet air

$$f = (99/Ps)^{0.7} * (T/298)^{1.5}$$

3.3.1 For a test to be recognised as valid, the parameter fa shall be such that $0.98 \leq fa \leq 1.02$.

3.4 Sampling and measuring apparatus:

The light-absorption coefficient of the exhaust gases shall be measured with an opacimeter satisfying the conditions of installation of opacimeter mentioned in Appendix 7 of this Chapter.

4. EVALUATION OF THE ABSORPTION COEFFICIENT

4.1 For each of the engine speeds at which the absorption coefficient is measured pursuant to clause 2.2 of this Appendix, the nominal gas flow shall be calculated by means of the following formulae:

for two-stroke engines $G = V * n/60$

for four-stroke engines $G = V * n/120$

where –

G	nominal gas flow, in liters per second, (l/s)
V	cylinder capacity of the engine, in liters, (l)
n	engine speed, in revolutions per minute(rpm)

4.2 Where the value of the nominal flow is not one of those given in the Table 1 of this Appendix above. the limit value applicable shall be obtained by interpolation on the principle of proportional parts.

CHAPTER 1- APPENDIX 6

TEST UNDER FREE ACCELERATION

1. SCOPE

This Appendix describes the method of determining the emissions of visible pollutants during the free acceleration test. The test shall be carried out on an engine installed on a test bench or on a vehicle.

This appendix is applicable for emission of visible exhaust pollutants under free acceleration from C.I. engines which are intended for fitting to vehicles of categories L, M and N.

This is applicable for naturally aspirated and supercharged (turbocharged) engine/vehicles.

1.1 The emissions of visible pollutants under free acceleration, when tested according to the procedure detailed in clause 3 of this Appendix shall not exceed limit mentioned in respective Gazette Notification.

2. TEST CONDITIONS

2.1 The test shall be carried out on an engine installed on a test bench or on vehicle.

2.1.1 If the engine test is a bench test it shall be carried out as soon as possible after the test for measurement of opacity under full load at steady speed. In particular, the cooling water and the oil shall be at the normal temperatures stated by the manufacturer.

2.1.2 If the test is carried out on a stationary vehicle the engine shall first be brought to normal operating conditions during a road run or on a dynamic test. The test shall be carried out as soon as possible after completion of this warming up period.

2.2.2 The combustion chamber shall not have been cooled or fouled by a prolonged period of idling preceding the test.

2.2.3 The test conditions prescribed in clause 3.1, 3.2 and 3.3 of Appendix 5 of the Chapter shall apply.

2.2.4 The test conditions prescribed in clause 3.4 of Appendix 5 of this Chapter with regard to the sampling and measuring apparatus shall apply.

3. TEST METHODS

3.1 If the test is a bench test, the engine shall be disconnected from the brake, the latter being replaced either by the rotating parts driven when no gear is engaged or by an inertia substantially equivalent to that of the said parts.

3.2 If the test is carried out on a vehicle, the gear-change control shall be set in the neutral position and the drive between engine and gear-box engaged.

3.3 With the engine idling, the accelerator control shall be operated quickly, but not violently, so as to obtain maximum delivery from the injection pump. This position shall be maintained until maximum engine speed is reached and the governor comes into action. During each free acceleration, maximum no-load rpm reached shall be within the bandwidth of ±500 rpm of the average value in respect of 3-wheeled vehicles and ±300 rpm of the average value for all other categories of vehicles.

For vehicles with automatic transmission or CVT, the engine speed specified by the vehicle manufacturer shall be achieved. As soon as this speed is reached the accelerator shall be released until the engine resumes its idling speed and the opacimeter reverts to the corresponding conditions.

3.3.1 The sequence mentioned in clause 3 of this Appendix for complete cycle for measurement can be defined based on time.

1) Acceleration time from idle to fly up speed :- 5 sec (max)

2) Stabilising time at maximum speed :- 2 sec (max)

3) De-acceleration Phase :- Engine comes back to idle speed by its own natural time

4) Idling Phase:- Operator to start next acceleration within 5 to 20 secs.

5) Repeat 1) to 4) above.

3.4 The operation described in clause 3.3.1 of this Appendix shall be repeated not less than three times in order to clear the exhaust system and to allow for any necessary adjustment of the apparatus. The maximum opacity values read in each successive acceleration shall be noted until stabilised values are obtained. No account shall be taken of the values read while, after each acceleration, the engine is idling. The values read shall be regarded as stabilised when three of them consecutively are situated within a band width of 25% of the arithmetic mean of these three readings or within a band width of 0.25K whichever is higher and do not form a decreasing sequence. The absorption coefficient to be recorded shall be the arithmetical mean of these three values. In case the smoke density recorded is not within the limits, then, the test may be repeated with engine oil temperature measured by a probe in the oil level dipstick tube to be at least 60° C.

3.5 In cases where the engine has several exhaust outlets. the tests shall be carried out with all the outlets joined in an adequate device ensuring mixture of the gases and ending in a single orifice. Free acceleration tests, however, may be carried out on each outlet. In this case the value to be used for calculating the correction to the absorption coefficient shall be the arithmetical mean of the values recorded at each outlet, and the test shall be regarded as valid only if the extreme values measured do not differ by more than $0.15\ m^{-1}$.

4. EXTENSION CRITERIA

The approval may be extended without carrying out any type test for the following conditions ;

4.1 Maximum rated speed not greater than 100% nor less than 75% of that of the engine in the type approval test;

4.2 Minimum rated speed not less than that of the engine in the type approval test;

4.3 Rated torque not greater than 100%, nor less than 70% of that of the engine at the speed in the type approval test;

4.4 Steady state absorption values are not greater than 1.1 times the values obtained in the type approval test and do not exceed the prescribed limits in Table 1 of Appendix 5 of this Chapter

4.5 Exhaust back pressure not greater than that of the engine in the type approval test;

4.6 Exhaust system volume does not differ by more than 40%;

4.7 Intake depression not greater than that of the engine in the type approval test;

4.8 Moment of inertia of a new combined fly wheel and transmission is within ± 15% of the engine fly wheel and transmission system approved.

CHAPTER 1- APPENDIX 7

OPACIMETERS AND THEIR INSTALLATIONS

1. SCOPE

This appendix covers the requirements of opacimeters and their installation on engines for full load and free acceleration tests, mentioned in Appendix 5 and Appendix 6 of this Chapter.

2. TECHNICAL SPECIFICATIONS OF OPACIMETERS

2.1 **General**

2.1.1 The gas to be measured shall be confined in an enclosure having a non- reflecting internal surface in the instrument.

2.1.2 In determining the effective length of the light path through the gas, account shall be taken of the possible influence of devices protecting the light source and the photoelectric cell. This effective length shall be indicated on the instrument.

2.1.3 The indicating dial of the opacimeter shall have two measuring scales one in absolute units of light absorption from 0 to ∞ (m^{-1})) and the other, linear from 0 to 100; both scales shall range from 0 at total light flux to full scale at complete obscuration.

2.2 Construction specifications

The design shall be such that under steady-speed operating conditions the smoke chamber is filled with smoke of uniform opacity.

2.2.1 Smoke chamber and opacimeter casing:

2.2.1.1 The impingement on the photoelectric cell of stray light due to internal reflections or diffusion effects shall be reduced to a minimum (e.g. by finishing internal surfaces in mat black and by a suitable general layout).

2.2.1.2 The optical characteristics shall be such that the combined effect of diffusion and reflection does not exceed one unit on the linear scale when the smoke chamber is filled with smoke having an absorption coefficient near 1.7 per meter.

2.2.2 Light source :

The light source shall be an incandescent lamp with a colour temperature in the range 2,800K to 3,250K.

2.2.3 **Receiver:**

2.2.3.1 The receiver shall consist of a photoelectric cell with a spectral response curve similar to the photopic curve of the human eye (maximum response in the range 550/570 nm ; less than 4% of that maximum response below 430 nm and above 680 nm).

2.2.3.2 The construction of the electrical circuit, including the indicating dial, shall be such that the current output from the photoelectric cell is a linear function of the intensity of the light received over the operating temperature range of the photoelectric cell.

2.2.4 **Measuring Scales**

2.2.4.1 The light-absorption coefficient k shall be calculated by the formula $ø = O_0.e^{(-k*L)}$ where L is the effective length of the light path through the gas to be measured, Fo the incident flux and F the emergent flux. When the effective length L of a type of opacimeter cannot be assessed directly from its geometry, the effective length L shall be determined -

- Either by the method described in clause 2.7 of this Appendix

or

- through correlation with another type of opacimeter for which the effective length is known.

2.2.4.2 The relationship between 0 - 100 linear scale and the light absorption coefficient k is given by the formula

$$k = (-1/L)*(\text{Log e } (1-N/100))$$

where N is the reading on the linear scale and k the corresponding value of the absorption coefficient.

2.2.4.3 The indicating dial of the opacimeter shall enable an absorption coefficient of 1.7/m to be read with an accuracy of 0.025/m.

2.3 Adjustment and calibration of the measuring apparatus

2.3.1 The electrical circuit of the photoelectric cell and of the indicating dial shall be adjustable so that the pointer can be reset at 0 when the light flux passes through the smoke chamber filled with clean air or through a chamber having identical characteristics.

2.3.2 With the lamp switched off and the electrical measuring circuit open or short circuited, the reading on the absorption coefficient scale shall be ∞ and it shall remain at ∞ with the measuring circuit reconnected. An intermediate check shall be carried out by placing in the smoke chamber a screen representing a gas whose known light absorption coefficient k, measured as described in clause 2.2.4.2 of this Appendix is between 1.6/m and 1.8/m. The value of k must be known to within 0.025/m. The check consists in verifying that this does not differ by more than 0.05/m from that read on the opacimeter indicating dial when the screen is introduced between the source of light and the photoelectric cell.

2.4 Opacimeter Response

2.4.1 The response time of electrical measuring circuit, being the time necessary for the indicating dial to reach 90% of full scale deflection on insertion of a screen fully obscuring the photoelectric cell, shall be 0.9 to 1.1 second.

2.4.2 The damping of the electrical measuring circuit shall be such that the initial overswing beyond the final steady reading after any momentary variation in input (eg. calibration screen) does not exceed 4% of that reading in linear scale units.

2.4.3 The response time of opacimeter which is due to physical phenomena in the smoke chamber is the time taken from the start of the gas entering the chamber to complete filling of the smoke chamber; it shall not exceed 0.4 second.

2.4.4 These provisions shall apply solely to opacimeters used to measure opacity under free acceleration.

2.5 Pressure of the Gas to be measured and of scavenging air

2.5.1 The pressure of the exhaust gas in the smoke chamber shall not differ by more than 75 mm (water gauge) from the atmospheric pressure.

2.5.2 The variations in the pressure of the gas to be measured and of the scavenging air shall not cause the absorption coefficient to vary by more than 0.05/m in the case of a gas having an absorption coefficient of 1.7/m.

2.5.3 The opacimeter shall be equipped with appropriate devices for measuring the pressure in the smoke chamber.

2.5.4 The limits of pressure variation of gas and scavenging air in the smoke chamber shall be stated by the manufacturer of the apparatus.

2.6 Temperature of the Gas to be measured

2.6.1 At every point in the smoke chamber the gas temperature at the instant of measurement shall be between 70°C and a maximum temperature specified by the opacimeter manufacturer such that the readings over the temperature range do not vary by more than 0.1/m when the chamber is filled with a gas having an absorption coefficient of 1.7/m.

2.6.2 The opacimeter shall be equipped with appropriate devices for measuring the temperature in the smoke chamber.

2.7 Effective Length "L" of the Opacimeter

2.7.1 In some types of opacimeters, the gas between the light source and the photoelectric cell, or between transparent parts protecting the source and the photoelectric cell, is not of constant opacity. In such cases the effective length L shall be that of a column of gas of uniform opacity which gives the same absorption of light as that obtained when the gas is normally admitted into the opacimeter.

2.7.2 The effective length of the light path is obtained by comparing the reading N of the opacimeter operating normally with the reading No obtained with the opacimeter modified so that the test gas fills a well defined length Lo

2.7.3 It will be necessary to take comparative readings in quick succession to determine the correction to be made for shifts of zero.

2.7.4 **Method of assessment of L**

2.7.4.1 The test gas shall be an exhaust gas of constant opacity or a light absorptive gas of a gravimetric density similar to that of exhaust gas.

2.7.4.2 A column of length Lo of the opacimeter, which can be filled uniformly with the test gas, and the ends of which are substantially at right angles to the light path shall be accurately determined. This length Lo shall be close to the effective length of the opacimeter.

2.2.4.3 The mean temperature of the test gas in the smoke chamber shall be measured.

2.7.4.4 If necessary an expansion tank of sufficient capacity to damp the pulsations and of compact design may be incorporated in the sampling line as near to the probe as possible. A cooler may also be fitted. The addition of the expansion tank and of the cooler should not unduly disturb the composition of the exhaust gas.

2.7.4.5 The test for determining the effective length shall consist in passing a sample of test gas alternately through opacity meter operating normally and through the same apparatus modified as indicated in clause 2.7.2. of this Appendix

2.7.4.6 The opacimeter readings shall be recorded continuously during the test with a recorder whose response time is equal to or shorter than that of the opacimeter.

2.7.4.7 With opacimeter operating normally, the reading on the linear scale of opacity is N and that of the mean gas temperature expressed in Kelvin degrees is T.

2.7.4.8 With the known length Lo filled with the same test gas, the reading on the linear scale of opacity is No and that of the mean gas temperature expressed in Kelvin degrees is To.

2.7.4.9 The effective length will be

$$L = Lo * (T*(Log(1-N/100))/(To*(Log(1-No/100)))$$

2.7.4.10 The test shall be repeated with at least 4 test gases giving readings evenly spaced between the readings 20 and 80 on the linear scale.

2.7.4.11 The effective length L of the opacimeter will be the arithmetic average of the effective lengths obtained as stated in clause 2.7.4.9 of this Appendix for each of the gases.

3. INSTALLATION OF THE OPACIMETER

3.1 The instrument should be prepared, used and maintained following the directions given in the instrument manufacturer's operation manual,and it should be serviced and calibrated at such intervals as to ensure accuracy.

3.2 **Sampling of Opacimeter**

3.2.1 Installation of opacimeter

3.2.1.1 The ratio of the cross-sectional area of the probe to that of the exhaust pipe shall not be less than 0.05. The back pressure measured in the exhaust pipe at the opening of the probe shall not exceed 75 mm (water gauge).

3.2.1.2 The probe shall be a tube with an open end facing forward in the axis of the exhaust pipe, or of the extension pipe if one is required. It shall be situated in a section where the distribution of smoke is approximately uniform. To achieve this, the probe shall be placed as far downstream in the exhaust pipe as possible, or, if necessary, in an extension pipe so that, if D is the diameter of the exhaust pipe at the opening, the end of the probe is situated in a straight portion at least 6D in length upstream of the sampling point and 3 D in length downstream. If an extension pipe is used, no air shall be allowed to enter the joint.

3.2.1.3 The pressure in the exhaust pipe and the characteristics of the pressure drop in the sampling line shall be such that the probe collects a sample sensibly equivalent to that which would be obtained by isokinetic sampling.

3.2.1.4 If necessary, an expansion tank of compact design and of sufficient capacity to damp the pulsations may be incorporated in the sampling line as near to the probe as possible. A cooler may also be fitted. The design of the expansion tank and cooler shall not unduly disturb the composition of the exhaust gas.

3.2.1.5 A butterfly valve or other means of increasing the sampling pressure may be placed in the exhaust pipe at least 3 D downstream from the sampling probe.

3.2.1.6 The connecting pipes between the probe, the cooling device, the expansion tank (if required) and the opacimeter shall be as short as possible while satisfying the pressure and temperature requirements prescribed in clause 2.5 and 2.6 of this Appendix. The pipe shall be inclined upwards from the sampling point to the opacimeter, and sharp bends where soot might accumulate shall be avoided. If not embodied in the opacimeter, a by-pass valve shall be provided upstream.

3.2.1.7 A check shall be carried out during the test to ensure that the requirements of clause 2.5 of this Appendix, concerning pressure and those of clause 2.6 of this Appendix concerning temperature in the measuring chamber are observed.

3.2.2 **FULL-FLOW OPACIMETER**

3.2.2.1 The only general precautions to be observed in steady-speed and free acceleration tests are the following :

3.2.2.2 Joints in the connecting pipes, if any, between the exhaust pipe and the opacimeter shall not allow air to enter from outside.

3.2.2.3 The pipes connecting with opacimeter shall be as short as possible, as prescribed in the case of sampling opacimeters. The pipe system shall be inclined upwards from the exhaust pipe to the opacimeter, and sharp bends where soot might accumulate shall be avoided. A by-pass valve may be provided upstream of the opacimeter to isolate it from the exhaust gas flow when no measurement is being made.

3.2.2.4 A cooling system may also be required upstream of the opacimeter.

4. Any other method/equipment may be approved, if it is found that they yield equivalent results.

CHAPTER 1 – APPENDIX 8

DETERMINATION OF THE MAXIMUM TORQUE AND MAXIMUM POWER OF L-CATEGORY VEHICLES EQUIPPED WITH A HYBRID PROPULSION

1. REQUIREMENTS

1.1 Hybrid propulsion including a positive-ignition combustion engine

The maximum total torque and maximum total power of the hybrid propulsion assembly of combustion engine and electric motor shall be measured according to the requirements of Appendix 3 or 4 and Appendix 8 of this Chapter.

1.2 Hybrid propulsion including a compression ignition combustion engine.

The maximum total torque and maximum total power of the hybrid propulsion assembly of combustion engine and electric motor shall be measured according to the requirements of Appendix 1 and Appendix 8 of this Chapter.

1.3 Hybrid propulsion including an electric motor

Clause 1.1. or 1.2 of this Appendix shall apply and, in addition, the maximum torque and maximum continuous rated power of the electric motor shall be measured according to the requirements of Appendix 8A of this Chapter.

1.4 If the hybrid technology used on the vehicle allows multi-mode hybrid running conditions, the same procedure shall be repeated for each mode and the highest measured propulsion unit performance value shall be taken as the final test result of the propulsion unit performance test procedure.

2. MANUFACTURER'S OBLIGATION

The vehicle manufacturer shall ensure that the test set-up of the test vehicle equipped with a hybrid propulsion shall result in the maximum attainable total torque and power being measured. Any series-mounted feature resulting in a higher propulsion unit performance in terms of maximum design vehicle speed, maximum total torque or maximum total power shall be regarded as a defeat device.

CHAPTER 1-APPENDIX 8A

REQUIREMENTS CONCERNING THE METHODS FOR MEASURING THE MAXIMUM TORQUE AND MAXIMUM CONTINUOUS RATED POWER OF A HYBRID PROPULSION TYPE

1. REQUIREMENTS

1.1 L-category vehicles equipped with a hybrid propulsion shall meet all the relevant requirements with regard to the measurements of the maximum torque and the maximum 30 minute power of electric drive trains set out in Appendix 2 of this Chapter.

1.2 By means of derogation if the manufacturer can prove to the Test Agency that the vehicle is physically not capable of achieving the 30 minutes speed the maximum 15minute speed may be used instead.

CHAPTER 2

TECHNICAL SPECIFICATIONS OF ENGINE TO BE SUBMITTED BY THE MANUFACTURER

The manufacturer shall submit technical specifications of engine as per AIS-007, as amended from time to time, to the Test Agency.

CHAPTER 3

ESSENTIAL CHARACTERISTICS OF THE ELECTRIC DRIVE TRAIN AND INFORMATION CONCERNING THE CONDUCT OF TESTS

The manufacturer shall submit essential characteristics of the electric drive train and information concerning the conduct of tests, as per AIS-007, as amended from time to time, to the Test Agency.

CHAPTER 4

RESERVED

CHAPTER 5
CHECKS ON CONFORMITY OF PRODUCTION

0. CHECKS ON CONFORMITY OF PRODUCTION FOR M AND N CATEGORY OF VEHICLES HAVING GVW MORE THAN 3,500 kg FOR MEASUREMENT OF NET POWER

1. GENERAL

These requirements are consistent with tests to be held to check conformity of production, according to conformity of production procedure that shall comply with those set out in this chapter with the following requirements:

A) Engine approved under this Part shall be so manufactured as to conform to the type approved.

B) The minimum requirement for conformity of production control procedure set forth in this Chapter shall be complied.

2. TEST PROCEDURES

The methods of testing and measuring instruments shall be those described in Appendix 1 to this part.

3. COLLECTION OF SAMPLES

Randomly selected engine has to be chosen. If test result does not comply the requirement of clause 4 of this Chapter, the engine is not considered as conforming to the requirements of this part, two more engines have to be tested

4. MEASUREMENT CRITERIA

4.1. Net power of internal combustion engine

During the tests to verify conformity of production, the power shall be measured at two engine speeds S1 and S2, corresponding respectively to the measurement points of maximum power and maximum torque accepted for type approval. At these two engine speeds, which are subject to a tolerance of ±5 per cent, the net power measured at at least one point within the ranges S1 ± 5 per cent and S2 ± 5 per cent shall not differ by more than ±5 per cent from the approval figure.

5. EVALUATION OF RESULTS

5.1. If the net power of the engine tested pursuant to clause 2 of this Chapter, fulfills the requirement of clause 4 of this Chapter, the production is considered to conform to the type approval.

5.2. If the requirements of paragraph 4. above are not fulfilled, two more engines are tested in the same way.

5.3 If the net power of the second and/or third engine of clause 5.2 of this Chapter do not fulfils the requirements of clause 4. of this Chapter, the production shall be considered not to conform to the requirements of this Part

6. CHECKS ON CONFORMITY OF PRODUCTION FOR EMISSION OF VISIBLE EXHAUST POLLUTION UNDER FREE ACCELERATION FROM C.I. ENGINES WHICH ARE INTENDED FOR FITTING TO VEHICLES OF CATEGORIES L, M AND N

6.1 For verifying the conformity of production in the case of a vehicle with a naturally aspirated/supercharged (turbocharged) compression-ignition engine, the vehicle selected at random from the series production should be subjected to the free acceleration test described in Appendix 6 of Chapter 1 of this Part without running in of the vehicle or after running in of the engine in case the engine is offered, and the light absorption coefficient shall be below the limit mentioned in respective Gazette Notification. On the request of the manufacturers, commercially available fuel may be used instead of reference fuel.

6.2 If it does not meet the requirements of clause 6.1 above, another 10 engines/vehicles shall be taken from the series at random and shall be tested as per Appendix 6 of Chapter 1 of this Part. At least 9 engines/vehicles should meet the limit values specified in respective Gazette Notification.

Further, two engines/vehicles selected at random from the above lot of 10 should be subjected to emissions at steady speeds over full load, prescribed in Appendix 5 of Chapter 1 of this Part. If both the samples meet the requirements of Table 1 of Appendix 5 of Chapter 1 of this Part the series is deemed to conform.

ANNEXURE 1

(See Introduction)

COMPOSITION OF A COMMITTEE FOR FORMULATION OF THIS STANDARD AS PER MORTH OFFICE MEMORANDUM NO. RT-11035/28/2015-MVL DATED 3rd SEPTEMBER, 2015

Chairperson	
Mrs. Rashmi Urdhwareshe	Director, The Automotive Research Association of India (ARAI), Pune
Co-ordinator and Member Secretary	
Mr. K. Srinivas	The Automotive Research Association of India (ARAI), Pune
Members	**Representing**
Representative from	International Centre for Automotive Technology (iCAT), Manesar, Gurgaon
Representative from	Society of Indian Automobile Manufacturers (SIAM), New Delhi
Representative from	Ministry of Petroleum & Natural Gas (MoPNG), New Delhi
Representative from	Emission Control Manufacturers Association (ECMA), New Delhi
Representative from	Automotive Component Manufacturers Association of India (ACMA), New Delhi
Representative from	Vehicles Research and Development Establishment (VRDE), Ahmednagar
Representative from	Central Institute of Road Transport (CIRT), Pune
Representative from	Indian Institute of Petroleum (IIP), Dehra Dun
Representative from	Ministry of Road Transport and Highways (MoRTH), New Delhi

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