FINALIZED DRAFT

AUTOMOTIVE INDUSTRY STANDARD

DOCUMENT ON TEST METHOD, TESTING EQUIPMENT AND RELATED PROCEDURES FOR

Method of Measuring Power of Internal Combustion Engines and electric drive trains intended for the propulsion of motor vehicles with regard to the measurement of net power for categories L, M, N and the maximum 30 minutes power of electric drive trains

PART-5

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	Method of Measuring Power of Internal Combustion Engines and electric drive trains intended for the propulsion of motor vehicles with regard to the measurement of net power for categories L, M, N and the maximum 30 minutes power of electric drive trains
	CHAPTER 1 **Overall Requirements**
1.	**Scope**
1.1.	This Chapter 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 engines.
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 engines net power for M & N Category of vehicles and L category vehicles fitted with compression ignition engines (Refer Appendix 1).
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 of maximum torque and maximum net power for mopeds fitted with spark ignition engine (Refer Appendix 3).
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1.4.6	Method for test under free acceleration (Refer Appendix 6).
1.4.7	Smoke meter and their installation (Refer Appendix 7).

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 2 to this AIS 137,Part 5.
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 Appendix 2 to this part 5.
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 Table 1 of Appendix 2 to 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 paragraph 3.3 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 to AIS 137 Part4 or mounted on a vehicle type approved with regards to its emissions according to AIS 137 Part4 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;
2.9.	**"*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, 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-l 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	***"Opacity Meter"*** Means an instrument for continuous measurement of the light absorption coefficient of the exhaust gases emitted by automotive vehicles.
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.
2.33	**"*Maximum net power*"** means the maximum value of the net power measured at full engine load.
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 the engine shall be so designed, constructed and assembled as to enable the engine in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this chapter.
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 not less than six to define correctly the power, torque and specific fuel consumption curve between the maximum and the minimum rated speeds recommended by the manufacturer. This range of speeds shall include the speeds of revolution at which the engine produces its rated net power, 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 petrol: The fuel used shall be the one available on the market. In any case of dispute, the fuel shall be one of the reference fuels as specified in gazette notification.
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 fuel used shall be the one available on the market. In any case of dispute the fuel shall be one of the reference fuels specified as specified in gazette notification.
3.2.3.2.2.	In the case of an engine without self-adaptive fuelling: The fuel used shall be the reference fuel specified in as specified in Chapter 4 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 fuel used shall be the one available on the market. In any case of dispute the fuel shall be one of the references fuels specified in as specified in Chapter 4.
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 Chapter 4, 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 Chapter 4if 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 G20 specified in Chapter 4 if the engine is labelled LNG20.
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 fuel used shall be the one available on the market. In any case of dispute, the fuel shall be the reference fuel as specified in Chapter 4 for compression ignition engines.
3.2.3.5.	Positive ignition engines of vehicles that can run either on petrol or on a gaseous fuel, are to be tested with both fuels, in accordance with the provisions in paragraphs 3.2.3.1. to 3.2.3.3. The vehicles that can be fuelled with both petrol and a gaseous fuel, but where the petrol system is fitted for emergency purposes or starting only and of which the petrol tank cannot contain more than 15 liters of petrol 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 paragraphs 3.2.3.1 to 3.2.3.5.
3.2.4.	Measurements shall be carried out according to the provisions of appendix to chapter 1 of this part.
3.2.5.	The test report shall contain the results and all the calculations required to find the net power, as listed in the appendix to chapter 1 to this part. In order to draw up this document, the competent authority may use the report prepared by an approved or recognized laboratory pursuant to the provisions of this part.

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 to 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 three 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. 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.

	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) 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**	
	("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

6	Fuel injection equipment (petrol 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 Radiator Fan[5,6] Fan & Fan cowl Water pump Thermostat[7]	No Yes[5], standard production equipment
8	Air cooling Cowl Blower[5,6] Temperature regulating device	Yes, standard production 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 Yes, standard production equipment
11	Auxiliary test bench fan	Yes, if necessary
12	Anti-pollution devices[10]	Yes, standard production equipment

	Notes (1a) 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 (293.2 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* system, catalytic convertor, thermal reactor, secondary air supply system and fuel evaporation protecting system. *Exhaust gas recirculation.

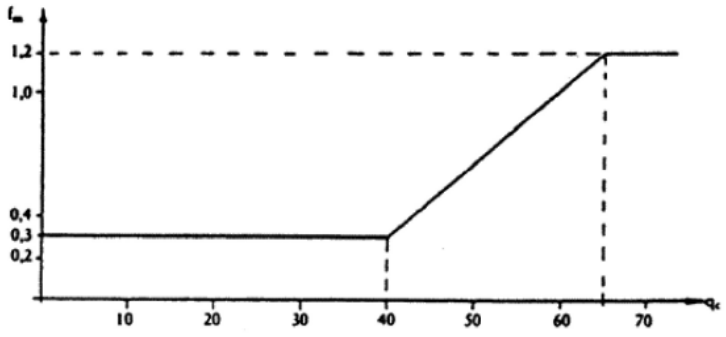
2.3.3.	*Compression-ignition engine starting auxiliaries* For the auxiliaries used in starting compression-ignition engines, the two following cases shall be considered: (a) Electric starting. A generator is fitted and supplies, where necessary, the auxiliaries essential for engine operation; (b) Starting 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.		
	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.		
3.2.	Data to be recorded are those indicated in paragraph 4. of the appendix to 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 para. 3.3. of this chapter) 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 paragraphs 3.7., 3.8. and 3.9. of this chapter.
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. Where $P_o = \alpha P$ 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 ≤ T ≤ 308 K
	For compression-ignition engines	283 K ≤ T ≤ 313 K
5.3.2.	Pressure (P_s) 80 kPa ≤ P_s ≤ 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.	Diesel engines - Factor α_d The power correction factor (α_d) for diesel 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
	(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.	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.

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):
	

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 manufacturer, the correction factor α_a or α_d shall be set to the value 1.

	Results of tests for measuring net engine power*	
	This form shall be completed by the laboratory performing the test.	
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	K
1.2.1.	Of the intake air:	K
1.2.2.	At the outlet of the engine intercooler:	
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 opacity meter	
1.5.1.	Make:	
1.5.2.	Type:	
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.):	
	[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 inapplicable. • The characterstic curves of the net power and the net torque shall be drawn as a function of engine speed.	

2.1.3.1.	Type:					
2.1.3.2.	Content:gdw100					mg/1
2.1.4.	Octane number RON:					(ASTM D 2699-70)
2.1.4.1.	Octane number MON:					
2.1.4.2.	Specific density:					g/cm^3 at 288 K
2.1.4.3.	Lower calorific value:					kJ/kg
	Table 1					
		Engine speed (min^{-1})	*Nominal flow G (litres/second)*	*Limit absorption values (m^{-1})*	*Measured absorption values (m^{-1})*	
	1					
	2					
	3					
	4					
	5					
	6					
	Maximum net power:			kW at		min^{-1}
	Maximum net torque:			Nm at		min^{-1}
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, 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[3]			
Pressure after pressure-charger, kPa[3]			
Pressure after charge air cooler, kPa			

Notes:

[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.

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

	Appendix 2: **Method for measuring net power and the maximum 30 minutes power of electric drive trains**
1.	**These requirements apply for measuring the maximum net power and the maximum 30 minutes power of electric drive trains used for propelling pure electric road vehicles.**
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 paragraphs 2.5.4. and 2.5.5. above.
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: ±2K.

	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 intended to determine maximum torque and maximum net power must be carried out at full throttle, with the engine equipped as specified in Table 1 .
1.2	The measurements must be carried out under normal , stable operating conditions and the air supply to the engine must be adequate. The engine must 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 must be selected as closely as possible to the reference conditions (see 4.2) in order to reduce the correction factor.
1.3.	The temperature of the engine induction air (ambient air) must 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 must be protected against heat radiation and be placed directly in the airstream. It must also be protected against vaporized fuel . An adequate number of positions must be used in order to yield a representative average inlet temperature .
1.4.	No measurement is 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 to the measurements its value must not vary by more than + 2 % .
1.6.	The brake load and the temperature of the induction air must be recorded simultaneously and the value obtained must be the average of the two stabilized records taken in succession, which must not differ by more than 2 % as regards the brake load.
1.7.	Where an automatically triggered device is used to measure rotational speed and consumption the measurement must last for at least 10 s and if the measuring device is manually controlled that period must be at least 20 s.
1.8.	The temperature of the liquid coolant recorded at the engine outlet must 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 must be maintained at + 0/- 20 K of the maximum temperature intended by the manufacturer under the reference conditions .

1.9.	The fuel temperature must be measured at the carburettor or injection system inlet and kept within the limits laid down by the manufacturer.
1.10.	The lubricant temperature, measured in the crankcase or at the oil heat exchanger outlet, where fitted, must lie within the limits laid down by the manufacturer.
1.11	The outlet temperature of the exhaust gases must be measured at right angles to the exhaust flange(s) or manifold(s) or orifices.
1.12	**Test sequence:** The measurements must be carried out at a sufficient number of rotational speeds to enable the power curve to be defined correctly between the lowest and highest speeds recommended by the manufacturer. That range of speeds must include the rotational speed at which the engine delivers its maximum torque and maximum power. The average of at least two stabilized measurements must be determined for each speed.
2.	**Accuracy Of Torque And Power Measurements Under Full Load**
2.1.	Torque: ±2% of torque measured .
2.2.	Rotational speed: the measurement must be accurate to ± 1 % .
2.3.	Fuel consumption ± 2 % for all the devices used .
2.4.	Temperature of engine induction air: + 2K.
2.5.	Barometric pressure: ± 70 Pa .
2.6.	Pressure in the exhaust and under-pressure of the intake air: ± 25 Pa .
	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) must 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.

	Table 1	
Sr. No.	**Accessories**	**Fitted for the torque and net-power test**
1	**Induction system** Induction manifold Air filter Inlet silencer Crankcase emission control system Speed-limiting device	If series-mounted : yes
2	**Exhaust system** Exhaust clean-up system Manifold Pipework ([1]) Silencer ([1]) Exhaust pipe [(1)]	If series-mounted: yes
3	Carburettor	If series-mounted: yes
4	Fuel injection system Upstream filter Filter Pump Pipework Injector Where fitted, air inlet flap ([2]) Regulator (if fitted)	If series-mounted: yes
5	Liquid-cooling equipment Radiator Fan ([4]) ([5]) Water Pump Thermostat ([6])	If series-mounted: yes))([3])
6	Air cooling Cowling Blower ([4]) ([5]) Temperature regulator Auxiliary bench blower	If series-mounted: yes, if necessary
7	Electrical equipment	If series-mounted: yes ([7])
8	Anti-pollution devices	If series-mounted: yes
9	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 must be that which controls the pneumatic inject pump regulator. (3) The radiator, fan, fan nozzle, water pump and thermostat must, on the test	

	bench, occupy the same position relative to each other as if they were on the vehicle. The liquid coolant must 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 thosein the engine cooling system. Where fitted the engine blind must be open. (4) Where a fan or blower may be disengaged the net engine power must first of all be stated with the fan (or blower) disengaged, followed by the net engine power with the fan (or blower) engaged. (5) Where a fixed electrically or mechanically-operated fan cannot be fitted on the test bench the power absorbed by that fan must 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, (6) The thermostat may be locked in the fully-open position. (7) 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.			
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.			
	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.	**POWER AND TORQUE CORRECTION FACTORS:**			
4-1	Definition of factor α1 and α2			
	The factors by which the observed torque and power are to be multiplied in order to determine the engine torque and power under the reference atmospheric conditions specified in 4.2 and the mechanical efficiency of the transmission as specified in 4.5.			
	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)	
	α2	=	the correction factor for the efficiency of the transmission	
	α1	=	the correction factor for reference atmospheric conditions	

4-2	Reference atmospheric conditions		
4.2.1.	Temperature 25 °C (298 K)		
4.2.2.	Dry reference pressure (Pso): 99 kPa (990 mbar)		
4.3.	**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 must be stated and the test conditions (temperature and pressure) specified exactly in the test report.		
	Note: Tests carried out in temperature-controlled rooms where it is possible to vary the atmospheric conditions are permitted.		
4.4.	Determination of the correction factor α1		
	Within the limits defined in 4.3 the correction factor is obtained via the following formula:		
	α1	=	$(99/Ps)^{1.2} * (T/298)^{0.6}$
	where:		
	T	=	the absolute temperature in Kelvins of the engine induction air
	P	=	the total atmospheric pressure, in kilopascals
	PV	=	the water vapour pressure, in kilopascals
	PS	=	P - PV
	This formula applies to the torque and power read-off at the brake without taking account of the mechanical efficiency of the engine.		
4.5	Determination of the correction factor for mechanical efficiency of the transmission α2 Determination of the factor α2 — where the measuring point is the crankshaft output side this factor must be 1 , — where the measuring point is not the output side of the crankshaft this factor is calculated via the formula: α2 1/nt where nt is the efficiency of the transmission located between the crankshaft and measuring point. This transmission efficiency nt is determined via the product (multiplication) of efficiency nj of each of the components of the transmission : nt = n1 x n2 ……. nj Efficiency nj of each of the components of the transmission is shown in the		

<table>
<tr><td></td><td colspan="3">following table :</td></tr>
<tr><td></td><td colspan="2">Type</td><td>Efficiency</td></tr>
<tr><td rowspan="9"></td><td rowspan="3">Gear wheel</td><td>Spur gear</td><td>0.98</td></tr>
<tr><td>Helical gear</td><td>0.97</td></tr>
<tr><td>Bevel gear</td><td>0.96</td></tr>
<tr><td rowspan="2">Chain</td><td>Roller</td><td>0.95</td></tr>
<tr><td>Silent</td><td>0,98</td></tr>
<tr><td rowspan="2">Belt</td><td>Cogged</td><td>0.95</td></tr>
<tr><td>Vee</td><td>0.94</td></tr>
<tr><td rowspan="2">Hydraulic coupling or convector</td><td>Hydraulic coupling ([1])</td><td>0.92</td></tr>
<tr><td>Hydraulic convertor ([1])</td><td>0.92</td></tr>
<tr><td colspan="3">([1]) If not locked up.</td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td>5.</td><td colspan="3">Maximum Torque and Maximum Net Power Measurement Tolerances</td></tr>
<tr><td>5.1.</td><td colspan="3">The maximum torque and the maximum net power of the engine as determined by the test agency may differ by ± 10% of the value specified by the manufacturer if the power measured is ≤1 kW and ± 5% if the power measured is > 1 kW, with a 3% tolerance for the engine speed.</td></tr>
</table>

	Appendix 4: **Method for measuring maximum torque and maximum net power for motorcycles and Three wheeler fitted with spark ignition engine.**
1.	**Test conditions.**
1.1.	The maximum-torque and net-power tests must be conducted at full throttle, the engine being equipped as specified in Table 1 of this appendix.
1.2.	The measurements must be carried out under normal, stabilized operating conditions with an adequate fresh-air supply to the engine. The engine must 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 must be selected as near to reference conditions (see 4.2) as possible in order to minimize the magnitude of the correction factor.
	The minimum conditions which must be fulfilled by the test installation and the scope for conducting the tests in accordance with paragraph 6 are defined below:
	V1 is the maximum speed of the vehicle; V2 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 V2 ≥ V1 and Ø > 0,25 m^2 the minimum conditions are fulfilled. If it is not possible to stabilize the operating conditions the method described in paragraph 6 applies. If V2 < V1 and/or Ø < 0,25 m^2:
	(a) if it is possible to stabilize the operating conditions the method described in (1.test conditions) is applied; (b) if it is not possible to stabilize the operating conditions: (i) if V2 ≥ 120 km/h and Ø ≥ 0,25 m2, the installation fulfils the minimum conditions and the method described in paragraph 6 may be applied; (ii) if V2 < 120 km/h and/or Ø < 0,25 m2, the installation does not fulfil the minimum conditions and the test equipment cooling system must be improved. However, in this case, the test may be carried out by means of the method described in paragraph 6, subject to approval by the manufacturer and the administration.

1.3.	The temperature of the (ambient) inlet air to the engine must 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 must be shielded from radiant heat and be placed directly in the airstream. 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.	No data must be taken until torque, speed and temperature have remained substantially constant for at least 30 s .
1.5.	The engine speed during a run or measurement must not vary by more than + /- 1 % .
1.6.	Brake load and inlet-air temperature readings must be taken simultaneously; the reading adopted for measurement purposes is the average of two stabilized successive values differing by less than 2% for brake load.
1.7.	The temperature of the coolant at the outlet from the engine must 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 must be 353 K ± 5 K. For air-cooled engines, the temperature at a point indicated by the manufacturer must be kept between + 0/- 20 K of the maximum temperature specified by the manufacturer under the reference conditions.
1.8	The fuel temperature must be measured at the inlet of the carburettor or injection system and be maintained within the limits set by the manufacturer.
1.9.	The lubricant temperature, measured in the crankcase or at the oil heat exchanger outlet, where fitted, must lie within the limits set by the manufacturer.
1.10	The outlet temperature of the exhaust gases must 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 must last for at least 10 s; if the measuring device is manually controlled it must measure for at least 20 s .
1.12 .	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 must 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.

1.13.	**Tests** The tests must be tested at a sufficient number of rotational speeds to enable the power curve to be defined correctly between the lowest and highest speeds recommended by the manufacturer. That range of speeds must include the rotational speed at which the engine delivers its maximum power. The average for each speed is determined by means of at least two stabilized measurements.
2.	**Accuracy of The Measurements Of Power And Torque At Full Load**
2.1	Torque: ± 1 % of the torque measured (1).
2.2.	Rotational speed: The measurement must be accurate to +/- 1 % .
2.3.	Fuel consumption: ± 1 % overall for the apparatus used.
2.4.	Engine inlet air temperature: ± 1 K
2.5	Barometric pressure: ±70 Pa
2.6.	Exhaust pressure and drop in intake air: ± 25 Pa
	([1]) The torque measuring device must 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 Chapter 10) must 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, must 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	
Sr. No.	**Accessories**	**Fitted for the torque and net-power test**
1	**Induction system** Induction manifold Air filter Inlet silencer Crankcase emission control system Speed-limiting device Electrical control device (where fitted)	If series-mounted : yes
2	**Induction Manifold heater**	If series-mounted: yes(if possible, it must be set in the most favourable position)
3	**Exhaust system** Exhaust clean-up system Manifold Pipework ([1]) Silencer ([1]) Exhaust pipe [(1)] Supercharger Electrical control device	If series-mounted: yes
4	Fuel supply pump	If series-mounted: yes
5	Carburettor	If series-mounted: yes
6	Fuel injection system Upstream filter Filter Pump Pipework Injector Where fitted, air inlet flap ([2]) Regulator (if fitted)	If series-mounted: yes
7	Liquid-cooling equipment Engine Bonnet Radiator Fan ([4]) ([5]) Fan Cowl Water Pump Thermostat ([6])	If series-mounted: yes))([3])
8	Air cooling Cowl Blower ([4]) ([5]) Temperature regulator Auxiliary bench blower	If series-mounted: yes, if necessary
9	Electrical equipment	If series-mounted: yes ([7])
10	Supercharging equipment(where fitted) -Compressor driven directly by the engine	If series-mounted: yes

	and/or by exhaust gases -Intercooler -Coolant pump or Fan(Engine driven) -Coolant Flow control device(where fitted)	
11	Oil Cooler(Where fitted)	If series-mounted: yes
12	Anti-pollution devices	If series-mounted: yes
13	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 must be that which controls the pneumatic inject pump regulator.	
	3. The radiator, fan, fan nozzle, water pump and thermostat must, on the test bench, occupy the same position relative to each other as if they were on the vehicle. The liquid coolant must 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 thosein the engine cooling system. Where fitted the engine blind must be open.	
	4. Where a fan or blower may be disengaged the net engine power must first of all be stated with the fan (or blower) disengaged, followed by the net engine power with the fan (or blower) engaged.	
	5. Where a fixed electrically or mechanically-operated fan cannot be fitted on the test bench the power absorbed by that fan must 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, 6. The thermostat may be locked in the fully-open position.	
	7. 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.	
3.2	**Setting conditions** The setting conditions for the test to determine maximum torque and maximum net power are set (as mentioned in Table 2 of Appendix 3)	

4.	**POWER AND TORQUE CORRECTION FACTORS:**		
4.1.	Definition of factors α1 and α2 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 α2) that are possibly used during the tests in order to bring that torque and that power within the reference atmospheric conditions specified in 4.2.1 (factor α1).		
	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)
	α2	=	the correction factor for the efficiency of the transmission
	α1	=	the correction factor for reference atmospheric conditions
	P	=	the power measured (power observed)
4.2.	Atmospheric conditions		
4.2.1.	Reference atmospheric conditions		
4.2.1.1.	Reference temperature (T_0)		
	298 K (25 °C).		
4.2.1.2.	Dry reference pressure (P so) 99 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 < 318 K		
4.3.	Determination of the correction factors		
4.3.1.	Determination of the factor α_2		
	- Where the measuring point is the crankshaft output side this factor is equal to 1. - Where the measuring point is not the output side of the crankshaft this factor is calculated via the formula : $\alpha_2 = 1/n_t$		
	where nt is the efficiency of the transmission located between the crankshaft and measuring point.		

	This transmission efficiency nt is determined via the product (multiplication) of efficiency of each of the components of the transmission: $n_t = n_1 \times n_2 \times ... \times n_j$		
	Efficiency nj of each of the components of the transmission is shown in the following table :		
	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.		
4.3.2.	Determination of factor α1 ([1])		
4.3.2.1 .	Definition of physical magnitudes T, Ps for correction factors α_1		
	T	=	the absolute temperature of the ingested air
	Ps	=	the dry atmospheric pressure in kilopascals (kPa) i.e. the total barometric pressure minus the steam pressure.
4.2.2.2.	Factor α_1 Correction factor is obtained from the following $\alpha_1 = (99/Ps)^{1.2} * (T/298)^{0.6}$ That formula only applies if: $0,93 \leq \alpha_1 , \leq 1,07$. If the limit values are exceeded the corrected value obtained must be stated and the test conditions (temperature and pressure) stated exactly in the test report.		

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, may differ from the values specified by the manufacturer, by ± 5 % if the power measured is ≤ 11 kW and ± 2% if the power measured is > 11 kW with a 1,5% tolerance for the engine speed.

	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 to be carried out either on an engine or on a vehicle. This appendix is applicable for emission of visible exhaust pollution 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 Appendix 1. 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.

	Limit values Applicable in the test at steady speed			
	Nominal Flow	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 opacity meter satisfying the conditions of installation of opacity meter mentioned in Appendix 8.			
4	**Evaluation of the Absorption Coefficient:**			
4.1	For each of the six engine speeds at which the absorption coefficient is measured pursuant to Paragraph 2.2 above, the nominal gas flow shall be calculated by mean of the following formulae:			
	for two-stroke engines $G = V * n/60$ for four-stroke engines $G = V * n/120$ where –			
	(l/s)	G	nominal gas flow, in liters per second,	
	(l)	V	cylinder capacity of the engine, in liters,	
	(rpm),	n	engine speed, in revolutions per minute	
4.2	Where the value of the nominal flow is not one of those given in the fig.1 above. the limit value applicable shall be obtained by interpolation on the principle of proportional parts.			

	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 pollution under free acceleration from C.I. engines which are intended for fitting to vehicles of categories L, M and N. 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 temperature stated by the manufacturer. 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.. 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 paragraph 3 below 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.
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. As soon as this speed is reached the accelerator shall be released until the engine resumes its idling speed and the opacity meter reverts to the corresponding conditions.
3.3.1	The sequence mentioned in para 3 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 Para 3.3.1 above 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 four readings or within a band width of 0.25K whichever is higher and do not form a decreasing sequence. The absorption coefficient XM to be recorded shall be the arithmetical mean of these four 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 $0.15\ m^{-1}$.

5.	**Extension Criteria:** The approval may be extended without carrying out any type test for the following conditions ;
5.1	Maximum rated speed not greater than 100% nor less than 75% of that of the engine in the type approval test;
5.2	Minimum rated speed not less than that of the engine in the type approval test;
5.3	Rated torque not greater than 100%, nor less than 70% of that of the engine at the speed in the type approval test;
5.4	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 5.2.4 of this Chapter.
5.5	Exhaust back pressure not greater than that of the engine in the type approval test;
5.6	Exhaust system volume does not differ by more than 40%;
5.7	Intake depression not greater than that of the engine in the type approval test;
5.8	Moment of inertia of a new combined fly wheel and transmission is within ± 15% of the fly wheel and transmission system approved.

	Appendix 7: **SMOKE METERS AND THEIR INSTALLATIONS**
1	**Scope :** This appendix covers the requirements of smoke meters and their installation on engines for full load and free acceleration tests, mentioned in Appendix 5 and appendix 6 .
2.	**Technical Specifications of Opacity meters**
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 opacity meter 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.
2.1.4	The design shall be such that under steady-speed operating conditions the smoke chamber is filled with smoke of uniform opacity.
2.2	Construction specifications
2.2.1	Smoke chamber and opacity meter 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.
2.2.2.	**Measuring Scales**
2.2.4.1	The light-absorption coefficient k shall be calculated by the formula $F = Fo.e^{(-k*L)}$ 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 opacity meter cannot be assessed directly from its geometry, the effective length L shall be determined - - Either by the method described in paragraph 2.7 of this Chapter or - through correlation with another type of opacity meter 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 opacity meter 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 paragraph 2.2.4.1 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 opacity meter indicating dial when the screen is introduced between the source of light and the photoelectric cell.

2.4	**Opacity meter 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 opacity meter 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 opacity meters 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 opacity meter 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 deg. C and a maximum temperature specified by the opacity meter 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 opacity meter shall be equipped with appropriate devices for measuring the temperature in the smoke chamber.
2.7	**Effective Length "L" of the Opacity meter**
2.7.1	In some types of opacity meters, 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 opacity meter.

2.7.2	The effective length of the light path is obtained by comparing the reading N of the opacity meter operating normally with the reading N obtained with the opacity meter 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 opacity meter, 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 opacity meter.
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 paragraph 2.7.2.
2.7.4.6	The opacity meter readings shall be recorded continuously during the test with a recorder whose response time is equal to or shorter than that of the opacity meter.
2.7.4.7	With opacity meter 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 opacity meter will be the arithmetic average of the effective lengths obtained as stated in paragraph 2.7.4.9 for each of the gases.
3	**Installation of the Opacity meter :**
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 Opacity meter**
3.2.1	Installation for full load tests
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 opacity meter shall be as short as possible while satisfying the pressure and temperature requirements prescribed. The pipe shall be inclined upwards from the sampling point to the opacity meter, and sharp bends where soot might accumulate shall be avoided. If not embodied in the opacity meter, 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 para 2.5, concerning pressure and those of para 2.6 concerning temperature in the measuring chamber are observed.
3.2.3	The only general precautions to be observed in steady-speed and free acceleration tests are the following :
3.2.3.1	Joints in the connecting pipes, if any, between the exhaust pipe and the opacity meter shall not allow air to enter from outside.
3.2.3.2	The pipes connecting with opacity meter shall be as short as possible, as prescribed in the case of sampling opacity meters. The pipe system shall be inclined upwards from the exhaust pipe to the opacity meter, and sharp bends where soot might accumulate shall be avoided. A by-pass valve may be provided upstream of the opacity meter to isolate it from the exhaust gas flow when no measurement is being made.
3.2.3.3	A cooling system may also be required upstream of the opacity meter.
4	Any other method/equipment may be approved, if it is found that they yield equivalent results.

	CHAPTER 2:
	Technical Specification of engine. As per AIS: 007

	CHAPTER 3 :
	Essential characteristics of the electric drive train and information concerning the conduct of tests: As per AIS: 007

	CHAPTER 4:
	Reference fuels The reference fuel shall be as per CMVR notification

	CHAPTER 5
	Checks on conformity of production for M and N Category of vehicles Category of vehicles.
	Checks on conformity of production for M and N Category of vehicles having GVW more than 3.5T 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 shall comply with those set out in the chapter with the following requirements: A) Engine approved under this chapter 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 paragraph . 4 below, 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 paragraph 2 above, fulfills the requirement of paragraph 4 above,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 paragraph 3. do not fulfils the requirements of paragraph 4. above, the production shall be considered not to conform to the requirements of this Chapter.
	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
1.1	For verifying the conformity of production in the case of a vehicle with a naturally aspirated/supercharged (turbocharged) compression ignition engine of L, M & N, the vehicle selected at random from the series production should be subjected to the free acceleration test described in Appendix 7 above 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.
1.2	If it does not, another 10 engines/vehicles shall be taken from the series at random and shall be tested as per Appendix 1 of this Part. At least 9 engines/vehicles should meet the limit values specified in para 5.4 above.
	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 6 above of this Part. If both the samples meet the requirements of para 4 above the series is deemed to conform.

ANNEX 1
(See Introduction)

COMPOSITION OF COMMITTEE FOR PART 6*

(To be included)

ANNEX 2
(See Introduction)

COMMITTEE COMPOSITION *

Automotive Industry Standards Committee

(To be included)