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भारतीय मानक मसौदा

स्वचल वाहन – धनात्मक एवं संपीड़न प्रज्वलन इंजनों की कार्यकारिता अपेक्षाएँ (पावर, एसएफसी अपारदर्शिता का मापन) – परीक्षण पद्धति

(पहला पुनरीक्षण)

Draft Indian Standard

AUTOMOTIVE VEHICLES — PERFORMANCE REQUIREMENTS (MEASUREMENT OF POWER, SFC, OPACITY) OF POSITIVE AND COMPRESSION IGNITION ENGINES — METHOD OF TEST

(First Revision)

ICS 43.060.01; 19.020

Last date for receipt of comments is XX/XX/XXXX

Automotive Prime Movers, Transmission System and Internal Combustion Engine Sectional Committee, TED 2

FOREWORD

This Indian Standard will be adopted by the Bureau of Indian Standards, after the draft is finalized by the Automotive Prime Movers, Transmission System and Internal Combustion Engine Sectional Committee and is approved by the Transport Engineering Division Council.

This Indian Standard was first published in 1999. This first revision of the Indian Standard was undertaken to incorporate updated testing methods and to harmonize the Indian Standard with the [AIS 137 (Part 5)] as stipulated in *Central Motor Vehicles Rules,* 1989.

This standard has been divided in following sections:

a) Section 1: Method for measuring internal combustion engines (Positive ignition and Compression ignition) net power for M & N Category of vehicles and L category vehicles fitted with compression ignition engines;

b) Section 2: Method for measuring of maximum torque and maximum net power for mopeds fitted with spark ignition engine;

c) Section 3: Method for measuring of maximum torque and maximum power for motorcycle and three wheeler fitted with spark ignition engine;

d) Section 4: Method for measuring emission of visible pollutants at steady speeds over the full load of compression ignition engines;

e) Section 5: Method for test under free acceleration;

f) Section 6: Smoke meter and their installation; and

g) Section 7: Calculation of specific fuel consumption.

In the revision of this standard, considerable assistance has been taken from AIS 137 (Part 5):2019 ‘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’.

Annex A forms normative part of this standard. The procedure of extension of criterion, as given in AIS 137 (Part 5): 2019, has been included as Annex B which is for information only.

The composition of the technical committee responsible for the formulation of this standard is given in Annex C.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off it shall be done in accordance with IS 2: 2022 ‘Rules for rounding off numerical values (*Second Revision*)’.

Draft Indian Standard

AUTOMOTIVE VEHICLES — PERFORMANCE REQUIREMENTS (MEASUREMENT OF POWER, SFC, OPACITY) OF POSITIVE AND COMPRESSION IGNITION ENGINES — METHOD OF TEST

1 SCOPE

1.1 This standard specifies the method of measuring net power of internal combustion engines intended for the propulsion of motor vehicles for L, M and N categories of vehicles as defined in IS 14272.

1.2 This standard also covers the calculation of specific fuel consumption and opacity (smoke) of the exhaust gas of compression ignition engines.

2 REFERENCES

The following standards given below contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards:

IS No.	*Title*
8118 : 1998	Automotive vehicles — Opacity (smoke) of exhaust gas from in-service vehicles equipped with compression ignition engines operating under free acceleration - Method of measurement (second revision)
14272 : 2011	Automotive Vehicles – Types Terminology
14553 : 1998	Automotive vehicles — Apparatus for the measurement of opacity (smoke) of exhaust gas from vehicles equipped with compression ignition engines - Specification

3 TERMINOLOGY

For the purposes of this standard, the following definitions shall apply:

3.1 Air Intake Temperature — The temperature, expressed in kelvin (K), measured within 150 mm of the air filter.

3.2 Approval of a Drive Train — The approval of a drive train type with regard to its net power measured in accordance with the procedure specified in the standard.

3.3 Cold Start Device — A device which enriches the fuel-air mixture of the engine temporarily and thus assist in engine start up.

3.4 Compression Ignition Engine — An internal combustion engine in which ignition occurs by the temperature of the cylinder contents resulting solely from their compression.

3.5 Coolant Temperature — Temperature(s) at given point(s) such as after the thermostat or of the fluid cooling system(s) expressed in kelvin (K).

3.6 Dedicated Dual - Fuel Engine — An engine system that is designed to simultaneously operate with diesel fuel and a gaseous fuel only, both fuels being metered separately, where the consumed amount of one of the fuels relative to the other one may vary depending on the operation. The operation of the engine in diesel only mode will be restricted by reduced power output to cater limp home mode.

3.7 Diesel Mode — The normal operating mode of a dual-fuel engine during which the engine does not use any gaseous fuel for any engine operating condition.

3.8 Drive Train Type — A category of an internal combustion engine for installation in a motor vehicle which does not differ in such essential characteristics as those defined in **Annex B**.

3.9 Dual - Fuel Engine — An engine system 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.

3.10 Dual - Fuel Mode — 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.

3.11 Dual - Fuel Vehicle — 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.

3.12 Engine Speed — The number of revolutions of crankshaft in a given period of time.

3.13 Engine Torque — 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 and determined under reference atmospheric conditions. It is expressed in N.m.

3.14 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. It is expressed in kPa.

3.15 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).

3.16 Fuel Temperature — 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.

In case of compression ignition engines, the fuel temperature 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 representing the engine operating condition.

3.17 Idle Speed — 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.

3.18 Intake Air Depression — The mean pressure head below atmospheric (suction) pressure existing in the intake manifold with an air cleaner fitted. It is expressed in kPa.

3.19 Light Absorption Coefficient — The percentage of light absorption in one meter length of measurement tube of the smoke meter.

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

3.21 Lubricating Oil Temperature — Oil temperature(s) at given point(s) of the lubricating system(s) expressed in kelvin (K).

3.22 Maximum Net Power — The maximum value of the net power measured at full engine load.

3.23 Maximum Rated Speed — The maximum speed permitted by governor at full load, unless otherwise declared by the manufacturer.

3.24 Minimum Rated Speed — The highest of the either of the following three engine speeds:

a) 45 percent of maximum net power speed for L, M, N, or
b) 55 percent of maximum power speed for A & C Category of vehicles, or
c) 1 000 rev/min, or
d) Minimum speed permitted by the idling control, or
e) Such lower speed as the manufacturer may specify.

3.25 Net Power — The power obtained on a test bench at the end of the crankshaft or its equivalent (if power measurement can be carried out on an engine with the gear box mounted, the efficiency of the gear-box shall be taken into account) at the corresponding engine speed with the auxiliaries listed and determined under reference atmospheric condition. It is expressed in kW.

3.26 Opacity Meter — An instrument for continuous measurement of the light absorption

coefficient of the exhaust gases emitted by automotive vehicles.

3.27 Positive Ignition Engine — 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.

3.28 Rated Net Power — Engine net power as declared by the manufacturer at rated speed.

3.29 Smoke Density — The light absorption coefficient of the exhaust gases emitted by the vehicle expressed in terms of m^{-1} or in other units such as Hartridge, percent opacity.

3.30 Standard-Production Equipment — Equipment provided by the manufacturer for a particular application.

3.31 Starting Aid — A device which assists the engine start up without enrichment of the fuel mixture such as glow plug, change of injection timing.

3.32 Specific Fuel Consumption — The quantity of fuel consumed by the engine. It is expressed in g/kWh.

SECTION 1 METHOD FOR MEASURING INTERNAL COMBUSTION ENGINES NET POWER FOR M & N CATEGORY OF VEHICLES AND L CATEGORY VEHICLES FITTED WITH COMPRESSION IGNITION ENGINES

4.1 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 requirements.

4.2 Description of Tests for Internal Combustion Engines

4.2.1 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.

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 on the diesel mode of that same engine.

4.2.2 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 declared by the manufacturer. This range of speed shall include the speed of revolution at which the engine produces its rated net power, maximum power and its

maximum torque as declared by the manufacturer. For each speed, the average of at least two stabilized measurements are to be determined.

4.3 The Fuel

4.3.1 *Positive Ignition Engines Fuelled with Petrol*

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

4.3.2 *Positive Ignition Engines and Dual-Fuel Engines Fuelled with LPG*

4.3.2.1 *Engine with self-adaptive fueling*

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

4.3.2.2 *Engine without self-adaptive fueling*

The test fuel shall be the reference fuel as specified in gazette notification with the lowest C3-content.

4.3.2.3 *Engine labelled for one specific fuel composition*

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

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

4.3.3 *Positive Ignition Engines and Dual-Fuel Engines Fuelled with Natural Gas*

4.3.3.1 *Engine with self-adaptive fueling*

The test fuel shall be the reference fuel as specified in gazette notification. A Commercial available fuel may be used.

4.3.3.2 *Engine without self-adaptive fueling*

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

4.3.3.3 *Engine labelled for one specific fuel composition*

The fuel used shall be the one available on the market with a Wobbe index of 52.6 MJm^{-3} (4°C, 101.3 kPa) *Min* if the engine is labelled for the H-range of gases, or 47.2 MJm^{-3} (4 °C, 101.3 kPa) *Min* if the engine is labelled for the L-range of gases.

In case of dispute the fuel used shall be the reference fuel G20 specified in gazette notification if

the engine is labelled for the H-range of gases, or the reference fuel G23 if the engine is labelled for the L-range of gases, that is the fuel with the highest Wobbe Index for the relevant range.

4.3.3.4 *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 gazette notification if the engine is labelled LNG 20.

4.3.3.5 *Engine labelled for one specific fuel composition*

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

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

4.3.4 *Compression Ignition Engines and Dual-Fuel Engines*

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

4.3.5 Vehicles fitted with positive ignition engines that can run either on petrol or on a gaseous fuel, are to be tested with both fuels, in accordance with **4.3.1** to **4.3.3**. The vehicles that can be fuelled with both petrol and a gaseous fuel, but where the petrol system is fitted for emergency or starting purpose only and the petrol tank cannot contain more than 15 liters of petrol will be regarded for the test as vehicles that can only run on gaseous fuel.

4.3.6 Dual-fuel engines or vehicles that have a diesel mode are to be tested with the fuels appropriate to each mode, in accordance with **4.3.1** to **4.3.4**.

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

5 TEST CONDITIONS

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

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

5.3 Accessories

5.3.1 *Accessories to be Fitted*

During the test, the accessories necessary for the operation of the engine (*see* Table 1) shall be installed on the test bench as far as possible in the same position as in the intended application.

5.3.2 *Accessories to be Removed*

Accessories mounted on the engine necessary for operation of the vehicle shall be removed for the test. A non-exhaustive list is given below as a sample:

a) Air compressor for brakes
b) Power steering compressor
c) Suspension compressor
d) 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
(*Clause* 5.3.1)

Sl No.	Auxiliaries	Fitted for Net Power Test
(1)	(2)	(3)
i)	Intake system	
	Intake manifold	Yes: Standard-production equipment.
	Crankcase emission control system	
	Air filter	Yes: Standard-production equipment.[1a)]
	Intake silencer	
	Speed limiting device	Yes: Standard-production equipment.
ii)	Induction heating device of intake manifold	Yes, standard production equipment. If possible, to be set in the most favourable position.
iii)	Exhaust system	
	Exhaust purifier	Yes: Standard-production equipment.
	Exhaust manifold	
	Supercharging device	
	Connecting pipes[lb]	
	Silencer[lb)]	
	Tail pipe[lb)]	
	Exhaust brake[2)]	
iv)	Fuel supply pump[3)]	Yes, standard production equipment.
v)	Carburettor	
	Electronic control system, air flow meter, etc..(if fitted)	Yes, standard production equipment.
	Pressure reducer	Equipment for gas engines.
	Evaporator	
	Mixer	
vi)	Fuel injection equipment (petrol and diesel)	

Prefilter	
Filter	
Pump	
High pressure pipe	
Injector	
Air intake valve4, if fitted	Yes, standard production equipment.
Electronic control system air, flow meter, etc... if fitted	
Governor/control system.	
Automatic full-load stop for the control	

	rack depending on atmospheric conditions	
vii)	Liquid-cooling	
	Engine bonnet	No
	Bonnet air outlet	No
	Radiator Fan[5), 6)]	Yes[5)], standard production equipment.
	Fan and Fan cowl	
	Water Pump	
	Thermostat[7)]	
viii)	Air cooling	
	Cowl	Yes, standard production equipment.
	Blower[5), 6)]	
	Temperature regulating device	
ix)	Electrical equipment	Yes[8)], standard production equipment.
x)	Supercharging equipment (if fitted)	
	Compressor driven either directly by the engine, and/or by the exhaust gases	Yes, standard production equipment.
	Charge air cooler[9)]	
	Coolant pump or fan (engine driven) (if fitted)	
xi)	Auxiliary test bench fan	Yes, if necessary.
xii)	Anti-pollution devices[10]	Yes, standard production equipment.

NOTES — Standard production equipment means equipment provided by the manufacturer for a particular application.

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

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

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

iii) 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:

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

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

iii) 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] 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 shall be used.

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

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

5.3.3 *Compression-Ignition Engine Starting Auxiliaries*

The two following cases shall be considered for the auxiliaries used for starting compression-ignition engines:

a) *Electric start*

A generator is fitted and supplies, where necessary, the auxiliaries essential for engine operation;

b) *Other than electric start*

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.

5.4 Setting Conditions

The setting conditions for the test to determine the net power are indicated in Table 2.

Table 2 Setting Conditions
(*Clause* 5.4)

Sl. No (1)	(2)	(3)
1	Setting of carburetor (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	

6 DATA TO BE RECORDED

6.1 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 equipped as specified in Table 1.

6.2 Data to be recorded are those indicated in Annex A. 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 as possible in order to minimize the magnitude of the correction factor.

6.3 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.

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

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

6.6 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 percent for the brake load and fuel consumption.

6.7 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 ± 5 K. For air-cooled engines, the temperature at a point indicated by the manufacturer shall be kept within $\pm^{0}_{20}$ K of the *Max* value declared by the manufacturer in the reference conditions.

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

6.9 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 declared by the manufacturer.

6.10 An auxiliary regulating system may be used if necessary to maintain the temperature within the limits specified in **6.7, 6.8** and **6.9.**

7 ACCURACY OF MEASUREMENTS

7.1 The accuracy of measurement of various parameters shall be as given blow:

i) Torque	: ± 1 percent of measured torque
ii) Engine speed	: within ± 0.5 percent
iii) Fuel consumption	: ± 1 percent of measured consumption
iv) Fuel temperature	: ± 2 K
v) Engine inlet air temperature	: ± 1 K
vi) Barometric pressure	: ± 100 Pa
vii) Pressure in intake-duct	: ± 50 Pa
viii) Pressure in exhaust duct	: ± 200 Pa

7.2 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 should be ±2 percent of measured torque.

7.3 Engine speed shall be measured preferably with an automatically synchronized revolution counter and chronometer (or counter-timer).

8 POWER CORRECTION FACTORS

8.1 The power correction factor is the coefficient to determine the engine power under the reference atmospheric conditions specified in **8.2**.

$$P_o = \alpha P$$

where

P_o = Corrected power, in kW (power under reference atmospheric conditions);

α = Correction factor (α_a or α_d); and

P = measured power, in kW (test power).

8.2 Reference Conditions

The reference conditions to be used for calculating corrected power shall be as follows:

a) Temperature (T_o) : 298 K (25°C); and
b) 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.

8.3 Test Conditions

The atmospheric conditions during the test shall be as follows:

8.3.1 *Temperature* (T)

a) For positive-ignition engines : 288 K ≤ T ≤ 308 K; and
b) For compression-ignition engines : 283 K ≤ T ≤ 313 K

8.3.2 *Pressure* (P_s) : 80 kPa ≤ P_s ≤ 110 kPa

8.4 Determination of Correction Factor

8.4.1 *Correction Factor for Naturally Aspirated or Pressure-Charged Positive-Ignition Engine*

The correction factor (α_a) is obtained by applying the formula:

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

$$P_s = P - P_v$$

where

α_a = correction factor naturally aspirated or pressure-charged positive-ignition engine;

P_s = dry atmospheric pressure, in kPa;

T = temperature of the air drawn in by the engine, in kelvin (K);

P = total barometric pressure, in kPa; and

P_v = water vapour pressure.

For a test to be valid, the value of correction factor (α_a) shall lie between 0.93 and 1.07 (both values inclusive). If these limits are exceeded, the corrected value obtained shall be given and precise test conditions (temperature and pressure) shall be stated in the test report.

8.4.2 *Correction Factor for Diesel Engine*

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

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

where

α_d = correction factor for diesel engine;

f_a = atmospheric factor; and

f_m = characteristic parameter for each type of engine and adjustment.

NOTE — The test may be carried out in air-conditioned test room where the atmospheric conditions may be controlled.

8.4.2.1 *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.

8.4.2.1.1 *Naturally aspirated and mechanically supercharged engines*

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

where

f_a = atmospheric factor;

P_s = dry atmospheric pressure, in kPa; and

T = temperature of the air drawn in by the engine, in kelvin (K).

8.4.2.1.2 *Turbocharged engines with or without cooling of inlet air*

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

where

f_a = atmospheric factor;

P_s = dry atmospheric pressure, in kPa; and

T = temperature of the air drawn in by the engine, in kelvin (K).

8.4.2.2 *Engine factor* (f_m)

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

$$f_m = 0.036\ q_c - 1.14$$

$$q_c = q\ /r$$

where

f_m = Engine factor;

q_c = fuel flow corrected, in milligram per cycle per litre of total swept volume [mg/(l.cycle)];

q = fuel flow, in milligram per cycle per litre of total swept volume [mg/(l.cycle)];and

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

The formula is valid if the value of fuel flow corrected lies between 40 mg/ (l.cycle) and 65 mg/ (l.cycle). For fuel flow corrected values lower than 40 mg/ (l.cycle), engine factor will be taken as 0.3 (f_m = 0.3). For fuel flow corrected values higher than 65 mg/ (l.cycle), engine factor will be taken as 1.2 (f_m = 1.2) (*see* Fig. 1)

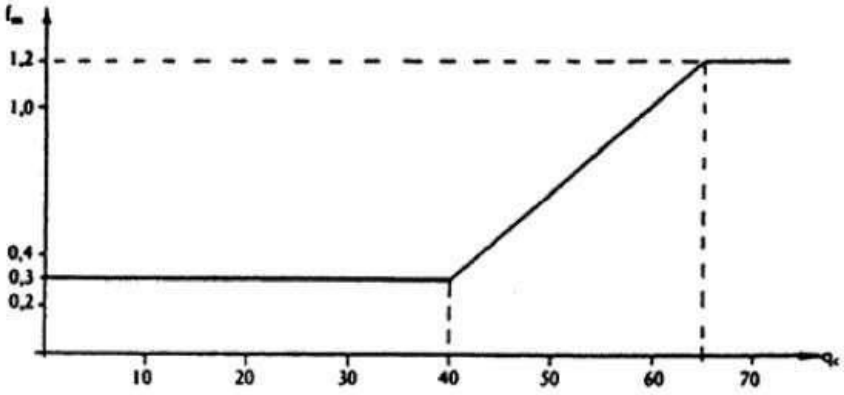

FIG. 1 Engine Factor as a Function of Corrected Fuel Delivery

8.4.2.3 For a test to be valid, the value of correction factor (α_d) shall be $0.90 \leq \alpha_d \leq 1.1$. If these limits are exceeded, the corrected value obtained shall be given and precise test conditions (temperature and pressure) stated in the test report.

8.4.3 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).

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

9 INTERPRETATION OF RESULTS

The net power indicated by the manufacturer for the type of drive train shall be accepted if it does not differ by more than ± 2 percent for maximum power and more than ± 4 percent at the other measurement points on the curve with a tolerance of ± 2 percent for engine speed, or within the engine speed range (X_1 min^{-1} + 2 percent) to (X_2 min^{-1} − 2 percent) from the values measured 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.

SECTION 2 METHOD FOR MEASURING THE MAXIMUM TORQUE AND MAXIMUM NET POWER FOR MOPEDS FITTED WITH SPARK IGNITION ENGINE

10 TEST CONDITIONS

10.1 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 3.

10.2 The measurements shall be carried out under normal, stable operating conditions and the air supply to the engine shall be adequate. The engine shall have been run in under the conditions recommended by the manufacturer. The combustion chambers may contain deposits, but in limited quantities. The test conditions such as the temperature of the induction air shall be selected as closely as possible to the reference conditions (*see* **13.2**) in order to reduce the correction factor.

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

10.4 No measurement is taken until the torque, rate of rotation and temperatures have remained substantially constant for at least 30 s.

10.5 Once a rate of rotation has been selected to the measurements, its value shall not vary by more than ± 2 percent.

10.6 The brake load and the temperature of the induction air shall be recorded simultaneously and the value obtained shall be the average of the two stabilized records taken in succession, which shall not differ by more than 2 percent as regards the brake load.

10.7 Where an automatically triggered device is used to measure rotational speed and consumption the measurement shall last for 10s *Min.* and if the measuring device is manually controlled that period shall be 20s *Min*.

10.8 The temperature of the liquid coolant recorded at the engine outlet must be maintained at ± 5 K of the upper thermostat setting temperature declared by the manufacturer. If the manufacturer does not declare any values the temperature shall be 353 K ± 5 K. In the case of air-cooled engines the temperature at a point specified by the manufacturer shall be maintained at $^{+0}_{-20}$ K of the *Max* temperature declared by the manufacturer under the reference conditions.

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

10.10 The lubricant temperature, measured in the crankcase or at the oil heat exchanger outlet, where fitted, shall lie within the limits declared by the manufacturer.

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

10.12 Test Sequence

The measurements shall 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 shall include the rotational speed at which the engine delivers its *Max* torque and *Max* power. The average of at least two stabilized measurements shall be determined for each speed.

11 ACCURACY OF TORQUE AND POWER MEASUREMENTS UNDER FULL LOAD

The accuracy of measurement of various parameters shall be as given below:

a) Torque	: ± 2 percent of measured torque
b) Rotational speed	: ± 1 percent
c) Fuel consumption	: ± 2 per cent for all the devices used
d) Temperature of engine induction air	: + 2 K
e) Barometric pressure	: ± 70 Pa
f) Pressure in exhaust and under-pressure of the intake air	: ± 25 Pa

12 TEST FOR THE MEASUREMENT OF MAXIMUM TORQUE AND MAXIMUM NET ENGINE POWER

12.1 Accessories

12.1.1 *Accessories to be Fitted*

During the test the accessories needed for operation of the engine in the application under consideration (*see* Table 3) shall be located on the test bench as far as possible in the position they would occupy for the application under consideration.

12.1.2 *Accessories Not to be Fitted*

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 3 Auxiliaries to be Fitted During the Test in Order to Determine Torque and Net Engine Power
(*Clause* 12.1.1)

No.	Auxiliaries	Fitted for Net Power Test
(1)	(2)	(3)
i)	Air Intake system Induction manifold Air filter Inlet silencer Crankcase emission control system Speed-limiting device	If series-mounted: yes
ii)	Exhaust system Exhaust clean-up system manifold Pipework[1)] Silencer[1)] Exhaust pipe[1)]	If series-mounted: yes
iii)	Carburettor	If series-mounted: yes
iv)	Fuel injection system Upstream filter Filter Pump Pipework Injector Air inlet flap[2)], where fitted Regulator, if fitted	Ra dia tor
v)	Liquid-cooling Equipment	

If series-mounted: yes

	Fan[4), 5)] Water Pump Thermostat[6)]	If series-mounted: yes[3)]
vi)	Air cooling Cowling Blower[4), 5)] Temperature regulator Auxullary bench blower	If series-mounted: yes, if necessary
vii)	Electrical equipment	If series-mounted: yes[7)]
viii)	Anti-pollution devices	If series-mounted : yes
ix)	Lubrication system oil feeder	If series-mounted : yes

NOTES ─

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

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

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

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

[5)] Where a fixed electrically or mechanically-operated fan cannot be fitted on the test bench the power absorbed by that fan shall be determined at the same rotational speeds at which 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)] 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.

12.2 Setting Conditions

The conditions applying to settings during the tests to determine maximum torque and maximum net power are set out in Table 4.

Table 4 Setting Conditions

(*Clause* 12.2)

Sl. No (1)	(2)	(3)
i)	Setting of carburetor(s)	Setting carried out in accordance with the manufacturer's specifications for series production applied, without any other change, to the use under consideration.
ii)	Setting of injection pump of flowrate	
iii)	Ignition or injection setting (advance curve)	

13 POWER AND TORQUE CORRECTION FACTORS

13.1 Correction Factors — $\alpha 1$ and $\alpha 2$

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 conditions specified in **13.2** and the mechanical efficiency of the transmission specified in **13.5**.
The power correction formula is as follows:

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

Where:

P_0 = corrected power, in kW (the power under the reference conditions at the end of the crank shaft);

α_1 = correction factor for reference conditions;

α_2 = correction factor for the efficiency of the transmission;

P = measured power, in kW (test power).

13.1.1 *Limits to the use of the Correction Formula*

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

NOTE — Tests carried out in temperature-controlled rooms where it is possible to vary the atmospheric conditions are permitted.

13.2 Reference Atmospheric Conditions

The reference atmospheric conditions during the test shall be as follows:

a) Temperature (T_o) : 298 K (25°C); and

b) Dry reference pressure (P_{so}) : 99 kPa (990 mbar)

13.3 Correction Factor for Reference Atmospheric Conditions, α_1

In the limits specified in **13.1.1**, the correction factor shall be calculated using the following formula:

$$\alpha_1 = (99/P_s)^{1.2} \times (T/298)^{0.6}$$

$$P_S = P - P_V$$

where,

T = absolute temperature of the engine induction air, in kelvin (K);

P_s = dry atmospheric pressure, in kPa;

P = total atmospheric pressure, in kPa; and

P_V = water vapour pressure, in kPa.

This formula applies to the torque and power read-off at the brake without taking account of the mechanical efficiency of the engine.

13.4 Correction Factor for Mechanical Efficiency of the Transmission, α_2

13.4.1 Where the measuring point is the crankshaft output side this factor shall be 1.

13.4.2 Where the measuring point is not the output side of the crankshaft correction factor is calculated using the formula:

$$\alpha_2 = 1/n_t$$

where

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

13.4.3 The transmission efficiency n_t is determined by the product (multiplication) of efficiency n_j of each of the components of the transmission:

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

Efficiency n_j 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.		

14 MAXIMUM TORQUE AND MAXIMUM NET POWER MEASUREMENT TOLERANCES

The maximum torque and the maximum net power of the engine as determined during testing may differ by ± 10 percent of the value specified by the manufacturer if the power measured is less than or equal to 1 kW and ± 5 percent if the power measured is greater than 1 kW, with a 3 percent tolerance for the engine speed.

SECTION 3 METHOD FOR MEASURING MAXIMUM TORQUE AND MAXIMUM NET POWER FOR MOTORCYCLES AND THREE WHEELER FITTED WITH SPARK IGNITION ENGINE.

15 TEST CONDITIONS

15.1 The maximum-torque and net-power tests shall be conducted at full throttle, the engine being equipped as specified in Table 5.

15.2 The measurements shall be carried out under normal, stabilized operating conditions with an adequate fresh-air supply to the engine. The engine shall have been run in accordance with the manufacturer's recommendations. Combustion chambers may contain deposits, but in limited quantities. Test conditions such as air inlet temperature shall be as near to reference conditions (*see* **18.2.1**) as possible in order to minimize the magnitude of the correction factor.

15.2.1 The minimum conditions which shall be fulfilled by the test installation and the scope for conducting the tests, specified in **15.3** to **15.12**, are defined below:

Case 1:

$$V_2 \geq V_1 \text{ and } Ø \geq 0.25 \text{ m}^2$$

where

V_2 = maximum velocity of the cooling air flow at the fan delivery side; in km/ hr;
V_1 = maximum speed of the vehicle; in km/ hr; and
$Ø$ = cross-section of the cooling air flow, in m^2.

Case 2: $V_2 < V_1$ or $Ø < 0.25\ m^2$

The minimum conditions are fulfilled provided it is possible to stabilize the operating conditions.

Case 3: If is not possible to stabilize the operating conditions, the minimum conditions are fulfilled provided $V_2 \geq 120$ km/ h and $Ø \geq 0.25\ m^2$

Case 4*:* The minimum conditions are not fulfilled when it is not possible to stabilize the operating conditions and $V_2 \geq 120$ km/ h and $Ø < 0.25\ m^2$

In this case the installation does not fulfil the minimum conditions and the test equipment cooling system shall be improved. The test may be carried out as specified in **15.3** to **15.12** subject to approval by the manufacturer.

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

15.4 No data shall be taken until torque, speed and temperature have remained substantially constant for at least 30s. In case, it is not possible to stabilize the operating conditions, the measurement shall be taken under normal operating conditions.

15.5 The engine speed during a run or measurement shall not vary by more than ± 1 percent or ± 10 min^{-1}, whichever is greater.

15.6 Brake load and inlet-air temperature readings shall be taken simultaneously. The reading adopted for measurement purposes is the average of two stabilized successive values differing by less than 2 percent for brake load.

15.7 The temperature of the coolant at the outlet from the engine shall be kept within ± 5K from the upper thermostatically controlled temperature specified by the manufacturer. If no temperature is specified by the manufacturer the temperature shall be 353 ± 5 K. For air cooled engines, the temperature at a point indicated by the manufacturer shall be kept between $^{+0}_{-20}$ K of the *Max* temperature specified by the manufacturer under the reference conditions.

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

15.9 The lubricant temperature, measured in the crankcase or at the oil heat exchanger outlet, where fitted, shall lie within the limits set by the manufacturer.

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

15.11 Where an automatically triggered device is used to measure engine speed and consumption the measurement shall last for at least 10s. If the measuring device is manually controlled it shall measure for at least 20s.

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

15.13 Tests

Measurements shall be taken 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 shall 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.

16 ACCURACY OF THE MEASUREMENTS OF POWER AND TORQUE AT FULL LOAD

The accuracy of measurement of various parameters shall be as given blow:

a) Torque	: ± 1 percent of torque measured[1)]
b) Rotational speed	: ± 1 percent
c) Fuel consumption	: ± 1 percent overall for the apparatus used
d) Engine inlet air temperature	: ± 1 K
e) Barometric pressure	: ± 100 Pa
f) Exhaust pressure	: ± 200 Pa
and drop in intake air	: ± 50 Pa

1) The torque measuring device shall be calibrated in order to take account of frictional losses. This accuracy may be ± 2 percent for the measurements carried out at power levels less than 50 percent of

the maximum value. It will in all cases be ± 1 percent for the measurement maximum torque.

17 TESTS TO MEASURE MAXIMUM TORQUE AND MAXIMUM NET ENGINE POWER

17.1 Accessories

17.1.1 *Accessories to be fitted*

During the test, the auxiliaries necessary for the engine operation in the intended application (*see* Table 5) shall be installed on the test bench as far as possible in the same position as in the intended application.

17.1.2 *Accessories to be Removed*

Accessories necessary only for operation of the vehicle itself and which may be mounted on the engine shall be removed for the test. Where accessories cannot be removed, the power absorbed by them under no load condition may be determined and added to the engine power measured.

Table 5 Auxiliaries to be Fitted During the Propulsion Unit Performance Test in Order to Determine Torque and Net Engine Power

(*Clause* 15.1)

Sr. No.	Accessories	Fitted for the torque and net-power test
(1)	(2)	(3)
i)	Induction system Induction manifold Air filer Induction silencer Crankcase emission control system Electrical control device (where fitted)	If series-mounted : yes
ii)	Induction manifold heater	If series-mounted: yes (if possible, it shall be set in the most favourable position)
iii)	Exhaust system Exhaust manifold Exhaust clean-up system (secondary air system) (where fitted) Pipework (1)	Silencer (1) Exhaust pipe1) Supercharger

Electrical control device
(where fitted)

If series-mounted: yes

iv)	Carburettor Fuel injection system Upstream filter Filter Fuel supply pump and high	If series-mounted: yes
v)	Pressure Pump, if applicable High pressure lines Injector Air inlet flap[2)], where fitted Fuel pressure/flow regulator, where fitted	If series-mounted: yes
vi)	Maximum rotational speed or power governors	If series-mounted: yes
vii)	Liquid-cooling equipment Engine Bonnet Radiator Fan[3)] Fan Cowl Water Pump Thermostat [4)]	If series-mounted: yes[(5)]
viii)	Air cooling Cowl Blower[3)] Cooling temperature regulating device(s) Auxiliary bench blower	If series-mounted: yes, if necessary
ix)	Electrical equipment Supercharger or turbocharger (where fitted) Compressor driven directly by the engine or by exhaust gases	If series-mounted: yes[(6)]
x)	Charge air cooler[7)] Coolant pump or fan (engine driven) Coolant Flow control device (where fitted)	If series-mounted: yes
xi)	Pollution Control device[8)]	If series-mounted: yes
xii)	Lubrication system Oil feeder Oil cooler (where fitted)	If series-mounted: yes

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

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

[3)] Where a fan or blower may be disengaged the net engine power shall first of all be stated with the fan (or blower)

disengaged, followed by the net engine power with the fan (or blower) engaged.

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

[4] The thermostat may be locked in the fully-open position.

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

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

[7] Charge air cooled engines shall be tested with charge air cooling, whether liquid or air cooled, but if the manufacturer prefers, a test bench 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 of the engine air across the charge air cooler on the test bench system as those specified by the manufacturer for the system on the complete vehicle.

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

17.2 Setting conditions

The setting conditions for the test to determine maximum torque and maximum net power shall be as specified in Table 4.

18 POWER AND TORQUE CORRECTION FACTORS

18.1 Correction Factors — α_1 and α_2

The factors by which the measured torque and power are to be multiplied in order to determine the engine torque and power, taking account of the efficiency of the transmission factor ($\alpha_{2)}$ specified in **18.5,** that are used during the test in order to calculate torque and power under the reference atmospheric conditions specified in **18.2**.

The power correction formula is as follows:

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

where:

P_0 = corrected power, in kW (the power under the reference conditions at the end of the crank shaft);

α_1 = correction factor for reference atmospheric conditions;
α_2 = correction factor for the efficiency of the transmission; and
P = measured power, in kW (power observed).

18.2 Atmospheric Conditions

18.2.1 *Reference Atmospheric Conditions*

The reference atmospheric conditions during the test shall be as follows:

a) Temperature (T_o) : 298 K (25°C); and
b) Dry reference pressure (P_{so}) : 99 kPa (990 mbar).

NOTE — The dry reference pressure is based on a total pressure of 100 kPa and a water vapour pressure of 1 kPa

.

18.2.2 *Atmospheric Temperature*

During the test the atmospheric temperature shall lie within 283 K < T < 318 K.

18.3 Correction Factor

18.3.1 *Correction Factor for Reference Atmospheric Conditions,* α_1

In the limits specified in **18.3.1.1**, the correction factor shall be calculated using the following formula:

$$\alpha_1 = (99/P_s)^{1.2} \times (T/298)^{0.6}$$

$$P_S = P - P_V$$

where

T = absolute temperature of the ingested air, in kelvin (K);
P_s = dry atmospheric pressure, in kPa (the total barometric pressure minus water vapour pressure);
P = total atmospheric pressure, in kPa; and
P_V = water vapour pressure, in kPa.

18.3.1.1 *Limits to the use of the correction formula*

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

18.3.2 *Correction Factor for Mechanical Efficiency of the Transmission,* α_2

18.3.2.1 Where the measuring point is the crankshaft output side this factor shall be 1.

18.3.2.2 Where the measuring point is not the output side of the crankshaft correction factor is calculated using the formula:

$$\alpha_2 = 1/n_t$$

where

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

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

$$n_t = n_1 \times n_{2 \times} \ldots\ldots\times n_j$$

Efficiency n_j 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
NOTE – 1) If not locked up.		

19 MAXIMUM TORQUE AND MAXIMUM NET POWER MEASUREMENT TOLERANCES

The maximum torque and the maximum net power of the engine may differ from the values specified by the manufacturer, by ± 5 percent if the power measured is less than or equal to 11 kW and ± 2 percent if the power measured is more than 11 kW with a 1.5 percent tolerance for the engine speed.

SECTION 4 EMISSION OF VISIBLE POLLUTANTS AT STEADY SPEEDS OVER THE FULL-LOAD CURVE

20 GENERAL

This section 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 section is applicable for emission of visible exhaust pollution from compression ignition engines which are intended for fitting to vehicles of L, M and N categories.

21 MEASUREMENT PRINCIPLE

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

21.2 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.

22 TEST CONDITION

22.1 Vehicle or Engine

22.1.1 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.

22.1.2 The engine shall be tested with the equipment specified in Table1.

22.1.3 The settings of the engine shall be prescribed by the manufacturer and as specified in **5.4.**

22.1.4 In the case of a test on an engine the power of the engine shall be measured as specified in section 1 and the requirements of power tolerance specified in **9** shall also meet. 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.

22.1.5 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.

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

Table 6 Limit Values Applicable in the Test at Steady Speed

(*Clause* 23.2)

Sl. No	**Nominal Flow**	**Light Absorption Coefficient**	**Nominal Flow**	**Light Absorption Coefficient**
	(G)	**(k)**	**(G)**	**(k)**
	(1/s)	(1/m)	(1/s)	(1/m)
(1)	(2)	(3)	(4)	(5)

i)	< = 42	2.26	120	1.37
ii)	45	2.19	125	1.345
iii)	50	2.08	130	1.32
iv)	55	1.985	135	1.30
v)	60	1.90	140	1.27
vi)	65	1.84	145	1.25
vii)	70	1.775	150	1.205
viii)	75	1.72	160	1.19
ix)	80	1.665	165	1.17
x)	85	1.62	170	1.155
xi)	90	1.575	175	1.14
xii)	95	1.535	180	1.125
xiii)	100	1.495	185	1.11
xiv)	105	1.465	190	1.095
xv)	110	1.425	195	1.08
xvi)	115	1.395	>200	1.065

NOTE — The emissions of visible pollutants when tested as detailed in this section shall not exceed the limit values of light absorption coefficient given above for various nominal flows.

22.2 Fuel

The test fuel shall be the reference fuel as specified in gazette notification. A commercially available fuel may be used.

22.3 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) shall be measured 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. The atmospheric factor F_a shall be calculated as give below:

a) For naturally aspirated and mechanically super charged engines:

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

where

f_a = atmospheric factor;
T = absolute temperature of the air, in kelvin (K); and
P_s = dry atmospheric pressure, in kPa (the total barometric pressure minus water vapour pressure).

b) For Turbo super charge engines with or without cooling of inlet air:

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

where

f_a = atmospheric factor;
T = absolute temperature of the air, in kelvin (K); and
P_s = dry atmospheric pressure, in kPa (the total barometric pressure minus water vapour pressure).

22.3.1 For a test to be as valid, the value of atmospheric factor F_a shall be between 0.98 and 1.02

(both values included).

22.4 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 section 6.

23 EVALUATION OF THE ABSORPTION COEFFICIENT

23.1 For each of the six engine speeds at which the absorption coefficient is measured pursuant to **21.2,** the nominal gas flow shall be calculated by mean of the following formula:

a) For two-stroke engines

$$G = V \times n/60$$

b) For four-stroke engines

$$G = V \times n /120$$

Where

G = nominal gas flow, in liters per second, (l/s);

V = cylinder capacity of the engine, in liters, (l); and

n = engine speed, in revolutions per minute (rpm).

23.2 Where the value of the nominal flow is not one of those given in the Table 6, the limit value applicable shall be obtained by interpolation on the principle of proportional parts.

SECTION 5 TEST UNDER FREE ACCELERATION

24 General

This section 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 section is applicable for emission of visible exhaust pollution under free acceleration from compression ignition engines which are intended for fitting to vehicles of L, M and N categories. 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.

24.1 The emissions of visible pollutants under free acceleration, when tested as per **26** shall not exceed limit mentioned in respective gazette notification.

25 TEST CONDITIONS

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

25.1.1 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.

25.1.2 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.

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

26 TEST METHODS

26.1 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.

26.2 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.

26.3 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.

26.3.1 The sequence mentioned in **26.3** for complete cycle for measurement can be defined based on time.

26.3.1.1 Acceleration time from idle to fly up speed: 5 sec (*Max*)

26.3.1.2 Stabilizing time at maximum speed: 2 sec (*Max*)

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

26.3.1.4 Idling Phase: Operator to start next acceleration within 5 to 20s.

26.3.1.5 Repeat **26.3.1.1** to **26.3.1.4**.

26.4 The operation described in **26.3.1.** 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 stabilized 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 stabilized when three of them consecutively are situated within a band width of 25 percent of the arithmetic mean of these three readings or within a band width of 0.25K whichever is higher and do not form a decreasing sequence. The absorption coefficient (*XM*) to be recorded shall be the arithmetical mean of these three values. In case the smoke density recorded is not within the limits, then, the test may be repeated with engine oil temperature measured by a probe in the oil level dipstick tube to be at least 60° C.

26.5 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}.

SECTION 6 SMOKE METERS AND THEIR INSTALLATIONS

27 SCOPE

This appendix covers the requirements of smoke meters and their installation on engines for full load and free acceleration tests, mentioned in section 4 and section 5 respectively.

28 TECHNICAL SPECIFICATIONS OF OPACITY METERS

28.1 General

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

28.1.2 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.

28.1.3 The indicating dial of the opacity meter shall have two measuring scales, one in absolute units of light absorption from 0 to infinity and the other, linear from 0 to 100; both scales shall range from 0 at total light flux to full scale at complete obscuration.

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

28.2 Construction Specifications

28.2.1 Smoke chamber and opacity meter casing

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

28.2.1.2 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/m.

28.2.2 *Light Source*

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

28.2.3 *Receiver*

28.2.3.1 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 nm to 570 nm; less than 4 percent of that maximum response below 430 nm and above 680 nm).

28.2.3.2 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.

28.2.4 *Measuring Scales*

28.2.4.1 The light-absorption coefficient (k) shall be calculated by the formula:

$$F = F_o \times e^{(-k \times L)}$$

where

L = effective length of the light path through the gas to be measured;
F_o = incident flux; and
F = 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 **28.7** or through correlation with another type of opacity meter for which the effective length is known.

28.2.4.2 The relationship between 0 - 100 linear scale and the light absorption coefficient (k) is given by the formula:

$$k = \left(\frac{-1}{L}\right) \times [\ln_e \{1 - (N/100)\}]$$

where

N = reading on the linear scale; and
K = corresponding value of the absorption coefficient.

28.2.4.3 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.

28.3 Adjustment and Calibration of the Measuring Apparatus

28.3.1 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.

28.3.2 With the lamp switched off and the electrical measuring circuit open or short circuited, the reading on the absorption coefficient scale shall be infinite (∞) and it shall remain at infinite (∞) 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 **28.2.4.1** is between 1.6/m and 1.8/m. The value of light absorption coefficient shall 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.

28.4 Opacity Meter Response

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

28.4.2 The damping of the electrical measuring circuit shall be such that the initial over swing beyond the final steady reading after any momentary variation in input (for example, calibration screen) does not exceed 4 percent of that reading in linear scale unit.

28.4.3 The response time of opacity meter shall not exceed 0.4 s. (The time taken from the start of the gas entering the chamber to complete filling of the smoke chamber).

28.4.4 These provisions shall apply solely to opacity meters used to measure opacity under free acceleration.

28.5 Pressure of the Gas to be Measured and of Scavenging Air

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

28.5.2 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.

28.5.3 The opacity meter shall be equipped with appropriate devices for measuring the pressure in the smoke chamber.

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

28.6 Temperature of the Gas to be Measured

28.6.1 At every point in the smoke chamber the gas temperature at the instant of measurement shall be between 70°C and a maximum temperature declared by the 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.

28.6.2 The opacity meter shall be equipped with appropriate devices for measuring the temperature in the smoke chamber.

28.7 Effective Length (*L*) of the Opacity Meter

28.7.1 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.

28.7.2 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 *L*o.

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

28.7.4 *Method of Assessment of Effective Length*

28.7.4.1 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.

28.7.4.2 A column of length L_o 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 L_o shall be close to the effective length of the opacity meter.

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

28.7.4.4 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.

28.7.4.5 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 **28.7.2.**

28.7.4.6 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.

28.7.4.7 With opacity meter operating normally, the reading on the linear scale of opacity is *N* and that of the mean gas temperature, *T* expressed in kelvin.

28.7.4.8 With the known length L_o filled with the same test gas, the reading on the linear scale of opacity is N_o and mean gas temperature, T_o expressed in kelvin.

28.7.4.9 The effective length will be

$$L = L_o \times \left[\frac{T \times Log\left(\frac{1-N}{100}\right)}{T_o \times Log\left(\frac{1-No}{100}\right)} \right]$$

where

L = effective length of the light path through the gas to be measured;
L_o = known length of test gas;
T = temperature of exhaust gas; and
T_o = temperature of test gas.

28.7.4.10 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.

28.7.4.11 The effective length *L* of the opacity meter will be the arithmetic average of the effective lengths obtained as stated in **28.7.4.9** for each of the gases.

29 INSTALLATION OF THE OPACITY METER

29.1 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.

29.2 Sampling of Opacity meter

29.2.1 *Installation for Full Load Tests*

29.2.1.1 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).

29.2.1.2 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 6*D* 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.

29.2.1.3 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.

29.2.1.4 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.

29.2.1.5 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.

29.2.1.6 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.

29.2.1.7 A check shall be carried out during the test to ensure that the requirements of **28.5** concerning pressure and **28.6** concerning temperature in the measuring chamber are observed.

29.2.1.8 The only general precautions which shall be observed in steady speed and free acceleration tests are the following:

a) Joints in the connecting pipes, if any, between the exhaust pipe and the opacity meter shall not allow air to enter from outside;

b) 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; and

c) A cooling system may also be required upstream of the opacity meter.

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

SECTION 7 CALCULATION OF SPECIFIC FUEL CONSUMPTION (SFC)

31 GENERAL

This section specifies method of measurement of specific fuel consumption.

31.1 The Specific Fuel Consumption (SFC) is calculated from measured fuel consumption in g/h

and the corrected net power.

31.2 In case of two-stroke positive ignition engines where pre-mixing of lubricating oil and fuel is carried out, the specified fuel consumption shall be calculated taking the specific gravity of the fuel alone in the combination (not the specific gravity of the fuel mixed with lubricating oil). However, while carrying out the arithmetical calculation for determining the gravimetric specific fuel consumption, a due allowance for the volume of lubricating oil shall be made.

For Example:

If '*V*' ml of fuel, containing '*v*' percent of lubricating oil, takes '*t*' seconds for being consumed while the engine is developing ***'P'*** kW of corrected net power and the specific gravity of the fuel is '*s*' g/ml, then the specific fuel consumption is given by the following formula:

$$SFC = \frac{V}{(1+\frac{v}{100})} \times 3\,600 \times \frac{s}{P_c \times t}$$

where

SFC = fuel consumption in g/kWh;
V = quantity of fuel in ml;
s = specific gravity of the fuel in g/ml;
v = percent of lubricant oil;
P_c = corrected net power in kW; and
t = specific time taken in seconds.

ANNEX A

(*Clause* 6.2)

RESULTS OF TESTS FOR MEASURING NET ENGINE POWER

This form shall be completed by the laboratory performing the test.

A-1 TEST CONDITIONS

A-1.1 Pressures Measured At Maximum Power

A-1.1.1 *Total Barometric Pressure*.....Pa

A-1.1.2 *Water Vapour Pressure*.....Pa

A-1.1.3 *Exhaust Pressure* ..... Pa

A-1.2 Temperatures Measured at Maximum Power

A-1.2.1 *Of The Intake Air*.....K

A-1.2.2 *At The Outlet of The Engine Intercooler*.....K

A-1.2.3 *Of The Cooling Fluid*

A-1.2.3.1 *At the engine cooling fluid outlet*..... K

A-1.2.3.2 *At the reference point in the case of air cooling*.....K

A-1.2.4 *Of The Lubricating Oil*.....K (indicate point of measurement)

A-1.2.5 *Of The Fuel*

A-1.2.5.1 *At the fuel pump inlet*..... K

A-1.2.5.2 *In the fuel consumption measuring device*.....K

A-1.2.6 *Of the exhaust measured at the point adjacent to the outlet flange(s) of the exhaust manifold(s)* ..... °C

A-1.3 Engine Speed When Idling: ..... min^{-1}

A-1.4 Characteristics of The Dynamometer

A-1.4.1 *Make* :…… *Model*: .....

A-1.4.2 *Type*: .....

A-1.5 Characteristics of the Opacity Meter

A-1.5.1 *Make*: .....

A-1.5.2 *Type*: .....

NOTES −

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

2 Delete as appropriate.

A-2 FUEL

A-2.1 For Positive-Ignition Engines Operating On Liquid Fuel

A-2.1.1 *Make*: .....

A-2.1.2 *Specification*: .....

A-2.1.3 *Anti-Knock Additive* (lead, etc.): .....

A-2.1.3.1 *Type*: .....

A-2.1.3.2 *Content*:..... mg/1

A-2.1.4 *Octane number RON*:.....[IS 1448 (Part 27):2018]

A-2.1.4.1 *Octane number MON*: .....

A-2.1.4.2 *Specific density*.....g/cm^3 at 288 K

A-2.1.4.3 *Lower calorific value*..... kJ/kg

Table 7

	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}

A-2.2 For Positive-Ignition Engines and Dual-Fuel Engines Operating On Gaseous Fuel

A-2.2.1 *Make***:** .....

A-2.2.2 *Specification:* .....

A-2.2.3 *Storage Pressure: bar*

A-2.2.4 *Utilization Pressure* ..... bar

A-2.2.5 *Lower Calorific Value*: .....kJ/kg

A-2.3 For Compression-Ignition Engines Operating On Gaseous Fuels

A-2.3.1 *Feed System: Gas*.....

A-2.3.2 *Specification of Gas Used*: .....

A-2.3.3 *Fuel Oil/Gas Proportion*: .....

A-2.3.4 *Lower Calorific Value*: .....

A-2.4 For Compression-Ignition Engines and Dual-Fuel Engines operating on Diesel Fuel

A-2.4.1 *Make*: .....

A-2.4.2 *Specification of Fuel Used*: .....

A-2.4.3 *Cetane Number* [IS 1448 (Part 9):2019] .....

A-2.4.4 *Specific Density*.....g/cm^3 at 288 K

A-2.4.5 *Lower Calorific Value*.....kJ/kg

A-3 LUBRICANT

A-3.1 Make: .....

A-3.2 Specification: .....

A-3.3 SAE viscosity: .....

A-4 DETAILED RESULTS OF MEASUREMENTS[1)]

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	No. 1		
auxiliaries in excess	No. 2		
of Table 1, kW	No. 3		
Engine speed, min^{-1}			
Measured torque, Nm			
Measured power, kW			
Barometric pressure, kPa			
Water vapour pressure, kPa			
Inlet air temperature, K			
Power to be added for			
Auxiliaries in excess			
of Table 1, kW			
Power correction factor			

NOTES −

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

2 Delete as appropriate.

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

4 Delete where inapplicable.

ANNEX B
(*Informative*)

B-1 Extension Criteria: The approval may be extended without carrying out any type test for the following conditions;

B-2 Maximum rated speed not greater than 100% nor less than 75% of that of the engine in the type approval test;

B-3 Minimum rated speed not less than that of the engine in the type approval test;

B-4 Rated torque not greater than 100%, nor less than 70% of that of the engine at the speed in the type approval test;

B-5 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.

B-6 Exhaust back pressure not greater than that of the engine in the type approval test;

B-7 Exhaust system volume does not differ by more than 40%;

B-8 Intake depression not greater than that of the engine in the type approval test;

B-9 Moment of inertia of a new combined fly wheel and transmission is within ± 15% of the fly wheel and transmission system approved.

ANNEX C
(*Foreword*)

COMMITTEE COMPOSITION

AUTOMOTIVE PRIME MOVERS, TRANSMISSION SYSTEM AND INTERNAL COMBUSTION ENGINES SECTIONAL COMMITTEE, TED 2

Organization	***Representative(s)***
Automotive Research Association of India, Pune	SHRI N.V. MARATHE (***Chairman***)
Advik Hi-Tech Pvt. Ltd.	SHRI SHYAM GAWADE
Ashok Leyland Ltd, Chennai	SHRI V FAUSTINO SHRI MUTHUKUMAR N *(Alternate)* SHRI HARISH V (*YP*)
Association of State Road Transport Undertakings, New Delhi	SHRI R. R. K. KISHORE SHRI PRAFUL MATH *(Alternate)* SHRI SACHIN MOTIRAM CHACHARE (*YP*)
Automotive Research Association of India, Pune	DR P.G. BHAT DR S S RAMDASI *(Alternate)* SHRI N V PAWAR (*YP*)
Automotive Components Manufacturers Association, New Delhi	SHRI SANJAY TANK MS SEEMA BABAL *(Alternate)*
Bajaj Auto Ltd, Pune	SHRI A.V. KUMBHAR SHRI ADISH AGGARWAL *(Alternate)*
BEML Limited, Mysore	SHRI MAHADEV NELLUR SHRI M. SASI KUMAR *(Alternate)*
Bosch Limited, Bangalore	SHRI K U RAVINDRA SHRI H. SIVAPRAKASH *(Alternate)*
Central Institute of Road Transport, Pune	SHRI M. M. PATHAK SHRI NILESH TAGAD *(Alternate)* SHRI SHIVRAJ DUDHE (*YP*)
Central Pollution Control Board, New Delhi	SHRI A. SUDHAKAR SHRI SUNEEL DAVE *(Alternate)*
CONCERT, Chennai	SHRI S. SAINATH SHRI MOHAN MAHADEVAN *(Alternate)*
Cummins India Ltd, Pune	SHRI JUGAL K MITTAL SHRI TUSHAR KADAM *(Alternate)*
Directorate General of Quality Assurance, New Delhi	BRIG BK POKHRIYAL COL O.P. BHARTI *(Alternate)*
Denso International India Pvt. Ltd. (ACMA)	SHRI NOEL ALEXANDER PETERS SHRI ALOK KUMAR *(Alternate)* MS. ALKA SHARMA (*YP*)
Eaton Industrial System Pvt Ltd	SHRI HEMANG RAVAL SHRI K V RAO *(Alternate)*
Fleet guard filters (P) Ltd., Pune	DR ASHOK KUMAR VAIKUNTAM SHRI VIKAS SALUNKE *(Alternate)*

Organization	*Representative(s)*
Greaves Cotton Ltd (Diesel Engines Unit), Aurangabad	DR KALIMUDDIN SYED SHRI KEDAR A KANASE *(Alternate)*
Hero Moto Corp Ltd, Dharuhera	SHRI RAKESH SHARMA SHRI FEROZ ALI KHAN *(Alternate)*
Honda India Power Products Limited, UP	SHRI TARIQ MAHMOOD SHRI RAJINDER KHURANA *(Alternate)* SHRI DHARMENDRA KUMAR (*YP*)
India Pistons Limited Perambur, Chennai	SHRI BALASUBRAMANI K *(Alternate)*
Indian Diesel Engine Manufacturers Association, Bangalore	SHRI ARVIND RANGANATH DR RAVI PRASANTH *(Alternate)*
Indian Institute of Petroleum, Dehradun	DR DEVENDRA SINGH DR SUNIL PATHAK *(Alternate)*
Indian Institute of Technology (IIT), New Delhi	DR S. P. SINGH DR SUDIPTO MUKHERJEE *(Alternate)*
International Centre for Automotive Technology, Manesar	SHRI VAIBHAV PRASHANT YADAV MS VIJAYANTA AHUJA *(Alternate)*
Mahindra & Mahindra, Nasik	SHRI SHASHIKANT NIKAM SHRI S. SAKTHIVELAN *(Alternate)* SHRI SEKAR GANESH (*YP*)
Maruti Suzuki India Ltd, Gurgaon	SHRI GURURAJ RAVI SHRI ARUN KUMAR *(Alternate)* SHRI RAJESH KUMAR (*YP*)
Ministry of Heavy Industries & Public Enterprises, New Delhi	SHRI R. K. JAISWAL
Ministry of Road Transport & Highways, New Delhi	SHRI K. C. SHARMA
MG India Motor (P) Ltd	SHRI VAIBHAV UTPAT
National Small Industries Corporation, Rajkot	SHRI U. VENKATCHALAPATHI SHRI KAMAL KANT SAHU *(Alternate)*
Ordnance Factory Board, Kolkata	SHRI S. K. GUND SHRI SURENDRA PATI *(Alternate)*
Rajkot Engineering Association, Rajkot	SHRI MAYUR N SHAH SHRI ABHISHEK GONDALIYA *(Alternate)*
Shriram Pistons (P) Ltd	SHRI SHANKAR BRAHMA SHRI VINEET AHLUWALIA *(Alternate)*
Society of Indian Automobile Manufacturers, New Delhi	SHRI P. K. BANERJEE DR SANDEEP GARG *(Alternate)*
Tata Motors Ltd, Pune	SHRI MILIND PAGARE (*Principle*) SHRI GOWRISHANKAR P. S. (*Principle*)
Tractor Manufacturers Association, New Delhi	SHRI PHILIP KOSHY SHRI MADHAV BHADE *(Alternate)*
U.P. Diesel Engine Manufacturers Association, Agra	SHRI RAJESH GARG SHRI MANISH DONERIA *(Alternate)*
Vehicle Research and Development Establishment, Ahmednagar	SHRI D M VAIDYA SHRI RUPESH KUMAR *(Alternate)*
	SHRI P. V. SRIKANTH, SCIENTIST 'D' & HEAD (TED)

Organization	*Representative(s)*
BIS Directorate General	[REPRESENTING DIRECTOR GENERAL (EX-OFFICIO)]

MEMBER SECRETARY
SHRI GAURAV JAYASWAL
SCIENTIST B / ASSISTANT DIRECTOR
(TRANSPORT ENGINEERING DEPARTMENT)