

Specification for

The performance of diesel engines for road vehicles

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Foreword

This British Standard was first published in 1967 under the authority of the Automobile Industry Standards Committee of the British Standards Institution for the purpose of defining certain features of engine specification and performance to avoid misunderstandings which have occurred in the past and to provide a basis for the comparison of the performance of different engines using the test methods given in the standard.

The performance of an engine will vary with:

- 1) atmospheric conditions,
- 2) the test bed procedure,
- 3) the adjustment and settings of the engine.

Item 3) should be in accordance with the maker's recommendations for the intended duty and service life. The type of fuel and lubricant, and the design of the intake and the exhaust systems are amongst the factors which need to be specified before engine test results can be reproduced. Limits on the engine exhaust smoke emission are given which are considered to be a reasonable compromise between social and economic acceptability and it is emphasized that these limits largely control the engine performance.

In revising the standard, account has been taken of the requirements for engine testing given in corresponding Draft Recommendations¹⁾ which have been prepared by the International Organization for Standardization (ISO), and the limits on engine exhaust smoke emission given in a draft Regulation now under preparation by Working Party 29 of the Economic Commission for Europe (ECE). The opportunity has been taken also to effect certain amendments, mainly for the purpose of clarification, as a result of experience in the use of the standard.

NOTE Different output conditions are provided for use as appropriate, since this standard is intended for engines with a wide range of duties. It is insufficient and misleading to quote an output value to this standard without specifying the test conditions.

This standard makes reference to the following British Standards:

BS 1042, *Code for flow measurement*.

BS 1704, *General purpose thermometers*.

BS 1780, *Bourdon tube pressure and vacuum gauges*.

BS 2869, *Petroleum fuels for oil engines and burners*.

BS 3403, *Indicating tachometers for general industrial use*.

BS AU..., *Diesel engine exhaust gas opacimeter (in course of preparation)*.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 22 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

¹⁾ ISO/R..., "Engine tests — net power" (in course of preparation).
ISO/R..., "Engine tests — gross power" (in course of preparation).

1 Scope

This British Standard applies to compression ignition (diesel) engines, utilizing liquid fuel only, for propelling vehicles designed primarily for use on the public highway.

It specifies the standard test conditions for the test bed procedure, the equipment to be included on the engine for standard tests at the approved engine power outputs and the smoke control of the exhaust gases under “steady state” conditions. It includes a type test, incorporating a 100 h test, and output tolerances and exhaust gas opacity limits on production engines.

NOTE The titles of the British Standards referred to in this standard are listed in the Foreword.

2 Definitions

For the purposes of this British Standard the following definitions apply:

2.1

compression ignition (diesel) engine

a prime mover in which the fuel is injected into the cylinder or combustion space of the engine and is there ignited, during normal running, solely by the heat of compression of the cylinder charge, the power output being transmitted through a crankshaft or crankshafts

2.2

torque

the turning moment at the output shaft

NOTE If the speed of the output shaft differs from that of the crankshaft this is disclosed by the engine maker, but a fluid flywheel is regarded as part of the transmission and not of the engine.

2.3

brake power output

the power output measured at the crankshaft or its equivalent

2.4

net calorific value of fuel

the heat resulting from the complete combustion of unit quantity of fuel with air, without condensation of the water vapour (see Appendix A)

2.5

specific fuel consumption

the rate per unit of output at which fuel is used by the engine at any specified operating condition

2.6

exhaust back-pressure

the mean static pressure head existing in the exhaust pipe of an engine test bed installation, measured at a point in the pipe adjacent to the outlet flange of the engine manifold or the turbo-charger by pressure tapings in accordance with BS 1042

2.7

inlet depression

the mean static depression existing in the air inlet system, measured at a point in the pipe adjacent to the inlet flange of the engine manifold or the turbo-charger by pressure tapings in accordance with BS 1042

2.8

air inlet temperature

the temperature of the air being drawn into the engine, as measured within 150 mm of the air inlet of the air cleaner or intake system by a thermometer shielded from radiant heat. A sufficient number of locations are used to give a representative average inlet temperature

2.9

observed reading

a reading or measurement recorded during the progress of a test

2.10**corrected reading**

an observed reading modified by the appropriate correction factors

2.11**fuel temperatures**

the temperature of the fuel at

- a) the inlet to the fuel injection pump or equivalent, and
- b) the point where the fuel consumption is measured.

these temperatures may differ substantially

2.12**certifying authority**

the independent body or association which gives type approval to the engine under consideration and certifies that it conforms to the requirements of this standard

3 Rating

3.1 The power output, as declared by the manufacturer, shall be presented in the form of performance curves showing the maximum brake power at various speeds obtained under the standard test conditions specified in Clause 5. The power output will be selected by the manufacturer to give, with suitable maintenance, a satisfactory service life and overhaul period.

3.2 The exhaust gas opacity for all power outputs shall be within the limits specified in Clauses 7 and 8.

3.3 Some variation of the brake power output will be caused by the number and nature of the auxiliaries attached to the engine and the nature of the equipment.

3.4 The brake power output under the standard test conditions specified in Clause 5, corrected if necessary as given in Clause 9, shall be determined, as required, by the following methods.

1) *Gross brake power output.* For the engine speed specified by the manufacturer the gross brake power output shall be measured on a test bed (the engine being equipped only with those directly driven auxiliaries essential to its operation, as listed in 5.2) and established by a type test as specified in Clause 8.

2) *Installed brake power output.* For the engine speed specified by the manufacturer the installed brake power output is that delivered by the engine when fitted with all the equipment, as listed in 5.2, which is required for a particular vehicle installation.

Subsequent to the satisfactory completion of a type test in the gross power output condition as specified in Clause 8, the installed brake power output can be measured on a test bed and established by a performance test as specified in 8.3, the engine being prepared in accordance with the requirements of 8.2.

The installed brake power output may be alternatively derived by deducting from the gross output, as defined in 1), the separately determined powers absorbed by the auxiliaries required for the particular installation. In this case, a list of the auxiliaries and their separately determined powers shall be given, as in Appendix C.

3.5 The standard test conditions specified in Clause 5 indicate the operating condition of the engine equipment and accessories which, in general, are in the “off-load” condition.

3.6 Where the specified conditions in regard to the air inlet depression and the exhaust back pressure do not apply, the installed power output within the specified exhaust gas opacity limits given in Clauses 7 and 8 shall be determined by the engine manufacturer, and certified by the certifying authority.

4 Quality control of production engines

4.1 Any engine taken from production and prepared as for the type test (see 8.2) shall meet the initial performance test requirements specified in 8.3.

4.2 Adequate quality control procedures shall be applied by the engine manufacturer to ensure that any engine taken from production after the manufacturer’s normal test and then run-in according to the manufacturer’s recommendations shall only exceptionally exceed the exhaust gas opacity limits specified in Clause 7.

5 Standard test conditions

5.1 The standard conditions for test are:

- 1) mean barometric pressure: 101.5 kN/m² (760 mmHg)
- 2) humidity: for the purposes of correction, changes of humidity are neglected because it is considered that they have no significant effect on the correcting factor
- 3) air temperature at inlet: 20 °C (equivalent, at mean barometric pressure, to a dry air density of 1.206 kg/m³)
- 4) air inlet depression: to be set at the maximum rated full load and speed; to be within ± 5 mmH₂O of the upper limit specified by the engine manufacturer with the air filter, if fitted, in the clean condition. Air inlet systems shall remain fixed over the whole engine speed range; consequently, lower inlet depressions will occur at speeds below the maximum
- 5) test bed exhaust back pressure: to be set at the maximum rated full load and speed; to be within ± 5 mmHg of the upper limit specified by the engine manufacturer. Exhaust systems shall remain fixed over the whole engine speed range; consequently, lower exhaust back pressures will occur at speeds below the maximum
- 6) fuel: BS 2869, Class A1 or A2, net calorific value 42 800 kJ/kg (18 400 Btu/lb) (see Appendix A). In cases of dispute, initial and final performance tests only shall be made using C.E.C. Reference Fuel ERF-DI (see Appendix D).
NOTE The use of smoke suppressants is not permitted for testing
- 7) fuel supply system: head not greater than 2 m above the entry to the engine system which includes, where fitted, the feed pump
- 8) fuel injection equipment: set before test to engine manufacturer's setting; the maximum fuel delivery stop setting to remain unaltered during the test
- 9) governor: set during preliminary running to engine manufacturer's setting, or as specified in 8.4.2
- 10) lubrication system: engine manufacturer's system, with additional cooling if required to compensate for absence of air flow caused by motion of vehicle

5.2 The following equipment shall be fitted during the test (see **5.2.1** to **5.2.4**):

Component	For gross brake output conditions	For installed brake output condition (see 3.4 2)
Air filter	optional — see 5.1 4)	vehicle type, in clean condition, or depression equivalent to vehicle type
Exhaust system	test bed — see 5.1 5)	vehicle type, or back pressure equivalent to vehicle type
Electrical generator, hydraulic pump, compressor, exhauster any other equipment	} if required for the operation of the engine, but at their minimum power setting	} vehicle system, operating at its minimum power setting
<i>Cooling system</i> 1) liquid cooled engines; radiator, fan and cowl assembly;	} omitted	} vehicle type with additional, or alternative, cooling if required (see 5.2.1 and 5.2.2)
2) air cooled engines; coolant pumps or fans;	} included, with additional cooling if required	} included, with additional cooling if required
3) auxiliary test bed fan	if required	if required
<i>Supercharging equipment (if fitted)</i> Supercharger, driven either directly or indirectly by the engine and/or the exhaust gases	} included (see 5.2.3)	} included (see 5.2.3)
Intercooler, if fitted	included (see 5.2.3 and 5.2.4)	included (see 5.2.3)
Cooling pump or fan (engine driven) if fitted	included	included
Coolant flow control device, if fitted	included (see 5.2.4)	included

5.2.1 The radiator, the fan, the fan cowl, the water pump and the thermostat should be located on the test bed in the positions they will occupy on the vehicle. The cooling liquid circulation should be operated by the engine water pump only. The radiator shutter, if used, should be in the open position.

Cooling may be produced either by the engine radiator or by an external circuit, provided the pressure loss of this circuit remains substantially the same as that of the engine cooling system.

Where a fixed fan, electrically or mechanically operated, cannot be fitted on the test bed, the power absorbed by the fan should be determined at the same engine speeds as those used for the measurement of the engine output. This power should be deducted from the corrected output to obtain the installed brake power.

5.2.2 Where a disconnectable fan is used, the installed brake power should be determined firstly with the fan disconnected, then with the fan connected. The power with the fan connected shall be used in determining the installed brake power.

5.2.3 The temperature of the air at the inlet manifold should be that given by the engine manufacturer, if specified.

5.2.4 The production intercooler and coolant flow control device may be replaced by an alternative type, provided the same pressure loss and the same temperature at the inlet manifold are maintained as with the production unit, as specified by the manufacturer.

6 Units of measurement and limits of accuracy

All test measurements and readings shall be made with instruments of requisite accuracy and maintained in good condition.

For the determination of specific fuel consumption, measurement of fuel quantity and the number of engine revolutions counted during the same measured time interval is recommended. Where the quantity of fuel is measured by volume, the temperature of the fuel shall be measured at the point or points of volume measurement and used with the determined specific gravity to calculate the mass of fuel. The measuring accuracy and the units of measurement for the necessary data are specified in the following table.

Measurement	Units	Limits of accuracy
Brake load	N	± 0.5 % of the maximum test reading
Torque	N m	± 0.5 % of maximum value
Engine speed ^a	rev/min	± 1 % of maximum test reading
Power	kW	± 1.5 % of maximum value
Specific fuel consumption	g/kW h	± 2 % for full load
Temperature	°C	below 150 °C: ± 1 °C ^b above 150 °C: ± 5 °C
Barometric pressure	kN/m ² (mmHg)	± 0.1 kN/m ² (± 0.5 mmHg)
Pressures below atmospheric	mmH ₂ O	± 2.5 mm H ₂ O
Pressures above atmospheric	kN/m ² (mmHg)	± 1.5 % of maximum test reading ^c

^a See BS 3403. Grade A accuracy is sufficient provided that the maximum scale value does not exceed 1.3 times the maximum test reading.

^b These accuracies correspond with the requirements of BS 1704.

^c Attainable with concentric scale instruments complying with the requirements of BS 1780, where the maximum scale value lies between 1.1 and 1.3 times the maximum test reading.

The following conversion factors apply:

1 Btu/lb	= 2.326 kJ/kg
1 inHg	= 3.386 39 kN/m ² = 33.8639 mbar
1 inH ₂ O	= 0.249 09 kN/m ²
1 lb/bhp h	= 608.014 g/kW h
1 lbf/in ²	= 6.894 76 kN/m ²
1 lbf	= 4.448 22 N
1 hp	= 745.7 W
1 lbf ft	= 1.36 N m

7 Exhaust smoke control

7.1 Introduction

7.1.1 Exhaust smoke is objected to as a result of its light obscuration characteristics (opacity). A relevant measure of smoke density is, therefore, the light absorption coefficient of an element of exhaust gas.

7.1.2 It has been shown by subjective observations that the limit of exhaust gas opacity which is visually acceptable decreases with the increase of gas flow.

7.1.3 For black smoke there is a near linear relationship between light obscuration and soot concentration (gravimetric density, i.e. g/m³). It has been found experimentally that when the exhaust gas opacity is expressed in these gravimetric units (C) the relation between acceptable exhaust gas density and exhaust volume flow (G), over the range from about 40 l/s to 150 l/s, is given by a simple formula $C/G = \text{constant}$.

In practice, the correlation between light obscuration and soot concentration cannot be determined with sufficient accuracy for the units to be used interchangeably with mean correlation curves, and hence for the purpose of this standard, exhaust gas opacity is defined and measured directly by light obscuration smokemeters (opacimeters). The symbols referred to above are as follows:

G is the nominal gas flow for naturally aspirated and for pressure-charged engines;