

Testing earth-moving machinery

Part 4. Method for the evaluation of engine power output

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Road Engineering Standards Policy Committee (RDB/-) to Technical Committee RDB/21, upon which the following bodies were represented:

- AFRC Institute of Engineering Research
- Associated Offices Technical Committee
- British Coal Corporation
- Construction Industry Training Board
- Construction Plant-Hire Association
- Federation of Civil Engineering Contractors
- Federation of Manufacturers of Construction Equipment and Cranes
- Health and Safety Executive
- Institution of Civil Engineers
- Institution of Highways and Transportation
- Ministry of Defence

This British Standard, having been prepared under the direction of the Road Engineering Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 30 November 1990

© BSI 1990

The following BSI references relate to the work on this standard:
Committee reference RDB/21
Draft for comment 88/10937 DC

ISBN 0 580 19112 5

Amendments issued since publication

Amd. No.	Date	Text affected

Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Method	
1 Scope	1
2 Normative references	1
3 Definitions	1
4 Accuracy of measurements	1
5 Tests	3
6 Correction factors	5
7 Measurement of smoke value for compression-ignition engines	6
8 Test report	8
9 Statement of results	12
10 Expression of results	12
Annexes	
A Reference fuel CEC RF-01-A-80 for spark-ignition engines — Specifications — Premium gasoline leaded	15
B Reference fuel CEC RF-03-A-84 for compression-ignition engines — Specifications	16
C Reference fuel CEC RF-08-A-85 for spark-ignition engines — Specifications — Premium gasoline unleaded	17
D Bibliography	18
Tables	
1 Installation of auxiliaries during test	2
2 Setting conditions	4
Figures	
1 Engine factor, f_m , as a function of corrected fuel flow, q_c	7
2 Characteristic curves of torque, power and fuel consumption	14

National foreword

This Part of BS 6911 has been prepared under the direction of the Road Engineering Standards Policy Committee. It is identical with ISO 9249 : 1989 'Earth-moving machinery — Engine test code — Net power' published by the International Organization for Standardization (ISO).

Cross-references

International standard	Corresponding British Standard
ISO 6165 : 1987	BS 6914 Terminology (including definitions of dimensions and symbols) for earth-moving machinery Part 1 : 1988 Glossary of terms for basic types of earth-moving machinery (Identical)

The Technical Committee has reviewed the provisions of ISO 3173, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

ISO 1585 is listed for information only and does not affect the validity of this British Standard.

NOTE. ISO 1585, the terminology of which is based on ISO 2710 : 1978 'Reciprocating internal combustion engines — Vocabulary' is also the basis for the following parallel documents:

- ISO 2288 : 1989 Agricultural tractors and machines — Engine test code (bench test) — Net power
- ISO 4106 : 1978 Road vehicles — Motorcycles — Engine test code — Net power
- ISO 4164 : 1978 Road vehicles — Mopeds — Engine test code — Net power

Annexes A, B, C, and D of this international standard are for information only.

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

Earth-moving machinery — Engine test code — Net power

1 Scope

This International Standard specifies a method for testing internal combustion engines intended for propulsion of earth-moving machinery as defined in ISO 6165. It applies to evaluation of performance with a view in particular to presenting curves of power and specific fuel consumption at full load as a function of engine speed. The engines may be naturally aspirated or pressure-charged.

IOTE — This International Standard is in conformity with ISO 1585; it relates to tests on an engine capable of being fitted into earth-moving machinery.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1585 : 1982, *Road vehicles — Engine test code — Net power*.

ISO 3173 : 1974, *Road vehicles — Apparatus for measurement of the opacity of exhaust gas from diesel engines operating under steady state conditions*.

ISO 6165 : 1987, *Earth-moving machinery — Basic types — Vocabulary*.

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 net power : Power obtained on a test bed at the end of the crankshaft or its equivalent at the corresponding engine speed with the auxiliaries listed in table 1. If the power measurement can be carried out only with the gear-box mounted, the efficiency of the gear-box shall be taken into account.

3.2 auxiliaries : Equipment and devices listed in table 1.

3.3 standard production equipment : Any equipment provided by the manufacturer for the particular engine application.

4 Accuracy of measurements

4.1 Torque

The dynamometer torque-measuring system shall give an accuracy within $\pm 1\%$ in the range of scale values required for the test. It shall be calibrated to take friction losses into account.

4.2 Engine rotational frequency

Engine rotational frequency shall be measured preferably with a revolution counter and an automatically synchronized chronometer (or counter timer). The accuracy of the measured value shall be $\pm 0,5\%$.

4.3 Fuel consumption

Accuracy of fuel consumption measurements shall be $\pm 1\%$ overall for the apparatus used.

4.4 Fuel temperature

Accuracy of fuel temperature measurements shall be to within $\pm 2\text{ K}$ ($\pm 2\text{ }^{\circ}\text{C}$).

4.5 Air temperature

The accuracy of this temperature measurement shall be $\pm 2\text{ K}$ ($\pm 2\text{ }^{\circ}\text{C}$).

4.6 Barometric pressure

Barometric pressure shall be measured to $\pm 100\text{ Pa}$ ($\pm 1\text{ mbar}^{1)}$.

4.7 Pressure in exhaust duct

Subject to footnote 2) to table 1, this pressure shall be measured to $\pm 200\text{ Pa}$ ($\pm 2\text{ mbar}^{1)}$.

4.8 Pressure in intake duct

Subject to footnote 1) to table 1, this pressure shall be measured to $\pm 50\text{ Pa}$ ($\pm 0,5\text{ mbar}^{1)}$.

1) $1\text{ bar} = 10^5\text{ Pa}$

Table 1 — Installation of auxiliaries during test

No.	Auxiliaries	Fitted for net power test
1	Intake system Intake manifold Crankcase emission control system Air filter ¹⁾ Intake silencer and duct work ¹⁾ Speed-limiting device ¹⁾	Yes, standard production equipment
2	Induction-heating device of intake manifold	Yes, standard production equipment. If possible, to be set in the most favourable condition.
3	Exhaust system Exhaust purifier Manifold Connecting pipes ²⁾ Silencer ²⁾ Tail pipe ²⁾ Exhaust brake ³⁾	Yes, standard production equipment
4	Fuel supply pump ⁴⁾	Yes, standard production equipment
5	Carburettor Electronic control system, air-flow meter, etc. (if fitted) Pressure reducer Evaporator Mixer	Yes, standard production equipment Equipment for gas engine
6	Fuel injection equipment Prefilter Filter Pump High-pressure pipe Injector Air intake valve (if fitted) ⁵⁾ Governor (if fitted)	Yes, standard production equipment

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

- where there is a risk of noticeable influence upon engine power;
- in case of two-stroke and spark-ignition engines;
- when the manufacturer requests that this should be done.

In other cases an equivalent system may be used and a check made to ascertain that intake pressure does not differ by more than ± 100 Pa (± 1 mbar) from the limit specified by the manufacturer for a clean air filter.

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

- where there is a risk of noticeable influence upon engine power;
- in case of two-stroke and spark-ignition engines;
- when the manufacturer requests that this should be done.

In other cases, an equivalent system may be installed providing pressure measurement at the outlet of the engine exhaust system does not differ by more than $\pm 1\,000$ Pa (± 10 mbar) from that specified by the manufacturer.

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

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

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

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

Table 1 — (concluded)

No.	Auxiliaries	Fitted for net power test
7	Liquid cooling equipment ⁶⁾ Engine bonnet Bonnet air outlet Radiator Fan ^{6), 7)} Fan cowl Water pump Thermostat ⁸⁾	No Yes, standard production equipment
8	Air cooling Cowl Fan or blower ^{6), 7)} Auxiliary test bed fan Temperature regulating device	Yes, standard production equipment Yes, if necessary Yes, standard production equipment
9	Electrical equipment ⁹⁾	Yes, standard production equipment
10	Pressure-charging equipment (if fitted) Compressor — driven either directly or indirectly by the engine (supercharger), and/or by the exhaust gases (turbocharger) Intercooler ¹⁰⁾ Coolant pump or fan (engine-driven) Coolant flow control device (if fitted)	Yes, standard production equipment
11	Anti-pollution devices	Yes, standard production equipment

6) The radiator, fan, fan cowl, water pump and thermostat shall be located on the test bed in the same relative positions as those they will occupy on the machine. The cooling liquid circulation shall be operated by the engine water pump only.

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

Where the fan, radiator and cowl system cannot conveniently be fitted to the engine, the power absorbed by the fan when separately mounted in its correct position in relation to the radiator and cowl (if used) shall be determined at the speeds corresponding to the engine speeds used for measurement of the engine power either by calculation from standard characteristics or by practical tests. This power corrected to the standard atmospheric condition defined in 6.2 should be deducted from the corrected power.

7) Where a disconnectable or progressive fan or blower is incorporated, the test shall be made with it disconnected or running at maximum slip, as appropriate.

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

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

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

5 Tests

5.1 Auxiliaries

5.1.1 Auxiliaries to be fitted

During the test, auxiliaries necessary to make the engine acceptable for service in the intended application (as listed in table 1) shall be installed on the test bed as far as possible in the same position as in the intended application.

5.1.2 Auxiliaries to be removed

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

- machine hydraulic system(s) pumps;
- air compressor for brakes;

- power-steering pump;
- air-conditioning system.

Where accessories cannot be removed, the power absorbed by them in the unloaded condition may be determined and added to the measured engine power.

5.1.3 Compression-ignition engine starting auxiliaries

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

- a) Electrical starting: the generator is fitted and supplies, where necessary, the auxiliaries indispensable to the operation of the engine.
- b) Starting other than electrical: if there are any electrically operated accessories indispensable to the operation of the engine, the generator is fitted to supply these accessories. Otherwise it is removed.

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

5.2 Setting conditions

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

Table 2 — Setting conditions

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

5.3 Test conditions

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

5.3.2 Performance data shall be obtained under stabilized operating conditions, with an adequate fresh air supply to the engine. The engine shall have been run-in in accordance with the manufacturer's recommendations. Combustion chambers may contain deposits, but in limited quantity. Test conditions such as inlet air temperature shall be selected as near to reference conditions (see 6.2) as possible in order to minimize the magnitude of the correction factor.

5.3.3 The temperature of the inlet air to the engine (ambient air) shall be measured not more than 0,15 m upstream of the point of entry to the air filter, or, if no air filter is used, within 0,15 m of the air inlet horn. The thermometer or thermocouple shall be shielded from radiant heat and located 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.

5.3.4 No data shall be taken until torque, rotational frequency and temperature have been maintained substantially constant for at least 1 min.

5.3.5 The engine rotational frequency during a run or reading shall not deviate from the selected rotational frequency by more than ± 1 % or ± 10 r/min, whichever is greater.

5.3.6 Observed brake load, fuel consumption and inlet air temperature data shall be recorded simultaneously and shall in each case be the average of two stabilized sustained readings which do not vary by more than 2 % for the brake load and fuel consumption.

5.3.7 The temperature of the coolant at the outlet from the engine shall be kept within ± 5 K (± 5 °C) of the upper thermostatically controlled temperature specified by the manufacturer. If no temperature is specified by the manufacturer, the temperature shall be 353 K ± 5 K (80 °C ± 5 °C). For air-cooled engines, the temperature at a point indicated by the manufacturer shall be kept within ${}^0_{-20}$ K (${}^0_{-20}$ °C) of the maximum value specified by the manufacturer for the reference conditions.

5.3.8 The fuel temperature shall be controlled at the inlet to the fuel injection system to a temperature of 313 K ± 3 K (40 °C ± 3 °C). Where the test facility cannot maintain this fuel inlet temperature, a correction factor as calculated by 6.4 shall be applied.

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

5.3.10 An auxiliary regulation system may be used if necessary to maintain temperatures within limits specified in 5.3.7, 5.3.8 and 5.3.9.

5.3.11 For compression-ignition engines, the fuel shall be one supplied and delivered by the refinery to the customer without any smoke-suppressant additives. In cases of dispute, tests shall be made with the CEC¹⁾ reference fuel CEC RF-03-A-84 (see annex B). For spark-ignition engines, in cases of dispute, tests shall be carried out using CEC reference fuel CEC RF-01-A-80 or CEC RF-08-A-85 (see annex A or C).

5.4 Test procedure

Record data at a sufficient number of engine rotational frequencies to define the engine torque curve between the manufacturer's rated engine rotational frequency and the engine rotational frequency at which maximum torque is developed. The average of at least two stabilized measurements is to be determined.

5.5 Data to be recorded

Data to be recorded are those indicated in clause 8.

1) Co-ordinating European Council for the Development of Performance Tests for Lubricants and Engine Fuels. These fuels can be obtained from the Council at
61 New Cavendish Street
London W1M 8AR
United Kingdom

This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.