
British Standard

Reciprocating internal combustion engines: Performance

Part 2. Test methods

Moteurs alternatifs à combustion interne: Performances
Partie 2. Méthodes d'essai

Kolbenverbrennungsmotoren: Leistungsfähigkeit
Teil 2. Prüfverfahren

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National foreword

This Part of BS 5514 has been prepared under the direction of the Machinery and Components Standards Committee, and is identical with ISO 3046-2 : 1987 'Reciprocating internal combustion engines — Performance — Part 2 : Test methods', published by the International Organization for Standardization (ISO).

It is a revision of BS 5514 : Part 2 : 1978, which is withdrawn.

BS 5514 covers the performance of reciprocating internal combustion engines. The series comprises:

- Part 1 Specification for standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption
- Part 2 Test methods
- Part 3 Test measurements
- Part 4 Speed governing
- Part 5 Torsional vibrations
- Part 6 Specification for overspeed protection
- Part 7 Specification for codes for engine power

Parts 1 to 6 supersede BS 649, BS 765, BS 2953 and BS 3109, which were withdrawn in 1979.

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used throughout as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words 'part of ISO 3046' appear, referring to this standard, they should be read as 'Part of BS 5514'.

Cross-references

International standard	Corresponding British Standard
ISO 3046/1-1986	BS 5514 Reciprocating internal combustion engines : Performance Part 1 : 1987 Specification for standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption (Identical)
ISO 3046/3-1979	Part 3 : 1979 Test measurements (Technically equivalent)
ISO 3046/4-1978	Part 4 : 1979 Speed governing (Identical)
ISO 3046/5-1978	Part 5 : 1979 Torsional vibrations (Identical)
ISO 3046/6-1982	Part 6 : 1983 Specification for overspeed protection (Identical)

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

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Reciprocating internal combustion engines: Performance

Part 2. Test methods

1 Scope

This part of ISO 3046 specifies acceptance and type test methods for reciprocating internal combustion engines in commercial production. Where necessary, individual requirements are given for particular engine applications.

2 Field of application

This part of ISO 3046 covers reciprocating internal combustion engines for land, rail-traction and marine use, excluding engines used to propel agricultural tractors, road vehicles and aircraft.

This part of ISO 3046 may be applied to engines used to propel road construction and earth-moving machines, industrial trucks and for other applications where no suitable International Standard for these engines exists.

This part of ISO 3046 may be applied to tests on a test bed at the manufacturer's works and to tests on site (see 7.1.4).

3 References

ISO 3046, *Reciprocating internal combustion engines — Performance* —

Part 1: Standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption.

Part 3: Test measurements.

Part 4: Speed governing.

Part 5: Torsional vibrations.

Part 6: Overspeed protection.

4 Definitions

For the purposes of this part of ISO 3046, the following definitions apply.

4.1 acceptance test: Test carried out as an overall check on the manufacturing quality, and to establish that the contractual commitments have been fulfilled.

4.2 type test: Test carried out on representative engines of a certain engine type to establish the main performance data of the engine and, as far as possible, to enable their reliability and durability in service to be assessed.

4.3 special test: Test additional to acceptance or type tests carried out to meet the requirements of inspecting and legislative authorities, Classification Societies or customers.

NOTE — Special tests are subject to agreement between the manufacturer and customer.

4.4 power adjustment: Calculation procedure by which a power at one set of ambient conditions is modified to represent the power expected under another set of ambient conditions. Power adjustment may require engine adjustment. (See 4.6 and 7.2.1.)

4.5 power correction: Calculation procedure by which a power determined under engine test conditions is modified so that it represents the power expected under other operational or reference conditions without any engine adjustment.

4.6 engine adjustment: Physical procedure of modifying an engine for the purpose of adapting it to a different set of ambient conditions, such as by moving the limiting fuel stop, re-matching the turbocharger, changing the fuel injection timing or other mechanical changes.

5 Designation of tests

This part of ISO 3046 gives two test categories: reference may be made to the relevant category of test as follows:

- ISO 3046-2 — A (for acceptance tests; see 10.1);
- ISO 3046-2 — T (for type tests; see 10.2).

6 Extent of tests

6.1 The programme of acceptance and type tests shall be established by the manufacturer.

6.2 It is the responsibility of the manufacturer to define the extent of measurements, which shall be agreed with the customer. Table 1 may be taken as a guide for selecting the engine groups appropriate to the test measurements given in list A (see table 2).

Table 1 — Measurement selection guide

Engine group number	Typical characteristics of engine group
1	Engines the operating conditions of which are not measured in service, usually with maximum design speeds of more than 1 800 min ⁻¹
2	Naturally aspirated engines with maximum design speeds of approximately 1 500 min ⁻¹ and above
3	Pressure-charged engines with maximum design speeds of approximately 1 500 min ⁻¹ and above
4	Engines with maximum design speeds of approximately 250 to 1 500 min ⁻¹
5	Engines with maximum design speeds up to 250 min ⁻¹

6.3 For mass-produced engines not all tested on load, an adequate inspection procedure may be used instead of a full acceptance test.

6.4 Dependent on the test categories and the engine group number, five lists of recommended test measurements, calculated values and functional checks (lists A, B, C, D, E) are given in clause 10.

7 Test conditions

7.1 General

7.1.1 Before an engine test, the manufacturer shall submit the necessary technical documentation concerning the engine type and application, when mutually agreed between the manufacturer and the customer.

7.1.2 A period of running-in and preliminary tests considered adequate by the manufacturer shall precede the acceptance or type test.

7.1.3 The measurements for an acceptance or type test shall be carried out only when the engine has reached stable operating conditions as specified by the manufacturer.

7.1.4 Unless otherwise agreed between the manufacturer and the customer, tests shall be carried out on a test bed at the manufacturer's works.

7.1.5 Tests shall be carried out on the engine equipped with dependent auxiliaries necessary for its operation either supplied with the engine or belonging to the test bed equipment.

7.1.6 Test bed equipment may be used, provided that the contractual requirements are fulfilled.

7.1.7 Only those engines which are supplied with built-in transmission systems (for example, hydraulic mechanisms, reversing couplings) or electric generators, and which cannot be tested separately, need to be tested with the transmission systems or generator coupled to the engine.

If engines are tested with coupled driven machinery or a transmission system which is separable, then any variation in power, due to these coupled items, shall be eliminated from a power declared in accordance with ISO 3046-1.

7.1.8 If the acceptance test is carried out on site and the rated power at the corresponding speed cannot be verified or achieved, due to the special circumstances of the installation and/or situation of the installation, the manufacturer and the customer shall accept the test report of the test on the manufacturer's works test bed as valid, and verify only

- the declared speed at a power other than the rated power; or
- the rated power at a speed other than the rated speed.

In either case the measurement of the fuel consumption shall be omitted.

7.1.9 During tests on the engine no additional measures, other than those required to maintain the test conditions and those required for normal operation as given in the working manual, may be made.

7.1.10 The only interruptions in testing permitted are those necessary for engine maintenance as given in the working manual. In all other cases, if an interruption should occur caused by some defect of parts of the engine, the decision on whether to repeat the tests partially or entirely shall be agreed between the manufacturer and the customer.

7.1.11 The standard reference conditions and declarations of power, fuel and lubricating oil consumption shall be as specified in ISO 3046-1.

7.1.12 In cases where it is not possible to maintain the specified ambient conditions and the fuel or fluid properties for the acceptance or type test, the influence of the differing conditions and/or properties and the necessary correction of test results shall be subject to agreement between the manufacturer and customer.

NOTE — In dual-fuel engines the acceptance test is carried out with liquid fuel. An additional acceptance test with gaseous fuel may be stipulated by agreement if gaseous fuel is available at the manufacturer's works with approximately the same ignition characteristic as the gaseous fuel available on site.

In the case of spark-ignition gas engines and pilot injection gas engines, the acceptance test may be carried out at the manufacturer's works only if the composition and ignition characteristics of the gaseous fuel available are approximately the same as those of the gaseous fuel used on site.

If the acceptance test must be carried out on the basis of a special agreement at the manufacturer's works with a gaseous fuel with chemical values and properties differing significantly from those on

site, the test can be made at agreed values of rated power, rated speed and fuel consumption by resetting the engine accordingly. In such a case a readjustment of the engine is necessary for the engine operation with the contractually specified gaseous fuel which is used on site.

7.2 Power adjustment, specific fuel consumption adjustment and power correction

These procedures will be carried out to determine

- whether the values of power and fuel consumption attained under engine test ambient conditions correspond to the declared values;
- the permissible maximum power under test ambient conditions to prevent the engine overloading which excess air allows.

Two possible cases are recognized :

- a) Adjusted engines, where the power is adjusted to control the limiting performance parameters when the ambient conditions differ from the standard reference conditions (e.g. to maintain an approximately constant thermal and/or mechanical load on critical engine components). (See 7.2.1.)
- b) Non-adjusted engines, where the fuel settings are pre-set, so the power and performance parameters may vary as a function of ambient conditions. (See 7.2.2.)

7.2.1 Adjusted engines

The test power may be determined, using the formulae in ISO 3046-1 where necessary, in one or more of the following ways :

- a) By adjusting the ISO power from standard reference conditions to test ambient conditions.
- b) By adjusting the declared service power from the site ambient conditions to the power under test ambient conditions.
- c) By making the test power equal to the declared service power and testing under conditions altered artificially according to 7.2.1.4 to simulate the site ambient conditions.
- d) By testing under conditions simulating some of the site ambient conditions according to 7.2.1.4 and adjusting the declared service power to allow for the remaining differences.

NOTE — Power adjustment by using formulae from ISO 3046-1 is only permissible if the turbocharging equipment or timing of the engine is not changed or modified for site ambient conditions.

7.2.1.1 When adjusting the power, the engine manufacturer shall specify which of the formulae given in ISO 3046-1 : 1986, table 1, shall be used.

If there is no suitable formula for power adjustment in ISO 3046-1, the method of adjustment shall be agreed in writing by the manufacturer and the customer.

7.2.1.2 If a turbocharged engine at the declared power and under the standard reference conditions attains neither the turbocharger speed limit nor the exhaust gas temperature limit at the turbine inlet, the manufacturer may declare substitute reference conditions as specified in ISO 3046-1 for the power adjustment.

7.2.1.3 When adjusting the site-declared power for test ambient conditions, results may be attained where for example the maximum combustion pressure in the engine cylinder exceeds the permitted value. In this case the engine test shall be carried out at such a power considered safe by the manufacturer, at which the permitted value is not exceeded.

The values of the engine parameters corresponding to the required power may be extrapolated from the measured values by a method to be agreed between the manufacturer and the customer.

7.2.1.4 Engine tests may be carried out under ambient conditions created artificially to simulate site ambient conditions : the following methods may be used :

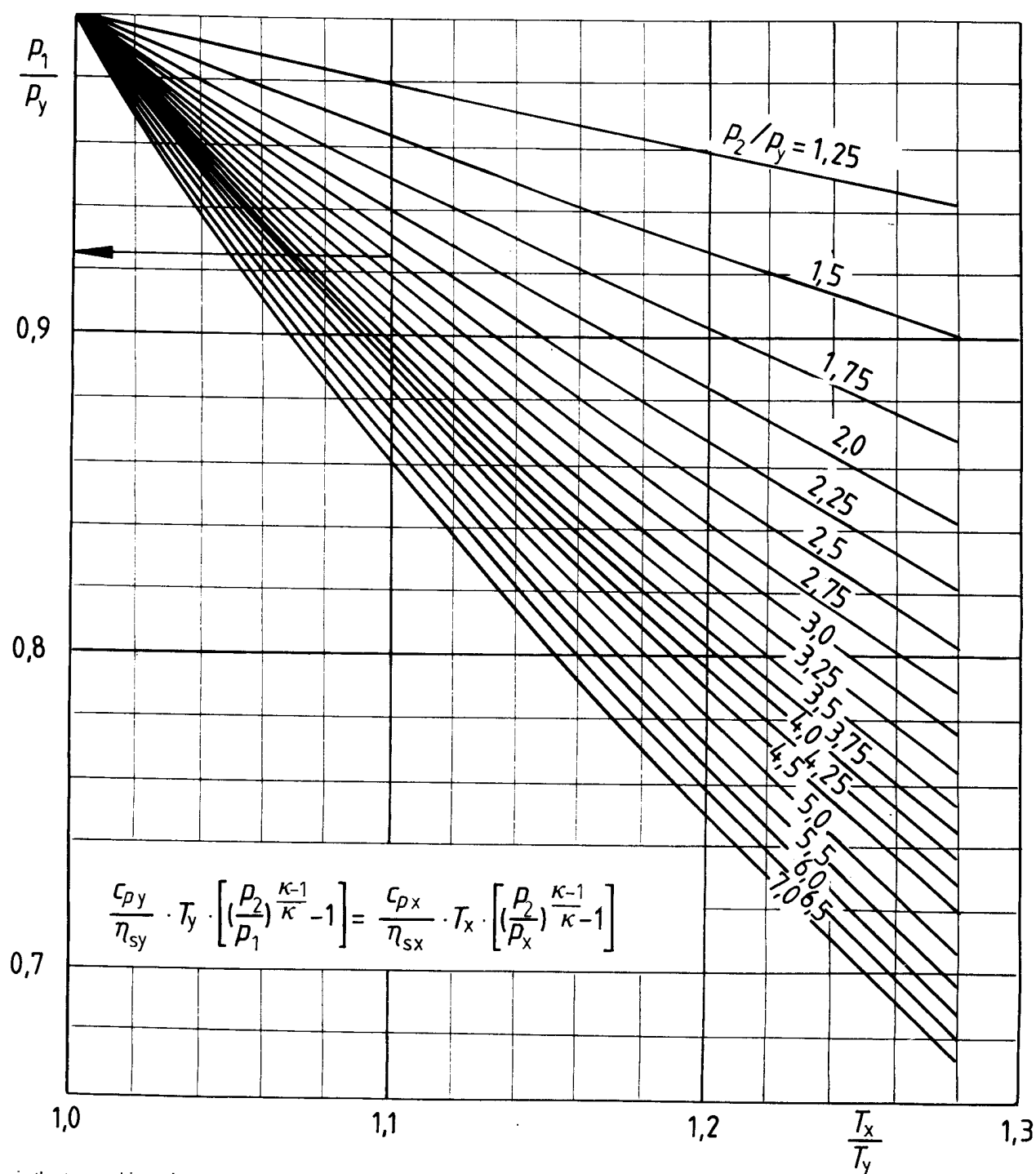
- a) Throttling of the engine (turbocharger) inlet with simultaneous depression at the outlet and in the crankchamber by an extractor device. Maximum vacuum shall not exceed the limits set by the turbocharger manufacturer.
- b) Increasing the air temperature at the engine inlet by artificial heating.
- c) Altering the coolant temperature at the inlet of the charge air cooler, etc.
- d) On pressure-charged engines having a charge air cooler, the effect of increased ambient temperature can be easily simulated by throttling at the turbocharger inlet and controlling the air temperature after the charge air cooler to be the same as that on site. The throttle ratio can be determined using figure 1.

NOTE — Examples illustrating how power adjustment, specific fuel consumption adjustment and simulation of high on-site ambient temperature are applied when testing are given in annex A.

7.2.2 Non-adjusted engines (engines with pre-set fuel settings)

Where the test conditions differ from the standard reference conditions, the method in clause 8 may be used for power correction of measured power to standard reference conditions (correction by calculation).

7.2.3 The manufacturer shall specify which method (power adjustment or power correction) is applicable to his engine with respect to 7.2.4.



- p_y is the test ambient air pressure
 p_x is the site ambient air pressure
 p_1 is the air pressure after throttle
 p_2 is the air pressure at the compressor outlet
 T_y is the test ambient air temperature
 T_x is the site ambient air temperature
 κ is the adiabatic index
 c_{py} is the test specific heat capacity at constant pressure
 c_{pX} is the site specific heat capacity at constant pressure
 η_{sy} is the test adiabatic compressor efficiency
 η_{sX} is the site adiabatic compressor efficiency
 Δh_y is the test specific enthalpy difference
 Δh_x is the site specific enthalpy difference

NOTES

- Example 2 in clause A.2 of annex A provides an example of the application of figure 1.
- The following conventional assumptions are made:
 - equal compressor work;
 - equal pressure at the compressor outlet;
 - equal charge air temperature after cooler;
 - equal air consumption through compressor;
 - difference between c_{py} and c_{pX} is neglected;
 - adiabatic compressor efficiency is taken constant.

Figure 1 — Determination of depression at compressor inlet when simulating high on-site air temperature