

---

---

**Internal combustion engines —  
Determination and method for the  
measurement of engine power —  
General requirements**

*Moteurs à combustion interne — Détermination et méthode de  
mesure de la puissance du moteur — Exigences générales*



STANDARDSISO.COM : Click to view the full PDF of ISO 15550 :2016



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2016, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Ch. de Blandonnet 8 • CP 401  
CH-1214 Vernier, Geneva, Switzerland  
Tel. +41 22 749 01 11  
Fax +41 22 749 09 47  
copyright@iso.org  
www.iso.org

# Contents

|                                                                                                                                                 | Page      |
|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| Foreword .....                                                                                                                                  | iv        |
| Introduction .....                                                                                                                              | v         |
| <b>1 Scope .....</b>                                                                                                                            | <b>1</b>  |
| <b>2 Normative references .....</b>                                                                                                             | <b>1</b>  |
| <b>3 Terms and definitions .....</b>                                                                                                            | <b>2</b>  |
| <b>4 Symbols .....</b>                                                                                                                          | <b>11</b> |
| <b>5 Standard reference conditions .....</b>                                                                                                    | <b>17</b> |
| <b>6 Tests .....</b>                                                                                                                            | <b>17</b> |
| 6.1 General .....                                                                                                                               | 17        |
| 6.2 Test method 1 .....                                                                                                                         | 17        |
| 6.2.1 Preamble .....                                                                                                                            | 17        |
| 6.2.2 Test designation .....                                                                                                                    | 17        |
| 6.2.3 Extent of tests .....                                                                                                                     | 17        |
| 6.2.4 Measurement techniques .....                                                                                                              | 18        |
| 6.2.5 Test conditions .....                                                                                                                     | 19        |
| 6.2.6 Test procedures .....                                                                                                                     | 21        |
| 6.3 Test method 2 .....                                                                                                                         | 24        |
| 6.3.1 General .....                                                                                                                             | 24        |
| 6.3.2 Measuring equipment and instrument accuracy .....                                                                                         | 24        |
| 6.3.3 Setting conditions .....                                                                                                                  | 25        |
| 6.3.4 Test conditions .....                                                                                                                     | 25        |
| 6.3.5 Test procedure .....                                                                                                                      | 27        |
| 6.3.6 Data to be recorded .....                                                                                                                 | 27        |
| <b>7 Method of power correction .....</b>                                                                                                       | <b>27</b> |
| 7.1 General .....                                                                                                                               | 27        |
| 7.2 Test atmospheric conditions .....                                                                                                           | 27        |
| 7.3 Correction factor $\alpha_a$ for naturally aspirated and pressure-charged spark-ignition engines (with or without charge air cooling) ..... | 28        |
| 7.4 Correction factor $\alpha_c$ for compression-ignition (diesel) engines .....                                                                | 28        |
| 7.4.1 General .....                                                                                                                             | 28        |
| 7.4.2 Atmospheric factor $f_a$ .....                                                                                                            | 28        |
| 7.4.3 Engine factor, $f_m$ .....                                                                                                                | 29        |
| 7.4.4 Limitation in use of correction factor equation .....                                                                                     | 30        |
| 7.5 Other types of engine .....                                                                                                                 | 30        |
| <b>8 Measurement and correction of smoke value for compression-ignition (diesel) engines .....</b>                                              | <b>30</b> |
| 8.1 General .....                                                                                                                               | 30        |
| 8.2 Correction factor for the smoke light absorption coefficient .....                                                                          | 31        |
| 8.3 Determination of the correction factor for the smoke light absorption coefficient .....                                                     | 31        |
| 8.4 Limits of application .....                                                                                                                 | 31        |
| <b>9 Test report .....</b>                                                                                                                      | <b>31</b> |
| 9.1 Test method 1 .....                                                                                                                         | 31        |
| 9.1.1 General .....                                                                                                                             | 31        |
| 9.1.2 Type test report .....                                                                                                                    | 31        |
| 9.2 Test method 2 .....                                                                                                                         | 32        |
| 9.2.1 General .....                                                                                                                             | 32        |
| 9.2.2 Type test report .....                                                                                                                    | 32        |
| <b>Bibliography .....</b>                                                                                                                       | <b>43</b> |

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 70, *Internal combustion engines*.

This second edition cancels and replaces the first edition (ISO 15550:2002), of which it constitutes a minor revision.

## Introduction

This document establishes the framework for ISO engine power measurement standards. By applying this framework, the disadvantages of the existence of many similar, but different, ISO standards for the definition and determination of engine power can be avoided.

This framework uses the “Core” and “Satellite” approach. The “Core” standard contains the requirements that are common to all engine applications described in the scope and the “Satellite” standard contains those requirements that are necessary to tailor power measurement and declaration to suit a particular engine application.

This document is only applicable in conjunction with a particular “Satellite” standard in order to completely specify the requirements for the particular engine application. The “Core” standard, therefore, is not a document that can stand alone, but only represents addenda to a particular “Satellite” standard used to create a complete standard together with the said “Satellite” standard.

The advantage of this approach is that the use of standards for the same or similar engines used in different applications will be rationalized and the harmonization of standards in the course of revision or development will be ensured.

This document is the “Core” standard.

This document was prepared in order to serve as the “Core” standard for making engine power measurements. It was drafted in close co-operation with technical committees ISO/TC 22 *Road vehicles*, ISO/TC 23 *Machinery for forestry and agriculture*, ISO/TC 127 *Earth moving machinery* and ISO/TC 188 *Small craft*. The prerequisite for any future modification of this document will be the formal approval of all the above technical committees. Together with the “Satellite” standard for each engine application, the “Core” standard serves as the basis for engine power declaration and measurement. Each technical committee is fully responsible for the administration of its own “Satellite” standard(s).

Any further requirements are subject to agreement between the manufacturer and customer.

STANDARDSISO.COM : Click to view the full PDF of ISO 15550 :2016

# Internal combustion engines — Determination and method for the measurement of engine power — General requirements

## 1 Scope

**1.1** This document specifies standard reference conditions and methods of declaring the power, fuel consumption, lubricating oil consumption and test methods for internal combustion engines in commercial production using liquid or gaseous fuels. It is applicable to the following:

- a) reciprocating internal combustion (RIC) engines (spark-ignition or compression-ignition engines) but excluding free piston engines;
- b) rotary piston engines.

These engines can be naturally aspirated or pressure-charged either using a mechanical pressure-charger or turbocharger.

**1.2** This document is applicable to engines used for the following:

- a) land, rail-traction and marine use as defined in ISO 3046-1;
- b) the propulsion of automotive vehicles as defined in ISO 1585 and ISO 2534;
- c) motorcycles as defined in ISO 4106;
- d) the propulsion of agricultural tractors and machines
- e) the propulsion of earth-moving machinery as defined in ISO 9249;
- f) the propulsion of recreational craft or other small marine craft up to 24 m hull length as defined in ISO 8665.

This document can be applied to engines used to propel road construction machines, industrial trucks and for other applications where no suitable International Standard for these engines exists.

It also can be applied to tests performed both on a test bed at a manufacturer's works as well as on site.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2710-1, *Reciprocating internal combustion engines — Vocabulary — Part 1: Terms for engine design and operation*

ISO 3046-4, *Reciprocating internal combustion engines — Performance — Part 4: Speed governing*

ISO 3046-5, *Reciprocating internal combustion engines — Performance — Part 5: Torsional vibrations*

ISO 3046-6, *Reciprocating internal combustion engines — Performance — Part 6: Overspeed protection*

ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3675, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method*

ISO 5163, *Petroleum products — Determination of knock characteristics of motor and aviation fuels — Motor method*

ISO 5164, *Petroleum products — Determination of knock characteristics of motor fuels — Research method*

ISO 5165, *Petroleum products — Determination of the ignition quality of diesel fuels — Cetane engine method*

ISO 11614, *Reciprocating internal combustion compression-ignition engines — Apparatus for measurement of the opacity and for determination of the light absorption coefficient of exhaust gas*

ASTM D 240, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter*

ASTM D 3338/D 3338M, *Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2710-1, ISO 3046-4, ISO 7876-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### 3.1 Auxiliaries and equipment

##### 3.1.1

##### **dependant auxiliary**

item of equipment, the presence or absence of which affects the final shaft power output of the engine

##### 3.1.2

##### **independent auxiliary**

item of equipment that uses power supplied from a source other than the engine

##### 3.1.3

##### **essential auxiliary**

item of equipment that is essential for the continued or repeated operation of the engine

##### 3.1.4

##### **non-essential auxiliary**

item of equipment that is not essential for the continued or repeated operation of the engine

##### 3.1.5

##### **standard production equipment**

##### **SPE**

equipment specified by the manufacturer for a particular engine application that is fitted as standard to the engine

## 3.2 Engine

### 3.2.1

#### **engine adjustment**

physical procedure of modifying an engine for the purpose of adapting it to deliver a power adjusted 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 physical changes

Note 1 to entry: Once the modifications have been completed, the engine is an adjusted engine.

### 3.2.2

#### **non-adjusted engine**

engine which is pre-set so that no physical procedure of modifying the engine for the purpose of adapting it to a different set of ambient conditions is carried out

### 3.2.3

#### **engine speed**

number of revolutions of the crankshaft in a given period of time

[SOURCE: ISO 2710-1:2000, 11.1]

### 3.2.4

#### **declared engine speed**

engine speed corresponding to the *declared power* ([3.3.1](#))

[SOURCE: ISO 2710-1:2000, 11.1.2 — modified]

Note 1 to entry: In some applications, the declared engine speed is named “rated speed”.

### 3.2.5

#### **declared intermediate engine speed**

engine speed less than 100 % of the declared speed, declared by the manufacturer taking into account the specific requirement defined in the relevant “Satellite” standard

### 3.2.6

#### **low idle engine speed**

##### **idling speed**

lowest steady-state engine speed without load

[SOURCE: ISO 2710-1:2000, 11.1.4 — modified]

### 3.2.7

#### **engine speed at maximum torque**

engine speed at maximum torque on maximum fuel stop, including additional torque fuel setting, if applicable

[SOURCE: ISO 3046-4:2009, 2.3.13 — modified]

## 3.3 Power and load

### 3.3.1

#### **declared power**

value of the power, declared by the manufacturer, which an engine will deliver under a given set of circumstances

Note 1 to entry: In some applications, the declared power is named “rated power”.

#### 3.3.1.1

##### **declared propeller shaft power**

value of the power, declared by the manufacturer, at the propeller shaft of an engine sold with complete propulsion units or at the coupling to the propeller shaft of an engine sold with reduction and/or reversing gears

**3.3.1.2****declared crankshaft power**

value of the power, declared by the manufacturer, at the engine power output shaft of an engine sold without reduction or reversing gears, stern drives or sail drive units

**3.3.2****indicated power**

total power developed in the working cylinders as a result of the pressure of the working medium acting on the pistons

[SOURCE: ISO 2710-1:2000, 13.1]

**3.3.3****brake power**

power or the sum of the powers delivered at the end of the crankshaft or its equivalent, with the equipment and auxiliaries fitted as required by the relevant "Satellite" standard

Note 1 to entry: See [Table 1](#).

**Table 1 — Equipment and auxiliaries to be installed for the test to determine engine power**

| 1   | 2                                               | 3                                                                                                | 4                                                              | 5                                                         |
|-----|-------------------------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------|
| No. | Equipment and auxiliaries                       | Fitted for engine net power test in accordance with ISO 1585<br>ISO 8665<br>ISO 9249<br>ISO 4106 | Fitted for engine gross power test in accordance with ISO 2534 | Fitted for engine power test in accordance with ISO 14396 |
| 1   | Inlet system: Inlet manifold                    | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Crankcase emission control system               | Yes, if SPE                                                                                      | Optional                                                       | Yes, if SPE                                               |
|     | Control devices for dual induction              | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Inlet manifold system: Air flow meter           | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Air inlet ductwork                              | Yes, if SPE <sup>a</sup>                                                                         | Optional <sup>a</sup>                                          | Yes <sup>a</sup>                                          |
|     | Air filter                                      | Yes, if SPE <sup>a</sup>                                                                         | Optional <sup>a</sup>                                          | Yes <sup>a</sup>                                          |
|     | Inlet silencer                                  | Yes, if SPE <sup>a</sup>                                                                         | Optional <sup>a</sup>                                          | Yes <sup>a</sup>                                          |
|     | Speed-limiting device                           | Yes, if SPE <sup>a</sup>                                                                         | No                                                             | Yes <sup>a</sup>                                          |
| 2   | Induction-heating device of inlet manifold      | Yes, if SPE. If possible, to be set in the most favourable condition.                            |                                                                |                                                           |
| 3   | Exhaust system: Exhaust purifier                | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Exhaust manifold                                | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Pressure-charging device                        | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Connecting pipes                                | Yes, if SPE <sup>b</sup>                                                                         | Optional, may use minimum loss test bed system <sup>b</sup>    | Yes <sup>b</sup>                                          |
|     | Silencer                                        | Yes, if SPE <sup>b</sup>                                                                         |                                                                | Yes <sup>b</sup>                                          |
|     | Tail pipe                                       | Yes, if SPE <sup>b</sup>                                                                         |                                                                | Yes <sup>b</sup>                                          |
|     | Exhaust brake                                   | Yes, if SPE <sup>c</sup>                                                                         | No <sup>c</sup>                                                | No <sup>c</sup>                                           |
| 4   | Fuel supply pump                                | Yes, if SPE <sup>d</sup>                                                                         | Yes, if SPE <sup>d</sup>                                       | Yes, if SPE <sup>d</sup>                                  |
| 5   | Carburation equipment: Carburettor              | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Electronic control system, air flow meter, etc. | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Equipment for gas engines: Pressure reducer     | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |
|     | Evaporator                                      | Yes, if SPE                                                                                      | Yes, if SPE                                                    | Yes, if SPE                                               |

Table 1 (continued)

|    |                                                                                                           |                              |                              |                                                   |
|----|-----------------------------------------------------------------------------------------------------------|------------------------------|------------------------------|---------------------------------------------------|
|    | Mixer                                                                                                     | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
| 6  | Fuel injection equipment [spark-ignition (petrol) and compression-ignition (diesel)]:                     |                              |                              |                                                   |
|    | Prefilter                                                                                                 | Yes, if SPE                  | Optional                     | Yes, if SPE or test bed equipment                 |
|    | Filter                                                                                                    | Yes, if SPE                  | Optional                     | Yes, if SPE                                       |
|    | Fuel injection pump                                                                                       | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | High-pressure pipes                                                                                       | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | Injector                                                                                                  | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE <sup>e</sup>                          |
|    | Air inlet valve                                                                                           | Yes, if SPE <sup>e</sup>     | Yes, if SPE <sup>e</sup>     | Yes, if SPE                                       |
|    | Electronic control system, air flow meter, etc.                                                           | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | Governor/control system                                                                                   | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | Automatic full-load stop for the control rack depending on atmospheric conditions                         | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
| 7  | Liquid-cooling equipment: Radiator                                                                        | Yes, if SPE <sup>f</sup>     | No                           | No                                                |
|    | Fan                                                                                                       | Yes, if SPE <sup>f,g</sup>   | No <sup>f</sup>              | No                                                |
|    | Fan cowl                                                                                                  | Yes, if SPE <sup>f</sup>     | No                           | No                                                |
|    | Water pump                                                                                                | Yes, if SPE <sup>f</sup>     | Yes, if SPE                  | Yes, if SPE <sup>f</sup>                          |
|    | Thermostat                                                                                                | Yes, if SPE <sup>f,h</sup>   | Optional <sup>h</sup>        | Yes, if SPE <sup>h</sup>                          |
| 8  | Air cooling: Cowl                                                                                         | Yes, if SPE <sup>f</sup>     | No                           | No                                                |
|    | Fan or blower                                                                                             | Yes, if SPE <sup>f,g</sup>   | No <sup>f</sup>              | No <sup>i</sup>                                   |
|    | Temperature-regulating device                                                                             | Yes, if SPE                  | No                           | No                                                |
| 9  | Electrical equipment: Generator                                                                           | Yes, if SPE <sup>j</sup>     | Yes, if SPE <sup>j</sup>     | Yes, if SPE <sup>j</sup>                          |
|    | Spark distribution system                                                                                 | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | Coil or coils                                                                                             | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | Wiring                                                                                                    | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | Spark-plugs                                                                                               | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | Electronic control system including knock sensor/spark-retard system                                      | Yes, if SPE <sup>k</sup>     | Yes, if SPE <sup>k</sup>     | Yes, if SPE <sup>k</sup>                          |
| 10 | Pressure-charging equipment: Compressor driven either directly by the engine and/or by the exhaust gases: | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
|    | Boost control                                                                                             | Yes, if SPE <sup>l</sup>     | Yes, if SPE <sup>l</sup>     | Yes, if SPE <sup>l</sup>                          |
|    | Charge air cooler                                                                                         | Yes, if SPE <sup>f,g,m</sup> | Yes, if SPE <sup>f,g,m</sup> | Yes, if SPE, or test bed equipment <sup>i,m</sup> |
|    | Coolant pump or fan (engine-driven)                                                                       | Yes, if SPE                  | Yes, if SPE                  | No <sup>i</sup>                                   |
|    | Coolant flow control device                                                                               | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |
| 11 | Auxiliary test-bed fan                                                                                    | Yes, if necessary            | Yes, if necessary            | Yes, if necessary                                 |
| 12 | Anti-pollution device                                                                                     | Yes, if SPE <sup>n</sup>     | Yes, if SPE <sup>n</sup>     | Yes, if SPE <sup>n</sup>                          |
| 13 | Lubricating oil pump                                                                                      | Yes, if SPE                  | Yes, if SPE                  | Yes, if SPE                                       |

**Table 1** (continued)

NOTE "Yes, if SPE" means that this equipment shall be fitted for the engine power determination if it is Standard Production Equipment (SPE).

a — For net power/gross power test:

If used (for gross power test) and except in the case where there is a risk of the system having a noticeable influence upon engine power, an equivalent may be used. In this case, a check shall be made to ascertain that inlet depression does not differ by more than 100 Pa from the limit specified by the manufacturer for a clean air filter.

— For engine power test for ISO 8178:

The complete inlet system for the intended application shall be fitted

- where there is a risk of an appreciable effect on the engine power;
- in the case of naturally aspirated spark ignition engines;
- when the manufacturer requests that this should be done.

In other cases, an equivalent system may be used and a check shall be made to ascertain that the inlet pressure does not differ by more than 100 Pa from the upper limit specified by the manufacturer for a clean air filter.

b — For net power test:

Except in the case where there is a risk of the system having a noticeable influence upon engine power, an equivalent system may be used. In this case, a check shall be made to ascertain that the back-pressure in the engine exhaust system does not differ by more than 1 000 Pa from the upper limit specified by the manufacturer.

— For gross power test:

If used and except in the case where there is a risk of the system having a noticeable influence upon engine power, an equivalent system may be used. In this case, a check shall be made to ascertain that the back-pressure in the engine exhaust system does not differ by more than 1 000 Pa from that specified by the manufacturer. However, a minimum loss system may be used.

— For engine power test for ISO 8178:

The complete exhaust system for the intended application shall be fitted:

- where there is a risk of an appreciable effect on the engine power;
- in the case of naturally aspirated spark ignition engines;
- when the manufacturer requests that this should be done.

In other cases an equivalent system may be installed provided that the pressure measured does not differ by more than 1 000 Pa from the upper limit specified by the manufacturer.

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

d If necessary, the fuel feed pressure may be adjusted to reproduce the fuel pressures existing in the particular engine application (particularly when a "fuel return" system, e.g. to tank or filter, is used).

e The air inlet valve is the control valve for the pneumatic governor of the injection pump. The governor or the fuel injection equipment may contain other devices which may affect the amount of fuel injected.

Table 1 (continued)

f — For net power test:

The radiator, fan, fan cowl, water pump and thermostat shall be located on the test bed in the same relative positions that they are to occupy on the vehicle or machine. The cooling liquid circulation shall only be operated by the engine water pump.

Cooling of the liquid may be provided 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 remains substantially the same as those of the engine cooling system. The radiator shutter, if incorporated, shall be set 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 conditions defined in [Clause 5](#), shall be deducted from the corrected power.

— For gross power test:

When the engine cooling fan or blower is of the fixed type, that is neither disconnectable nor progressive, and it is fitted for the test, then the power absorbed shall be added to the test results. The fan or blower power shall be determined at the speeds corresponding to the engine speeds used for the measurement of engine power either by calculation from standard characteristics or by practical tests.

— For engine power test for ISO 8178:

The cooling-liquid circulation shall only be operated by the engine pump. Cooling of the liquid may be produced by an external circuit, such that the pressure loss in this circuit and the pressure at the pump inlet remain substantially the same as those of the engine cooling system.

g — For net power test:

Where a disconnectable or progressive fan or blower is incorporated, the test shall be performed with the fan or blower disconnected or with the progressive fan running at maximum slip.

— For gross power test:

Where a separate disconnectable or progressive fan or blower is incorporated for the charge air cooler, the test shall be performed with the disconnectable fan or blower disconnected or with the progressive fan running at maximum slip.

Table 1 (continued)

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| h | The thermostat may be fixed in the fully open position.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| i | When the cooling fan or blower is fitted for the test, the power absorbed shall be added to the test results. The power absorbed by the fan or blower shall be determined at the speeds used for the test either by calculation from standard characteristics or by practical tests.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| j | The electrical power of the generator shall be the minimum. It shall be limited to that necessary for operation of accessories which are indispensable for engine operation. If the connection of a battery is necessary, a fully charged battery in good condition shall be used.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| k | The spark advance shall be representative of in-use conditions established with the minimum octane fuel recommended by the manufacturer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| l | For engines equipped with variable boost as a function of charge or inlet air temperature, octane rating and/or engine speed, the boost pressure shall be representative of in-vehicle or in-machine conditions established with the minimum octane fuel as recommended by the manufacturer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| m | <p>— For net power test/gross power test:</p> <p>Charge air-cooled engines shall be tested with the charge air-cooling system operating, whether this system is liquid- or air-cooled. If the engine manufacturer prefers, a test bed system may replace an 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 in the test bed the same as those specified by the manufacturer for the system on the complete vehicle or machine.</p> <p>— For engine power test for ISO 8178:</p> <p>Charge air-cooled engines shall be tested with the charge air-cooling system operating, whether this system is liquid- or air-cooled. If the manufacturer prefers, a test bed system may replace an air-cooled cooler. In either case, the measurement of power at each speed shall be made with the maximum pressure drop and the minimum temperature drop of the engine air across the charge air-cooler in the test bed system the same as those specified by the manufacturer.</p> |
| n | These may include, e.g. Exhaust Gas Recirculation (EGR), catalytic converter, thermal reactor, secondary air-supply and fuel evaporation protection systems.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

**3.3.3.1****net power**

power obtained on a test bed at the end of the crankshaft or its equivalent at the corresponding engine speed with the equipment and auxiliaries specified by ISO 1585, ISO 8665, ISO 9249 or ISO 4106

Note 1 to entry: If the power measurement can only be carried out with a mounted gear-box, the losses in the gear-box should be added to the measured power to give the net engine power.

**3.3.3.2****gross power**

power obtained on a test bed at the end of the crankshaft or its equivalent at the corresponding engine speed with the equipment and auxiliaries specified by ISO 2534

Note 1 to entry: If the power measurement can only be carried out with a mounted gear-box, the losses in the gear-box should be added to the measured power to give the gross engine power.

**3.3.3.3****engine power for ISO 8178**

power obtained on a test-bed at the end of the crank-shaft or its equivalent, at the *declared engine speed* (3.2.4) specified by the manufacturer at the *declared power* (3.3.1) with the engine being fitted only with the equipment and auxiliaries specified in ISO 14396

**3.3.4****continuous power**

power which an engine is capable of delivering continuously, between the normal maintenance intervals stated by the manufacturer, at the stated speed and under stated ambient conditions, the maintenance prescribed by the manufacturer having been carried out

**3.3.5****overload power**

power which an engine may be permitted to deliver, with a duration and frequency of use depending on the service application, at stated ambient conditions, immediately after operating at the *continuous power* (3.3.4) restricted to 1 h in a 12 h time span

**3.3.6****fuel stop power**

power which an engine is capable of delivering during a stated period corresponding to its application, and stated speed and under stated ambient conditions, with the fuel limited so that this power cannot be exceeded

**3.3.7****ISO power**

power determined under the operating conditions of the manufacturer's test bed and adjusted or corrected as determined by the manufacturer to the standard reference conditions specified in ISO 14396

**3.3.7.1****ISO standard power**

continuous *brake power* (3.3.3) that the engine manufacturer declares that an engine is capable of delivering with only the essential dependent auxiliaries fitted, between the normal maintenance intervals as stated by the manufacturer, and under the following conditions:

- a) at a stated speed at the operating conditions of the engine manufacturer's test bed;
- b) with the *declared power* (3.3.1) adjusted or corrected as determined by the manufacturer to the standard reference conditions specified in ISO 14396;
- c) with the maintenance prescribed by the engine manufacturer having been carried out.

**3.3.8****service power**

power delivered under the ambient and operating conditions of an engine application

**3.3.8.1****service standard power**

continuous *declared power* (3.3.1) that the engine manufacturer declares that an engine is capable of delivering, with only the essential dependent auxiliaries fitted, between the normal maintenance intervals stated by the manufacturer and under the following conditions:

- a) at a stated speed at the ambient and operating conditions of the engine application;
- b) with the *declared power* (3.3.1) adjusted or corrected as determined by the manufacturer to the stated ambient and operating conditions of the engine application;
- c) with the maintenance prescribed by the engine manufacturer having been carried out.

**3.3.9****power adjustment**

calculation procedure by which a power value under one set of ambient conditions is modified to represent the power value expected under another set of ambient conditions, to maintain approximately constant thermal and/or mechanical load in critical engine components

### 3.3.10

#### **power correction**

calculation procedure by which a power value determined under engine test conditions is modified so that it represents the power value expected under other operating or reference conditions without any *engine adjustment* ([3.2.1](#))

Note 1 to entry: In this case, the power and performance parameters may vary as a function of ambient conditions (see [Clause 7](#)).

### 3.3.11

#### **load**

general term describing the magnitude of the “power” or “torque” demanded from the engine by its driven machinery and usually expressed relative to a *declared power* ([3.3.1](#)) or torque

Note 1 to entry: The term “load” is physically imprecise and should be avoided. For quantitative purposes, the terms “power” or “torque” should be used, instead of “load”, together with a statement of speed.

[SOURCE: ISO 2710-1:2000, 13.4]

### 3.3.12

#### **net torque**

torque transmitted on a test bed at the end of the crankshaft or its equivalent at the corresponding engine speed with the equipment and auxiliaries specified by ISO 1585, ISO 8665, ISO 9249 or ISO 4106

## 3.4 Consumption and delivery

### 3.4.1

#### **fuel consumption**

quantity of fuel consumed by an engine per unit of time at stated power and under stated ambient conditions

#### 3.4.1.1

##### **specific fuel consumption**

quantity of fuel consumed by an engine per unit of power and time

#### 3.4.1.2

##### **ISO specific fuel consumption**

name given to the specific fuel consumption at the *ISO standard power* ([3.3.7.1](#))

### 3.4.2

#### **fuel delivery**

metered volume (mass) of fuel delivered by a fuel injection system during one working cycle

[SOURCE: ISO 7876-1]

#### 3.4.2.1

##### **specific fuel delivery**

metered volume (mass) of fuel delivered by a fuel injection system during one working cycle per litre of engine swept volume

### 3.4.3

#### **lubricating oil consumption**

quantity of lubricating oil consumed by an engine per unit of time

[SOURCE: ISO 2710-1:2000, 14.3]

## 3.5 Tests

### 3.5.1

#### acceptance test

test carried out as an overall check of the manufacturing quality and to establish that the contractual commitments have been fulfilled

### 3.5.2

#### type test

test carried out on a representative engine of a certain engine type to establish its main performance data and, as far as possible, to enable its reliability and durability in service to be assessed

### 3.5.3

#### special test

test additional to acceptance or *type test* (3.5.2) carried out to meet the requirements of the inspecting and legislative authorities, classification societies or customers, e.g. type approval test

### 3.5.4

#### production conformity test

test performed to verify that a production engine meets the requirements of the declared design specification or approval

## 4 Symbols

The symbols used in [Formula \(1\)](#) to [Formula \(11\)](#) and in the relevant “Satellite” standard are given in [Table 2](#). Subscripts to these symbols are given in [Table 3](#).

Symbols and subscripts used in this document for parameters under measurement are given in [Table 4](#).

**Table 2 — Symbols**

| Symbol     |                    | Designation                                                                                          | Unit      |
|------------|--------------------|------------------------------------------------------------------------------------------------------|-----------|
| Common use | EDP representation |                                                                                                      |           |
| $a$        | A                  | Humidity factor                                                                                      | 1         |
| $b_r$      | BR                 | Specific fuel consumption under standard reference conditions                                        | kg/(kW·h) |
| $b_x$      | BX                 | Specific fuel consumption under site ambient conditions                                              | kg/(kW·h) |
| $b_y$      | BY                 | Specific fuel consumption under test ambient conditions                                              | kg/(kW·h) |
| $f_a$      | FA                 | Atmospheric factor                                                                                   | 1         |
| $f_m$      | FM                 | Engine factor (characteristic parameter for each type of engine)                                     | 1         |
| $k$        | K                  | Ratio of indicated power                                                                             | 1         |
| $m$        | M                  | Exponent of the dry air pressure ratio or total barometric pressure ratio                            | 1         |
| $n$        | N                  | Exponent of the ambient air thermodynamic temperature ratio                                          | 1         |
| $p_a$      | PD                 | Ambient dry barometric pressure during test                                                          | kPa       |
| $p_r$      | PR                 | Standard reference total barometric pressure                                                         | kPa       |
| $p_{ra}$   | PRA                | Substitute reference total barometric pressure                                                       | kPa       |
| $p_{sr}$   | PSR                | Standard reference saturated water vapour pressure                                                   | kPa       |
| $p_{sx}$   | PSX                | Ambient saturated water vapour pressure on site                                                      | kPa       |
| $p_{sy}$   | PSY                | Ambient saturated water vapour pressure during test                                                  | kPa       |
| $p_x$      | PX                 | Ambient total barometric pressure on site                                                            | kPa       |
| $p_y$      | PY                 | Ambient total barometric pressure during test                                                        | kPa       |
| $P$        | PP                 | Power measured at the end of the crankshaft or its equivalent                                        | kW        |
| $P_o$      | PPO                | Corrected net power; i.e. power under standard reference conditions and at the end of the crankshaft | kW        |
| $P_r$      | PPR                | Brake power under standard reference conditions                                                      | kW        |

Table 2 (continued)

| Symbol      |                    | Designation                                                                                                    | Unit         |
|-------------|--------------------|----------------------------------------------------------------------------------------------------------------|--------------|
| Common use  | EDP representation |                                                                                                                |              |
| $P_{ra}$    | PPRA               | Brake power under substitute reference conditions                                                              | kW           |
| $P_x$       | PPX                | Brake power under ambient conditions on site                                                                   | kW           |
| $P_y$       | PPY                | Brake power under ambient conditions during test                                                               | kW           |
| $q$         | Q                  | Fuel mass per cycle per litre of engine swept volume                                                           | mg/(cycle·l) |
| $q_c$       | QC                 | Fuel mass per cycle per litre of air available for combustion                                                  | mg/(cycle·l) |
| $r$         | R                  | Boost pressure ratio (ratio of absolute air pressure at the compressor outlet to that at the compressor inlet) | 1            |
| $r_r$       | RR                 | Boost pressure ratio under standard reference conditions                                                       | 1            |
| $r_{r,max}$ | RRMAX              | Maximum permissible boost pressure ratio under standard reference conditions                                   | 1            |
| $s$         | S                  | Exponent of the charge air coolant thermodynamic temperature ratio                                             | 1            |
| $t_{cr}$    | TCR                | Standard reference charge air coolant temperature                                                              | °C           |
| $t_{cx}$    | TCX                | Ambient charge air coolant temperature on site                                                                 | °C           |
| $t_r$       | TR                 | Standard reference ambient air temperature                                                                     | °C           |
| $t_x$       | TX                 | Ambient air temperature on site                                                                                | °C           |
| $T_{cr}$    | TTCR               | Standard reference charge air coolant thermodynamic temperature                                                | K            |
| $T_{cra}$   | TTCRA              | Substitute reference charge air coolant thermodynamic temperature                                              | K            |
| $T_{cx}$    | TTCX               | Ambient charge air coolant thermodynamic temperature on site                                                   | K            |
| $T_{cy}$    | TTCY               | Ambient charge air coolant thermodynamic temperature during test                                               | K            |
| $T_r$       | TTR                | Standard reference ambient air thermodynamic temperature                                                       | K            |
| $T_{ra}$    | TTRA               | Substitute reference ambient air thermodynamic temperature                                                     | K            |
| $T_x$       | TTX                | Ambient air thermodynamic temperature on site                                                                  | K            |
| $T_y$       | TTY                | Ambient air thermodynamic temperature during test                                                              | K            |
| $\alpha$    | ALP                | Power adjustment factor                                                                                        | 1            |
| $\alpha_a$  | ALPA               | Power correction factor for spark-ignition engines                                                             | 1            |
| $\alpha_c$  | ALPC               | Power correction factor for compression-ignition (diesel) engines                                              | 1            |
| $\alpha_m$  | ALPM               | Power correction factor for efficiency of the transmission                                                     | 1            |
| $\alpha_s$  | ALPS               | Correction factor for smoke light absorption coefficient                                                       | 1            |
| $\beta$     | BET                | Fuel consumption recalculation factor                                                                          | 1            |
| $\eta_i$    | ETAI               | Efficiency of each element constituting the transmission                                                       | 1            |
| $\eta_m$    | ETAM               | Mechanical efficiency                                                                                          | 1            |
| $\eta_t$    | ETAT               | Efficiency of the transmission which is located between the crankshaft and the measurement point               | 1            |
| $\phi_r$    | PPHIR              | Standard reference relative humidity                                                                           | %            |
| $\phi_x$    | PPHIX              | Ambient relative humidity on site                                                                              | %            |
| $\phi_y$    | PPHIY              | Ambient relative humidity during test                                                                          | %            |

Table 3 — Subscripts

| Subscript                                  | Meaning                                                                                    |
|--------------------------------------------|--------------------------------------------------------------------------------------------|
| a                                          | Atmospheric                                                                                |
| c                                          | Compression-ignition engine <sup>a</sup><br>Coolant <sup>a</sup><br>Corrected <sup>a</sup> |
| d                                          | Dry                                                                                        |
| i                                          | Each element                                                                               |
| m                                          | Mechanical                                                                                 |
| max                                        | Maximum                                                                                    |
| o                                          | Standard reference conditions and at the end of the crankshaft                             |
| P                                          | Maximum power                                                                              |
| r                                          | Standard reference conditions                                                              |
| ra                                         | Substitute reference conditions                                                            |
| s                                          | Saturated <sup>a</sup><br>Smoke <sup>a</sup>                                               |
| t                                          | Total                                                                                      |
| T                                          | Maximum torque                                                                             |
| x                                          | Site conditions                                                                            |
| <sup>a</sup> Dependant on the application. |                                                                                            |

Table 4 — List of parameters

| No.      | Parameter                                       | Definition                                                                                   | Symbol    | Unit                                          | Permissible deviation |
|----------|-------------------------------------------------|----------------------------------------------------------------------------------------------|-----------|-----------------------------------------------|-----------------------|
| 1        | 2                                               | 3                                                                                            | 4         | 5                                             | 6                     |
| <b>1</b> | <b>General parameters</b>                       |                                                                                              |           |                                               |                       |
| 1.1      | Engine brake torque <sup>a</sup>                | Mean torque delivered by the engine, measured at the engine driving shaft extremity          | $T_{tq}$  | kNm                                           | ±2 %                  |
| 1.2      | Engine speed <sup>b</sup>                       | Number of revolutions of the crankshaft in a given period of time                            | $n$       | s <sup>-1</sup><br>min <sup>-1</sup><br>r/min | ±2 %                  |
| 1.3      | Engine driving shaft speed                      | Number of revolutions of the engine driving shaft in a given period of time                  | $n_d$     | s <sup>-1</sup><br>min <sup>-1</sup><br>r/min | ±2 %                  |
| 1.4      | Turbocharger speed                              | Number of revolutions of the turbocharger shaft in a given period of time                    | $n_t$     | s <sup>-1</sup><br>min <sup>-1</sup><br>r/min | ±2 %                  |
| 1.5      | Brake power <sup>c</sup>                        | Power or sum of the powers measured at the driving or shafts                                 | $P_d$     | kW                                            | ±3 %                  |
| <b>2</b> | <b>Pressure<sup>e,f</sup></b>                   |                                                                                              |           |                                               |                       |
| 2.1      | Ambient pressure <sup>g</sup>                   | Pressure level of the atmosphere in the vicinity from where the engine takes its air         | $p_a$     | kPa                                           | ±0,5 %                |
| 2.2      | Compression pressure in a cylinder <sup>h</sup> | Maximum pressure of the working medium present in a cylinder at momentary fuel cut-off       | $p_{co}$  | MPa                                           | ±5 %                  |
| 2.3      | Maximum cylinder pressure <sup>h</sup>          | Maximum pressure of the working medium present in a cylinder attained during a working cycle | $p_{max}$ | MPa                                           | ±5 %                  |

Table 4 (continued)

| No.      | Parameter                                                                                                                                                  | Definition                                                                                                                      | Symbol          | Unit | Permissible deviation |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------|------|-----------------------|
| 1        | 2                                                                                                                                                          | 3                                                                                                                               | 4               | 5    | 6                     |
| 2.4      | Inlet depression                                                                                                                                           | Arithmetic mean inlet depression at engine or pressure-charger inlet                                                            | $\Delta p_d$    | kPa  | $\pm 5 \%$            |
| 2.5      | Pressure                                                                                                                                                   | Arithmetic mean absolute pressure at engine or pressure-charger inlet                                                           | $p_d$           | kPa  | $\pm 1 \%$            |
| 2.6      | Boost pressure                                                                                                                                             | Arithmetic mean charge air pressure after a pressure-charger                                                                    | $p_b$           | kPa  | $\pm 2 \%$            |
| 2.7      | Boost pressure before cylinder inlet                                                                                                                       | Arithmetic mean of the air pressure before the cylinder inlet                                                                   | $p_{ba}$        | kPa  | $\pm 2 \%$            |
| 2.8      | Boost pressure drop through the air cooler                                                                                                                 |                                                                                                                                 | $\Delta p_{ba}$ | kPa  | $\pm 10 \%$           |
| 2.9      | Exhaust gas pressure at the turbine inlet or inlet of other exhaust gas-assisted pressure charger (valid only for engines with a constant-pressure system) | Arithmetic mean of the pressure in the exhaust pipe before the turbine                                                          | $p_{g1}$        | kPa  | $\pm 5 \%$            |
| 2.10     | Exhaust back pressure                                                                                                                                      | Arithmetic mean of the pressure in the exhaust pipe after the turbine                                                           | $p_{g2}$        | kPa  | $\pm 5 \%$            |
| 2.11     | Coolant pressure                                                                                                                                           | Pressure(s) at given point(s) of the fluid cooling system(s)                                                                    | $p_d$           | kPa  | $\pm 5 \%$            |
| 2.12     | Lubricating oil pressure                                                                                                                                   | Oil pressure(s) at given point(s) of the lubricating system(s) (in individual circuits before and after filters, coolers, etc.) | $p_o$           | kPa  | $\pm 5 \%$            |
| 2.13     | Fuel supply pressure                                                                                                                                       | Arithmetic mean of the fuel pressure at the inlet of the injection pump                                                         | $p_t$           | kPa  | $\pm 10 \%$           |
| <b>3</b> | <b>Temperatures<sup>i,j</sup></b>                                                                                                                          |                                                                                                                                 |                 |      |                       |
| 3.1      | Ambient temperature                                                                                                                                        | Temperature level of the atmosphere in the environment of the engine installation at a given point or location                  | $T_a$           | K    | $\pm 2 \text{ K}$     |
| 3.2      | Inlet temperature                                                                                                                                          | Air temperature at the engine or pressure-charger inlet                                                                         | $T_d$           | K    | $\pm 2 \text{ K}$     |
| 3.3      | Charge air temperature after the pressure-charger                                                                                                          |                                                                                                                                 | $T_b$           | K    | $\pm 4 \text{ K}$     |
| 3.4      | Charge air temperature after the air cooler                                                                                                                | Air temperature before the cylinder inlet                                                                                       | $T_{ba}$        | K    | $\pm 4 \text{ K}$     |
| 3.5      | Exhaust gas temperature at the cylinder outlet                                                                                                             | Mean temperature of the exhaust gas measured by the thermal pick-up at a given cylinder                                         | $T_{g,cyl}$     | K    | $\pm 25 \text{ K}$    |
| 3.6      | Exhaust gas temperature at the turbine inlet or inlet of other exhaust gas-assisted pressure-charger                                                       | Mean temperature of the exhaust gas measured by the thermal pick-up before the turbine                                          | $T_{g1}$        | K    | $\pm 25 \text{ K}$    |

Table 4 (continued)

| No.      | Parameter                                                                                                       | Definition                                                                                                       | Symbol       | Unit                 | Permissible deviation                    |
|----------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------|----------------------|------------------------------------------|
| 1        | 2                                                                                                               | 3                                                                                                                | 4            | 5                    | 6                                        |
| 3.7      | Exhaust gas temperature in the exhaust pipe or after the turbine or other exhaust gas-assisted pressure-charger | Mean temperature of the exhaust gas measured by the thermal pick-up in the exhaust manifold or after the turbine | $T_{g2}$     | K                    | ±15 K                                    |
| 3.8      | Coolant temperature                                                                                             | Temperature(s) at given point(s) of the fluid cooling system(s)                                                  | $T_d$        | K                    | ±2 K                                     |
| 3.9      | Lubricating oil temperature                                                                                     | Oil temperature(s) at given point(s) of the lubricating system(s)                                                | $T_o$        | K                    | ±2 K                                     |
| 3.10     | Fuel temperature                                                                                                | Fuel temperature at a given point of the fuel system                                                             | $T_t$        | K                    | ±5 K                                     |
| <b>4</b> | <b>Consumptions<sup>k</sup></b>                                                                                 |                                                                                                                  |              |                      |                                          |
| 4.1      | Fuel consumption                                                                                                | Mass of fuel consumed by the engine per unit of time                                                             | $B$          | g/s<br>kg/s<br>kg/h  | ±3 %                                     |
| 4.2      | Specific fuel consumption                                                                                       | Fuel consumption per unit of power                                                                               | $b$          | g/(kW·h)<br>g/MJ     | ±3 %                                     |
| 4.3      | Cylinder lubricating oil consumption                                                                            | Mass of cylinder oil supplied by the lubricator per unit of time                                                 | $C_{cyl}$    | g/s<br>kg/s<br>kg/h  | ±10 %                                    |
| 4.4      | Specific consumption of cylinder oil                                                                            | Cylinder lubricating oil consumption per unit of power                                                           | $c_{cyl}$    | g/(kW·h)<br>g/MJ     | ±13 %                                    |
| 4.5      | Air consumption                                                                                                 | Mass of air drawn into the engine from the atmosphere per unit of time                                           | $A$          | kg/s<br>kg/h         | ±5 %                                     |
| 4.6      | Specific air consumption                                                                                        | Air consumption per unit of power                                                                                | $a$          | kg/(kW·h)<br>kg/MJ   | ±5 %                                     |
| <b>5</b> | <b>Flows</b>                                                                                                    |                                                                                                                  |              |                      |                                          |
| 5.1      | Cooling fluid flow                                                                                              | Mass of fluid flowing through the engine cooling system per unit of time                                         | $m_{cl}$     | kg/s<br>kg/s         | ±10 %                                    |
| 5.2      | Lubricating oil flow                                                                                            | Mass of fluid flowing through the engine lubricating system per unit of time                                     | $m_o$        | kg/s<br>kg/h         | ±10 %                                    |
| <b>6</b> | <b>Exhaust gas emission characteristics</b>                                                                     |                                                                                                                  |              |                      |                                          |
| 6.1      | Smoke index <sup>l</sup>                                                                                        | Filter soiling (expressed as function of light reflectivity) by undiluted gas                                    | $r$          | Smoke number         | ±0,3 on a scale of 10 units <sup>n</sup> |
| 6.2      | Smoke opacity <sup>l</sup>                                                                                      | a) Light obscuration by undiluted gas<br>b) Coefficient of light absorption <sup>p</sup>                         | $N$<br>$k$   | %<br>m <sup>-1</sup> | ±5 %<br>±5 %                             |
| 6.3      | Soot content <sup>l</sup>                                                                                       | Gravimetric carbon concentration <sup>q</sup>                                                                    | $C_c$        | g/m <sup>3</sup>     | ±10 %                                    |
| 6.4      | Gaseous emission composition <sup>r</sup>                                                                       | Volumetric concentration of gaseous components                                                                   | $C_B$<br>$s$ | % or ppm             | AMC <sup>t</sup>                         |

Table 4 (continued)

| No. | Parameter                  | Definition                                      | Symbol     | Unit     | Permissible deviation |
|-----|----------------------------|-------------------------------------------------|------------|----------|-----------------------|
| 1   | 2                          | 3                                               | 4          | 5        | 6                     |
| 6.5 | Emission rate <sup>u</sup> | Mass of each component emitted per unit of time | $E_B$<br>s | g/h      | AMC <sup>t</sup>      |
| 6.6 | Specific emission          | Emission rate per unit of power                 | $E_B^a$    | g/(kW·h) | AMC <sup>t</sup>      |

a Measured by hydraulic brake, electric dynamometer or similar equipment.

b Measured by a tachometer, revolution counter, tachoscope or similar equipment.

c Calculated from measured values of engine driving shaft torque and speed.

d Where necessary the suffix “e” shall be used in accordance with ISO 2710-1 to distinguish brake power from another power.

e The permissible deviation of each pressure (except those in 2.1 and 2.5) is given as a percentage of the gauge pressure.

f Bar may be used instead of kPa or MPa.

g Measured by spring-loaded, fluid-type barometers or similar equipment.

h Measured by a recording maximum pressure gauge, mechanical indicator, from an indicator diagram or similar means.

i Measured by electrical methods (resistance thermometers or a thermocouple with measuring apparatus) or fluid-type thermometers.

j The unit °C may be used instead of K.

k Consumptions are measured using mass or volume methods (the unit assumes using mass in this document), by determining the time during which a given quantity of fluid is consumed, or alternatively by using normal pressure differential systems or other types of flowmeter.

l The engine manufacturer may select either parameter indicated in 6.1 or 6.3 for non-opacity measurement or in 6.2 for opacity measurement according to the facilities available.

m Measured by passing a known volume of gas through a specified area of (white) filter paper and determining the reduction in light reflected from the filter.

n For automatic continuous measurement, the permissible deviation in 6.1 may be ±0,6 on a scale of 10 units.

o Measured over the entire cross-section of the exhaust plume close to the point of exit from the exhaust pipe or over defined length of the smoke column, the linear dimension in each case being denoted by  $L$ , expressed in metres

p The value  $k$  is given by the following formula:

$$k = -\frac{1}{L} \log_e \left( 1 - \frac{N}{100} \right)$$

where  $N$  is the reading of smoke opacity on a linear scale from 0 to 100 units

q Measured by the increase in mass of a filter through which a known volume of undiluted exhaust gas has been passed and corrected to standard reference temperature and pressure.

r Measured by chemical or physical method appropriate to each component (and/or its concentration).

s “B” is suffix of an individual component of the exhaust gas.

t By agreement between engine manufacturer and customer.

u Calculated from the emission concentration measurement and calculated rate of exhaust gas flow.

## 5 Standard reference conditions

For the purpose of determining the power and fuel consumption of an engine, the following standard reference conditions shall be used:

|                                 |                                                       |
|---------------------------------|-------------------------------------------------------|
| Total barometric pressure:      | $p_r = 100 \text{ kPa}$ ;                             |
| Air temperature:                | $T_r = 298 \text{ K}$ ( $t_r = 25 \text{ °C}$ );      |
| Relative humidity:              | $\phi_r = 30 \text{ %}$ ;                             |
| Charge air coolant temperature: | $T_{cr} = 298 \text{ K}$ ( $t_{cr} = 25 \text{ °C}$ ) |

NOTE A relative humidity of 30 % at a temperature of 298 K corresponds to a water pressure of 1 kPa. The corresponding dry barometric pressure is 99 kPa.

## 6 Tests

### 6.1 General

There are two different procedures for engine testing identified as method 1 and method 2. Depending upon the particular engine application, the appropriate method to be used is specified in the relevant "Satellite" standard.

### 6.2 Test method 1

#### 6.2.1 Preamble

This test method is used for verifying the declared parameters of an individual engine in accordance with the requirements of the contract. It establishes the requirements for acceptance tests, type tests and/or special tests to be performed with the engine mounted on a test bed at the manufacturer's plant or installed on site.

If required, acceptance tests shall be included in the contract. Type tests and/or special tests are subject to agreement between the manufacturer and customer.

#### 6.2.2 Test designation

Test method 1 gives two test categories; reference may be made to the relevant category of test as follows:

- a) for acceptance tests (see [3.5.1](#)) ISO \_\_\_\_\_ A;
- b) for type tests (see [3.5.2](#)) ISO \_\_\_\_\_ T.

#### 6.2.3 Extent of tests

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

**6.2.3.2** It is the responsibility of the manufacturer to define the measurements to be taken, which shall be agreed with the customer.

[Table 5](#) may be taken as a guide for selecting the engine groups appropriate to the test measurements given in list A (see [Table 6](#)).

**Table 5 — Engine groups for selection of test measurements**

| Engine group number | Typical engine group characteristics                                                                                                             |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                   | Engines whose operating conditions are not measured in service; usually with maximum design engine speeds of more than 1 800 min <sup>-1</sup> . |
| 2                   | Naturally aspirated engines with maximum design engine speeds of approximately 1 500 min <sup>-1</sup> and above.                                |
| 3                   | Pressure-charged engines with maximum design engine speeds of approximately 1 500 min <sup>-1</sup> and above.                                   |
| 4                   | Engines with maximum design engine speeds of approximately 250 min <sup>-1</sup> to 1 500 min <sup>-1</sup> .                                    |
| 5                   | Engines with maximum design engine speeds up to 250 min <sup>-1</sup> .                                                                          |

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

**6.2.3.4** Dependent on the test category 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 [6.2.6](#).

The following requirements are not included in the purchase contract and are subject to agreement between the manufacturer and customer:

- a) additional measurements or tests requested to be performed during the test procedure by the customer or his representative;
- b) if necessary, the source and date of provision of data necessary for additional calculations.

**6.2.3.5** Whether some or all of the results from previous tests shall be recognized as a part of the acceptance test is subject to agreement between the manufacturer and customer.

## **6.2.4 Measurement techniques**

### **6.2.4.1 Measurements methods**

Methods to be used during acceptance tests and type tests, symbols for parameters under measurement, units, etc. are described in [6.2.4.3](#).

### **6.2.4.2 Data storage**

Printed and/or stored data measured or recorded shall be displayed during the test.

### **6.2.4.3 Test measurements**

#### **6.2.4.3.1 Measurement accuracy**

The measurement accuracy depends on a number of factors. Therefore, for each measured parameter, it is necessary to specify the permissible deviation to cover the following factors which result in measurement uncertainty:

- a) instrument accuracy;
- b) correctness of the measuring instrument location;
- c) conditions under which the measuring instrument is used;
- d) accuracy of the readings;
- e) scatter of the readings of the measuring instrument during the measuring period.

The permissible deviations define the permissible range between the extreme values of each individual measurement for the engine under consideration.

#### 6.2.4.3.2 Operating conditions

Before a set of measurements is taken, the engine shall have been operated at particular conditions of load and speed for a sufficient length of time to ensure that it has reached stable operating conditions as specified by the engine manufacturer.

During the period in which a set of measurements is being made, the torque, speed and all fluid temperatures and pressures shall be maintained constant within the permissible deviations given in [Table 4](#).

#### 6.2.4.3.3 Measurement methods

Measurement methods shall be selected by the engine manufacturer and, if necessary, may be subject to contractual agreement between the engine manufacturer and customer and/or inspecting authority.

The location of the measurement points shall be specified by the engine manufacturer.

#### 6.2.4.3.4 Permissible deviation of parameters

The permissible deviation for each individual measurement and for the engine under consideration given in [Table 4](#), column 6, applies only to the declared power shown in the relevant "Satellite" standard.

The permissible deviation quoted is that considered adequate for most acceptance test purposes. Engine manufacturers may adopt reduced permissible deviations for

- a) type tests, and
- b) special contractual or legislative requirements.

Unless otherwise agreed, all measuring instruments and apparatus used during tests shall be tested and calibrated periodically over the range of expected readings at the time intervals specified by the engine manufacturer.

Where the total measurement uncertainty involves a number of quantities each with its own measurement uncertainty or where individual measurement is dependent on several parameters, each with its own measurement uncertainty, the overall measurement uncertainty is taken as the square root of the sum of the squares of the separate measurement uncertainties each multiplied by an appropriate factor equal to the exponent of its parameter in the formula.

Where measurements are used in subsequent calculations, measurement uncertainties of the measured parameters shall be selected so that the deviation of the final calculated parameter complies with the corresponding permissible deviation.

#### 6.2.4.4 List of parameters

Engine performance parameters and their permissible deviations are given in [Table 4](#).

NOTE All footnotes appear at the end of [Table 4](#).

### 6.2.5 Test conditions

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

**6.2.5.2** A period of running-in and preliminary testing considered adequate by the manufacturer shall precede any acceptance or type test.

**6.2.5.3** 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.

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

- If the acceptance test is carried out on site, testing shall take place after the engine is in its operating condition and at a time agreed upon by the customer and engine manufacturer. The presence of the engine manufacturer or his representative and their authority during acceptance testing, if required, should be included in the purchase agreement. The engine manufacturer or his representative shall be given the opportunity to instruct all on-site personnel in operating the engine set and in the application of the measuring equipment.
- If the acceptance test is carried out on site, the customer shall provide sufficient fuel, lubricants, coolants and auxiliary personnel to support the programme, unless otherwise agreed with the engine manufacturer.
- For engine-related machinery not supplied by the engine manufacturer, the points of measurement shall be identified by the customer on instructions from the engine manufacturer.

**6.2.5.5** Tests shall be carried out on the engine with any dependent auxiliaries necessary for its operation, either supplied with the engine or belonging to the test-bed equipment, fitted.

**6.2.5.6** Test-bed equipment (e.g. air-inlet system, exhaust system and independent auxiliaries such as water pumps, oil filters, heat exchangers, etc.) may be used, provided that the contractual requirements are met.

**6.2.5.7** Engines that are supplied with built-in transmission systems (e.g. hydraulic mechanisms, reversing couplings) or electric generators, and that cannot be tested separately from them, shall be tested with the transmission system or generator installed.

If engines are tested with driven machinery or a transmission system fitted and these are separable, any variation in power, due to these coupled items, shall be eliminated from the power declared in accordance with this document.

**6.2.5.8** If the acceptance test is carried out on site and the declared power at the corresponding speed cannot be verified or achieved, due to special circumstances and/or situation of the installation, the manufacturer and the customer shall accept the test report prepared from the test performed on the manufacturer's works test bed as valid, and verify only a) the declared speed at a power other than the declared power, or b) the declared power at an engine speed other than the declared speed.

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

**6.2.5.9** During the engine tests, no additional measures, other than those required to maintain the test conditions and those required for normal operation as given in the working manual, shall be taken.

**6.2.5.10** The only permitted interruptions in testing are those necessary for engine maintenance as given in the working manual. If an interruption should occur caused by a defect in the engine or test equipment, the decision to partially or entirely repeat the tests shall be taken between the manufacturer and customer.

**6.2.5.11** The standard reference conditions and declarations of power, fuel and lubricating oil consumption shall be as specified in [Clause 5](#) and the relevant "Satellite" standard.

**6.2.5.12** 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 the test results shall be subject to agreement between the manufacturer and customer.

In dual-fuel engines, the acceptance test shall be performed using liquid fuel. An additional acceptance test with gaseous fuel may be stipulated if gaseous fuel is available at the manufacturer's works with approximately the same ignition characteristics as the gaseous fuel available on site, if agreed between the manufacturer and customer.

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, after agreement between the manufacturer and customer, the acceptance test is performed at the manufacturer's works using gaseous fuel with chemical values and properties differing significantly from those on site, the test may be made at agreed values of declared power, declared speed and fuel consumption by resetting the engine accordingly. Readjustment of the engine to achieve correct operation with fuel having properties different from those on site is acceptable in this case.

## 6.2.6 Test procedures

### 6.2.6.1 Acceptance tests

**6.2.6.1.1** Acceptance tests comprise a specified sequence of power settings, measurements and calculated values given in list A (see [Table 6](#)).

**6.2.6.1.2** The duration of the acceptance test programme depends on the engine power and applications.

**6.2.6.1.3** The measurements shown in list A (see [Table 6](#)) shall be made according to the specified engine group for each operating condition wherever appropriate and where provision exists on the engine for doing so.

Measurements carried out to verify the declaration of power, engine speed and fuel consumption, shall be carried out at least twice. A measurement shall be considered valid if the variations of the engine brake torque and engine speed values in relation to the settings of the operating values do not exceed  $\pm 2$  %. The variation of the power output during this period shall not exceed  $\pm 3$  %. This requirement shall not apply to spark-ignition engines with a brake power less than 50 kW.

The measurements shown in list A (see [Table 6](#)) are arranged in an ascending order of test measurement complexity and are presented for guidance when the contract is drawn up between the manufacturer and customer. Either party may, by agreement, add to or delete from the measurements in list A, to suit the particular type of engine involved. Where no provision exists on the engine for a particular measurement, this shall be stated by the manufacturer.

**Table 6 — List A: Test measurements**

| No. | Parameter to be measured                              | Engine group number<br>(see <a href="#">Table 5</a> ) |   |   |   |   |
|-----|-------------------------------------------------------|-------------------------------------------------------|---|---|---|---|
|     |                                                       | 1                                                     | 2 | 3 | 4 | 5 |
| A1  | Barometric pressure, humidity and ambient temperature | X                                                     | X | X | X | X |
| A2  | Engine speed or cycle frequency                       | X                                                     | X | X | X | X |
| A3  | Engine brake torque and/or fuel pump or governor      | X                                                     | X | X | X | X |
| A4  | Throttle control rod setting                          |                                                       |   |   |   |   |
| A5  | Fuel consumption                                      |                                                       | X | X | X | X |

**Table 6** (continued)

| No. | Parameter to be measured                                                                 | Engine group number<br>(see Table 5) |   |   |   |   |
|-----|------------------------------------------------------------------------------------------|--------------------------------------|---|---|---|---|
|     |                                                                                          | 1                                    | 2 | 3 | 4 | 5 |
| A6  | Lubricating oil pressure                                                                 |                                      | X | X | X | X |
| A7  | Temperature and pressure of exhaust gas leaving the engine                               |                                      | X | X | X | X |
| A8  | Air inlet pressure and temperature at the engine or pressure charger inlet               |                                      | X | X | X | X |
| A9  | Exhaust-gas temperature at the turbine inlet                                             |                                      |   | X | X | X |
| A10 | Boost pressure in the air manifold                                                       |                                      |   | X | X | X |
| A11 | Turbocharger speed                                                                       |                                      |   | X | X | X |
| A12 | Coolant mean temperature in and out of the cylinder block                                |                                      |   | X | X | X |
| A13 | Lubricating oil temperature at the engine inlet and outlet                               |                                      |   | X | X | X |
| A14 | Boost pressure drop through the charge air cooler                                        |                                      |   | X | X | X |
| A15 | Boost pressure after each charge air cooler                                              |                                      |   | X | X | X |
| A16 | Charge air temperature after each charge air cooler                                      |                                      |   | X | X | X |
| A17 | Coolant mean temperature at the inlet and outlet of the charge air cooler                |                                      |   | X | X | X |
| A18 | Maximum cylinder pressure                                                                |                                      |   |   | X | X |
| A19 | Exhaust-gas pressure at the turbine inlet                                                |                                      |   | X | X | X |
| A20 | Exhaust-gas temperature of each cylinder                                                 |                                      |   |   | X | X |
| A21 | Individual coolant circuit temperatures and pressures                                    |                                      |   |   | X | X |
| A22 | Lubricating-oil pressure in individual circuits, e.g. turbocharger, piston cooling, etc. |                                      |   |   | X | X |
| A23 | Lubricating-oil pressure before and after filters and coolers                            |                                      |   |   | X | X |
| A24 | Secondary coolant and lubricating oil temperatures in and out of heat exchangers         |                                      |   |   | X | X |
| A25 | Fuel supply pressure and temperature                                                     |                                      |   |   | X | X |
| A26 | Compression pressure                                                                     |                                      |   |   |   | X |

**Table 7 — List B: Test results**

| No. | Parameter to be calculated |
|-----|----------------------------|
| B1  | Brake power                |
| B2  | Specific fuel consumption  |

**6.2.6.1.4** Where appropriate, the manufacturer shall supply the calculated values given in list B (see Table 7) on the basis of the test measurements made from list A (see Table 6).

Measurement of the fuel consumption shall be carried out during the measurement of power.

For engines having a brake power of 200 kW and above, if the variation between the results of two fuel consumption measurements is more than 2 %, the measurement shall be repeated for this operating point.

Fuel fed to the engine and that is not consumed shall be taken into account in the fuel consumption measurements.

**6.2.6.1.5** List C (see Table 8) shows the functional checks which may additionally be carried out on engines in groups 2 to 5 in Table 5.

Selection from list C shall be made by agreement between the manufacturer and customer.

### 6.2.6.2 Type tests

**6.2.6.2.1** A type test comprises running the engine at a specified sequence of power/engine speed combinations, reversals and stop.

**6.2.6.2.2** Type tests shall include, as far as applicable, all measurements, calculations and functional checks shown in list A, engine group 5 (see [Table 6](#)), and lists B and C (see [Table 7](#) and [Table 8](#)), and in additional list D (see [Table 9](#)).

**Table 8 — List C: Functional checks**

| No. | Function to be verified                                                                                                                                                                                                                                                                |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C1  | The correct functioning of the overspeed limiting device in accordance with ISO 3046-6                                                                                                                                                                                                 |
| C2  | The correct functioning of the speed governing system in accordance with ISO 3046-4                                                                                                                                                                                                    |
| C3  | The ability of all malfunction protection and warning devices to respond correctly to the fault conditions in which they should operate (e.g. low lubricating oil pressure, high lubricating oil temperatures, high coolant temperatures, pressure rise in the engine crankcase, etc.) |
| C4  | The correct functioning of all automatic pressure and temperature controls                                                                                                                                                                                                             |
| C5  | The ability of the starting system to perform prior to and/or after the acceptance test conditions of the engine are reached, subject to agreement between the manufacturer and customer                                                                                               |
| C6  | The correct functioning of the reversing mechanism, built-in reverse reduction gear and couplings                                                                                                                                                                                      |
| C7  | That the temperature of important components is satisfactory                                                                                                                                                                                                                           |
| C8  | That the crank web deflection does not exceed the given limits                                                                                                                                                                                                                         |
| C9  | Stability of the engine on its support                                                                                                                                                                                                                                                 |
| C10 | The condition after test of one or more piston and cylinder assemblies and bearings, chosen randomly for inspection                                                                                                                                                                    |

**Table 9 — List D: Additional tests**

| No. | Parameter/measure                                                        |
|-----|--------------------------------------------------------------------------|
| D1  | Air consumption                                                          |
| D2  | Lubricating oil consumption                                              |
| D3  | Dismantling, inspection and measuring of important parts subject to wear |

### 6.2.6.3 Special tests

Special tests are defined as any of those shown in list E (see [Table 10](#)) which may be required by inspection authorities, classification societies, legislation or the customer.

**Table 10 — List E: Special tests (examples)**

| No. | Parameter or function                                                                                                                                                                          |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| E1  | Torsional vibration frequencies and amplitudes at prescribed power/engine speed combinations when the engine is tested coupled to its contract driven machinery, in accordance with ISO 3046-5 |
| E2  | Engine heat balance                                                                                                                                                                            |
| E3  | Sound level                                                                                                                                                                                    |
| E4  | Exhaust-gas emission characteristics                                                                                                                                                           |
| E5  | Tests in conjunction with contract driven machinery                                                                                                                                            |
| E6  | Parallel running and other electrical tests of engine-driven generators                                                                                                                        |
| E7  | Emergency reversal of marine engines                                                                                                                                                           |
| E8  | Determination of minimum stable engine speed of marine engines                                                                                                                                 |

Table 10 (continued)

| No. | Parameter or function                                                                                                                       |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------|
| E9  | Change-over on dual-fuel engines                                                                                                            |
| E10 | Ability to carry out maintenance tasks within the time stated by the manufacturer                                                           |
| E11 | Ability to manoeuvre and provide a stated power when operating with specified malfunctions, e.g. with one or more turbochargers inoperative |

### 6.3 Test method 2

#### 6.3.1 General

This test method is used for verifying the net and/or gross power of an engine type with the declared values. It presents engine performance at full power/torque as a function of engine speed by generating curves of power and fuel consumption.

It also applies to the determination of engine power for exhaust emission measurement in accordance with the requirements of ISO 8178.

Conformity of the engine type to the declaration is fulfilled when the difference between the measured and declared values are within the tolerances specified in the relevant "Satellite" standard.

#### 6.3.2 Measuring equipment and instrument accuracy

##### 6.3.2.1 Torque

**6.3.2.1.1** The dynamometer torque measuring system shall have an accuracy of  $\pm 1$  % in the range of values required for the test.

**6.3.2.1.2** 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 may be  $\pm 2$  % of measured torque.

##### 6.3.2.2 Engine speed

The engine speed measuring system shall have an accuracy of  $\pm 0,5$  %.

##### 6.3.2.3 Fuel flow

The fuel flow measuring system shall have an accuracy of  $\pm 1$  %.

##### 6.3.2.4 Fuel temperature

The fuel temperature measuring system shall have an accuracy of  $\pm 2$  K.

##### 6.3.2.5 Engine inlet air temperature

The air temperature measuring system shall have an accuracy of  $\pm 2$  K.

##### 6.3.2.6 Barometric pressure

The barometric pressure measuring system shall have an accuracy of  $\pm 100$  Pa.

NOTE 1 Pa = 1 N/m<sup>2</sup>

### 6.3.2.7 Back pressure in exhaust system

The system used to measure the back pressure in the exhaust system shall have an accuracy of  $\pm 200$  Pa. The measurement shall be made subject to [Table 1](#), footnote b.

### 6.3.2.8 Depression in inlet system

Subject to [Table 1](#), footnote a, this pressure shall be measured to  $\pm 50$  Pa.

### 6.3.2.9 Absolute pressure in inlet duct

The system used to measure the absolute pressure in the inlet duct shall have an accuracy of  $\pm 2$  % of the measured pressure.

## 6.3.3 Setting conditions

The setting conditions for the test to determine engine power are indicated in [Table 11](#).

**Table 11 — Setting conditions**

|   |                                             |                                                                                                                                    |
|---|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Setting of carburettor(s)                   | Set in accordance with the manufacturer's specifications and used without further alteration for the particular engine application |
| 2 | Setting of injection-pump delivery system   |                                                                                                                                    |
| 3 | Ignition or injection timing (timing curve) |                                                                                                                                    |
| 4 | Governor setting                            |                                                                                                                                    |
| 5 | Anti-pollution devices                      |                                                                                                                                    |
| 6 | Boost control                               |                                                                                                                                    |

## 6.3.4 Test conditions

**6.3.4.1** The 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 (diesel) engines, the engine being equipped with standard SPE and as specified in [Table 1](#).

**6.3.4.2** Performance data shall be obtained under stabilized operating conditions, with an adequate fresh-air supply to the engine.

Before the test, 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 to be as near to the standard reference conditions (see [Clause 5](#)) as possible in order to minimize the magnitude of the correction factor.

**6.3.4.3** The temperature of the inlet air to the engine shall be measured within the inlet ductwork. The inlet depression measurement shall be made at the same point.

The thermometer or thermocouple shall be shielded from fuel spray-back and radiant heat and located directly in the air stream. A sufficient number of locations shall be used to give a representative average of the inlet temperature.

**6.3.4.4** The inlet depression shall be measured downstream of the entry ducts, air filter, inlet silencer or speed-limiting device (if fitted).

**6.3.4.5** The absolute pressure at the entry to the engine downstream of the compressor and heat exchanger, if fitted, shall be measured in the inlet manifold and at any other point where pressure is to be measured to calculate correction factors.

**6.3.4.6** The exhaust back pressure shall be measured at a point at least three pipe diameters downstream from the outlet flange(s) of the exhaust manifold(s) and downstream at the turbocharger(s), if fitted.

The location shall be specified.

**6.3.4.7** No data shall be taken until torque, engine speed and temperatures have been maintained substantially constant as specified by the manufacturer.

**6.3.4.8** The engine speed during a test run or reading shall not deviate from the selected speed by more than  $\pm 1\%$  or  $\pm 10 \text{ min}^{-1}$ , whichever is greater.

**6.3.4.9** Observed brake load, fuel flow and inlet air temperature data shall be taken simultaneously and shall, in each case, be the average of at least two stabilized consecutive readings. No adjustment shall be made to the engine between these readings.

**6.3.4.10** The temperature of the coolant at the outlet from the engine shall be kept within  $\pm 5 \text{ K}$  from the upper thermostatically controlled temperature specified by the manufacturer. If no temperature is specified by the manufacturer, the temperature shall be  $353 \text{ K} \pm 5 \text{ K}$ .

For air-cooled engines, the temperature at a point indicated by the manufacturer shall be kept within  $0$  to  $-20 \text{ K}$  of the maximum value specified by the manufacturer for the reference conditions.

**6.3.4.11** Fuel temperatures shall be as follows.

- a) For spark-ignition engines, the fuel temperature shall be measured as near as possible to the inlet of the carburettor or fuel injector manifold assembly. Fuel temperature shall be maintained to within  $\pm 5 \text{ K}$  of the temperature specified by the manufacturer. However, the minimum test fuel temperature allowed shall be the ambient air temperature. If the test fuel temperature is not specified by the manufacturer, it shall be  $298 \text{ K} \pm 5 \text{ K}$ .
- b) For compression-ignition (diesel) engines, the fuel temperature shall be measured at the inlet to the fuel injection pump. At the manufacturer's request the fuel temperature measurement can be made at another point in the pump representative of the engine operating condition or in the fuel supply pipe between the filter and the fuel injection pump, upstream of the entry point for any backflow fuel.

Fuel temperature shall be maintained within to  $\pm 3 \text{ K}$  of the temperature specified by the manufacturer. In all cases, the minimum permissible fuel temperature at the pump inlet is  $303 \text{ K}$ . If the test fuel temperature is not specified by the manufacturer, it shall be  $313 \text{ K} \pm 3 \text{ K}$  for distillate fuels.

**6.3.4.12** The temperature of the lubricating oil shall be measured at either the gallery inlet, the outlet from the oil cooler (if fitted) or as specified by the manufacturer. The temperature shall be maintained within the limits specified by the manufacturer.

**6.3.4.13** If necessary, an auxiliary regulation system may be used to maintain the temperatures within the limits specified in [6.3.4.10](#), [6.3.4.11](#) and [6.3.4.12](#).

**6.3.4.14** The selection of fuel for the power test shall be agreed by the parties involved and be selected in accordance with the requirements of [Table 12](#).

Table 12 — Test Fuels

| Test Purpose                  | Interested parties                                | Fuel selection                                                                       |
|-------------------------------|---------------------------------------------------|--------------------------------------------------------------------------------------|
| Type approval (certification) | Certification body,<br>manufacturer or supplier   | Reference fuel, if one is defined<br>Commercial fuel if no reference fuel is defined |
| Acceptance test               | Manufacturer or supplier<br>Customer or inspector | Commercial fuel as specified by the manufacturer                                     |

### 6.3.5 Test procedure

Measurements shall be taken at a sufficient number of engine speeds to completely define the power and torque curve between the lowest and the highest engine speeds recommended by the manufacturer. The speed range shall include the point at which the engine produces its maximum power and torque.

### 6.3.6 Data to be recorded

Data to be recorded shall be those indicated in 9.2.1 or as specified in the relevant “Satellite” standards.

## 7 Method of power correction

### 7.1 General

This power correction method has been verified by tests on a representative number of pre-set engines with engine speeds of 2 000 min<sup>-1</sup> and above. Manufacturers may extend this method to other engines as considered appropriate, or restrict it, if justified by experience.

This power correction method shall be used to calculate the power at the standard reference conditions specified in Clause 5 from the power observed (determined) under test ambient conditions.

For the purpose of power correction, the observed (determined) power shall be multiplied by a factor as follows:

for spark-ignition engines:

$$P_r = \alpha_a \times P_y \quad (1)$$

or, for compression-ignition (diesel) engines:

$$P_r = \alpha_c \times P_y \quad (2)$$

### 7.2 Test atmospheric conditions

The atmospheric conditions during the test shall be within the ranges given below.

#### a) Temperature, $T_y$

- for spark-ignition engines:  $288 \text{ K} \leq T_y \leq 308 \text{ K}$
- for compression-ignition (diesel) engines:  $283 \text{ K} \leq T_y \leq 313 \text{ K}$

#### b) Dry Pressure, $p_d$

NOTE  $p_d = p_y - \phi_y p_{sy}$

- for all engines:  $90 \text{ kPa} \leq p_d \leq 110 \text{ kPa}$

### 7.3 Correction factor $\alpha_a$ for naturally aspirated and pressure-charged spark-ignition engines (with or without charge air cooling)

The correction factor  $\alpha_a$  shall be as calculated from [Formula \(3\)](#):

$$\alpha_a = \left( \frac{p_r - \phi_r p_{sr}}{p_y - \phi_y p_{sy}} \right)^{1,2} \left( \frac{T_y}{T_r} \right)^{0,6} \quad (3)$$

[Formula \(3\)](#) applies to engines with carburettors and to other engines where the fuel management system is designed to maintain a relatively constant fuel/air ratio as ambient conditions change. For other engine types, see [7.5](#).

[Formula \(3\)](#) is only applicable if:

$$0,96 \leq \alpha_a \leq 1,06$$

If these limits are exceeded, the corrected power value obtained shall be given and the test conditions (temperature and pressure) precisely stated in the test report.

### 7.4 Correction factor $\alpha_c$ for compression-ignition (diesel) engines

#### 7.4.1 General

The power correction factor ( $\alpha_c$ ) for compression-ignition (diesel) engines at constant fuel delivery setting (pre-set fuel delivery) is obtained by applying [Formula \(4\)](#):

$$\alpha_c = (f_a)^{f_m} \quad (4)$$

where

$f_a$  is the atmospheric factor (see [7.4.2](#));

$f_m$  is the characteristic parameter for each type of engine and fuel setting (see [7.4.3](#)).

Limitation in use of [Formula \(4\)](#) is given in [7.4.4](#).

#### 7.4.2 Atmospheric factor $f_a$

This factor, which indicates the effects of environmental conditions (pressure, temperature and humidity) on the air drawn in by the engine and differs according to the type of engine, shall be as calculated from [Formula \(5\)](#), [Formula \(6\)](#) or [Formula \(7\)](#):

for naturally aspirated engines and mechanically pressure-charged engines:

$$f_a = \left( \frac{p_r - \phi_r p_{sr}}{p_y - \phi_y p_{sy}} \right) \left( \frac{T_y}{T_r} \right)^{0,7} \quad (5)$$

for turbocharged engines without charge air cooling or with charge air cooling by air/air cooler:

$$f_a = \left( \frac{p_r - \phi_r p_{sr}}{p_y - \phi_y p_{sy}} \right)^{0,7} \left( \frac{T_y}{T_r} \right)^{1,2} \quad (6)$$

for turbocharged engines with charge air cooling by air to liquid charge air cooler:

$$f_a = \left( \frac{p_r - \phi_r p_{sr}}{p_y - \phi_y p_{sy}} \right)^{0,7} \left( \frac{T_y}{T_r} \right)^{0,7} \quad (7)$$

#### 7.4.3 Engine factor, $f_m$

Factor  $f_m$  is dependent on the type of engine and the trapped air/fuel ratio corresponding to the fuel setting.

The engine factor  $f_m$  is a function of the corrected specific fuel delivery  $q_c$ , and shall be calculated from [Formula \(8\)](#):

$$f_m = 0,036q_c - 1,14 \quad (8)$$

in which

$$q_c = \frac{q}{r_r} \quad (9)$$

where  $q$  is the fuel delivery parameter in milligrams per cycle per litre of engine swept volume  $[\text{mg} / (\text{l} \cdot \text{cycle})]$  and is equal to:

$$q = \frac{(Z) \times [\text{Fuel flow g (g/s)}]}{[\text{Displacement (l)}] \times [\text{Engine speed (min}^{-1}\text{)}]} = \frac{z (1) \times \dot{V} (\text{g / s})}{v_H (1) \times n (\text{min}^{-1})} \quad (10)$$

where

$Z$  120 000 for four-stroke cycle engines and  $Z = 60\,000$  for two-stroke cycle engines;

$r_r$  is the ratio between the absolute static pressure at the compressor outlet and compressor inlet under standard reference conditions ( $r_r = 1$  for naturally aspirated engines). For two-stage turbocharging,  $r$  is the overall pressure ratio.

[Formula \(8\)](#) is valid for the following range of  $q_c$  (mg/l·cycle):

$$37,2 \leq q_c \leq 65$$

For  $q_c$  values lower than 37,2, a constant value of  $f_m$  equal to 0,2 ( $f_m = 0,2$ ) shall be taken. For  $q_c$  values higher than 65, a constant value of  $f_m$  equal to 1,2 ( $f_m = 1,2$ ) shall be taken (see [Figure 1](#)).

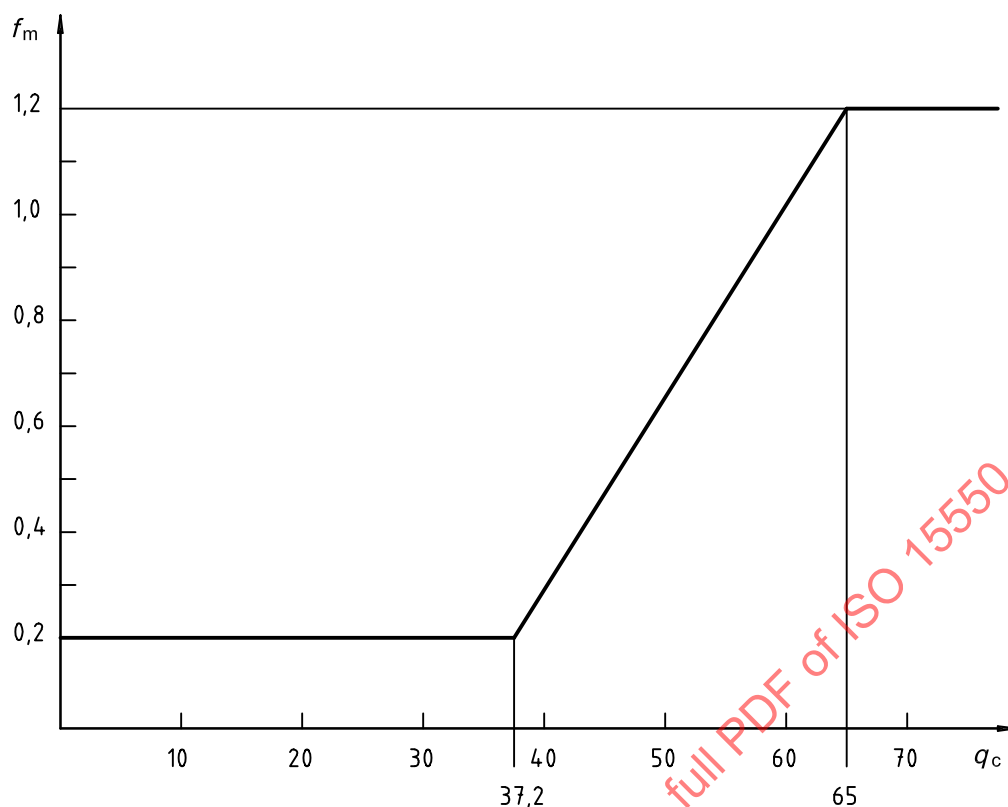


Figure 1 — Engine factor,  $f_m$ , as a function of the corrected fuel delivery,  $q_c$

#### 7.4.4 Limitation in use of correction factor equation

The correction factor [Formula \(4\)](#) is only applicable if  $0,96 \leq \alpha_c \leq 1,06$ .

If these limits are exceeded, the corrected power value obtained shall be given and the test conditions (temperature and pressure) precisely stated in the test report.

#### 7.5 Other types of engine

For engines not covered by [7.3](#) and [7.4](#), a correction factor equal to 1 shall be applied when the ambient air density does not vary by more than  $\pm 2$  % from the density at standard reference conditions. When the ambient air density is outside these limits, no correction shall be applied, but the test conditions shall be stated in the test report.

## 8 Measurement and correction of smoke value for compression-ignition (diesel) engines

### 8.1 General

If necessary, smoke value shall be measured and recorded. The opacimeter used, and its installation, shall be designed in accordance with ISO 11614.

## 8.2 Correction factor for the smoke light absorption coefficient

This is the factor by which the smoke light absorption coefficient,  $k$ , expressed in absolute units, shall be multiplied in order to determine the engine light absorption coefficient of smoke at the standard reference conditions specified in [Clause 5](#) and is given by [Formula \(11\)](#):

$$k_r = \alpha_s k \quad (11)$$

where

$\alpha_s$  is the correction factor (see [8.3](#));

$k$  is the measured smoke light absorption coefficient in reciprocal metres (observed smoke).

## 8.3 Determination of the correction factor for the smoke light absorption coefficient

The correction factor,  $\alpha_s$ , for compression-ignition (diesel) engines under constant fuel delivery settings is obtained from [Formula \(12\)](#):

$$\alpha_s = 1 - 5 (f_a - 1) \quad (12)$$

where  $f_a$  is the atmospheric factor (see [7.4.2](#)).

## 8.4 Limits of application

This correction factor,  $\alpha_s$ , only applies when:

$$0,92 \leq f_a \leq 1,08$$

$$283 \text{ K} \leq T_y \leq 313 \text{ K}$$

$$80 \text{ kPa} \leq p_d \leq 110 \text{ kPa}$$

## 9 Test report

### 9.1 Test method 1

#### 9.1.1 General

For engines to which Test method 1 of [6.2](#) is applied, the requirements for the test report are as follows.

#### 9.1.2 Type test report

The manufacturer shall provide a test report. Normally, acceptance test reports shall be provided only for engine groups numbers 3, 4 and 5 (see [Table 5](#)).

Type test reports shall be provided for all groups of engine.

The test report shall include the engine identification and the following test information:

- a) a reference to this document, i.e. ISO 15550;
- b) the date, place and designation of test and inspecting authority;

- c) the type of fuel and lubricating oil used during tests. Selection of test fuel shall be as follows:
- 1) If the fuel used complies with the specification of a national or International Standard, the properties need be verified by explicit agreement between the manufacturer and customer.
  - 2) If the fuel does not comply with the specification of a National or International Standard, the properties and constituents should be stated, as agreed between the manufacturer and customer.
  - 3) The lower calorific value of the fuel and its method of determination should be stated.
- d) the dependent auxiliaries, engine settings and proprietary equipment installed;
- e) the table of values measured during the test;
- f) the parameters calculated during the test;
- g) the results of functional checks;
- h) the results of additional tests or special tests, if required.

## 9.2 Test method 2

### 9.2.1 General

For engines to which Test method 2 of 6.3 is applied, the requirements for the test report are as follows.

### 9.2.2 Type test report

The manufacturer shall provide a test report including the following engine identification and test information.

NOTE In this test report, state "none" where inapplicable or delete.

#### 9.2.2.1 Compression-ignition engines — Essential characteristics<sup>1)</sup>

##### 9.2.2.1.1 Engine description

Make: .....

Type: .....

Cycle: four-stroke/two-stroke<sup>2)</sup>

Bore: ..... mm

Stroke: ..... mm

Number of cylinders: .....

Layout of cylinders: ..... Firing order: .....

Engine swept volume: ..... litres

Compression ratio<sup>3)</sup>: .....

1) In the case of non-conventional engines and systems, particulars equivalent to those referred to here shall be supplied by the manufacturer.

2) Strike out what does not apply.

3) Specify the tolerances.

**9.2.2.1.2 Cooling system**

## a) Liquid:

Nature of liquid: .....

Circulating pump: yes/no<sup>2)</sup> .....

Characteristics or make(s): ..... Type(s): .....

Drive ratio: .....

Thermostat setting: .....

Radiator: drawings or make(s)<sup>2)</sup>: ..... Type(s): .....

Relief valve; pressure setting: .....

Fan: characteristics or make(s)<sup>2)</sup>: ..... Type(s): .....

Fan drive system: .....

Drive ratio: .....

Fan cowl: .....

## b) Air:

Blower characteristics or make(s)<sup>2)</sup>: ..... Type(s): .....

Drive ratio: .....

Air ducting (standard production): .....

Temperature regulating system: yes/no<sup>2)</sup>: .....

Brief description: .....

**9.2.2.1.3 Temperatures specified by the manufacturer**

## a) Liquid cooling:

Maximum temperature at outlet: ..... K

## b) Air cooling:

Reference point (description): .....

Maximum temperature at reference point: ..... K

Maximum exhaust temperature: ..... K

Fuel temperature, min: ..... K max.: ..... K

Lubricant temperature, min.: ..... K max.: ..... K

**9.2.2.1.4 Pressure charger: with/without<sup>2)</sup>**

Description of the system: .....

Make: ..... Type: .....

Compressor system, Make: ..... Type: .....

Charge air cooling system, Make: ..... Type: .....

#### 9.2.2.1.5 Inlet system

Description and diagrams of air inlets and their accessories (heating device, inlet silencer, etc.):

Inlet manifold: ..... Description: .....

Air filter: ..... Make: ..... Type: .....

Inlet silencer: ..... Make: ..... Type: .....

#### 9.2.2.1.6 Additional anti-pollution devices (if any, and if not covered by another heading)

Description and diagrams: .....

#### 9.2.2.1.7 Fuel feed system

Fuel feed: .....

Feed pump: .....

Pressure: ..... kPa

or characteristic diagram<sup>2),3)</sup> .....

Injection system: .....

Pump:

Make(s): .....

Type(s): .....

Delivery: ..... mm<sup>3</sup> per stroke<sup>3)</sup> ..... at pump speed of ..... min<sup>-1</sup> <sup>3),4)</sup>

..... at full injection, or characteristic diagram<sup>3)</sup> .....

Quote the method used: on engine/on pump bench<sup>2)</sup>

Injection advance<sup>3)</sup>: .....

Injection advance curve: .....

Timing: .....

Injection piping:

Length: ..... mm

Internal diameter: ..... mm

Injector(s):

Make(s): .....

Type(s): .....

Opening pressure: ..... kPa

or characteristic diagram<sup>2),3)</sup>: .....

4) 1 min<sup>-1</sup> = 1 r/min