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Australia



# Earth-moving machinery — Engine test code — Net power



AS ISO 9249:2021

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- Department of Natural Resources, Mines and Energy, Qld
- Department of Regional NSW
- Engineers Australia
- Institute of Instrumentation, Control & Automation Australia
- Minerals Council of Australia
- Mining Electrical and Mining Mechanical Engineering Society
- University of Queensland

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# Earth-moving machinery — Engine test code — Net power

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## Preface

This Standard was prepared by the Standards Australia Committee ME-063, Earthmoving Equipment.

The objective of this document is to specify a method for testing the net power of internal combustion engines intended for the propulsion of earth-moving machinery as defined in ISO 6165. It is intended to provide a standardized means of reporting net power values to the end user of the earth-moving machines. It is applicable to—

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

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

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The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

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## 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 9249 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 1, *Test methods relating to machine performance*.

This third edition cancels and replaces the second edition (ISO 9249:1997), which has been technically revised. It also incorporates the Technical Corrigendum ISO 9249:1997/Cor 1:1999.

## Introduction

This International Standard is intended to be applied in conjunction with the “core” standard, ISO 15550, in order to define the net power ratings for earth-moving machinery where relevant equipment and accessories that absorb engine power (fan, pumps, air compressors and so forth) are deducted from the engine power rating. The “satellite” standard is therefore not a stand-alone document but is intended to be completed by the requirements laid down in ISO 15550.

ISO 15550 contains the requirements that are common to all engine applications, whereas this International Standard contains only those requirements that are necessary to tailor power measurement and declaration to suit the particular engine application defined in its Scope.

The relationship between this International Standard and ISO 14396 is explained in [Annex A](#).

## NOTES



# Australian Standard®

## Earth-moving machinery — Engine test code — Net power

### 1 Scope

This International Standard specifies a method for testing the net power of internal combustion engines intended for the propulsion of earth-moving machinery as defined in ISO 6165. It is intended to provide a standardized means of reporting net power values to the end user of the earth-moving machines. It is applicable to

- a) RIC spark- or compression-ignition engines but excluding free piston engines,
- b) rotary piston engines.

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

NOTE This International Standard is a companion standard to ISO 14396. The principle differences between the two is the fitting of certain cooling equipment and pressure-charging equipment auxiliaries (fans) for the test. It is possible to deduct the power requirements of equipment and auxiliaries from the engine ratings of ISO 14396 by test or calculation methods. See [Annex A](#) for the preferred calculation method for obtaining the net power ratings according to this International Standard. Both the test and the calculation method comply with this International Standard.

### 2 Normative references

The following referenced documents are indispensable for the application 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 6165, *Earth-moving machinery — Basic types — Identification and terms and definitions*

ISO 14396, *Reciprocating internal combustion engines — Determination and method for the measurement of engine power — Additional requirements for exhaust emission tests in accordance with ISO 8178*

ISO 15550:2002, *Internal combustion engines — Determination and method for the measurement of engine power — General requirements*

### 3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO 15550 and the following terms and definitions apply.

#### 3.1

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

engine speed corresponding to the declared power

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

[SOURCE: ISO 15550:2002, definition 3.2.4]

#### 3.2

##### **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”.

[SOURCE: ISO 15550:2002, definition 3.3.1]



### 3.3

#### **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.

[SOURCE: ISO 15550:2002, definition 3.2.1]

### 3.4

#### **engine speed**

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

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

### 3.5

#### **fuel delivery**

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

Note 1 to entry: Adapted from ISO 7876-1:1990, definition 10.24.

### 3.6

#### **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 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 15550:2002, definition 3.3.11]

### 3.7

#### **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 listed in ISO 15550:2002, Table 1, column 2, and required in column 3 (fitted for engine net power test)

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

Note 2 to entry: Adapted from ISO 15550:2002, definition 3.3.3.1.

### 3.8

#### **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 listed in ISO 15550:2002, Table 1, column 2, and required in column 3 (fitted for engine net power test)

Note 1 to entry: Adapted from ISO 15550:2002, definition 3.3.12.

### 3.9

#### **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

[SOURCE: ISO 15550:2002, definition 3.3.10]

Note 1 to entry: In this case, the power and performance parameters may vary as a function of ambient conditions (see ISO 15550:2002, Clause 7).



## 4 Standard reference conditions

The standard reference conditions shall be in accordance with ISO 15550:2002, Clause 5.

## 5 Tests

### 5.1 Test method

The test method shall be test method 2 as specified in ISO 15550:2002, 6.3.

### 5.2 Test conditions

The test conditions shall be in accordance with ISO 15550:2002, 6.3.4, together with the following:

- a) Equipment and auxiliaries shall be installed in accordance with ISO 15550:2002, Table 1, column 3, including [Table 1](#) footnotes. The fan shall include the entire fan system including the fan and all drive components such as the pump, lines and motor for a hydraulic fan. When the fan system is not fitted for the test then the power absorbed at 25 °C (ambient) shall be determined and subtracted from the measured engine power.
- b) Other machine accessories connected to the engine but that are only necessary for the operation of the machine should be removed for the test. Where accessories cannot be removed, the power absorbed by them in the unloaded condition shall be determined and added to the measured engine power. The following list of examples is non-exhaustive:
  - 1) machine control system(s) hydraulic system pumps;  
air compressor for machine systems;
  - 3) air-conditioning system compressor;
  - 4) transmission system pump(s);
  - 5) mounted gearbox(es).

Where a disconnectable or progressive fan or blower is incorporated, the test is performed with the fan or blower disconnected or with the progressive fan running at maximum slip, as specified in ISO 15550:2002, Table 1. The intent of this condition is to state net power at the minimum nominal fan system power, when a disconnectable or progressive fan, blower, variable speed fan or ON-OFF fan is incorporated. Measure fan power at the normal operating range of the machine as a function of ambient temperature and load factor (i.e. not at start-up or other machine non-operating range condition).

## 6 Method of power correction

The method of power correction shall be in accordance with ISO 15550:2002, Clause 7.

The test may be carried out in an air-conditioned test room where the atmospheric conditions are controlled in order to maintain the correction factor as close to 1,0 as possible. In the case of engines with an automatic air temperature control, if the device is such that, at full load and at standard atmospheric conditions (see ISO 15550:2002, Clause 5), no heated air is added to the inlet air, the test shall be carried out with the device operating normally and the exponent of the temperature term in the correction factor, as specified in ISO 15550:2002, 7.3 or 7.4.2, shall be taken as zero (no temperature correction).

A calculation of the deductions is permissible in place of an actual test. The calculation method shall be accurate such that the engine net power ratings meet the requirements of [Clause 9](#).



## 7 Test report

The test report shall be in accordance with ISO 15550:2002, 9.2.2.1, 9.2.2.2 and 9.2.2.3, and shall additionally contain information in accordance with [Table 1](#), as applicable.

**Table 1 — Test report (information additional to that specified in ISO 15550)**

Engine		
Test conditions		
Pressures measured at declared speed:		
a) total barometric pressure		kPa
b) water vapour pressure		kPa
c) exhaust back-pressure		kPa
Location of exhaust back-pressure measurement point:		
Inlet depression:		Pa
Absolute pressure in the inlet ductwork:		Pa
Temperature measured at the declared speed:		
a) inlet air		K
b) engine charge air cooler outlet		K
c) cooling fluid at the engine cooling fluid outlet/reference point in the air cooling case		K
d) lubricating oil:		K
— measurement point:		
e) fuel:		
— at the carburettor inlet/fuel injection system inlet		K
— in the fuel flow measuring device		K
NOTE In addition to the temperature, $T$ , expressed in Kelvin, use can be made of the Celsius temperature, $t$ , defined by the equation: $t = T - 273,15$ . The temperature unit of degrees Celsius can thus be used instead of degrees Kelvin.		

## 8 Statement of results as a function of engine speed

The statement of results shall be according to ISO 15550:2002, Table 13, with additional requirements as presented in [Table 2](#) below.

**Table 2 — Statement of results**

Parameter		Result	Unit
Power to be subtracted for equipment and auxiliaries not fitted on the engine, additional to those in accordance with 6.2 b), ISO 15550:2002, and ISO 15550:2002, Table 1. <sup>a</sup>			
	Aux.1		kW
	Aux.2		kW
	Aux.3		kW
Inlet depression			Pa
NOTE In addition to the temperature, $T$ , expressed in Kelvin, use can be made of the Celsius temperature, $t$ , defined by the equation: $t = T - 273,15$ . The temperature unit of degrees Celsius can thus be used instead of degrees Kelvin.			
<sup>a</sup> Equipment or auxiliaries not fitted on the engine but required for the engine to perform its intended service (i.e. additional turbo lubrication pump) can use calculations to subtract these power deductions.			
<sup>b</sup> Calculated with corrected power and corrected fuel flow.			

**Table 2** (continued)

Parameter		Result	Unit
Exhaust back-pressure			kPa
Fuel delivery per stroke or cycle <sup>b</sup>			ml <sup>3</sup>

In addition to the temperature,  $T$ , expressed in Kelvin, use can be made of the Celsius temperature,  $t$ , defined by the equation:  $t = T - 273,15$ . The temperature unit of degrees Celsius can thus be used instead of degrees Kelvin.

<sup>a</sup> Equipment or auxiliaries not fitted on the engine but required for the engine to perform its intended service (i.e. additional turbo lubrication pump) can use calculations to subtract these power deductions.

<sup>b</sup> Calculated with corrected power and corrected fuel flow.

## 9 Measurement accuracy

The measured power of an engine may differ from the power declared by the manufacturer by  $\pm 2\%$  or 0,3 kW, whichever is greater, at the declared engine speed, and by  $\pm 4\%$  at all other speeds.



## Annex A (informative)

### Determination of net power using ISO 14396

#### A.1 General

Like this International Standard, ISO 14396 is a “satellite” to ISO 15550. It is used to specify the method and additional requirements for determining the power of reciprocating internal combustion (RIC) engines when presented for an exhaust emission test in accordance with ISO 8178.

The testing requirements of this International Standard are very similar to those of ISO 14396, as both are based on the “core” standard, ISO 15550. The fundamental difference between them is that the power declared using this International Standard deducts relevant equipment and accessories from the power values of ISO 14396.

#### A.2 Calculation

For the calculation of net power according to this International Standard, deduct the power absorbed by

- the cooling equipment fan (if equipped),
- the pressure-charging equipment coolant pump or fan (if equipped), and
- equipment and auxiliaries listed in [Table 2](#),

from the corrected engine power measured in accordance with ISO 14396.

The power of the fan(s) and pump 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, corrected to the standard atmospheric conditions (see ISO 15550:2002, Clause 5).

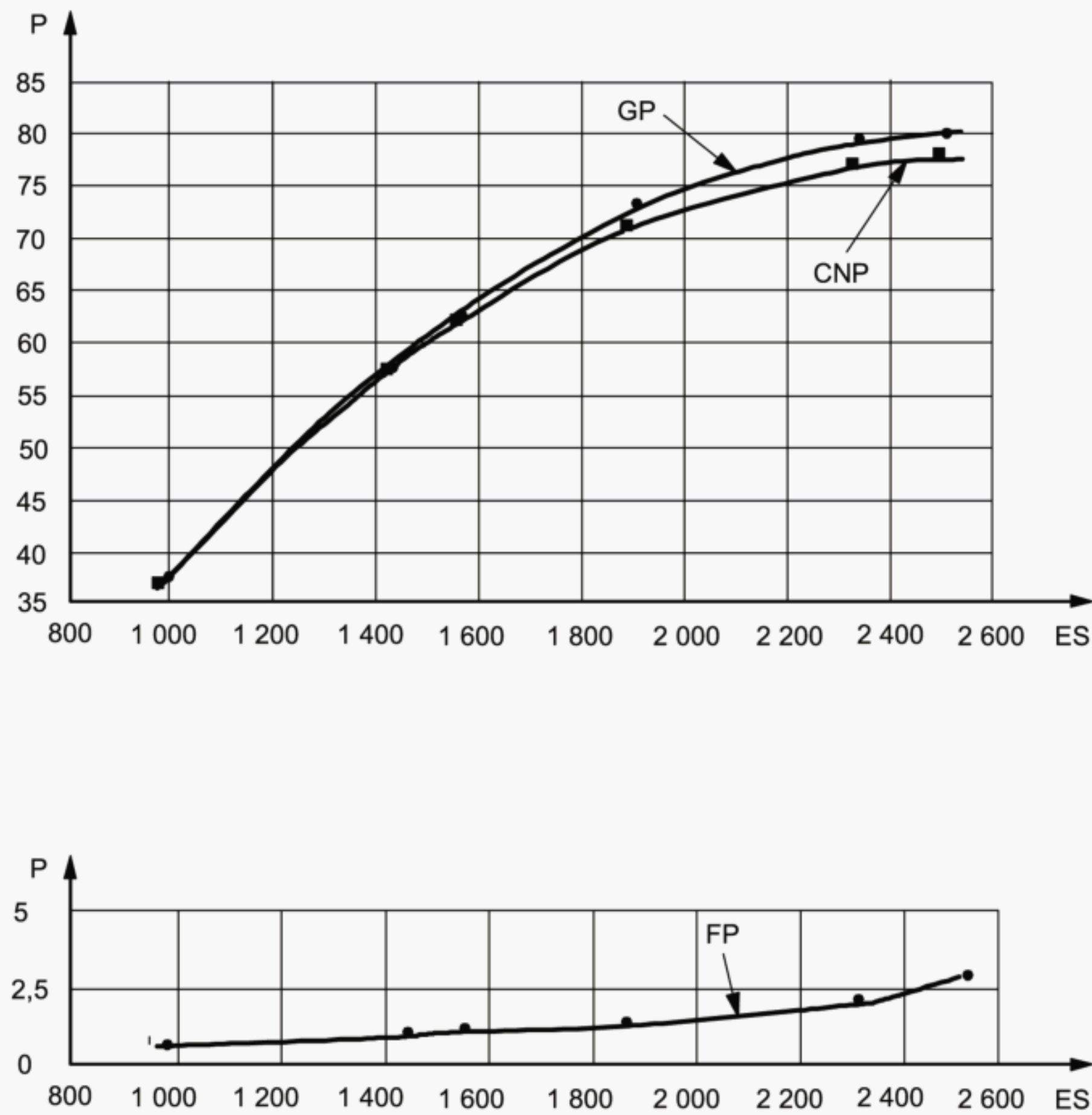
The accuracy of the net power ratings shall satisfy the requirements of [Clause 9](#).

An example and consequence of the calculation (using the example of a liquid cooling fan) is given in [Table A.1](#) and shown in [Figure A.1](#).

**Table A.1 — Calculation of net power**

		Speed <sup>a</sup> r/min					
		1 000	1 400	1 500	1 800	2 200	2 400
Power (kW)	for ISO 8178 (ISO 14396)	36,7	58,6	62,5	72,4	79,5	80,5
	fan power (absorption)	0,2	0,6	0,7	1,2	2,2	2,8
	net power (this International Standard)	36,5	58,0	61,8	71,2	77,3	77,7
<sup>a</sup> At speeds corresponding to the engine speeds used for the measurement of engine power according to ISO 8178.							



**Key**

CNP calculated net power, kW

ES engine speed, r/min

FP fan power, kW

GP power, kW (according to ISO 14396, i.e. without cooling equipment fan)

P power, kW

**Figure A.1 — Calculation of net power**

## Bibliography

- [1] ISO 2710-1, *Reciprocating internal combustion engines — Vocabulary — Part 1: Terms for engine design and operation*
- [2] ISO 7876-1, *Fuel injection equipment — Vocabulary — Part 1: Fuel injection pumps*
- [3] ISO 8178 (all parts), *Reciprocating internal combustion engines — Exhaust emission measurement*

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