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**Reciprocating internal combustion  
engines — Performance —**

**Part 4:  
Speed governing**

*Moteurs alternatifs à combustion interne — Performances —*

*Partie 4: Régulation de la vitesse*

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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 3046-4 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*.

This third edition cancels and replaces the second edition (ISO 3046-4:1997), which has been technically revised.

ISO 3046 consists of the following parts, under the general title *Reciprocating internal combustion engines — Performance*:

- <https://standards.iteh.ai/catalog/standards/sist/3f1ccf57-bb1a-4314-b65e-301226f5a005/iso-3046-4-2009>
- *Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods — Additional requirements for engines for general use*
  - *Part 3: Test measurements*
  - *Part 4: Speed governing*
  - *Part 5: Torsional vibrations*
  - *Part 6: Overspeed protection*

# Reciprocating internal combustion engines — Performance —

## Part 4: Speed governing

### 1 Scope

This part of ISO 3046 establishes a classification for the requirements and parameters of speed-governing systems and specifies terms and definitions of typical engine speeds for reciprocating internal combustion (RIC) engines. Where necessary, individual requirements are given for particular engine applications.

This part of ISO 3046 applies to RIC engines for land, rail-traction and marine use, excluding engines used to propel road-construction and earth-moving machines, agricultural and industrial types of tractors, road vehicles and aircraft. Also excluded are self-governing engines and those engines requiring only maximum speed or maximum fuel delivery limitation.

This part of ISO 3046 defines requirements for compression-ignition oil engines (diesel engines). For spark ignition engines and dual fuel engines, special requirements can apply.

NOTE 1 Performance and parameters for speed-governing systems applied to RIC engine driven generating sets are specified in ISO 8528-2 and ISO 8528-5.

NOTE 2 The terms and definitions of typical engine speeds in connection with overspeed protection devices are specified in ISO 3046-6.

### 2 Terms and definitions, symbols and subscripts

For the purposes of this document, the following terms and definitions, symbols and subscripts apply.

NOTE Terms and definitions related to overspeed devices are given in ISO 3046-6.

#### 2.1 Speed-governing systems

##### 2.1.1

##### **engine speed governor**

device which under specific engine operating conditions compares the actual speed and the setting speed and causes a modification of the fuel delivery into the engine in order to adjust the actual speed of the RIC engine towards the setting speed

NOTE 1 See ISO 7967-7:2005, 3.1.1.

NOTE 2 Speed governors can be classified according to:

- the speed sensing and amplification of their output signal (see ISO 7967-7:2005, 3.3.1);
- their dynamic behaviour (transfer function) (see ISO 7967-7:2005, 7.2);
- their related engine application (see ISO 7967-7:2005, 3.3.3).

2.1.2

**speed-setting device**

device allowing adjustment of the set point of a speed governor, depending on the application or required kind of adjustment respectively

NOTE Adapted from ISO 7967-7:2005, definition 3.1.2.

2.1.3

**torque control**

modification of the maximum natural fuel delivery curve obtained from the fuel injection system at speeds below the engine **declared speed**

NOTE Adapted from ISO 7967-7:2005, definition 3.5.3.

2.2 Speed-governing parameters

2.2.1

**declared speed droop**

$\delta n_{st,r}$

speed difference between the **declared no-load speed** and the **declared speed** at declared power, expressed as a percentage of the declared speed at a fixed speed setting, calculated using the following equation:

$$\delta n_{st,r} = \frac{n_{i,r} - n_r}{n_r} \times 100$$

where

$n_r$  is the declared speed;

$n_{i,r}$  is the declared no-load speed

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NOTE See Table 1 and Figures 4 and 5. <https://standards.iteh.ai/catalog/standards/sist/3f1ccf57-bb1a-4314-b65e-301226f5a005/iso-3046-4-2009>

2.2.2

**load sharing at parallel operation**

$\Delta P$

difference between the proportion of power supplied by an individual engine and the proportion of the total declared power supplied by all engines, expressed as a percentage, calculated using the following equation:

$$\Delta P = \left[ \frac{P_a}{P_r} - \frac{\sum P_a}{\sum P_r} \right] \times 100$$

where

$P_a$  is the actual delivered power of an individual engine;

$P_r$  is the declared (rated) power of an individual engine

2.2.3

**maximum force**

maximum value of the force at the output of the governor at any specified position of travel

[ISO 7967-7:2005, definition 3.4.1]

2.2.4

**maximum torque**

maximum value of the torque at the output shaft of the governor at any specified position of travel

[ISO 7967-7:2005, definition 3.4.2]

**2.2.5****range of speed setting** $\Delta n_s$ 

difference between the **lowest adjustable no-load speed** and the highest adjustable no-load speed determined by the speed-setting device

NOTE See 2.3.7 and 2.3.10.

**2.2.6****rate of change of speed setting** $v_n$ 

rate at which the speed setting can be changed within the **range of speed setting**, expressed as a percentage of the declared speed setting per second, calculated using the following equation:

$$v_n = \frac{n_{i,\max} - n_{i,\min}}{n_r \times t} \times 100$$

where

$n_i$  is the no-load speed;

$n_r$  is the declared speed;

$t$  is time

NOTE 1 See ISO 8528-2:2005, 6.3.4.

NOTE 2 For ship propulsion engines, the rate of change of speed setting will necessarily depend on the particular application, manufacturer and/or customer demand (e.g. different rate of change of speed setting for manoeuvring and normal acceleration/deceleration).

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**2.2.7****speed governor input signal**

input signal to the governor, which is a measure of the instantaneous engine speed

NOTE Adapted from ISO 7967-7:2005, definition 3.2.1.

**2.2.8****speed governor output signal**

signal delivered by the speed governor that is used to adjust the fuel delivery

NOTE Adapted from ISO 7967-7:2005, definition 3.2.2.

**2.2.9****steady-state speed band** $\beta n$ 

width of the envelope of oscillation,  $\Delta n$ , of speed at constant power around a mean value, expressed as a percentage of the declared speed,  $n_r$ , calculated using the following equation

$$\beta n = \frac{\Delta n}{n_r} \times 100$$

NOTE 1 See Figure 6.

NOTE 2 The operating limiting values for the steady-state speed band over the whole operating range of an RIC engine depend on the power output and whether the engine is coupled to the driven machinery or not. These operating limiting values also depend on the declared speed of the RIC engine.

The following cases can be differentiated.

a) Engines coupled with driven machinery:

- 1)  $n < 0,5 n_r$ ;
- 2)  $n \geq 0,5 n_r$  and  $P \geq 0,25 P_r$ ;
- 3)  $n \geq 0,5 n_r$  and  $P < 0,25 P_r$ .

b) Engines not coupled with driven machinery and running at lowest adjustable no-load speed.

The curves given in Figures 1 to 3 have been prepared on the basis of experience. These curves can also be expressed, as a percentage, using the following equation:

$$\beta n = c n_r^{-m}$$

where the values of  $c$  and  $m$  are given in Table 1 for the cases specified in a) and b).

NOTE 3 The values of  $c$  and  $m$  depend on the inertia of the system, the capability of the speed governor and the power output of the engine over the whole speed range, and, in this context, are therefore only important for the end user.

## 2.2.10

### work capacity

maximum work available from the governor as its output shaft or arm moves through its full available travel

## 2.3 Steady-state engine speeds

### 2.3.1

#### declared no-load speed

$n_{i,r}$

#### high idling speed

steady-state engine speed without load at the same speed setting as for the declared speed

### 2.3.2

#### declared speed

$n_r$

speed at which the engine delivers the declared power

[ISO 2710-1:2000, definition 11.1.2]

### 2.3.3

#### engaging speed

$n_c$

engine speed at which the driven device is coupled to the engine

### 2.3.4

#### engine speed

$n$

number of crankshaft revolutions in a given period of time

[ISO 2710-1:2000, definition 11.1]

### 2.3.5

#### fast idling speed

$n_{i,f}$

increased lowest adjustable no-load speed

NOTE This speed is often used for cold engine start and during engine warm-up. It can be achieved by either manual or automatic adjustment.

[ISO 7967-7:2005, definition 3.6.1.13]

### 2.3.6 firing speed

$n_{sf}$

speed to which an engine is accelerated from rest by the use of an external energy supply separate from the fuel feed system before it becomes self-sustaining

[ISO 2710-1:2000, definition 11.1.5]

NOTE The firing speed (and **starting speed**) depend upon the ambient and operating conditions of the engine during start and upon the type of starting system used.

### 2.3.7 highest adjustable no-load speed based on overload speed

$n_{i,ov}$

highest steady-state **engine speed** without load at the same speed setting as for **overload speed**

NOTE For generating sets, this speed can be selected by the speed governor speed-setting device (see ISO 8528-5).

### 2.3.8 no-load speed

$n_i$

steady-state **engine speed** without load

NOTE Adapted from ISO 2710-1:2000, definition 11.1.4.

### 2.3.9 lowest adjustable speed

$n_{p,min}$

lowest steady-state **engine speed** which can be selected by the **speed-setting device** with the engine coupled and operating on the propeller curve or on another specified power curve

### 2.3.10 lowest adjustable no-load speed

$n_{i,min}$

**low idling speed**

lowest steady-state **engine speed** without load at the same speed setting as for **lowest adjustable speed**

NOTE 1 For generating sets, this speed can be selected by the speed-setting device of the speed governor (see ISO 8528-5).

NOTE 2 Adapted from ISO 7967-7:2005, definition 3.6.1.8.

### 2.3.11 lowest continuous full-load speed

$n_{f,l}$

steady-state lowest permissible **engine speed** at full load (fuel control rod for rated power)

### 2.3.12 lowest continuous speed at partial power

$n_{p,l}$

steady-state lowest permissible continuous **engine speed** on the propeller curve or on another specified power curve

### 2.3.13 speed at maximum torque

$n_{tq}$

**engine speed at maximum torque** on maximum fuel position, including, if applicable, any additional torque fuel setting

**2.3.14**

**no-load speed based on speed at partial power**

$n_{i,p}$   
steady-state engine speed without load at the same speed setting as for speed at partial power

**2.3.15**

**overload speed**

$n_{ov}$   
speed at which the engine delivers the overload power declared by the manufacturer

**2.3.16**

**speed at partial power**

$n_p$   
steady-state engine speed between the declared speed and the lowest adjustable speed

**2.3.17**

**starting speed**

$n_s$   
maximum speed to which the engine (together with the mechanically-coupled auxiliaries) can be accelerated by the starting system when the fuel rack is in the stop position

NOTE 1 The starting speed (and firing speed) depend upon the ambient and operating conditions of the engine during start and upon the type of starting system used.

NOTE 2 The starting speed can be influenced by the power requirements of the auxiliary equipment and will be higher than the firing speed.

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**2.4 Dynamic speed behaviour (standards.iteh.ai)**

**2.4.1**

**overshoot speed**

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$n_{d,max}$   
maximum transient engine speed which occurs on change from a higher to a lower power or on change of speed setting from lower to higher speed

NOTE Adapted from ISO 7967-7:2005, definition 3.6.2.2.

**2.4.2**

**speed recovery time on load increase**

$t_{n,in}$   
**speed recovery time on load decrease**

$t_{n,de}$   
time interval between the departure from the steady-state speed band after a specified load change and the permanent re-entry of the speed into the specified steady-state speed band at the new speed

**2.4.3**

**transient speed difference (from initial speed) on load increase (–) or on load decrease (+)**

$\delta n_{dyn}$   
temporary speed difference between undershoot (or overshoot) speed and initial speed during the governing process following load change

NOTE Transient speed difference is expressed as a percentage of initial speed where a negative sign relates to an undershoot after a load increase and a positive sign to an overshoot after a load decrease, calculated using the following equations respectively:

$$\delta n_{dyn}^- = \frac{n_{d,min} - n_{i,p}}{n_p} \times 100$$

$$\delta n_{dyn}^+ = \frac{n_{d,max} - n_{i,p}}{n_p} \times 100$$

#### 2.4.4 undershoot speed

$n_{d,min}$

minimum transient engine speed which occurs on change from a lower to a higher power or on change of speed setting from higher to lower speed

NOTE Adapted from ISO 7967-7:2005, definition 3.6.2.1.

## 2.5 Symbols and subscripts

### 2.5.1 Symbols

$c$	constant to compute the steady-state speed band
$m$	constant for the exponents to compute the steady-state speed band
$P_a$	actual delivered power of an individual engine
$P_r$	declared (rated) power of an individual engine
$\Delta n$	width of the envelope of oscillation of speed at constant power around a mean value
$\sum P_a$	sum of powers actually delivered by all engines operating in parallel
$\sum P_r$	sum of the declared (rated) powers of all engines operating in parallel

### 2.5.2 Subscripts

a	actual
c	coupled
de	decrease
dyn	dynamic
f	full load
i	no load (idling)
in	increase
l	lowest
n	speed
ov	overload
p	partial-load power
r	declared (rated)
s	starting
sf	firing
st	static deviation (droop)
tq	torque