INTERNATIONAL STANDARD

ISO 3046-4

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Reciprocating internal combustion engines —

Part 4:
Speed governing

Moteurs alternatifs à combustion interne — Performances

Partie 4: Régulation de la vitesse

Reference number
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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.

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.

International Standard ISO 3046-4 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Subcommittee SC 5, *Special requirements.*

This second edition cancels and replaces the first edition (ISO 3046-4:1978), which has been technically revised.

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

— *Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods*

— *Part 3: Test measurements*

— *Part 4: Speed governing*

— *Part 5: Torsional vibrations*

— *Part 6 Overspeed protection*

— *Part 7: Codes for engine power*

Annex A of this part of ISO 3046 is for information only.

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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 may be 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 air-craft. 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 may apply.

NOTES

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

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

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 3046. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 3046 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7967-7:—[1]), *Reciprocating internal combustion engines — Vocabulary of components and systems — Part 7: Governing systems.*

1) To be published.

3 Symbols and subscripts

The symbols and subscripts used in this part of ISO 3046 are given in 3.1 and 3.2. They are in accordance with ISO 31-3 and, where applicable, to those used in ISO 8528-2.

3.1 Symbols

c	Constant to compute the steady-state speed band
m	Constant for the exponents to compute the steady-state speed band
n	Engine speed
n_{c}	Engaging speed
$n_{\mathrm{d,max}}$	Overshoot speed
$n_{\mathrm{d,min}}$	Undershoot speed
$n_{\mathrm{f,l}}$	Lowest continuous full-load speed
n_{i}	No-load speed (idling speed)
$n_{\mathrm{i,f}}$	High idling speed
$n_{\mathrm{i,min}}$	Lowest adjustable no-load speed
$n_{\mathrm{i,ov}}$	Highest adjustable no-load speed based on overload speed
$n_{\mathrm{i,p}}$	No-load speed based on speed at partial-load power
$n_{\mathrm{i,r}}$	Declared no-load speed (high idling speed)
n_{ov}	Overload speed
n_{p}	Speed at partial-load power
$n_{\mathrm{p,l}}$	Lowest continuous speed at partial-load power
$n_{\mathrm{p,min}}$	Lowest adjustable speed
n_{r}	Declared speed
n_{s}	Starting speed
n_{sf}	Firing speed
n_{tq}	Speed at maximum torque
P_{a}	Actual delivered power of an individual engine
P_{r}	Declared (rated) power of an individual engine
$t_{n,\mathrm{de}}$	Speed recovery time (load decrease)
$t_{n,\mathrm{in}}$	Speed recovery time (load increase)
β_n	Steady-state speed band
$\delta n_{\mathrm{st,r}}$	Declared speed droop
δn_{dyn}	Transient speed deviation (from initial speed)
$\delta n_{\mathrm{dyn}}^{-}$	Transient speed deviation (on load increase)

δn_{dyn}^{+} Transient speed deviation (on load decrease)

Δn Width of the envelope of oscillation of speed of constant power around a mean value

Δn_s Range of speed setting

ΔP Load sharing at parallel operation

v_n Rate of change of speed setting

ΣP_a Sum of powers actually delivered by all engines operating in parallel

ΣP_r Sum of the declared (rated) powers of all engines operating in parallel

3.2 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

4 Classification of speed-governing systems

For the classification and assessment of speed-governing systems the following characteristics or qualities are essential:

— speed sensing and amplification of the output signal;

— dynamic behaviour (transfer function);

— function related to engine application.

In addition, it is important to know the type of speed-setting device used.

The terms, symbols and definitions are given in 4.1 to 4.4.

4.1 Speed-governing systems

No.	Term	Definition
4.1.1	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. [ISO 7967-7:—, 5.1] Speed governors can be classified: a) according to speed sensing and amplification of the output signal (see ISO 7967-7:—, 7.1); b) according to dynamic behaviour (transfer function) (see ISO 7967-7:—, 7.2); c) according to function related to engine application (see ISO 7967-7:—, 7.3).
4.1.2	Speed-setting device	Device allowing adjustment of the set point of a speed governor, depending on the application or required kind of adjustment, respectively. [ISO 7967-7:—, 7.4]
4.1.3	Torque control	Modification of the maximum natural fuel delivery curve obtained from the fuel injection system at speeds below the engine declared speed. [ISO 7967-7:—, 9.1]

4.2 Parameters of speed governing

No.	Term	Symbol	Definition
4.2.1	Speed governor input signal		Input signal to the governor, which is a measured of the instantaneous engine speed. [ISO 7967-7:—, 6.1]
4.2.2	Speed governor output signal		Signal delivered by the speed governor which is used to adjust the fuel delivery. [ISO 7967-7:—, 6.7]
4.2.3	Work capacity		Maximum work available from the governor as its output shaft or arm moves through its full available travel. [ISO 7967-7:—, 6.8]
4.2.4	Maximum force		Maximum value of the force at the output of the governor at any specified position of travel. [ISO 7967-7:—, 6.9]
4.2.5	Maximum torque		Maximum value of the torque at the output shaft of the governor at any specified position of travel. [ISO 7967-7:—, 6.10]
4.2.6	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 fixed speed setting (see figures 4 and 5 and table 1): $\delta n_{st,r} = \frac{n_{i,r} - n_r}{n_r} \times 100$

No.	Term	Symbol	Definition
4.2.7	Steady-state speed band	β_n	Width of the envelope of oscillation Δ_n of speed at constant power around a mean value (see figure 6), expressed as a percentage of the declared speed: $$\beta_n = \frac{\Delta_n}{n_r} \times 100$$ 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 are specified. a) Engines coupled with driven machinery — $n < 0{,}5n_r$ — $n \geqslant 0{,}5n_r$ and $P \geqslant 0{,}25P_r$ — $n \geqslant 0{,}5n_r$ and $P < 0{,}25P_r$ 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, by the formula $$\beta_n = c n_r^{-m}$$ where the values of c and m are given in table 1 for the four cases specified. NOTE — This value depends 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, is therefore only important for the customer.
4.2.8	Range of speed setting	Δn_s	Difference between the lowest adjustable no-load speed and the highest adjustable no-load speed determined by the speed-setting device. (See 4.3.1.14 and 4.3.1.17)
4.2.9	Rate of change of speed setting (see table 1)	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. [ISO 8528-2:1993, 6.3.4] $$v_n = \frac{n_{i,max} - n_{i,min}}{n_r \times t} \times 100$$ NOTE — 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 manœuvering and normal acceleration/deceleration).
4.2.10	Load sharing at parallel operation	ΔP	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: $$\Delta P = \left[\frac{P_a}{P_r} - \frac{\Sigma P_a}{\Sigma P_r}\right] \times 100$$ In the case of parallel operation of all engines on one shaft, the load sharing of the engines depends on the speed droop and the accuracy of the speed-setting device of the fitted governor. By using an automatic load-sharing device, the limited values may be reduced. When adjusting the speed governor and the speed-setting device, the limited values for the lowest engine power at the lowest adjustable speed and the declared power at declared speed shall be smaller. To keep the limited values when load sharing, the speed droop shall be within the limits given in table 1.

4.3 Typical engine speeds and speed behaviour

NOTE — Terms and definitions of typical engine speeds related to the overspeed device are specified in ISO 3046-6.

See examples shown in figures 4 and 5. For example of an RIC engine at constant speed, refer to ISO 8528-2:1993, figure 1.

4.3.1 Typical steady state engine speeds

No.	Term	Symbol	Definition
4.3.1.1	Engine speed	n	The number of revolutions of the crankshaft in a given period of time. [ISO 2710-1:—, 10.2.1]
4.3.1.2	Firing speed[1)]	n_{sf}	The engine speed to which an engine must be accelerated from rest by the use of an external supply of energy separate from fuel feed system before it becomes self-sustaining. [ISO 2710-1:—, 10.2.2]
4.3.1.3	Starting speed[1), 2)]	n_s	The maximum engine 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.
4.3.1.4	Engaging speed	n_c	The engine speed at which the driven device is coupled to the engine.
4.3.1.5	Declared speed	n_r	The engine speed at which the engine delivers declared power [ISO 2710-1:—, 10.2.1.2]
4.3.1.6	No-load speed (idling speed)	n_i	Steady-state engine speed without load. (See ISO 2710-1:—, 10.2.1.4)
4.3.1.7	Declared no-load speed (high idling speed)	$n_{i,r}$	Steady-state engine speed without load at the same speed setting as for the declared speed n_r. [ISO 8528-2:1993, 6.2.4]
4.3.1.8	Speed at maximum torque	n_{tq}	The engine speed at maximum torque on maximum fuel position, including additional torque fuel setting, if applicable.
4.3.1.9	Speed at partial power	n_p	Steady-state engine speed between the declared speed and the lowest adjustable speed.
4.3.1.10	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 n_p.
4.3.1.11	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.
4.3.1.12	Lowest continuous full-load speed	$n_{f,l}$	Steady-state lowest permissible engine speed at full load (fuel control rod for rated power).
4.3.1.13	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 propeller curve or on another specified power curve.
4.3.1.14	Lowest adjustable no-load speed (low idling speed)	$n_{i,min}$	Lowest steady-state engine speed without load at the same speed setting as for lowest adjustable speed $n_{p,min}$. NOTE — For generating sets, this speed can be selected by the speed-setting device of the speed governor. (See ISO 8528-5) [ISO 7967-7:—, 8.4]
4.3.1.15	High idling speed	$n_{i,f}$	Increased lowest adjustable no-load speed. NOTE — This speed is often used for cold engine start and during engine warning-up time. It may be achieved either by manual or automatic adjustment. [ISO 7967-7:—, 8.2]

No.	Term	Symbol	Definition
4.3.1.16	Overload speed	n_{ov}	Speed at which the engine delivers the overload power declared by the manufacturer. [ISO 2710-1:—, 10.2.1.3]
4.3.1.17	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-setting device of the speed governor. (See ISO 8528-5)

1) The firing speed and the starting speed depend on the ambient and operating conditions of the engine during engine start and on the type of starting system.

2) The starting speed may be influenced by the power requirements of the auxiliary equipment and must be higher than the firing speed.

4.3.2 Dynamic speed behaviour

The dynamic speed behaviour (see figure 6) is dependent on

- the turbocharging system of the RIC engine;
- the brake mean effective pressure, p_{me}, of the RIC engine at declared power;
- speed governor behaviour;
- operating behaviour of the driven machinery;
- rotational inertia of the RIC engine and driven machinery;
- the coupling between the RIC engine and driven machinery.

Since the operating behaviour of the driven machinery is unknown to the engine manufacturer, no specifications or values for transient engine behaviour can be stated in this part of ISO 3046.

4.3.3 Typical dynamic speed

No.	Term	Symbol	Definition
4.3.3.1	Overshoot speed	$n_{d,max}$	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. [ISO 7967-7:—, 8.5]
4.3.3.2	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. [ISO 7967-7:—, 8.6]
4.3.3.3	Transient speed difference (from initial speed) on load increase (−) or on load decrease (+)	δn_{dyn} δn_{dyn}^{-} δn_{dyn}^{+}	Temporary speed difference between undershoot (or overshoot) speed and initial speed during the governing process following load change. It is expressed as a percentage of this speed. $\delta n_{dyn}^{-} = \frac{n_{d,min} - n_{i,p}}{n_p} \times 100$ $\delta n_{dyn}^{+} = \frac{n_{d,max} - n_p}{n_p} \times 100$ (A negative sign relates to an undershoot after a load increase and a positive sign to an overshoot after a load decrease.)
4.3.3.4	Speed recovery time	$t_{n,in}$ $t_{n,de}$	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. [ISO 7967-7:—, 8.7]