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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

[Revision of second edition (ISO 3046-4:1997)]

ICS 27.020

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Foreword

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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*, Subcommittee SC , .

This third edition cancels and replaces the second edition which has been technically revised.

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

— *Part 1: Declarations of power, fuel and lubrication oil consumptions and test methods – Additional requirements for engine use in general;*

— *Part 3: Test measurements;*

— *Part 4: Speed governing;*

— *Part 5 : Torsional vibrations;*

— *Part 6 : Overspeed protection.*

Annex A is for information only.

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 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 may apply.

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

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

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 31-3 : 1992, *Quantities and units - Part 3 : Mechanics*

ISO 2710-1: 2000 *Reciprocating internal combustion engines – Vocabulary – Part 1: Terms for engine design and operation*

ISO 3046-1 : 2002, *RIC engines – Performance - Part 1 : Declarations of power, fuel and lubricating oil consumptions and test methods – Additional requirements for engines for general use ("Satellite" standard)*

ISO 3046-6 : 1990, *RIC engines - Performance – Part 6 : Overspeed protection*

ISO 7967-7 : 2004, *Reciprocating internal combustion engines - Vocabulary of components and systems - Part 7 : Governing systems*

ISO 8528-2 : 2004, *Reciprocating internal combustion engine driven alternating current generating sets - Part 2: Engines*

ISO 8528-5 : 1993, *Reciprocating internal combustion engine driven alternating current generating sets - Part 5: Generating sets*

3 Symbols and subscripts

The symbols and subscripts used are in accordance with the requirements of ISO 31-3 and, where applicable, to those used in ISO 8528-2.

3.1 Symbols

Symbol	Name
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
Δn	Width of the envelope of oscillation of speed at constant power around a mean value
$\Delta \sum P_a$	Sum of powers actually delivered by all engines operating in parallel
$\Delta \sum P_r$	Sum of the declared (rated) powers of all engines operating in parallel

3.2 Subscripts

Subscript	Name
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

4.1 General

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

a) speed sensing and amplification of the output signal;

b) dynamic behavior (transfer function);

c) 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 4.2 to 4.4.

4.2 Speed governing systems

Number	Term	Definition
4.2.1	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 (see 5.1 of ISO 7967-7). Speed governors can be classified according to : a) the speed sensing and amplification of their output signal (see 7.1 of ISO 7967-7); b) their dynamic behavior (transfer function) (see 7.2 of ISO 7967-7); c) their related engine application (see 7.3 of ISO 7967-7).
4.2.2	Speed-setting device	Device allowing adjustment of the set point of a speed governor, depending on the application or required kind of adjustment, respectively (see 7.4 of ISO 7967-7).
4.2.3	Torque control	Modification of the maximum natural fuel delivery curve obtained from the fuel injection system at speeds below the engine declared speed (see 9.1 of ISO 7967-7).

4.3 Speed governing parameters

Number	Term	Symbol	Definition
4.3.1	Speed governor input signal	—	Input signal to the governor, which is a measure of the instantaneous engine speed (see 6.1 of ISO 7967-7)
4.3.2	Speed governor output signal	—	Signal delivered by the speed governor which is used to adjust the fuel delivery (see 6.7 of ISO 7967-7)
4.3.3	Work capacity	—	Maximum work available from the governor as its output shaft or arm moves through its full available travel (see 6.8 of ISO 7967-7)
4.3.4	Maximum force	—	Maximum value of the force at the output of the governor at any specified position of travel (see 6.9 of ISO 7967-7)
4.3.5	Maximum torque	—	Maximum value of the torque at the output shaft of the governor at any specified position of travel (see 6.10 of ISO 7967-7)
4.3.6	Declared speed droop	$\partial n_{st,r}$	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 (see Figures 4 and 5 and Table 1) : $\delta n_{st,r} = \frac{n_{i,r} - n_r}{n_r} \times 100$

Number	Term	Symbol	Definition
4.3.7	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 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, 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 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, is therefore only important for the customer.
4.3.8	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 4.4.2.14 and 4.4.2.17)

Number	Term	Symbol	Definition
4.3.9	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 (see 6.3.4 of ISO 8528-2) as given by : $$v_n = \frac{n_{i,\max} - n_{i,\min}}{n_r \times t} \times 100$$ 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).
4.3.10	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 : $$\Delta P = \left[\frac{P_\mathrm{a}}{P_\mathrm{r}} - \frac{\sum P_\mathrm{a}}{\sum P_\mathrm{r}}\right] \times 100$$ (also see 6)

4.4 Typical engine speeds and speed behaviour

4.4.1 General

The terms and definitions related to overspeed devices are shown in ISO 3046-6.

See the examples shown in Figures 4 and 5.

For an example of an RIC engine running at constant speed see Figure 1 of ISO 8528-2.

4.4.2 Typical steady state engine speeds

Number	Term	Symbol	Definition
4.4.2.1	Engine speed	n	The number of crankshaft revolutions in a given period of time (see 10.2.1 of ISO 2710-1)
4.4.2.2	Firing speed [a)]	n_sf	The 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 (see 10.2.2 of ISO 2710-1)
4.4.2.3	Starting speed [a), b)]	n_s	The 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.
4.4.2.4	Engaging speed	n_c	The engine speed at which the driven device is coupled to the engine.