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Reciprocating internal combustion engines : Performance — Part IV : Speed governing

Moteurs alternatifs à combustion interne : Performance — Partie IV : Régulation de la vitesse

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FOREWORD

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3046/IV was developed by Technical Committee ISO/TC 70, *Internal combustion engines*, and was circulated to the member bodies in May 1977.

It has been approved by the member bodies of the following countries :

Australia	India	South Africa, Rep. of
Austria	Ireland	Spain
Belgium	Italy	Switzerland
Bulgaria	Japan	Turkey
Chile	Korea, Dem. P. Rep. of	United Kingdom
Czechoslovakia	Korea, Rep. of	U.S.A.
Denmark	Mexico	U.S.S.R.
France	Netherlands	Yugoslavia
Germany	Romania	

No member body expressed disapproval of the document.

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Reciprocating internal combustion engines : Performance – Part IV : Speed governing

1 SCOPE

This International Standard establishes a classification for the requirements and parameters of speed governing systems for reciprocating internal combustion engines. Where necessary, individual requirements may be given for particular engine applications.

2 FIELD OF APPLICATION

This International Standard applies to reciprocating internal combustion 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, automobiles and trucks and aero-engines. Also excluded are self-governing engines and those engines requiring only maximum speed or fuel delivery limitation.

3 REFERENCES

ISO 3046/I, *Reciprocating internal combustion engines : Performance – Part I : Standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption.*

ISO 3046/II, *Reciprocating internal combustion engines : Performance – Part II : Test methods.*

ISO 3046/III, *Reciprocating internal combustion engines : Performance – Part III : Test measurements.*

4 CLASSIFICATION OF GOVERNING SYSTEMS

4.1 The classification of governing systems is based on :

a) the speed conditions to be controlled (table 1);

b) the accuracy of governing (table 2).

4.1.1 Suivant la plage de vitesse, trois types de régulation sont définis dans le tableau 1.

Governing of a selected speed or speeds is provided within prescribed limits of precision in accordance with table 1.

TABLE 1 – **Types of governing**

Type	Speed requirement
1 *Single speed*	At one predetermined speed
2 Multiple speeds	At two or more predetermined speeds
3 All speeds (variable speed)	At any selected speed within a predetermined speed range

4.1.2 The class of accuracy and the necessary parameters of this class required for a particular application shall be selected from tables 2 and 3 by agreement between the manufacturer and the customer, taking into account that not all kinds of engines (for example dual fuel engines, spark ignition gas engines, etc.) are capable of meeting all the requirements of each class of governing accuracy.

TABLE 2 – **Governing accuracy**

Class	Accuracy requirement
A_0	Highest requirements of governing accuracy
A_1	High requirements of governing accuracy
A_2	Normal requirements of governing accuracy
B_1	Normal requirements of governing accuracy over a wide range of speed
B_2	Reduced requirements of governing accuracy over a wide range of speed

NOTE – Class A usually refers to the single speed type of governor.

5 TECHNICAL REQUIREMENTS OF GOVERNING SYSTEMS

The requirements for the parameters of the governing system are given in table 3.

The manufacturer shall state the normal period of time required after the start of the engine to establish controllability within the limits specified in table 3.

Where special circumstances prevent attainment of the normal period, or where a reduced period is essential, the periods of time and the technical measures to be taken as a consequence shall be subject to mutual agreement between the manufacturer and the customer (AMC).

TABLE 3 – **Parameters of governing systems** (Refer to figure 1 for explanatory diagram and list of symbols)

No.	Parameter	Definition	Symbol	Formula	Class[1) A_0]				
					A_0	A_1	A_2	B_1	B_2
1	2	3	4	5	6	7	8	9	10
5.1	**Setting parameters**								
5.1.1	Range of speed setting (See figure 3)								
5.1.1.1	Upward range	The range of maximum possible upward adjustment of speed from the setting corresponding to the declared power, as a percentage of the declared speed	Δn_{max}	$\frac{n_{i\,max} - n_i}{n_r} \times 100$		$\geqslant 2,5$	$\geqslant 2,5$	$\geqslant 0$	$\geqslant 0$
5.1.1.2	Downward range	The range of maximum possible downward adjustment of speed from the setting corresponding to the declared power, as a percentage of the declared speed	Δn_{min}	$\frac{n_i - n_{i\,min}}{n_r} \times 100$		$\geqslant \delta_{st} + 2,5$	$\geqslant \delta_{st} + 2,5$	AMC[2)]	AMC
5.1.2	Speed setting	Maximum difference between real and predetermined speeds under remote control, expressed as a percentage of the declared speed	Δ			not applicable	not applicable	± 2	± 2
5.2	**Parameters of steady state behaviour**								
5.2.1	Steady state speed band	Width of the envelope of variation of the engine speed under steady state conditions, expressed as a percentage of the declared speed	ν						
5.2.1.1	Relative power ⩾ 25 %					$\leqslant 0,8$	$\leqslant 1,0$		
5.2.1.2	Relative power < 25 %					$\leqslant 1,0$	$\leqslant 1,5$		
5.2.1.3	Relative speed ⩾ 50 %							$\leqslant 1,5$	$\leqslant 2,0$
5.2.1.4	Relative speed < 50 %							AMC	AMC
5.2.2	Speed droop[3)]	Speed change between zero and declared power, expressed as a percentage of the declared speed at fixed speed setting	δ_{st}	$\frac{n_i - n_r}{n_r} \times 100$		$\leqslant 5$	$\leqslant 8$	$\leqslant 10$	$\leqslant 15$

1), 2), 3) : see page 4.

TABLE 3 — **Parameters of governing systems** *(continued)*

1	2	3	4	5	6	7	8	9	10
5.3	**Parameters of dynamic behaviour**[4)5)]								
5.3.1	Transient speed difference caused by :	Maximum deviation of speed after sudden load change from speed previous to steady state level, expressed as a percentage of the declared speed (figure 1)	δ_d						
5.3.1.1	– a sudden 100 % decrease of load for naturally aspirated and pressure charged engines		δ_d^+	$\frac{n_{max} - n_r}{n_r} \times 100$		$\leqslant 10$	$\leqslant 15$	$\leqslant 18$	$\leqslant 18$
5.3.1.2	– a sudden increase in load. The maximum possible amount of a sudden increase in load from zero is : – for naturally aspirated engines : 100 % – for turbocharged 4-stroke engines : a function of the brake mean effective pressure at the declared power (see figure 2) – for turbocharged 2-stroke engines : AMC – for engines with other charge systems : AMC		δ_d^-	$\frac{n_{min} - n_i}{n_r} \times 100$		$\leqslant 10$	$\leqslant 15$	$\leqslant 18$	$\leqslant 18$
5.3.2	Recovery time	The time interval from the point when the speed departs from the steady state speed band after the load change until the speed returns to and remains within the steady state speed band, associated with the new load (see figure 1); expressed in seconds	τ t						
5.3.2.1	At conditions of 5.3.1.1					$\leqslant 8$	$\leqslant 15$		
5.3.2.2	At conditions of 5.3.1.2					$\leqslant 8$	$\leqslant 15$		

4), 5) : see page 4.

TABLE 3 — **Parameters of governing systems** *(concluded)*

1	2	3	4	5	6	7	8	9	10
5.4	**Governing system factors for parallel operation**								
5.4.1	Rate of change of engine speed setting	Rate of change of speed setting under remote control, expressed as a percentage of the declared speed per second	ϑ			0,2–1	0,2–1	AMC	AMC
5.4.2	Load sharing at speed droop $\delta_{st} \geqslant 3$ % within relative load range 20 to 100 %[6]	The difference between the proportion of load taken by an individual engine and the proportion of the total load carried by all engines, expressed as a percentage	θ	$\left\lvert \frac{P_e}{P_{er}} - \frac{\Sigma P_e}{\Sigma P_{er}} \right\rvert \times 100$ P_e = individual engine load (power) ΣP_e = total load (power) P_{er} = engine declared power ΣP_{er} = total declared power		$\leqslant 10$	$\leqslant 12{,}5$		
5.4.3	Power variation band	Width of the envelope of variation of the actual engine power under steady state conditions, expressed as a percentage of the declared power of the engine	γ			AMC	AMC		

1) The values of Class A_0, which are important in the context of a particular application, should be subject to agreement between the manufacturer and the customer. Remaining values should conform to the next lower class.

2) AMC represents "by agreement between Manufacturer and Customer".

3) When engines conforming to group 1 (see ISO 3046/II) are fitted with simple governors and are set for a service speed lower than the maximum design speed, without mechanical changes in the governor components, the droop for Classes B_1 and B_2 shall be greater in approximately inverse proportion to the service speed.

4) The values of the parameters of dynamic behaviour are not only determined by the speed governing equipment. They are also influenced by factors such as the type of engine, its mean effective pressure, its dead time, its speed, the type of pressure charging system fitted, the setting of the fuel stop adjustment and the moment of inertia of the whole set (engine and its driven machinery).

5) For the purpose of this International Standard, the load is taken to be the power and/or torque demanded from the engine by its driven machinery.

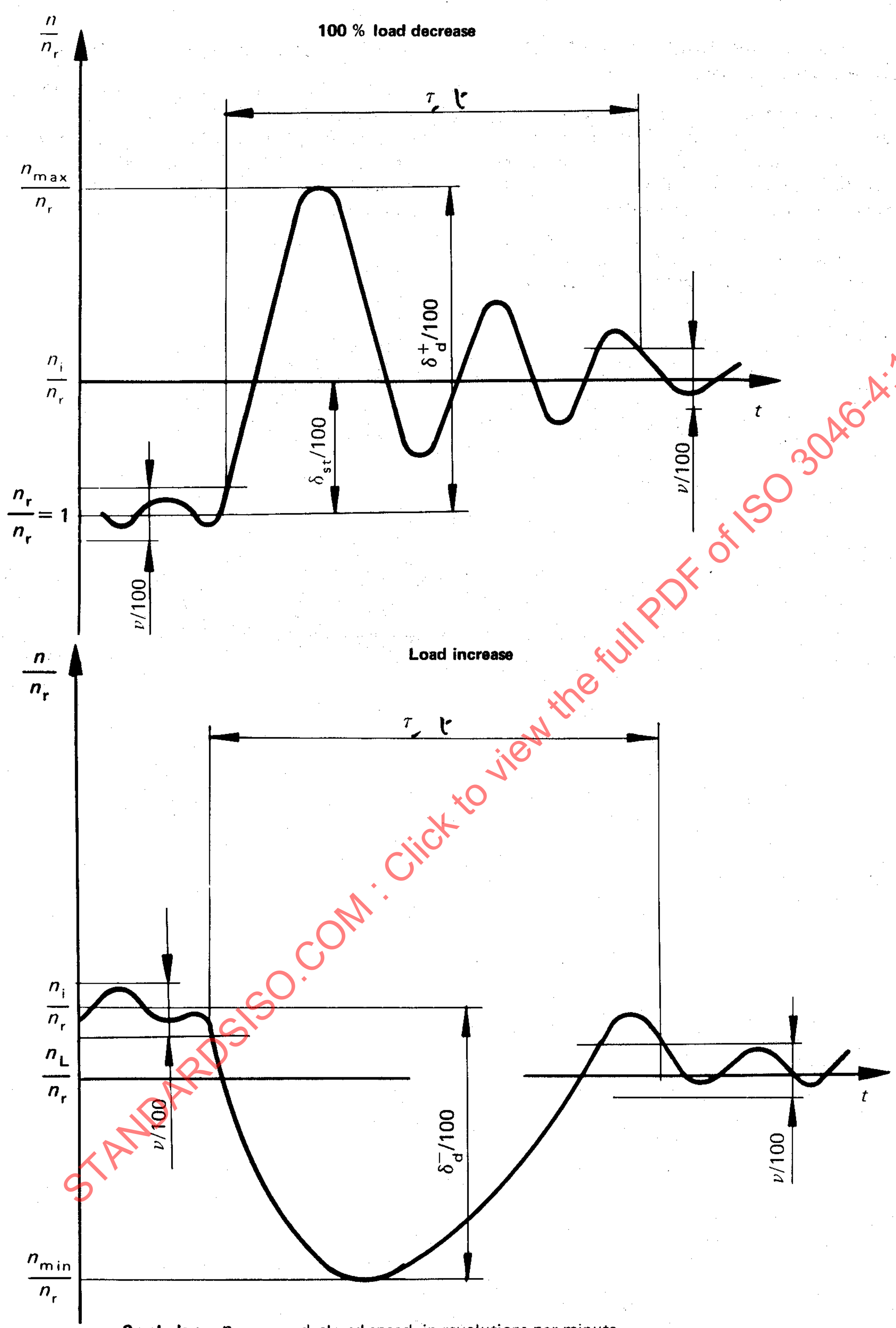
6) At speed droop of less than 3 % the load sharing shall be agreed between the manufacturer and the customer.

6 AGREEMENT AS TO REQUIREMENTS BETWEEN MANUFACTURER AND CUSTOMER

Whenever the customer is unable to select his requirements from the manufacturer's standard classes of governors, he should inform the manufacturer of the class of governing required and also the requirements of the auxiliary devices on the governor. Should some governing parameters required by the customer exceed those given in table 3, their values shall be subject to agreement between manufacturer and customer in accordance with table 3, class A_0.

7 TESTING OF GOVERNING SYSTEMS

The governing system shall be tested either during the acceptance test or, if necessary, during the operating test of the engine coupled to its contract driven machinery. The parameters to be checked and recorded shall be selected from table 3 by agreement between the manufacturer and the customer.



Symbols : n_r = declared speed, in revolutions per minute

n_i = idling speed, in revolutions per minute

n_{max}, n_{min} = transient speeds resulting from load change on the engine

n_L = steady state speed after partial load increase

t = time, in seconds

FIGURE 1 — **Speed control transients**

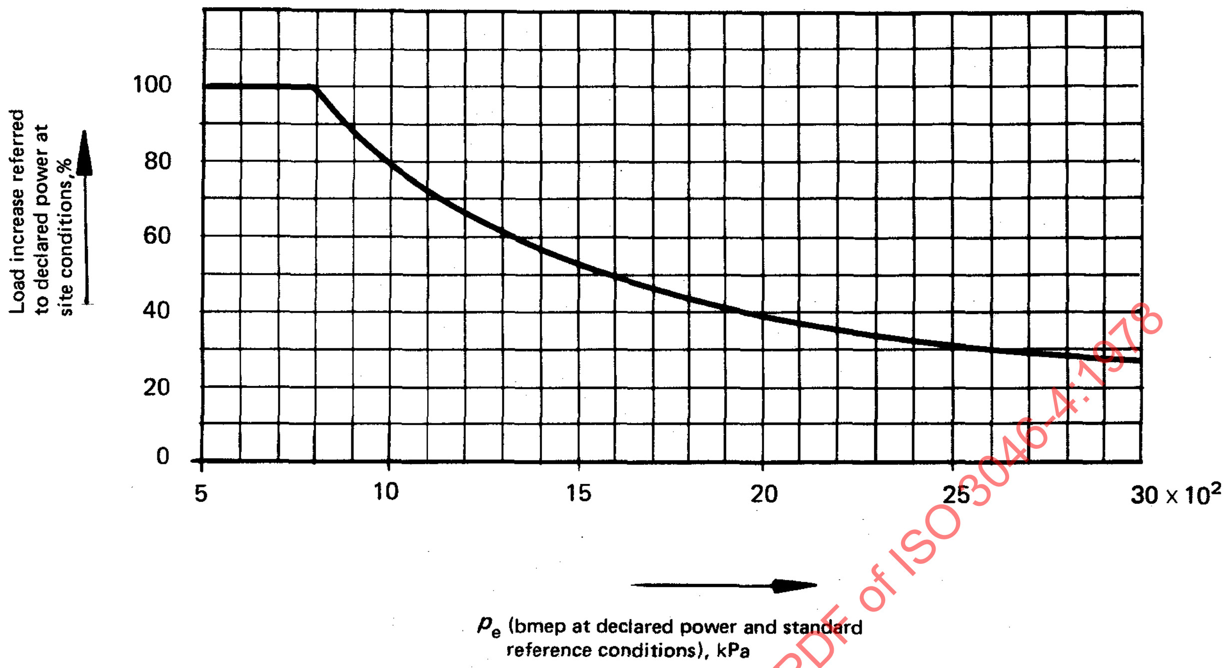


FIGURE 2 — **Maximum possible sudden load increase, from zero, of turbocharged 4-stroke engines as a function of the brake mean effective pressure, p_e, at declared power**

NOTE — The curve has been established from tests on a number of engines considered to be generally representative and shall be used in the absence of any other specific information. The further step or steps of an additional load increase shall be specified by the manufacturer.

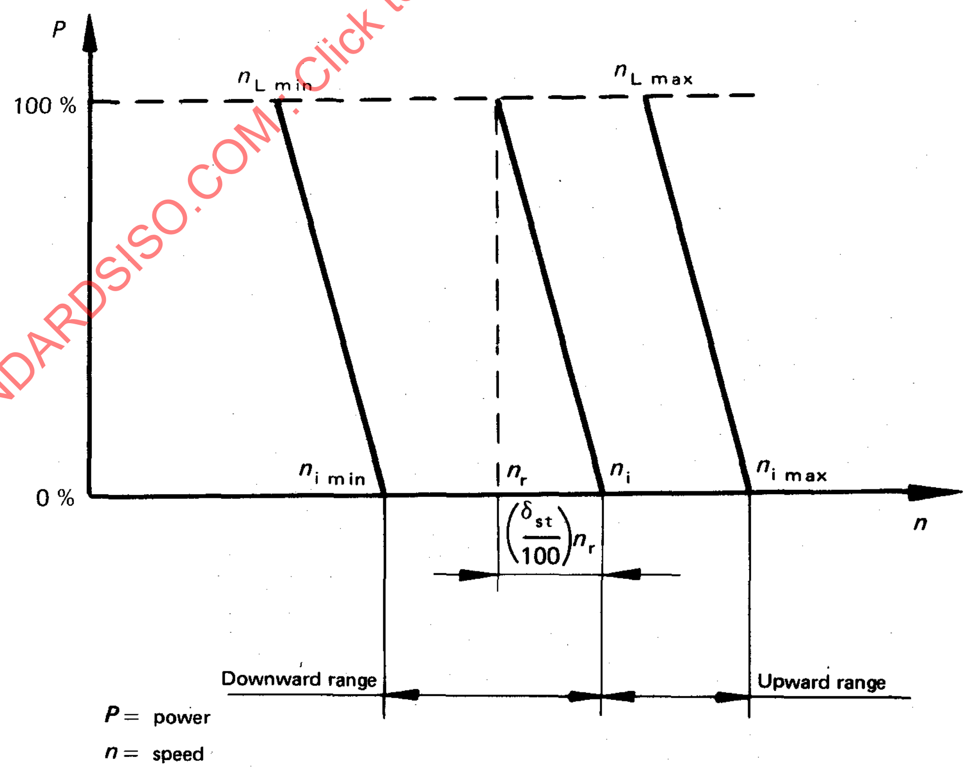


FIGURE 3 — **Range of speed setting**