INTERNATIONAL STANDARD

ISO 8178-4

Second edition
2007-12-15

Corrected version
2008-07-01

Reciprocating internal combustion engines — Exhaust emission measurement —

Part 4: Steady-state test cycles for different engine applications

Moteurs alternatifs à combustion interne — Mesurage des émissions de gaz d'échappement —

Partie 4: Cycles d'essai en régime permanent pour différentes applications des moteurs

Reference number
ISO 8178-4:2007(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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 8178-4 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Subcommittee SC 8, *Exhaust gas emission measurement*.

This second edition cancels and replaces the first edition (ISO 8178-4:1996) which has been technically revised.

ISO 8178 consists of the following parts, under the general title *Reciprocating internal combustion engines — Exhaust emission measurement*:

— *Part 1: Test-bed measurement of gaseous and particulate exhaust emissions*

— *Part 2: Measurement of gaseous and particulate exhaust emissions under field conditions*

— *Part 3: Definitions and methods of measurement of exhaust gas smoke under steady-state conditions*

— *Part 4: Steady-state test cycles for different engine applications*

— *Part 5: Test fuels*

— *Part 6: Report of measuring results and test*

— *Part 7: Engine family determination*

— *Part 8: Engine group determination*

— *Part 9: Test cycles and test procedures for test bed measurement of exhaust gas smoke emissions from compression ignition engines operating under transient conditions*

— *Part 10: Test cycles and test procedures for field measurement of exhaust gas smoke emissions from compression ignition engines operating under transient conditions*

— *Part 11: Test-bed measurement of gaseous and particulate exhaust emissions from engines used in nonroad mobile machinery under transient test conditions*

In this corrected version of ISO 8178-4:2007, in Table 7, the weighting factors for mode numbers 1 and 2 have been changed to 0,15 and 0,25, respectively.

Introduction

In comparison with engines for on-road applications, engines for off-road use are made in a much wider range of power output and configuration and are used in a great number of different applications.

The objective of this part of ISO 8178 is to rationalize the test procedures for off-road engines in order to simplify and make more cost effective the drafting of legislation, the development of engine specifications and the certification of engines to control gaseous and particulate emissions.

This part of ISO 8178 embraces three concepts in order to achieve the objectives.

The first principle is to group applications with similar engine operating characteristics in order to reduce the number of test cycles to a minimum, but ensure that the test cycles are representative of actual engine operation.

The second principle is to express the emissions results on the basis of brake power as defined in ISO 8178-1:2006, 3.9. This ensures that alternative engine applications do not result in a multiplicity of tests.

The third principle is the incorporation of an engine family concept in which engines with similar emission characteristics and of similar design may be represented by the highest emitting engine within the group.

Reciprocating internal combustion engines — Exhaust emission measurement —

Part 4: Steady-state test cycles for different engine applications

1 Scope

This part of ISO 8178 specifies the test cycles for the measurement and the evaluation of gaseous and particulate exhaust emissions from reciprocating internal combustion (RIC) engines coupled to a dynamometer. With certain restrictions, this part of ISO 8178 can also be used for measurements at site. The tests are carried out under steady-state operation using test cycles which are representative of given applications.

This part of ISO 8178 is applicable to RIC engines for mobile, transportable and stationary use, excluding engines for motor vehicles primarily designed for road use. It may be applied to engines used, e.g. for earth-moving machines, generating sets and for other applications.

For engines used in machinery covered by additional requirements (e.g. occupational health and safety regulations, regulations for powerplants) additional test conditions and special evaluation methods may apply.

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 8178-1:2006, *Reciprocating internal combustion engines — Exhaust emission measurement — Part 1: Test-bed measurement of gaseous and particulate exhaust emissions*

ISO 8178-2:1996, *Reciprocating internal combustion engines — Exhaust emission measurement — Part 2: Measurement of gaseous and particulate exhaust emissions at site*

ISO 8178-3:1994, *Reciprocating internal combustion engines — Exhaust emission measurement — Part 3: Definitions and methods of measurement of exhaust gas smoke under steady-state conditions*

ISO 8178-5:1997, *Reciprocating internal combustion engines — Exhaust emission measurement — Part 5: Test fuels*

ISO 8178-6:2000, *Reciprocating internal combustion engines — Exhaust emission measuremen — Part 6: Report of measuring results and test*

ISO 8178-7:1996, *Reciprocating internal combustion engines — Exhaust emission measurement — Part 7: Engine family determination*

ISO 8178-8:1996, *Reciprocating internal combustion engines — Exhaust emission measurement — Part 8: Engine group determination*

ISO 8528-1:2005, *Reciprocating internal combustion engine driven alternating current generating sets — Part 1: Application, ratings and performance*

ISO 14396:2002, *Reciprocating internal combustion engines — Determination and method for the measurement of engine power — Additional requirements for exhaust emission tests in accordance with ISO 8178*

3 Terms and definitions

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

3.1
test cycle
sequence of engine test modes each with defined speed, torque and weighting factor where the weighting factors only apply if the test results are expressed in grams per kilowatt hour

3.2
preconditioning of the engine
warming up of the engine under load conditions higher than 80 %, to stabilize the engine parameters according to the recommendations of the manufacturer

NOTE A preconditioning phase also protects the actual measurement against the influence of deposits in the exhaust system from a former test. There is also a period of stabilization in the test modes which has been included to minimize point-to-point influences.

3.3
mode
engine operating point characterized by a speed and a torque (or a power output)

3.4
mode length
time between leaving the speed and/or torque of the previous mode or the preconditioning phase and the beginning of the following mode

NOTE It includes the time during which speed and/or torque is being changed and the stabilization at the beginning of each mode.

3.5
rated speed
speed at which, according to the statement of the engine manufacturer, the rated power is delivered

NOTE For details see ISO 14396.

3.6
intermediate speed
speed declared by the manufacturer, taking into account the requirements governed by the torque curve

NOTE See 6.2.

3.7
low speed
lowest engine speed where 50 % of the rated or prime power is delivered

3.8
high speed
highest engine speed where 70 % of the rated or prime power is delivered

3.9
engine family
manufacturer's grouping of engines which, through their design, are expected to have similar exhaust emission characteristics where members of the family must comply with the applicable emission limit values

[ISO 8178-7:1996, definition 2.1]

4 Symbols and abbreviations

For the use of this part of ISO 8178 the symbols and abbreviations defined in ISO 8178-1, ISO 8178-2, ISO 8178-3, ISO 8178-5, ISO 8178-6, ISO 8178-7 and ISO 8178-8 shall be used.

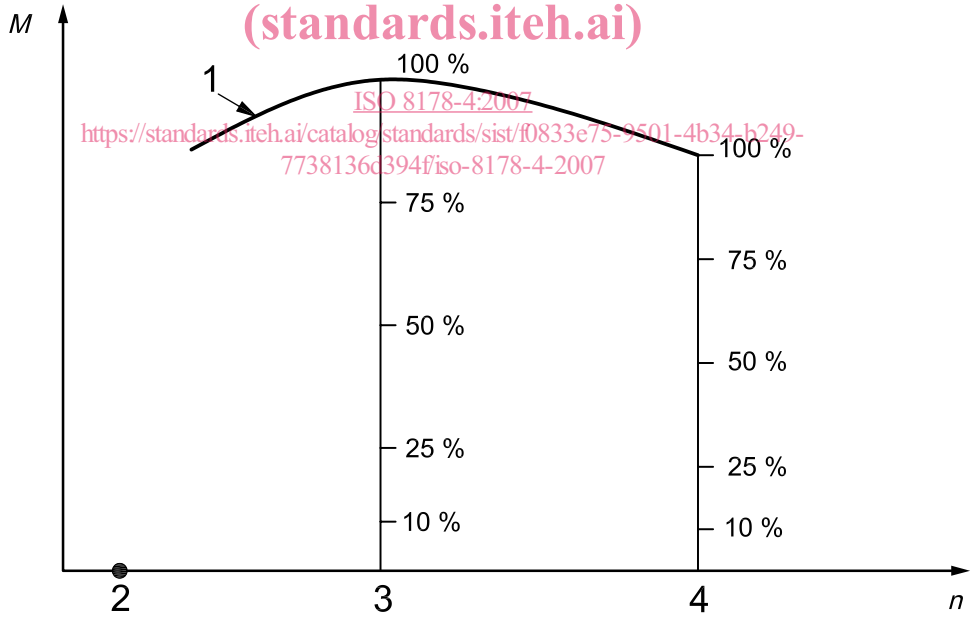
In addition, see Table 1:

Table 1 — Essential units for this part of ISO 8178

Symbol	Term	Unit
n	Engine speed	r/min
M	Torque	N·m
P	Power	kW
W_F	Weighting factor	1

5 Torque

5.1 The torque figures given in the test cycles are percentage values that represent, for a given test mode, the ratio of the required torque to the maximum possible torque (C1, C2, E1, E2, F, G1, G2, G3 and H) or of the torque corresponding to the continuous power or prime power rating as defined in ISO 8528-1 (D1, D2) at this given speed (see ISO 8178-1:2006, 12.5). Figure 1 shows torque scales for engines operating on a non-propeller curve.



Key

1 full-load torque curve
2 low idle
3 intermediate speed
4 rated speed

Figure 1 — Torque scales: percentage of full-load torque at each engine speed

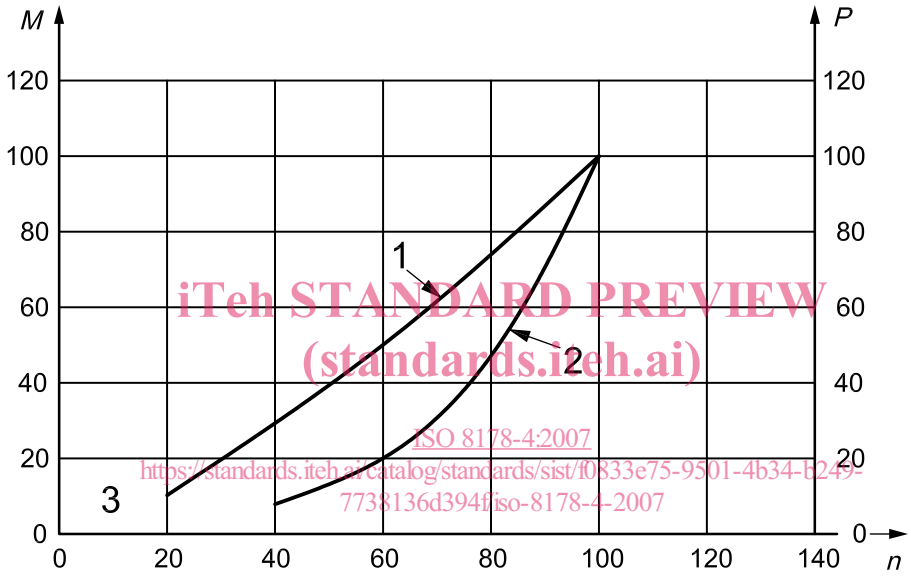
5.2 For the test cycle E3 the power figures are percentage values of the maximum rated power at the rated speed as this cycle is based on a theoretical propeller characteristic curve for vessels driven by heavy duty engines without limitation of length.

For the test cycle E4 the torque figures are percentage values of the torque at rated power. This cycle is based on the theoretical propeller characteristic curve representing typical pleasure craft spark ignition engine operation.

For the test cycle E5 the power figures are percentage values of the maximum rated power at the rated speed as this cycle is based on a theoretical propeller characteristic curve for vessels of less than 24 m in length driven by diesel engines.

NOTE Other propeller characteristic curves exist.

Figure 2 shows the two representative curves chosen by ISO/TC 70/SC 8.



Key

1 torque E4
2 power E3
3 idling

NOTE The values of n, M and P are expressed in percent of rated speed, maximum torque and maximum power respectively.

Figure 2 — Examples of torque and power scales for propeller curves

6 Test speeds

6.1 Rated speed

For the purposes of this part of ISO 8178, the rated speed is defined in 3.5. With the prior agreement of the parties involved, the following reference speed may replace the rated speed for running the test cycles listed in Clause 8.

Reference speed = low speed + 0,95 × (high speed − low speed)

where

low speed = lowest engine speed where 50 % of the rated or prime power is delivered;

high speed = highest engine speed where 70 % of the rated or prime power is delivered.

If the measured reference speed is within ± 3 % of the reference speed declared by the manufacturer, the declared reference speed shall be used. If the tolerance is exceeded, the measured reference speed shall be used.

6.2 Intermediate speed

6.2.1 For engines that are designed to operate over a speed range on a full-load torque curve, the intermediate speed shall be the declared maximum torque speed if it occurs between 60 % and 75 % of the rated speed, on condition that the torque observed on the test engine at the declared intermediate engine speed is not less than 96 % of the maximum torque observed between 60 % and 75 % of the rated speed.

If the declared maximum torque speed is less than 60 % of the declared rated speed, then the declared intermediate speed shall be 60 % of the rated speed.

If the declared maximum torque speed is greater than 75 % of the rated speed then the declared intermediate speed shall be 75 % of the rated speed.

If the torque observed at the declared intermediate engine speed is less than 96 % of the maximum torque observed between 60 % and 75 % of the rated speed then the observed maximum torque speed shall be the intermediate speed.

6.2.2 For engines which are not designed to operate over a speed range on a full-load torque curve at steady state conditions, the intermediate speed will typically be between 60 % and 70 % of the rated speed.

6.2.3 For marine application engines to be used to propel vessels with a fixed propeller, as specified in 8.5, the intermediate speeds are defined in Clause 8.

6.2.4 For engines to be tested on cycle G1, the intermediate speed shall be 85 % of the rated speed.

7 Information regarding preparation of the test

See Table 2.

Table 2 — Parameters

No.	Parameter	ISO 8178-1:2006, clause/subclause	ISO 8178-2:1996, clause/subclause
7.1	Test conditions	5	5.2
7.2	Power; brake power	3.9, 5.3	3.9, 5.3
7.3	Engine air inlet system	5.4.1	5.4
7.4	Engine exhaust system	5.4.2	5.5
7.5	Test fuels; reference fuels (ISO 8178-5)	6	6
7.6	Measurement equipment and data to be measured	7	7
7.7	Accuracy of the measuring instruments	7.4	7.3
7.8	Determination of exhaust gas flow	7.3	7.2
7.9	Determination of the gaseous components	7.5, 12.4	7.4, 15 [a]
7.10	Determination of the particulates	7.6, 17	7.5, 16 [a]
7.11	Calibration of the analytical instruments	8	8 [a]
7.11.1	Calibration procedure	8.5	8 [a]
7.11.2	Verification of the calibration	8.5.7	8 [a]
7.12	Efficiency test of the NO_x converter	8.7	8 [a]
7.13	Checking of HFID hydrocarbon response	8.8.2	8 [a]
7.14	Calibration intervals	8.10, 9.4	8 [a]
7.15	Calibration of the particulate measuring system	9	9 [a]
7.17	Test run	12	11 [a]
7.18	Data evaluation for gaseous and particulate emissions	13	12 [a]
7.19	Calculation of the gaseous emissions	14	13 [a]
7.20	Calculation of particulate emissions	15	14 [a]
7.21	Analytical and sampling systems	16	15 [a]

[a] For parameters 7.9 to 7.21 the operative clause of ISO 8178-2 contains references to the applicable clause(s) of ISO 8178-1. In some cases the necessary differences for the site conditions are described in ISO 8178-2.

8 Modes and weighting factors for test cycles

8.1 General remarks

The exhaust emission measurement and evaluation shall be carried out using the appropriate test cycle for the application as described in general in 8.3 to 8.8. With the prior agreement of the parties involved, the universal test cycle described in Annex B may be used and the emissions values for the respective application calculated using the appropriate weighting factors. For special cases not shown, an adequate choice shall be made and agreed upon by the parties concerned. Most of the following test cycles have been derived from and follow the same principles as the UN-ECE R49 [17] 13-mode steady-state test cycle.