INTERNATIONAL STANDARD

ISO 8178-6

Second edition
2018-04

Reciprocating internal combustion engines — Exhaust emission measurement —

Part 6:
Report of measuring results and test

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

Partie 6: Rapport de mesure et d'essai

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ISO 8178-6:2018
https://standards.iteh.ai/catalog/standards/sist/4fcac6de-529b-4cdf-b07b-
8a53afeb672d/iso-8178-6-2018

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document 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 8178-6:2000), which has been technically revised. The main changes compared to the previous edition are as follows:

— alignment with the latest editions of ISO 8178-1, ISO 8178-4, ISO 8178-5, ISO 8178-7 and ISO 8178-8;

— application to steady state RMC test cycle, transient test cycle and control area;

— update of test engine information;

— revision of exhaust components to be measured;

— consideration of Infrequent Regeneration Adjustment Factors (IRAF);

— comprehension of validation criteria for particulate sampling;

— provision of the background correction for particulate mass emission;

— simplification of the fuel characteristics table;

— update of the smoke test data.

A list of all parts in the ISO 8178 series can be found on the ISO website.

Introduction

Results of an emissions test are presented clearly and include all information pertinent to the derivation of the emission test results. An accuracy or uncertainty analysis relevant to the test system used and engine being evaluated is made by the laboratory. A record is made of the measurement equipment being used, the ambient conditions, the engine performance and the fuel used. Recommendations for the data to be recorded are given regardless of the type of fuel being used.

The data format described in this document is intended to be used by individuals measuring emissions using the ISO 8178 series.

As expressed in ISO 8178-1 and ISO 8178-2, the emission results are stated in either "g/kWh" (preferred) or in "g/m^3".

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Reciprocating internal combustion engines — Exhaust emission measurement —

Part 6:
Report of measuring results and test

1 Scope

This document specifies a data format for reporting the measurement results of exhaust emissions from RIC engines for mobile, transportable and stationary use, excluding engines for motor vehicles primarily designed for road use. It includes basic information of the engine being tested. Equivalent data formats including those that are electronically generated can be used as long as the required engine, test cell and test data information is made available.

This document applies to measurement in the laboratory and, where applicable, at site.

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

NOTE   Since the report format defined in this document is intended to be applicable to all types of internal combustion engines, some items are, in certain cases, not necessary for specific engines and/or tests, especially when measuring on site. On the other hand, some additional items can be necessary according to test purposes. Deletion and addition of items to be reported are based on agreement between the parties involved.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 (all parts), *Reciprocating internal combustion engines — Exhaust emission measurement*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8178 (all parts) apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Symbols and abbreviated terms

4.1 General symbols

For the EEC-UNO regulation equivalents of the symbols listed in Table 1, see ISO 8178-1.

Table 1 — General symbols

Symbol	Term	Unit
a_0	y intercept of the regression line	—
a_1	Slope of the regression line	—
D	Dilution factor	—
e_{gas}	Specific emission of gaseous components	g/kWh
f_a	Laboratory atmospheric factor	—
f_{fh}	Fuel specific factor used for the calculations of wet concentrations from dry concentrations	—
k_h	NOx humidity correction factor	—
k_r	Multiplicative regeneration factor	—
k_w	Dry to wet correction factor for the raw exhaust gas	—
P_{aux}	Declared total power absorbed by auxiliaries fitted for the test and not required by ISO 14396	kW
$P_{f,i}$	Power absorbed by auxiliaries to be fitted for the test but that were not installed	kW
$P_{m,i}$	Measured engine power	kW
$P_{r,i}$	Power absorbed by auxiliaries to be removed for the test but that were installed	kW
$q*_{mdx}$	Equivalent diluted exhaust gas mass flow rate on wet basis	kg/h
q_{mdx}	Diluted exhaust gas mass flow rate on wet basis	kg/h
q_{mp}	Sample flow of exhaust gas into partial flow dilution system	kg/s
r_d	Dilution ratio	—
r^2	Coefficient of determination	—
SEE	Standard error of estimate of y on x	—
S_L	Lug smoke value	m^{-1}
S_P	Peak smoke value	m^{-1}
S_S	Steady-state smoke value	m^{-1}
$q*_{Vdx}$	Equivalent diluted exhaust gas volume flow rate on wet basis	m^3/h
q_{Vdx}	Diluted exhaust gas volume flow rate on wet basis	m^3/h
W_{act}	Actual cycle work of the respective test cycle	kWh
W_{ref}	Reference cycle work of the respective test cycle	kWh
WF	Weighting factor	—
WF_e	Effective weighting factor	—

4.2 Symbols and abbreviated terms for the chemical components

C_1 Carbon 1 equivalent hydrocarbon

CH_3OH Methanol

CH_4 Methane

CO   Carbon monoxide

CO_2 Carbon dioxide

HC   Hydrocarbon

N_2O Nitrous oxide

NH_3 Ammonia

NMHC	Non-methane hydrocarbons
NO_x	Oxides of nitrogen
O_2	Oxygen
PM	Particulate matter
PN	Particle number
SO_2	Sulfur dioxide

4.3 Abbreviated terms

CNG	Compressed natural gas
DPT	Differential pressure transducer
DeNOx	NO_x after-treatment system
EAT	Exhaust after-treatment system
EGR	Exhaust gas recirculation
EOPL	Effective optical path length
GER	Gas energy ratio
IRAF	Infrequent regeneration adjustment factor
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MTS	Maximum test speed
NRTC	Non road transient cycle
PTT	Particle transfer tube
RMC	Ramped modal cycle
RME	Rapeseed methyl ester

5 Emissions test report

5.1 Introduction

The recommended test report consists of 13 data sheets (see Annex A) that contain all the information pertinent to a test run in a very compact way. The test report is a single document that can be filed easily for later review of the test results by authorities, customers and engine manufacturers. It incorporates the final test results and the information needed to trace the final results to the values originally measured, as well as the information on the test engine, the test cell equipment and the test fuel. The report format may be applied to all test cycles and fuels. It should be noted that the information that is being suggested for filling in the tables in the document are based upon computations that exist in the appropriate ISO 8178 procedures. The description provided in 5.4 to 5.6 and 5.9 is only there to assist in identifying the computations that can be required. It is not necessary to complete all parts of this test report. The parts to be completed shall be agreed between the parties concerned.

5.2   General information

Table A.1 includes the information essential for engine approval, such as engine identification, engine application, test cycle and test identification. The emission test results may be listed for different test cycles, if applicable. The gaseous and particulate emissions shall be expressed in grams per kilowatt hour whenever possible. Other units shall be indicated if used according to the provisions laid down in the Scope of this document. The smoke test results shall be listed for the smoke cycle applicable to the indicated application. The smoke values shall be expressed per metre whenever possible.

5.3   Engine information

Table A.2 contains the basic features of the engine under test. If more information is requested by other parties, this can be provided. Table A.3 contains other information on the engine under test pertinent to the identification of the engine family or group. These features are derived from ISO 8178-7 for engine family and ISO 8178-8 for engine group. If the engine family or group concept does not apply for the engine under test, Table A.3 does not need to be submitted.

5.4   Ambient and engine test data

For steady-state discrete mode test, Table A.4 includes in the upper part the relevant ambient data, in the lower part the relevant engine data required to be recorded in ISO 8178-4. In most cases, mechanical shaft power is used for the calculation of the final results. If other kinds of power are used, e.g. electrical, thermal or total power, this shall be indicated. Fuel flow, air flow and exhaust flow may be expressed as volume or mass flow rates, and the unit used shall be filled in. The measurement values shall be recorded for each mode individually, and the cycle value shall be calculated for the power and recorded. For further details, refer to ISO 8178-4.

For steady-state RMC test and transient test, the actual cycle work in Table A.5 shall be calculated by integrating over the cycle in order to calculate the brake specific emissions. For further details, refer to ISO 8178-4.

5.5   Gaseous emissions data

5.5.1   Steady-state discrete mode test

Table A.6 contains in the upper part the originally measured (or calculated for SO_2) concentrations of the gaseous emissions either in the raw or dilute exhaust gas for each individual mode.

For engines with infrequent exhaust regeneration, the recorded value shall be the one which has been corrected with the appropriate upward or downward regeneration adjustment factor, k_r. For further details, refer to ISO 8178-4.

5.5.2   Steady-state RMC test and transient test

Table A.7 includes in the upper part the measured cycle concentrations of the gaseous emissions uncorrected and corrected for background either in the raw or dilute exhaust gas. For dilute system with constant mass flow, the average background corrected concentration over the cycle shall be reported. For dilute systems with flow compensation, the background correction shall be applied directly to the instantaneous concentration values. For transient composite cycle, the total mass emission shall be a weighted average from cold start test and hot start test. In case of an infrequent exhaust regeneration, the specific emissions shall be corrected with the appropriate regeneration adjustment factor, k_r, either multiplicative or additive. For further details, refer to ISO 8178-4.

5.6   Particulate emissions data

5.6.1   Steady-state discrete mode test

Table A.8 contains the measurement values required for the calculation of PM or PN for each individual mode. For engines with infrequent exhaust regeneration, the specific emission shall be corrected with the appropriate regeneration adjustment factor, k_r, either multiplicative or additive. Reporting of the smoke values during the emissions test cycle is optional. The unit of the smoke measurement value depends upon the system used. For the estimation of the soot concentration from the smoke value, the correlation function used shall be reported. For further details, refer to ISO 8178-4.

5.6.2   Steady-state RMC and transient test

Table A.9 includes the measured cycle values required for the calculation of PM or PN depending on the dilution system used. For transient composite cycle, the total PM or PN shall be a weighted average from cold start test and hot start test. In case of an infrequent exhaust regeneration, the specific emissions shall be corrected with the appropriate regeneration adjustment factor, k_r, either multiplicative or additive. Reporting of the smoke value during the test cycle is optional.

5.7   Test cell information

Tables A.10 and A.11 contain information on the test cell and the measurement equipment. For the analysers, all measuring ranges used shall be reported. The calibration curves, converter check results, hydrocarbon response factors and interference results shall be appended to the report. The values of the different pressure transducers, temperature sensors, and humidity sensors shall be reported in Table A.11.

5.8   Fuel characteristics

Table A.12 requests confirmation, that the fuel used complies with the reference fuel properties listed in ISO 8178-5. The fuel type shall be indicated. The values required for the respective fuel shall be reported if they are used in the emission calculations or if requested by other parties.

5.9   Smoke test data

Table A.13 contains the measurement values of the smoke cycles. The ambient data shall be reported for each test run to determine if the smoke values are to be corrected. If applicable, ambient density correction shall be applied, but the uncorrected smoke values shall also be reported. The mean values and the maximum difference between the test runs shall be reported whenever required according to Table A.9. Since different smoke cycles apply to different engine applications, the smoke values shall be reported in the appropriate lines. For the loaded transient test (C1 applications), the smoke values, S_{P3}, S_{P6} and S_{P9}, shall be reported.

Annex A
(informative)

Tables for emissions test report

Table A.1 — ISO 8178 Emissions test report — General information

Test identification	Date/time:								
	Test site/bench:								
	Test number(s):								
Engine	Manufacturer:								
	Type (model):								
	Family:								
	Rated power:								kW
	Rated speed:								min^{-1}
	Maximum power:								kW
	Maximum power speed:								min^{-1}
	Identification number:								
Application[a]	Customer:								
	Final installation:								
Test cycle	Steady-state test:	☐ Discrete				☐ RMC			
	Speed:	☐ Variable				☐ Constant			
	Cycle(s):	C1	C2	D1	D2	E1	E2		
		E3	E4	E5	F	G1	G2		
		G3	H	I	NRTC	LSI-NRTC			

Final weighted emissions test results

	Steady-state test	Control area			Transient test			Unit
		1	2	3	Cold[e]	Hot[e]	Composite	
NO_x								g/kWh[b]
HC/NMHC/CH_4								g/kWh[b]
CO								g/kWh[b]
PM								g/kWh[b]
PN								#/kWh[b]
CO_2								g/kWh[b]
NH_3 ☐ average ☐ mass-weighted								μmol/mol
N_2O								g/kWh[b]

[a] If applicable or if known.

[b] Units other than g/kWh to be indicated.

[c] Units other than m^{-1} to be indicated.

[d] To be indicated in accordance with the requirements of the applicable smoke cycle.

[e] Not required if composite is entered.