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Reciprocating internal combustion engines — Exhaust emission measurement —

Part 9: Test cycles and test procedures for measurement of exhaust gas smoke emissions from compression ignition engines using an opacimeter

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

Partie 9: Cycles et procédures d'essai pour le mesurage au banc d'essai des émissions de fumées de gaz d'échappement des moteurs alternatifs à combustion interne à allumage par compression fonctionnant en régime transitoire

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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 of 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 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 third edition cancels and replaces ISO 8178-9:2012 and ISO 8178-10:2002, which have been technically revised.

The main changes compared to the previous editions are as follows:

— ISO 8178-10:2002 has been incorporated in this document;

— terms and definitions have been harmonized within the ISO 8178 series and differences to other ISO standards have been described where applicable;

— redundant specifications of testing equipment, calibration and verification requirements have been deleted or replaced by references to other parts of the ISO 8178 series;

— ambient density smoke correction has been deleted;

— order of annexes has been changed;

— Annex A has been added - Overview particulate and soot measurement methods;

— Annex H has been added - Test at steady speeds over full-load curve;

— Annex I has been added - Reporting smoke tests results.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

On a global scale, there are currently many smoke measurement procedures in various forms. Some of these smoke measurement procedures are designed for test bed testing and intended to be used for certification or type-approval purposes. Others are designed for field-testing and can be used in inspection and maintenance programs. Different smoke measurement methods exist to meet the needs of various regulatory agencies and industries.

The two smoke measurement methods typically used are (1) the FSN method, measuring light absorption based on the change in optical reflectance of visible light from a blackening filter paper relative to the clean filter (filter-type smoke meters) and (2) the exhaust gas opacity method, measuring transmittance based on light extinction caused by absorption and scattering of light (opacimeter-type smoke meters).

Figure A.1 in Annex A shows an overview of the measurement methods specified by an ISO standard including FSN and opacity respectively.

ISO 8178-4 specifies a number of different test cycles to be used to characterize and control gaseous and particulate emissions from nonroad engines using a variety of steady-state and transient operating conditions. The test cycles in ISO 8178-4 were developed in recognition of the differing operating characteristics of various categories of nonroad machines. Likewise, different smoke test cycles can be appropriate for different categories of nonroad engines and machines.

Reciprocating internal combustion engines — Exhaust emission measurement —

Part 9: Test cycles and test procedures for measurement of exhaust gas smoke emissions from compression ignition engines using an opacimeter

1 Scope

This document specifies the measurement procedures and test cycles for the evaluation of smoke emissions from compression ignition engines using an opacimeter. The tests are carried out under steady-state and transient operation using tests cycles which are representative of a given application.

The smoke testing is conducted using opacimeter-type smoke meters which operate on the light extinction principle. The purpose of this document is to define the smoke test cycles and the methods used to measure the opacity and for the determination of the light absorption coefficient. It allows the use of either full-flow or partial-flow opacimeters and corrects for differences in rise time between the two types of opacimeters. Specifications of the apparatus for the measurement of opacity can be found in ISO 11614. The test procedures and measurement techniques described in this document are applicable to reciprocating internal combustion (RIC) engines in general. Annex D, Annex E, Annex F and Annex G each contains a test cycle that is relevant only for those specific applications listed in the first subclause of that annex. Where possible, the smoke test cycle described in the annex utilizes the engine and machine categories developed in ISO 8178-4.

For certain categories of non-road engines “at site” rather than “test bed” smoke test procedures can prove to be necessary. For engines used in machinery covered by additional requirements (e.g. occupational health and safety regulations), additional test conditions and special evaluation methods can apply.

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 8178-1:—[1)], *Reciprocating internal combustion engines — Exhaust emission measurement — Part 1: Test-bed measurement systems of gaseous and particulate emissions*

ISO 8178-2, *Reciprocating internal combustion engines — Exhaust emission measurement — Part 2: Measurement of gaseous and particulate exhaust emissions under field conditions*

ISO 8178-4:—[2)], *Reciprocating internal combustion engines — Exhaust emission measurement — Part 4: Steady-state and transient test cycles for different engine applications*

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

1) Under preparation.

2) Under preparation.

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

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

ISO 11614:1999, *Reciprocating internal combustion compression-ignition engines — Apparatus for measurement of the opacity and for determination of the light absorption coefficient of exhaust gas*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1
exhaust gas smoke
visible suspension of solid and/or liquid particles in gases resulting from combustion or pyrolysis

Note 1 to entry: The exhaust gas smoke may be black smoke, blue smoke, brown smoke or white smoke depending on the components present in the exhaust gas after the combustion or pyrolysis process. Black smoke (also referred to as "soot") is mainly due to the presence of carbon particles. Blue smoke is usually due to droplets resulting from the incomplete combustion of fuel or lubricating oil. Brown smoke is due to the presence of NO_2 in the exhaust gas. White smoke is usually due to condensed water and/or liquid fuel.

3.2
transmittance
τ
fraction of light transmitted from a source through a smoke-obscured path which reaches the observer or the instrument receiver

Note 1 to entry: Transmittance is expressed as a percentage.

3.3
opacity
N
fraction of light transmitted from a source through a smoke-obscured path which is prevented from reaching the observer or the instrument receiver

Note 1 to entry: Opacity is expressed as a percentage.

Note 2 to entry: $N = 100 - \tau$.

3.4
effective optical path length
L_A
length of the smoke-obscured optical path between the *opacimeter* (3.8) light source and the receiver

Note 1 to entry: Effective optical path length is expressed in meters and corrected, as necessary, for non-uniformity due to density gradients and fringe effect.

3.5
standard effective optical path length
L_{AS}
measurement used to ensure meaningful comparisons of quoted *opacity* (3.3) values

Note 1 to entry: L_{AS} values are defined in 9.1.4.