DRAFT INTERNATIONAL STANDARD

ISO/DIS 12103-3

ISO/TC **22**/SC **34**

Secretariat: **ANSI**

Voting begins on:
2017-05-19

Voting terminates on:
2017-08-10

Road vehicles — Test contaminants for filter evaluation —

Part 3:
Soot aerosol

Titre manque —

Partie 3: Titre manque

ICS: 43.060.20; 43.060.40

This document is circulated as received from the committee secretariat.

Reference number
ISO/DIS 12103-3:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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 12103-3 was prepared by Technical Committee ISO/TC 22, *Road Vehicles*, Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids*.

This second/third/... edition cancels and replaces the first/second/... edition (), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

ISO 12103 consists of the following parts, under the general title *Road Vehicles — Test Contaminant for Filter Evaluation*:

— *Part 1: Arizona Test Dust*

— *Part 2:* Aluminum Oxides Test Dust

— *Part 3: Soot Contaminant*

— *Part 4: Salt Contaminant*

Introduction

This part of ISO 12103 specifies two grades of test aerosol made from soot, which is composed of soot from a combustion source similar to soot occurring in the environment that motor vehicles are commonly subjected to. This test aerosol may be used as a test contaminant in several standards such as ISO 11155-1 or DIN 71460-1.

Ambient aerosols include at least two distinct modes of aerosol: a sub-micron mode and a super-micron mode. Generally the sub-micron mode comes from combustion sources or condensation of gases. The super-micron mode comes from physical abrasion processes and wind-blown dust. The test dusts described in ISO 12103 part 1 can be used to simulate the super-micron mode of ambient aerosol for testing air filters. The soot aerosol described in this part of ISO 12103 is intended to simulate the sub-micron mode of ambient aerosol.

There are several possible methods of generating soot aerosol, to simulate the sub-micron mode for air filter testing purposes such as dispersing soot from a powder or using generated soot from a combustion process.

Particle size of soot $_{\text{dispersed from bulk powder}}$ exceeds the environmental soot considerably.

For generated soot from a combustion process, a new procedure is described in this part 3 of ISO 12103. Using aliphatic hydrocarbons, the soot consists of a combination of carbon, organic hydrocarbons and other substances.

Road vehicles — Test contaminants for filter evaluation —

Part 3:
Soot aerosol

1 Scope

This part of ISO 12103 defines particle size distribution by number and chemical content limits involving one grade of test aerosol made from combustion soot.

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 15900, *Determination of particle size distribution — Differential electrical mobility analysis for aerosol particles*

NIOSH 5040 *method*

ISO 29904, *Fire chemistry — Generation and measurement of aerosols*

3 Test Contaminant Definition

Test aerosols according to this part of ISO 12103 are generated by combustion of an organic fuel in the test lab. They consist primarily of agglomerates of carbon particles where the primary carbon particles are on the order of 20 nanometers diameter. Some organic compounds may be condensed on the carbon agglomerates during the combustion and dilution processes. The amount of condensed organic material determines the category of the test aerosol per section 3.

4 Test Contaminant Designation

Soot contaminants are produced by burning a fuel (gas or liquid) and are broken into two standard grades designated as follows:

— ISO 12103-3, S1 for ≥ 67% Carbon content

This flame shall lead to an aerosol consisting of 70% +/- 3% carbon, 29% +/- 3% OC and <1% other substances.

— ISO 12103-3, S2 for < 67 % Carbon content

This flame shall lead to an aerosol consisting of 50% +/- 3% carbon, 49% +/- 3% OC and <1% other substances.

Soot contaminant shall be tested per the methods and requirements of Section 7.

5 Terms and definitions

For the purposes of this document, the terms and definitions apply as given in the normative references. Terms and definitions specific for this standard apply as follows:

5.1
diffusion flame
a flame from a burner which gets its oxygen from the ambient surrounding air by diffusion and convection mechanisms instead of having the oxygen forcibly premixed into the fuel.

5.2
generation
within the scope of this standard this is a process in which airborne particles are produced and injected into a defined airstream.

5.3
mobility particle size
the particle size provided by an electro-static classifier.

Note 1 to entry: The method is based on a principle that uses the forces exerted on charged particle in an electro-static field. The method is used for particles in the nanometer range and the classifier is typically combined with a condensation particle counter to actually determine the concentration.

5.4
optical particle size
particle size as recorded by an optical particle sizing instrument or spectrometer.

Note 1 to entry: The optical size differs in general from the physical size of a particle as it depends on particle properties like the light diffraction index.

5.5
Particle size distribution
the number, mass or volume of particles as function of the particle size. For the scope of this standard the term is used for number distributions only. Particle size distributions may have a wide variety of shapes but for the purpose of this standard and application the distributions of soot particles can be assumed to be of a lognormal type.

5.6
SMPS
Scanning Mobility Particle Sizer:
System which is a combination of an electro-static classifier, a differential mobility analyser and a condensation nucleus counter. This device provides a mobility particle sizer for the soot aerosol.

5.7
Soot
particles composed mainly of carbon and being created during incomplete incineration of organic fuels. The particles start with clusters of several hundred carbon atom and can form large grains up to several hundred µm. Small soot particles have the tendency to agglomerate. Soot particle from combustions consists of elemental carbon (EC) and organic carbon (OC). A lot of organic compounds are known and most of them are bound on the EC-agglomerates. Some of the organic compounds are carcinogenic like poly aromatic hydrocarbon (PAH).

5.8
Thermal-optical analysis/transmission[3]
Thermal-optical analysis is a method to measure elemental carbon (EC) with relationship to atmospheric soot. For the thermal-optical transmission method (TOT), an emphasis on optical behavior presents it as a method for the accurate measurement of light-absorbing particulate carbon and thus allows EC to be defined as black carbon (BC) as in the aethelometer.

5.9
EEPS
Engine Exhaust Particle Sizer Spectrometer:
Analysis system which positively charges the particles and uses a differential mobility analyser. This device provides a mobility particle sizer for the soot aerosol.

6 Symbols and abbreviated terms

Symbol	Explanation
μ	mean value of a Gaussian standard distribution
σ	standard deviation of a Gaussian standard distribution
σ_{geo}	geometric standard deviation (the logarithm of the GSD is the standard deviation)
Abbreviations	**Explanation**
SMPS	Scanning Mobility Particle Sizer
Sub-micron	particles < 1μm
Super-micron	particles > 1μm
EC	Elemental Carbon
OC	Organic Carbon
TOT	Thermal-Optical Transmission
PAH	Poly aromatic hydrocarbons

7 Definition of soot aerosol

7.1 Generation of soot aerosol

Test aerosols according to this part of ISO 12103 are generated by combustion of an organic fuel in the test lab. They consist primarily of agglomerates of carbon particles where the primary carbon particles are on the order of 20 nanometers diameter. Organic compounds may be condensed on the carbon agglomerates during the combustion and dilution processes.

7.2 Particle size distribution

Particle size distribution shall be determined using electrical mobility sizing method. The size distributions shall be presented as normalized number distribution. The logarithmic normal distribution for soot test aerosol shall have a number mean mobility size of 95 ± 10 nm and a geometric standard deviation of between 1,75 ± 10%. Detailed information is given in Annex A.

7.3 Stability of aerosol concentration and particle size distribution

The soot aerosol mass concentration shall be stable within ± 5% and particle size distribution shall be stable within the limits above.

NOTE Care should be taken that the concentration is low enough to prevent size changes due to coagulation from occurring in the test system. Recommendation for maximum number concentration is $10^7/cm^3$. More detailed information is provided in Annex B.

7.4 Chemical composition

For generating the soot a diffusion flame with e.g. ethylene can be used. But any fuel yielding the defined chemical composition and size distribution is accepted.

This flame shall lead to an aerosol consisting of the content breakdowns presented in Section 4.

To achieve accurate reproducible filter test results, a dry soot aerosol ideally consisting of solely elemental carbon (EC) would be preferable. Because soot from combustion always contains more or less organic carbon (OC), the content of OC in the test aerosol shall be demonstrated. OC content should be as low as possible but it must not exceed 14% of the total aerosol mass concentration.

Samples of the aerosol shall be taken and analyzed per NIOSH test method 5040 issue 3 for EC/OC.

The ratio of OC has to be demonstrated by thermal-optical transmission analysis by the thermal protocol NIOSH 700+. It shall be demonstrated only once for each soot generator or after any significant modification of the unit e.g. after changing geometric dimensions of the burner, using another fuel gas or other flow settings, etc.

It shall be demonstrated for all fixed operating points which fit the described standardized soot aerosol in this document. For soot generators with continuously adjustable settings it shall be demonstrated by a suitable method that OC content does not exceed 14% within the adjustable range. This can be realized by analysis of probes at some single set-points at the minimum and at the maximum of the adjustable range at least and one or more between.

For more information about the thermal-optical transmission and about the sampling method refer to Annex E.

8 Analysis equipment and operating procedure

This section will identify the analysis equipment and procedure to sample, classify, and identify the soot aerosol, which is being produced in this standard.

8.1 Analysis equipment

The analysis equipment specified in ISO 29904, sections 5.6.5 and 5.6.6, specifically the SMPS and EEPS are equipment which shall be used to characterize the soot contaminant. ISO 29904 has four sections per piece of equipment; principle, method description, parameters produced, and the advantages and disadvantages of each piece of equipment.

8.2 Particle size analysis procedure

Analysis of ISO-specified soot test aerosol shall be performed using a differential mobility classifier with condensation particle counter detector or equivalent equipment at the outlet of the soot generator.

Mobility particle size must cover the range from 20 nm up to 500 nm at least. Particle measurement devices which do not fulfill this requirement are not suitable, since small particles will not be detected.

Characterizing of the distribution, the location of the characterization shall occur at the introduction point of the test. Using the sampling method specified in ISO 29904, Extractive measurement methods section, shall identify the method to sample the soot aerosol.

8.3 Instrument Calibration

Calibration of the Differential electrical mobility analyzer shall be calibrated per ISO 15900.

Annex A
(normative)

Particle Size Distributions by Number

A.1 General

For typical soot sources used within the scope of this standard the particles usually are lognormal distributed with regards to their size. These distributions can easily be converted into a standard normal distribution. A normal distribution is distinctly defined by two parameters. Therefore this standard describes the range of acceptable particle size distributions by defining those two parameters together with a set of tolerances. This Annex describes how this is done and how real particle size distributions can be checked for compliance with those targets.

A.2 Lognormal Distribution and Gaussian Normal Distribution

A typical particle size distribution for soot is shown in fig. 1 on a linear size axis together with a mathematically fitted lognormal curve. The general equation of that function is:

$$f(x) = \frac{a}{\sqrt{2 \cdot \pi} \cdot \sigma \cdot x} \cdot e^{\frac{-(\ln x - \mu)^2}{2 \cdot \sigma^2}} \quad \text{(A.1)}$$

for x > 0

a: being a scaling factor

x: particle diameter

$$\mu = \ln E - \frac{1}{2} \cdot \ln\left(1 + \left(\frac{stdev}{E}\right)^2 \right) \quad \text{(A.2)}$$