TECHNICAL SPECIFICATION

ISO/TS 11155-1

First edition
2001-11-01

Road vehicles — Air filters for passenger compartments —

Part 1:
Test for particulate filtration

Véhicules routiers — Filtres à air pour l'habitacle —

Partie 1: Essai de filtration des particules

Reference number
ISO/TS 11155-1:2001(E)

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Printed in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years with a view to deciding whether it should be confirmed for a further three years, revised to become an International Standard, or withdrawn. In the case of a confirmed ISO/PAS or ISO/TS, it is reviewed again after six years at which time it has to be either transposed into an International Standard or withdrawn.

Attention is drawn to the possibility that some of the elements of this part of ISO/TS 11155 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 11155-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 7, *Injection equipment and filters used on road vehicles*.

This first edition cancels and replaces the first edition of ISO/TR 11155-1:1994, of which it constitutes a technical revision.

ISO/TS 11155 consists of the following parts, under the general title *Road vehicles — Air filters for passenger compartments*:

— *Part 1: Test for particulate filtration*

— *Part 2: Test for gaseous filtration*

Annexes A, B, C, E, F and G form a normative part of this part of ISO/TS 11155. Annex D is for information only.

Introduction

The following passenger compartment air filter test code has been established to cover particulate air filters and the particulate filter section in combined filters (particulate and gas filtration) used in automotive interior ventilation systems.

The objective of this procedure is to maintain a uniform test method for evaluating the filter performance characteristics of particulate air filters on specified laboratory test stands.

The performance characteristics of greatest interest are pressure loss (or airflow restriction), overall and fractional efficiencies, and holding capacity for airborne particles.

The data collected according to this test code can be used to establish performance characteristics for filters tested in this manner. The actual field operating conditions, including contaminants, humidity, temperature, mechanical vibration and flow pulsation are too difficult to duplicate.

Road vehicles — Air filters for passenger compartments —

Part 1:
Test for particulate filtration

1 Scope

This part of ISO/TS 11155 specifies a particulate filtration test, including the critical characteristics of equipment, test procedure and report format, for the consistent assessment of filter elements in a laboratory test rig with particle sizes larger than 0,3 µm. It is applicable to filters for removing particulate matter from external or recirculated air used for ventilating motor vehicle passenger compartments or cabins.

The test specified in this part of ISO/TS 11155 enables an assessment of filter elements for pressure loss, fractional filtration efficiency and accelerated particulate holding capability against standardized laboratory particulate challenges. Because the test methods exclude the full range of possible particulate challenges and environmental effects, the relative ranking of filters may change in service.

NOTE 1 Absolute comparability is only possible with filter elements of the same shape and size as well as the same position in the test duct.

NOTE 2 Subject to agreement between supplier and the customer, the test procedure allows for the calculation of gravimetric efficiency as a single parameter for quality control purposes. For gravimetric efficiency tests refer to ISO 5011.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO/TS 11155. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO/TS 11155 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 5011, *Inlet air cleaning equipment for internal combustion engines and compressors — Performance testing*

ISO 12103-1, *Road vehicles — Test dust for filter evaluation — Part 1: Arizona test dust*

ASTM F-328, *Practice for determining counting and sizing accuracy of an airborne particle counter using near-monodispersed spherical particulate materials*, Annual Book of ASTM Standards, Vol. 10.05, 1989

3 Terms and definitions

For the purposes of this part of ISO/TS 11155, the following terms and definitions apply.

3.1
test air flow rate
volume of air passing through the test duct per unit time, expressed in actual cubic metres per hour (m^3/h)

3.2
pressure loss
permanent pressure reduction due to a decrease in the flow energy (velocity head) caused by the filter (in pascals at standard conditions of 23 °C and 101,3 kPa)

3.3
fractional efficiency
E_{fi}
ability of the air filter to remove particles of a specified size, expressed as a percentage

3.4
initial fractional efficiency
fractional efficiency before the collected particles have any measurable effect on the efficiency of the filter under test

NOTE The collected particles can affect the measured filter efficiency before enough aerosol is collected to affect the filter pressure loss.

3.5
fractional penetration
P_{fi}
ratio of the concentration of particles of specified size exiting the filter to the concentration of particles of specified size entering the filter, expressed as a percentage

3.6
test dust-holding capacity
mass of test dust collected by the filter at the specified terminal pressure loss and flow rate, expressed in grams

3.7
hydraulic diameter
D_h
equivalent diameter used to characterized non-round ducts, calculated as:

$$D_h = 4 \times (\text{area of cross-flow section/duct perimeter})$$

3.8
particle counter
aerosol spectrometer
instrument for sizing or counting aerosol particles, or both

3.9
test aerosol
particles suspended in air, used for filter-efficiency or -capacity evaluation

3.10
correlation ratio
R_o
ratio of the number of particles observed at the downstream sampling location to the number of particles at the upstream sampling location when no filter is installed in the test

NOTE The method of calculating the correlation ratio is given in annex B.

3.11
log mean diameter
$D_{l,i}$
weighted mean diameter calculated by:

$$D_{l,i} = (D_i \times D_{i+1})^{1/2} \quad (1)$$

where

$D_{l,i}$ is the log mean diameter;

D_i is the lower threshold size of the particle size range;

D_{i+1} is the upper threshold size of the particle size range

3.12
geometric (volume equivalent) diameter
$D_{g,i}$
diameter of sphere with the same volume as the particle being measured

3.13
optical (equivalent) diameter
$D_{o,i}$
diameter of a particle of the type used to calibrate an optical sizing instrument that scatters the same amount of light as the particle being measured

NOTE Optical diameter depends on the instrument, the type of particle used to calibrate the instrument (usually polystyrene latex spheres), the optical properties of the particle being measured, and the size of the particle.

3.14
aerodynamic (equivalent) diameter
$D_{ae,i}$
diameter of a sphere of density 1 g/cm^3 with the same terminal velocity due to gravitational force in calm air, as the particle being measured

NOTE The aerodynamic diameter is used to report results to avoid different diameter measures due to different sizing and counting techniques. Annex F provides additional information about aerodynamic diameter.

3.15
efficiency challenge aerosol
aerosol used to measure the efficiency of a test filter

NOTE The concentration is low enough to prevent coincidence-related errors in the particle counters, and does not change the filter efficiency due to loading. The aerosol charge is reduced so that it approximates a Boltzman equilibrium charge distribution. The requirements for the efficiency challenge aerosol are given in 4.2.3 and 4.2.4.

3.16
capacity challenge aerosol
aerosol used to load the filter

NOTE The concentration is high enough to allow loading of the filter in a reasonable time, but may be too high to allow the use of typical particle counting instruments. The requirements for the capacity challenge aerosol are given in 4.2.3 and 4.2.4.

3.17
neutralized aerosol
aerosol whose charge distribution is reduced until it provides a Boltzman equilibrium charge distribution

NOTE 1 The aerosol is not neutral in the sense that all individual particles are neutral.

NOTE 2 It may not be possible to obtain a true Boltzman equilibrium charge distribution in the short time available in a test system. The procedures in annex G are designed to minimize the effect of excess charge arising from the aerosol generation method.

4 Test equipment, accuracy and validation

4.1 Measurement accuracy

Accuracy requirements are given in Table E.1 (4.1).

4.2 Test system

4.2.1 System requirements

4.2.1.1 The test stand shall consist of a conductive and grounded vertical test section (at least in its section between dust addition and the downstream sample probe) with test-filter mounting framework, and shall be designed to minimize particle loss. It shall include equipment or apparatus for air conditioning and supply, flow rate measurement, pressure-loss measurement, and aerosol introduction and sampling. A test stand which meets the requirements of Tables E.1 and E.2 is acceptable. An example of a plenum chamber style test system is shown in Figure 1.

Other designs, such as tapered ducts where the filter mounting section is the same cross section as the filter, might be acceptable. In all cases, any deviations shall be arranged between the tester and the requester.

Test stand performance shall meet the requirements of this clause and shall be validated as part of the overall test system (test stand and associated equipment) as described in 4.4. Validation information shall be recorded in a standard format and made available to requesters. System validation shall be performed at least once per year in accordance with Table E.3.

The uniformity of air flow in the test duct shall be measured with a calibrated anemometer at the centre of each of four equal-sized areas, and at the centre at a distance of not more than 5 cm above the empty filter holder. The variation in air flow velocity shall be no more than ± 10 % from the mean flow velocity.

4.2.1.2 Provisions should be made to maintain the temperature and humidity of the test air in accordance with 4.3.4. Prior to mixing with test aerosol, air should be cleaned to a level of less than 1 % of the challenge aerosol concentration at all particle sizes. Use of HEPA filtration is required (see 4.3.3). The system shall demonstrate the ability to maintain these conditions over the period of time required to complete a filter evaluation.

The system shall be tightly sealed such that the leak rate is less than 100 l/min when the pressure in the duct is 500 Pa above ambient for systems that are pressurized, or 500 Pa below ambient for systems that are normally below ambient pressure. This test is conducted according to the method referenced in Table E.3.

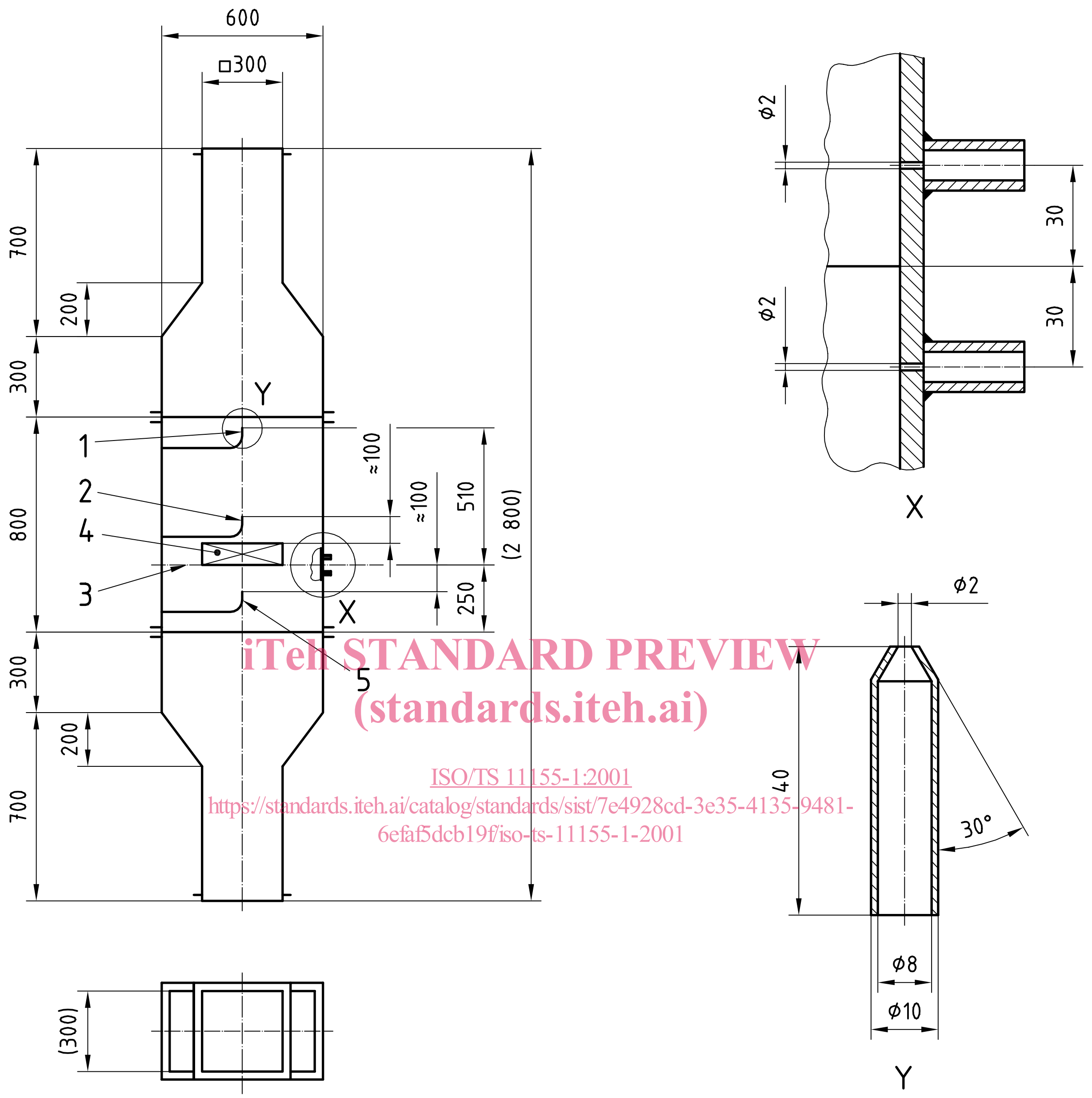
The system shall be capable of delivering the user-specified flow rate. Furthermore, it shall be capable of maintaining this flow rate for the duration of a test and in the face of an increasing differential pressure. This flow rate will be typically up to 680 m^3/h, with filter pressure loss of up to 1 000 Pa. The minimum flow rate at which the system validation shall be carried out is 150 m^3/h. The system may operate at either positive or negative pressure, provided it meets the requirements of 4.2.

4.2.1.3 Flow rate shall be measured in accordance with 4.1 across the range of the flow rate as specified in 4.2.1.2. Flow rate-measurement devices may be certified out of the test duct, provided they are installed in exact accordance with the manufacturer's requirements. If no manufacturer's installation instructions are available or if the flow rate-measurement devices are not installed according to such instructions, the flow rate measurement device shall be calibrated in place in the test rig and be traceable, once removed, to a standard calibrating source.

4.2.1.4 Pressure loss (differential pressure) across the test filter shall be measured with a differential pressure device connected to pressure taps in the test duct. These taps shall be located in sections which are straight-sided, have the same cross section as the section including the filter under test, and which are positioned not more than one duct diameter (hydraulic) upstream and downstream of the test filter. The pressure taps shall be of the static-pressure type and may be configured as in Figure 1, A and B.

The pressure-loss instrumentation shall be capable of measuring the full range of pressure loss expected for the test, plus 10 %. Accuracy of measurement over this range shall be in accordance with 4.1.

Dimensions in millimetres



Details not indicated should be selected in accordance with the application.

Key

1 Test dust feed
2 Sampling probe upstream of test unit
3 Test unit mounting plane
4 Test unit
5 Sampling probe downstream of test unit

X Pressure taps
Y Feed nozzle

Figure 1 — Example test duct

4.2.1.5 Aerosol shall be introduced into the duct and subsequently mixed in such a way that a uniform mixture of test aerosol will be delivered to the filter under test. In certifying the test system, the uniformity, concentration, and stability of the efficiency challenge aerosol shall be measured in accordance with 4.2.4.2. In addition, uniformity and concentration of the capacity challenge aerosol shall be verified in accordance with 4.2.4.3.

4.2.1.6 The test filter shall be mounted in the horizontal position with the geometric centre of the filter coincident with the centre line of the duct. The test filter shall be sealed in a frame.

4.2.2 Sampling

4.2.2.1 The test aerosol shall be sampled upstream and downstream of the filter under test. The aerosol may be drawn through the sampling apparatus into a particle counter or other device. The performance of the sampling apparatus shall be evaluated as part of the test system in accordance with 4.2.4.2.

4.2.2.2 Sampling probes shall be isokinetic (local velocity of duct and probe to be equal) to within ± 20 %. The same probe design should be used before and after the filter. Sampling probes shall be located on the centre line of the test duct. The upstream probe shall be located at a distance of approximately 100 mm upstream from the filter under test. The downstream probe shall be located at least 75 mm downstream of an active area of the filter in the centre of duct and filter.

4.2.2.3 Tubing leading to particle counters shall be as short as possible and minimize the number of bends and static build-up to avoid particle losses. The latter may be accomplished by using electrically conductive, grounded materials or choosing another material that has demonstrated good performance in this area. The use of valves and other restrictions should be avoided. If possible, the upstream and downstream sample lines should be identical.

4.2.3 Aerosol generator

4.2.3.1 An aerosol generator is used for fractional-efficiency tests. To measure the fractional efficiency either ISO 12103-1 A2 fine test dust or potassium chloride aerosol is used (see 4.2.3.2 or 4.2.3.3). Other aerosols can be used as specified by the requester. One should expect different results with different aerosols due to changes in the particle-counter response to particle refractive index, density, and shape. A calibration of the particle counter to the aerodynamic diameter of the test aerosol, or the use of a particle spectrometer directly measuring aerodynamic size will minimize the deviations when using different aerosols (see annex F).

Aerosol generators for fractional efficiency tests shall be capable of producing a stable aerosol concentration and size distribution. The size distribution of the aerosol shall have sufficient particles for statistical evaluation within each size class. Typically, this will be a minimum of 500 particles per size class per sample upstream; 100 particles per size class per sample downstream of the test filter are recommended. If high-resolution particle spectrometers are used, size classes may be combined to achieve the required counts using the size ranges in 4.2.5.1. The total concentration of the aerosol in the test duct shall not exceed the limit of the particle counter as discussed in 4.2.5.2. The efficiency challenge aerosol concentration shall be low enough so there is no change in efficiency during the test as described in 5.2.2 (i), i.e. no loading effects.

The aerosol concentration and size distribution shall be verified according to 4.2.4.2. The aerosol generator shall meet the performance requirements specified hereunder. The aerosol shall be charge-neutralized according to 4.2.6 prior to introduction into the test duct or within the test duct.

4.2.3.2 The aerosol generator for fractional efficiency tests shall disperse ISO 12103-1 A2 fine test dust to produce a homogenous dust aerosol with stable concentration and size distribution.

4.2.3.3 The potassium chloride aerosol generator for fractional efficiency tests shall nebulize a saline solution to produce a homogeneous mist aerosol with stable concentration and size distribution. The droplets shall be dried to form salt particles by using, for example, dry dilution air, heat or desiccant.

4.2.3.4 A dust-feeding system consisting of a dust disperser and dust injector shall be used for dust-holding capacity and gravimetric efficiency tests. The dust feeder shall feed dust at a continuous and uniform rate, with a stable size distribution. The dust injector is used to disperse dust into the test system and shall not change the airborne particle size distribution. The dust-feeding system shall produce an aerosol of ISO 12103-1 A2 fine test dust with a stable concentration (± 20 % variation over time). The feed rate of the dust feeder shall produce a dust concentration in the test duct between 50 mg/m^3 and 100 mg/m^3. The dust disperser and injection nozzle shall contain the ISO dust injector described in ISO 5011. The dust injector shall be operated at 0,1 MPa (1 bar)[1)] air pressure. In case of the use of other injectors it shall be demonstrated that the injector in question performs at least as well as the ISO 5011 dust injector. The aerosol may be charge-neutralized according to 4.2.6 prior to challenging the filter under test.

The dust disperser can be open-tray or turntable Venturi-suction feeder, a rotary-brush feeder, a fluidized bed feeder, or other dust feeder capable of producing the required test dust.

4.2.4 Aerosol challenge verification

4.2.4.1 The uniformity, concentration, and stability of the test aerosol challenges (efficiency and capacity) shall be verified according to 4.2.4. This verification is done to assure that test filters receive a known and repeatable aerosol challenge. If tapered duct geometry is used, this verification shall be repeated for each test section.

Verification of the aerosol challenge takes into account performance of the aerosol generator, aerosol introduction and mixing method, sampling system, and aerosol-measurement devices.

4.2.4.2 For verification of the efficiency challenge, the general procedures and requirements given in 4.2.3 should be followed.

For verification of uniformity and concentration of the efficiency challenge aerosol, no filter shall be installed in the location of the test filter. In the case of plenum chamber style test systems, the standard 200 mm × 300 mm orifice shall be used.

The uniformity of the particle size distribution and the concentration of the test aerosol used for efficiency tests shall be verified by use of a particle-sizing instrument that will also be used in the test system. This particle-sizing instrument shall draw samples upstream of the filter mounting position. Flow rate passing through the test stand shall be 300 m^3/h. Samples shall be drawn immediately in front of each of the four quadrants of the filter location and at the standard centre line sampling location. A minimum of five samples shall be drawn at each sampling location, and the resulting number distribution shall be averaged.

The average values for each reported particle-size range shall not vary by more than ± 10 % for 0,3 µm to 5 µm particles and ± 20 % for 5 µm to 10 µm particles among the five locations. This indicates that the challenge aerosol is uniformly distributed across the filter, and that the centre line sample is representative of the overall challenge.

Verification of the aerosol stability shall be combined with verification of the sampling apparatus used in efficiency testing. The stability of the aerosol challenge is evaluated over a period of time equivalent to an efficiency test. The sampling apparatus (including aerosol-measurement equipment) is evaluated for differences between upstream and downstream samples.

For verification of stability and sampling validity, no filter shall be installed in the location of the test filter. In the case of plenum chamber style test systems, the standard 200 mm × 300 mm orifice shall be used.

The method shall be as follows: The efficiency-test aerosol shall be sampled upstream and downstream of the test-filter location, with filter mounting framework in place, but with no test filter installed. All sampling apparatus shall be in place as described in 4.2.2.1. Samples shall be drawn isokinetically and performance shall be verified at 300 m^3/h.

Follow the sampling procedure specified in 5.2.2 (h). A total of three samples will be taken upstream and three samples downstream of the test-filter location. The count distribution (number of particles in each size class) shall be determined for each sample. The three upstream particle size distributions shall be compared and the numbers of particles measured in each size class should agree to within 10 % for 0,3 µm to 5 µm particles and ± 20 % for 5 µm to 10 µm particles among three particle size distributions. This criteria shall be applied to both the upstream, and the downstream particle size distribution.

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1) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2