TECHNICAL REPORT

ISO TR 11155-1

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Road vehicles — Air filters for passenger compartments —

Part 1:
Test for particle filtration

Véhicules routiers — Filtres à air pour l'habitacle —

Partie 1: Essai de filtrage des particules

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Contents

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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 main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 11155-1, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 7, *Injection equipment and filters for use on road vehicles*.

This document is being issued in the type 2 Technical Report series of publications (according to subclause G.4.2.2 of part 1 of the ISO/IEC Directives, 1992) as a "prospective standard for provisional application" in the field of filters for road vehicles because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this type 2 Technical Report will be carried out not later than two years after its publication with the options of: extension for another two years; conversion into an International Standard; or withdrawal.

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

— *Part 1: Test for particle filtration*

— *Part 2: Test for gases*

Annexes A and B form an integral part of this part of ISO/TR 11155. Annex C is for information only.

Introduction

This Technical Report is based on research work conducted by the Fraunhofer-Institut für Toxikologie und Aerosolforschung in Hanover, Germany, concerning the effects of all parameters in the test.

The main results concern

— selection of test dust;

— length and position of test duct with filter holder;

— test dust feed with nozzle and arrangement in test duct;

— test dust distribution in the duct;

— sampling probes and arrangement in test duct;

— relative limits of measurement of the fractional filtration rate;

— selective fine dust dilution.

Investigations with various test dusts have shown that SAE dust is the most suitable due to its worldwide availability, comparability and standardization. On the basis of the current position, a fractional filtration rate test in the particle size range from 0,5 µm to 15 µm aerodynamic diameter, which is dependent on the test dust and the measuring method, is used. A desired definition of the test procedure in a size spectrum from 0,1 µm to 30 µm could only be achieved at the present time with an unjustifiable increase in the complexity of the equipment and of the tests.

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Road vehicles — Air filters for passenger compartments —

Part 1:
Test for particle filtration

1 Scope

This part of ISO/TR 11155 specifies assessment criteria in order to permit the selection and comparability of air filters and filter elements under laboratory conditions. It applies to air filters used in motor vehicles to remove dust particles from the external air or recirculated air for the passenger compartment.

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.

The tests provide information on pressure differences, the filtration rate and fractional filtration rate, as well as the dust-holding capacity of a filter. For quality testing, it is in many cases, subject to agreement between supplier and customer, sufficient to determine the gravimetric filtration efficiency only.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO/TR 11155. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO/TR 11155 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5011:1988, *Inlet air cleaning equipment for internal combustion engines and compressors — Performance testing.*

DIN 24184:1990, *Type approval testing of high efficiency submicron particulate air filters; testing with paraffin oil mist as the test aerosol.*

DIN 24185-2:1980, *Testing of air filters for general ventilation; filter classification; designation; testing.*

BS 3928:1969, *Method for sodium flame test for air filters (other than for air supply to I.C. engines and compressors).*

MIL-STD-282, *Filter units, protective clothing, gas-mask components, and related products: Performance test methods.*

EUROVENT Doc. 4/5, *Method of testing air filters used in general ventilation.*

ASHRAE 52-1976, *Method of testing air cleaning devices used in general ventilation for removing particulate matter.*

3 Definitions

For the purposes of this part of ISO/TR 11155, the following definitions apply.

3.1 flowrate: Volume which flows through a filter per unit of time.

NOTE 2 The nominal flowrate or test flowrate for each application is to be agreed between the manufacturer and user.

3.2 pressure difference: Difference in the static pressures upstream and downstream of a filter.

NOTES

3 The parameter may also be called differential pressure.

4 The position of the pressure taps is as shown in detail A in figure A.2.

3.2.1 initial pressure difference: Pressure difference of a new, non-contaminated filter or filter element.

3.2.2 final pressure difference: Pressure difference of a filter or filter element after a certain operation or test period.

3.3 filter area: Effective surface of a filter element.

3.4 filtration efficiency: Measure of the efficiency of a filter or filter element under specified test conditions.

NOTE 5 The filtration rate, to be determined gravimetrically, is the ratio of the test dust mass retained by the filter to that fed to the filter:

$$\eta = 100 \frac{m_1 - m_2}{m_1}$$

where

m_1 is the mass of test dust added;

m_2 is the mass of test dust passed through the filter.

3.4.1 fractional filtration efficiency: Filtration efficiency for a certain particle size, x:

$$T_x = 100 \frac{C_{1x} - C_{2x}}{C_{1x}}$$

where

C_{1x} is the concentration of the particle size at the filter inlet;

C_{2x} is the concentration of the particle size at the filter outlet.

3.5 dust capacity: That mass of dust retained by the filter or filter element which produces specified terminal conditions, for example, a defined final pressure difference.

4 Symbols

For the purposes of this part of ISO/TR 11155, the symbols and units indicated in table 1 apply.

Table 1

Parameter	Symbol	Unit
Flowrate	$\dot{V}$	m^3/s or m^3/min
Volume	V	m^3
Air velocity	v	m/s
Air density	ϱ	kg/m^3
Pressure	p	Pa 1)
Pressure difference	Δp_d	Pa or hPa 1)
Initial pressure difference	Δp_A	Pa or hPa 1)
Final pressure difference	Δp_E	Pa or hPa 1)
Filter area	A	m^2
Filtration efficiency	η	%
Fractional filtration efficiency	T_x	%
Dust capacity	G	g
1) 1 bar = 10^5 Pa; 1 mbar = 1 hPa		

5 Reference conditions and test materials

5.1 Reference conditions

5.1.1 Condition of air

The temperature of the aspirated air shall be 23 °C ± 5 °C. The relative humidity shall be 75 % maximum.

5.1.2 Air cleaning

If necessary, the aspirated air shall be cleaned of natural aerosol substances with a pre-filter (e.g. filter class EU7 or EU8 to DIN 24185-2 or EUROVENT Document 4/5, the test procedure of which is equivalent to ASHRAE 52-76) and with a submicron particulate filter (e.g. filter class S to DIN 24184 or filter class EU 12 and EU 13 according to BS 3928 or 99,97 % DOP efficiency according to MIL-STD 282) fitted downstream.

NOTE 6 See annex C for sources of supply of documents.

5.2 Test materials

5.2.1 Test dust

The tests shall be performed with "coarse" test dust in accordance with ISO 5011. The particle size distribution shall be analysed and made available if requested by the user.

The test dust shall be conditioned in accordance with the test conditions in 5.1.1.

5.2.2 Aerosol for special tests

Sodium chloride or *lycopodium*, for example, may be used for performing additional tests. This shall be agreed between the manufacturer and the user.

6 Test equipment

6.1 General set-up

The test set-up arrangements for performing the tests shall be as shown in figures A.1 to A.5.

6.2 Air supply

The aspirated air shall be conditioned as in 5.1.2. A flowrate control device shall be integrated in the air supply duct coming from the air supply unit. It shall be possible to set a flowrate in the range between 100 m^3/h and 600 m^3/h, independently of the current dust supply state of the filter, within 2 %. The air supply shall be leaktight after the flowrate regulator; a leak rate of less than 10 l/min at 500 Pa is acceptable. The dimensions of the air duct components shall be designed accordingly.

6.3 Test duct

The test duct shall be vertical. Suitable measures such as baffles shall be used to ensure that the flow is equalized over the cross-section. The dimensions of the test duct shall be as indicated in figure A.2.

6.4 Test dust metering equipment

6.4.1 Dust supply test

Metering equipment shall be used which delivers the test dust uniformly. The particle size distribution shall not be altered in the tests by the equipment.

6.4.2 Fractional filtration rate test

In view of the coincidences in the case of small particles and the lack of statistical accuracy in the case of large particles, it is advisable, when measuring the fractional filtration rate, to modify the narrow band quantitative frequency distribution of the test dust with a particle-size-selective dilution device as in figure A.4. This device is inserted in the dust supply line after the metering equipment and may replace an additional dilution device before the particle dust feed.

The particle-size-selection dilution device shall however not be used for determination of the dust capacity.

6.5 Test dust feed

The dust is supplied by means of the nozzle and in the arrangement as shown in figure A.2. The connector tubes shall be made of electrically conductive material. The air feed pressure shall be 10^5 Pa and without water and oil content.

6.6 Sampling probes

The sampling probes shall be fitted up- and downstream of the filter/filter element against the direction of the air flow. The probes shall be adapted to the air velocity pertaining in the test duct as far as possible. The sampling velocity shall be equal to or greater than the duct velocity; the sampling probes before and after the filter element shall be of the same type. The specimen sampling probes shall be fitted in the centre of the duct cross-section and equally spaced about 100 mm from the surface of the filter; any deviations shall be agreed between the manufacturer and the user. The arrangement shall be indicated in the test report.

6.7 Connecting tubes

When arranging the connecting tubes, care shall be taken to ensure that particle losses due to impaction in the bends and to sedimentation are minimized. These losses particularly affect the large particles which are quantitatively under-represented. If the pipe length is greater than 1 m, it may be advisable to take a sample of a larger air volume with the aid of a suitable suction pump, and then to take a smaller volume sample from it for the particle counter.

The valve to switch over between sampling before and after the filter/filter element may be a three-way valve with a free passage without air restriction or deflection.

6.8 Particle counter

Particle counters used shall be capable of measuring in a size range from 0,5 µm to 15 µm aerodynamic diameter[1)] in at least six classes, fractionally subdivided. The last duct shall not have a size classification, but shall count all particles greater than 15 µm. Only such particle counters may be used as determine either the aerodynamic or the geometric particle diameter. The instrument shall be used in accordance with the manufacturer's recommendation.

A conversion formula for approximately geometrical equivalent particle diameter, d_g, in microns, is as follows:

$$d_g = d_{ae} \sqrt{\frac{1}{\varrho_p}}$$

where

d_{ae} is the aerodynamic particle diameter, in micrometres;

ϱ_p is the particle density, in grams per cubic centimetre.

6.9 Pressure tap locations

The pressure tap locations shall be as in figure A.2.

6.10 Pressure difference measuring meter

The pressure difference shall be measured with a micro-manometer or a calibrated electrical pressure sensor with an error tolerance, relative to the measured value, of 2 %.

6.11 Flow meter

The flowrate shall be measured with an instrument with an error tolerance of 2 %.

7 Preparation of filter/filter element for testing

For the following clauses the filter/filter element is called the test unit. The test unit shall be tested in a new and dry condition. The test unit shall be weighed to an accuracy of 0,1 g before the start of the test.

8 Tests

8.1 Determination of flowrate/pressure difference in new condition

The initial pressure-difference curve shall be determined and recorded for flowrates of 25 %, 50 %, 75 % and 100 % of the specified nominal flowrate.

8.2 Determination of fractional filtration rate curve at nominal flowrate

8.2.1 General

The following points shall be observed to ensure precise measurement of the initial fractional filtration rate.

a) The test duct shall be clean and airtight.

b) The inducted test air enriched with natural aerosol shall be negligible compared with the concentration of the feed test dust.

c) The test dust dosing device shall operate constantly and without interruption.

d) The sampling probes and the connecting tubes to the measuring instrument shall be clean; the tubes shall not be bent.

e) The particle counter shall be adjusted before the test.

f) The test unit shall be checked visually for defects, and it shall be ensured that it is mounted in the test unit holder in an airtight manner.

8.2.2 Test procedure

8.2.2.1 Check the particle counter for nil balance of display.

8.2.2.2 Connect the particle counter to the pure air probe without the dilution station. Operate the test duct at the nominal flowrate without the test unit and without adding test dust. Determine the particle quantity in the individual fractions.

8.2.2.3 Install the unit under test.

1) Assuming spherical particles, this corresponds for test dust "coarse" to a geometrical equivalent particle diameter of approximately 0,3 µm to 9 µm.

8.2.2.4 Take samples before and after the test unit. Repeat this process twice (a total of three times) and take the mean of the measurements. Scavenge between measurements, until at least twice the volumes of the sampling system and the instrument have passed through.

The dust concentration in the individual ducts and the test duration shall be such that

- it is possible to determine the fractional filtration rate with a relative accuracy within the tolerance range indicated in figure 1;
- the pressure difference of the test unit during measurement of the fractional filtration rate does not increase by more than 5 % of the initial pressure difference.

To avoid signal coincidences at the particle counter before the test unit, it may be necessary to interpolate dilution stations. The necessary dilution factor shall be determined experimentally for each size fraction.

8.2.2.5 Determine and record the curve of fractional filtration rate against particle size.

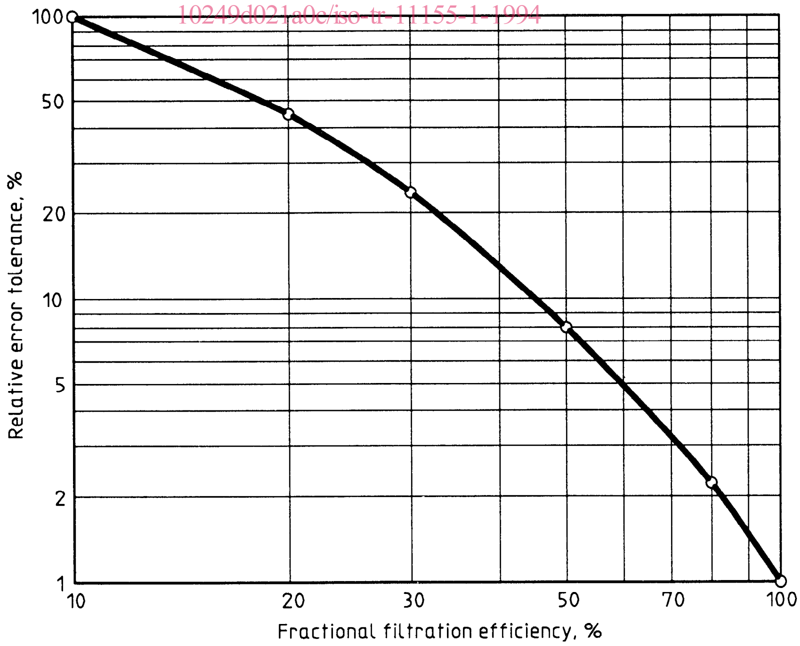
8.3 Determination of dust-holding capacity with fractional filtration rate and total filtration rate

8.3.1 General

At a fixed flowrate, a defined amount of test dust is introduced into the test duct. The dust concentration shall be 75 mg/m^3 $\pm$ 5 %; the added test dust shall be weighed to the nearest 0,1 g. The dust which passes through the test unit is deposited in the final filter. The final filter is then dismantled and re-weighed. The increase in mass is used to determine the gravimetric total filtration rate. While dust is being introduced, take at least four measurements, until the specified final pressure difference is reached. The change in the fractional and total filtration rates and the increase in the pressure difference as a function of the dust capacity are determined.

The direct weighing method in accordance with ISO 5011 is permitted provided the following laboratory conditions are available: a suitable accurate balance and close air humidity tolerance.

NOTE 7 Test dust which settles in the test unit mounting plane and in the pipe system before the test subject is not considered as being added; it is not taken into consideration when calculating efficiency and dust capacity.



NOTE — The largest abscissa value is 99 %, and the associated relative tolerance is $\pm$ 1 %

Figure 1 — Maximum acceptable relative deviation of repeat measurements of fractional filtration efficiency