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Inlet air cleaning equipment for internal combustion engines and compressors — Performance testing

Séparateurs aérauliques placés à l'entrée des moteurs à combustion interne et des compresseurs — Détermination des performances

Reference number
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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.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 5011 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 7, *Injection equipment and filters for use on road vehicles*.

This second edition cancels and replaces the first edition (ISO 5011:1988), which has been technically revised.

Annexes A, B and G form a normative part of this International Standard. Annexes C to F are for information only.

Inlet air cleaning equipment for internal combustion engines and compressors — Performance testing

1 Scope

This International Standard establishes and specifies uniform test procedures, conditions, equipment, and a performance report to permit the direct laboratory performance comparison of air cleaners.

The basic performance characteristics of greatest interest are air flow restriction or differential pressure, dust collection effciency, dust capacity, and oil carry-over on oil bath air cleaners. This test code therefore deals with the measurement of these parameters.

This International Standard is applicable to air cleaners used on internal combustion engines and compressors generally used in automotive and industrial applications.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard 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 5167-1, *Measurement of fluid flow by means of pressure differential devices — Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full.*

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

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1.1
air filter
air cleaner
device which removes particles suspended in the fresh charge as it is drawn into the engine

3.1.2
filter element
replaceable part of the air filter, consisting of the filter material and carrying frame

3.1.3
secondary element
air cleaner element fitted downstream of the primary element for the purpose of providing the engine with protection against dust in the event of

a) certain types of primary element failure, or

b) dust being present during the removal of the primary element for servicing

3.1.4
unit under test
either a single air cleaner element or a complete air cleaner assembly

3.1.5
single-stage air cleaner
air cleaner which does not incorporate a separate precleaner

3.1.6
multistage air cleaner
air cleaner consisting of two or more stages, the first usually being a precleaner, followed by one or more filter elements

NOTE If two elements are used, the first is called the primary element and the second one is called the secondary element.

3.1.7
precleaner
device usually using inertial or centrifugal means to remove a portion of the test dust prior to reaching the filter element

3.1.8
test air flow
measure of the quantity of air drawn through the air cleaner outlet per unit time

NOTE The flow rate is expressed in cubic metres per minute corrected to standard conditions.

3.1.9
rated air flow
flow rate specified by the user or manufacturer

NOTE It may be used as the test air flow.

3.1.10
scavenge air flow
measure of the quantity of air used to remove the collected dust from a precleaner

NOTE It is expressed as a percentage of the test air flow.

3.1.11
static pressure
pressure in a duct, at the observed air flow rate, measured by connecting a pressure gauge to a hole or holes drilled in the wall of the duct

NOTE In the tests specified in this International Standard, a static pressure is measured by a manometer (usually a liquid manometer) as a negative pressure difference against the atmospheric pressure and in the formulae this is treated as a positive value.

3.1.12
restriction
static pressure measured immediately downstream of the unit under test

3.1.13
differential pressure
difference in static pressure measured immediately upstream and downstream of the unit under test

3.1.14
pressure loss
measure of the loss of energy caused by an air cleaner at the observed air flow rate

NOTE 1 It is expressed as the differential pressure corrected for any difference in the dynamic head at the measuring points.

NOTE 2 For further information, see annex A.

3.1.15
absolute filter
filter downstream of the unit under test to retain the contaminant passed by the unit under test

3.1.16
efficiency
ability of the air cleaner or the unit to remove contaminant under specified test conditions

3.1.17
capacity
quantity of contaminant removed by the unit under test in producing specified terminal conditions

3.1.18
oil carry-over
appearance of oil at the cleaner outlet

3.1.19
test terminal condition
condition, relating to an air cleaner, the occurrence of which signifies the end of the test

NOTE A test terminal condition may be, for example, any one of the following:

— the restriction or the differential pressure reaches a specified or agreed value;

— the dust-removing efficiency or some other performance parameter falls to a specified or agreed value;

— oil carry-over occurs;

— a dust pot becomes filled.

3.1.20
automotive application
air cleaner generally used for internal combustion engines in passenger cars

3.1.21
industrial application
air cleaner generally used for internal combustion engines in heavy-duty trucks, construction equipment and agricultural tractors

3.2 Symbols and units

The following applied units, according to ISO 1000, are used.

Quantity	Symbol	Unit
Volume flow rate	q_V	m^3/min
Velocity	v	m/s
Density	ρ	kg/m^3
Mass flow rate	q_m	kg/min
Pressure	p	Pa
Restriction	Δp_r	Pa
Differential pressure	Δp_d	Pa
Pressure loss	Δp_l	Pa
Mass	m	g
Time	t	s

4 Measurement accuracy and standard conditions

4.1 Measurement accuracy

Measure the air flow rate to within ± 2 % of the actual value, except for the variable air flow test when accuracy may be ± 2 % of the maximum value of the cyclic flow rate through the cleaner.

Measure the differential pressure and restriction to within 25 Pa of the actual value.

Measure the temperature to within 0,5 °C of the actual value.

Measure the mass to within 1 % of the actual value except where noted.

Measure the relative humidity (RH) with an accuracy of ± 2 % RH.

Measure the barometric pressure to within 3 hPa.

The measurement equipment shall be calibrated at regular intervals to ensure the required accuracy.

4.2 Standard conditions

All airflow measurements shall be corrected to a standard condition of 20 °C at 1 013 hPa (1 013 mbar).

See annex G.

5 Test materials and test conditions

5.1 Test dust

5.1.1 Grade

The test dust to be used shall be ISO 12103 - A2 (ISO Fine) or ISO 12103 - A4 (ISO Coarse), subject to agreement between the filter manufacturer and client. The chemical analysis and the particle size distribution shall conform to ISO 12103-1.

In the absence of an agreement on the dust

— for single-stage filters, use ISO Fine test dust, and

— for multistage filters, use ISO Coarse test dust.

5.1.2 Preparation

Before using the test dust, a quantity sufficient to cover the test requirements shall be mixed in a sealed container for a minimum of 15 min. The test dust shall then be allowed to become acclimatised to a constant mass under the prevailing test conditions.

NOTE To ensure a constant rate of dust feed with some dust feeders, it may be found necessary to heat the dust prior to being fed to the injector.

5.2 Test oil for oil bath air cleaners

The oil used for testing oil bath air cleaners shall be that specified by the filter manufacturer and agreed by the user for use at the appropriate ambient temperature. If an oil is not specified, the test oil shall be a heavy-duty oil and the viscosity at the temperature of the test shall be adjusted as follows:

— 85 mm^2/s for oil carry-over and restriction/differential pressure tests;

— 330 mm^2/s for efficiency and capacity tests, including an oil carry-over test after the capacity test.

5.3 Absolute filter materials

5.3.1 Filter media

The absolute filter may consist of fibreglass media with a minimum thickness of 12,7 mm and a minimum density of 9,5 kg/m^3.[1)] The fibre diameter shall be 0,76 µm to 1,27 µm and the moisture absorption shall be less than 1 % by mass after exposure to 50 °C and 95 % relative humidity for 96 h. The absolute filter media shall be installed with nap side facing upstream, in an airtight holder that adequately supports the media. The face velocity shall not exceed approx. 0,8 m/s to maintain media integrity.

As an alternative, a non-woven filter media with the efficiency described in 5.3.2 may be used.

To reduce any subsequent errors in the measurements caused by losses of fibres or materials, the absolute filter shall be subject to a flow of at least 110 % of the rated flow of ambient air for 15 min before the first test weighing.

NOTE The use of an absolute filter with a backing will minimize fibre loss.

5.3.2 Validation of absolute filter media efficiency, E_a

Arrange two absolute filters in tandem. Perform a filter efficiency test and determine the mass increase of each absolute filter according to the test procedure given in 6.4.3 or 7.5.2:

$$E_a = \frac{\Delta m_A}{\Delta m_A + \Delta m_B} \times 100\ \% \qquad (1)$$

where

E_a is the absolute filter efficiency;

1) A suitable material is commercially available. Details may be obtained from the secretariat of ISO/TC 22 or from the ISO Central Secretariat.

Δm_A is the mass increase of upstream absolute filter;

Δm_B is the mass increase of downstream absolute filter.

The absolute filter efficiency should be a minimum of 99 % for the contaminant presented to it.

5.4 Absolute filter mass

The absolute filter shall be weighed, to the nearest 0,01 g, after the mass has stabilized. Stabilization may be achieved by storage in a ventilated oven at a constant temperature of 105 °C ± 5 °C. The absolute filter shall be weighed inside the oven. Alternatively, air conditioned according to 5.5 may be drawn through the absolute filter for 15 min then the filter is weighed. Repeat this procedure until the mass has stabilized.

5.5 Temperature and humidity

All tests shall be conducted with air entering the air cleaner at a temperature of 23 °C ± 5 °C. Tests shall be conducted at a relative humidity of (55 ± 15) %, the permissible variation at each weighing stage throughout each single test being ± 2 %.

The test results of an air cleaner will be affected by the relative humidity of the air passing through it and the results of otherwise identical tests carried out near the two extremes of the permitted range of relative humidity may not be directly comparable. The tests should be conducted within the narrowest range of temperature and humidity possible.

6 Test procedure for dry-type air cleaners for automotive applications

6.1 General

Performance tests shall be performed on a complete air cleaner assembly or on a single air cleaner element; tests on a complete air cleaner assembly are preferred. The tests shall consist of an air flow restriction/differential pressure test, an efficiency test and a capacity test. In addition, a pressure collapse test shall be performed on the air filter element.

6.2 Test equipment

6.2.1 Typical arrangements to determine resistance to air flow, dust capacity, dust removal characteristics and rupture collapse characteristics are shown in annex B, Figures B.1 and B.6 to B.11.

Use a dust feeder which when used with the dust injector in Figures B.2 and B.3 is capable of metering dust over the range of delivery rates required. This dust feed system shall not change the primary particle size distribution of the contaminant. The air feed pressure shall be 100 kPa minimum. The ISO heavy-duty injector pressure shall be 280 kPa minimum.

The dust feed system shall be validated as follows.

a) Charge the dust feeder with a pre-weighed amount of test dust.

b) Simultaneously start the dust feed system and timer.

c) At 5-min intervals, determine the mass of dust dispensed. Continue mass determinations of dust increments for 30 min.

d) Adjust the dust feeder until the average delivery rate is within 5 % of the desired rate and the deviation in delivery rate from the average is not more than 5 %.

6.2.2 Use a dust-transfer tube between the dust feeder and the injector of a size suitable to maintain dust suspension.

6.2.3 Use the dust injector described in Table 1 and shown in Figures B.2 and B.3.

Table 1 — Recommended ISO dust injectors (see Figures B.2 and B.3)

Dust feed rate g/min	**0 to 26**	**26 to 45**	**> 45**
Injector type	ISO injector	ISO injector or ISO heavy-duty injector	ISO heavy-duty injector

The specified ISO injector has been shown to feed dust satisfactorily at rates up to 45 g/min. Where dust feed rates greater than this are required, more than one injector will have to be used. It should be noted that the design of the system feeding test dust to the injector may affect this maximum rate of dust feed. The maximum attainable dust feed rate should therefore be determined prior to the dust feed/injector system being used for tests.

Injector nozzles are subject to natural erosion. Erosion may affect the distribution and delivery of test contaminant. Therefore, it is recommended to use a design with replaceable parts.

6.2.4 Use an inlet tube conforming to Figure B.4. The dust injector and inlet tube shall be positioned in such a way that there is no loss of dust.

6.2.5 Use a manometer or other differential pressure measuring device with the specified accuracy.

6.2.6 For air cleaner assembly testing, use a housing and set-up agreed upon by the manufacturer and user conforming to Figure B.11. For air filter element testing, use a test set-up and shroud conforming to Figures B.1 and B.5 or an arrangement as shown in Figures B.6 or B.7. Where the test equipment is as shown in Figure B.6, the dust is fed into the chamber and, to ensure that it does not adhere to the walls and is evenly distributed, dry compressed air jets on flexible tubing should be provided in the test chamber, arranged so to agitate any dust that settles out.

When using compressed air for agitating dust, care shall be taken not to eject any dust out of the champer. To ensure that no dust is ejected from the chamber, a negative pressure should be maintained between the chamber and the atmosphere.

6.2.7 Use an outlet tube conforming to Figure B.4. The cross-section shall be the same as the air cleaner outlet. In the case of non-uniform flow conditions caused by special outlet tubes, special precautions may be required.

6.2.8 Use an air flow rate measuring system having the accuracy described in 4.1.

Validate the air flow rate measuring system. The air flow meter shall be of an acceptable design, such as a calibrated orifice and manometer conforming to ISO 5167-1. The orifice unit shall be permanently marked such that it can be identified after calibration. Corrections shall be made for variations in absolute pressure and temperature at the meter inlet and the air flow rate shall be expressed in cubic metres per minute corrected to standard conditions (see 4.2).

6.2.9 Use an air flow rate control system capable of maintaining the indicated flow rate to within 1 % of the selected value during steady-state and variable air flow operation.

6.2.10 Use a blower/exhauster for inducing air flow through the system, which has adequate flow rate and pressure characteristics for the filters to be tested. Pulsation of flow rate shall be so low that it is not measurable by the flow rate measuring system.