

JIS

JAPANESE INDUSTRIAL STANDARD

**Test Methods of Air Cleaners
for Automobiles**

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Test Methods of Air Cleaners
for Automobiles

D 1612-1989

1. Scope

This Japanese Industrial Standard specifies performance test methods of air cleaners of dry type, wet type, oil bath type, cyclone type as well as multi-stage air cleaners combined with these types for automobiles, hereinafter referred to as the "air cleaners".

Further, this Standard may be applied to air cleaners of internal combustion engines, compressors, etc. for other than automobiles.

Remark: The units and numerical values given in { } in this Standard are based on the traditional units and are appended for informative reference.

2. Definitions

For the purpose of this Standard main definitions shall be as given in Appendix 1.

3. Test Items

Tests shall be carried out on following each item.

- (1) Air Flow Resistance Test
- (2) Efficiency Test
- (3) Dust Holding Capacity Test
- (4) Rupture and Collapse Test
- (5) Recovery Test
- (6) Leak Test
- (7) Precleaner Performance Test

Applicable Standards:

JIS K 2215-Internal Combustion Engine Oils

JIS Z 8901-Dusts and Aerosols for Industrial Testing

Corresponding International Standard:

ISO 5011 Inlet air cleaning equipment for internal combustion engines and compressors-Performance testing

(8) Scavenged Air Cleaner Performance Test(9) Oil bath Air Cleaner Performance Test

Remark: (7), (8) and (9) have respectively inherent conditions and test items for respective types of air cleaners, and therefore, test items are specified in arrangement for each type.

4. Measurement Accuracy

The measurement accuracy shall be, as a rule, as follows:

- (1) Measure air flow rate within $\pm 2\%$ of the set value except for the variable air flow test when accuracy shall be $\pm 2\%$ of the maximum value of the cyclic flow rate through the cleaner.
- (2) Measure pressure drop and restriction within ± 0.25 mbar ⁽¹⁾ $\{\pm 2.5$ mmAq $\}$ of the set value.
- (3) Measure temperature within $\pm 0.5^\circ\text{C}$ of the set value.
- (4) Measure mass within $\pm 1\%$ of the set value.
- (5) Measure relative humidity with an accuracy of $\pm 2\%$.
- (6) Measure barometric pressure within ± 3 mbar $\{\pm 2.3$ mmHg $\}$.

Note ⁽¹⁾ 1 mbar = 100 Pa, 1 mbar = 10.2 mmAq

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

5. Test Materials and Preparation5.1 Test Dust The test dust shall be as follows:

- (1) The test dust shall be of two grades of Class 7 (coarse) or Class 8 (fine) specified in JIS Z 8901. However, depending upon agreement between the parties concerned with delivery, ISO coarse dust or ISO fine dust may be used as special dust.

The chemical components and particle size distribution are shown in Appendix 2.

Remark: In the case of using ISO dusts, dusts shall be substituted as follows:

JIS Class 7 to ISO coarse dust, and JIS Class 8 to ISO fine dust.

- (2) For test dust, the sufficiently mixed and dried dust shall be used.

5.2 Absolute Filter

5.2.1 Absolute Filter Materials The absolute filter materials shall consist of fibreglass of several layers and be used with putting into a suitable container.

The absolute filter shall be of fibreglass of 0.8 to 1.3 μm in diameter treated with thermosetting resin, having thickness of about 13 mm, apparent specific gravity of about 0.01, and mass variation within 1 % when left in atmosphere of relative humidity of 95 % and used with the nap side facing the upstream of air flow.

The size of absolute filter shall have a sufficient capacity to carry out the efficiency test and an air velocity not more than 0.8 m/s when passing at the time of test.

Remark: To reduce measurement error due to carry out of fibres and the like, the absolute filter shall be subject to a flow of at least 110 % of the rated flow of ambient air for 15 min before weighing.

5.2.2 Confirmation of Efficiency of Absolute Filter Material The efficiency of absolute filter material shall be confirmed according to the following:

- (1) Arrange two absolute filters in tandem.
- (2) Perform an efficiency test of absolute filter according to the test procedure give in 9.5.1 and determine the mass increase of each absolute filter.

$$\eta_a = \frac{A}{A+B} \times 100$$

where η_a : efficiency of absolute filter (%)

A : mass increase of upstream absolute filter (g)

B : mass increase of downstream absolute filter (g)

5.2.3 Measurement of Absolute Filter Mass The absolute filter mass shall be weighed to the nearest 0.01 g after the mass has stabilized sufficiently.

5.3 Preparation of Specimen Air Cleaner The air cleaner shall, at the time of test, be performed with the preparation shown in Table 1.

Table 1. Preparation of Air Cleaner

Type of air cleaner	Preparation item		
	Scavenge sufficiently air cleaner to dry.	Make the air cleaner element the designated wet condition.	Flow the test-room air at a rated air flow rate for 15 min or more.
Dry type	○	—	○
Wet type	○ ⁽²⁾	○	○
Oil bath type ⁽³⁾	○	—	○ ⁽³⁾
Precleaner (cyclone type) ⁽⁴⁾	○	—	—
Multi-stage type	○ ⁽²⁾	△	○
Scavenged air type	○ ⁽²⁾	△	○

Notes ⁽²⁾ As to wet type air cleaner, remove the filter element.

⁽³⁾ As to oil bath type air cleaner, the preparation item and the content are different for each test item, and therefore prepare according to 16. Oil Bath Air Cleaner Performance Test.

⁽⁴⁾ As to precleaner, cyclone type air cleaner is used in many cases.

⁽⁵⁾ The scavenged type is a kind of multi-stage air cleaner combined with a precleaner.

Remarks 1. ○ mark indicates the execution item.

2. △ mark applies to the case where wet type element is used in multi-stage cleaner and scavenged air cleaner.

3. As to air cleaner using dry type and wet type elements, new elements shall be used for each test except items so specified as to use the element after test.

6. Atmospheric Condition of Test Room

The test shall be performed at room temperature.

Further, atmospheric pressure, temperature and relative humidity before and after each test shall be measured and recorded.

7. Test Equipment

The test equipment shall be as follows:

- (1) The test equipment shall be, as a rule, in accordance with Appendix 3.
- (2) The constitution of representative equipment to measure the air flow resistance, efficiency, dust holding capacity, rupture and collapse of filter elements shall be in accordance with Figs. 1, 5, 6, 7, 8, 10, 11, 13 and 14 of Appendix 3.

The equipment to be used for scavenged air cleaner test shall be in accordance with Fig. 15 of Appendix 3. The equipment to be used for oil carry-out test shall be in accordance with Figs. 16, 17, 18 and 19 of Appendix 3.

- (3) In the case where air cleaner assembly and element single body is tested in a chamber for test, the equipment shall be in accordance with Figs. 1, 5, 6 and 12.

Remarks 1. In the case where whole periphery suction type air cleaner and chimney type precleaner are used, the test shall be performed in a chamber for test which is capable of uniform feeding of test dust to the inlet as shown in Fig. 12 of Appendix 3. The chamber for test shall be able to feed securely all test dusts to air cleaner.

2. In the case where in assembly test and element single body test the precipitation of dusts fed into the chamber for test is caused, set a flexible tube to jet dry compressed air into the chamber for test as shown in Fig. 5 of Appendix 3, and stir the precipitating dust to disperse uniformly.

3. In the case where compressed air is used for floating the test dust, maintain the chamber for test at a negative pressure so as the test dust not to leak to outside from the chamber for test.

- (4) The dust feed equipment shall be able to set dust feed amount over the range of designated feed speed ⁽⁶⁾ without varying the particle size distribution of dust and under the uniform distribution condition, and, able to feed to dust injector.

The dust feed equipment shall adjust the feed amount of dust according to the following:

- (a) Fill the test dust weighed preliminarily into a dust feed equipment.
- (b) Start simultaneously the dust feed equipment and timer.
- (c) Measure the added dust amount from the dust feed equipment at intervals of 5 min, and continue it for 30 min.

Note ⁽⁶⁾ It is determined by the test air flow rate determined by agreement between the parties concerned with delivery and mixing ratio of air to dust.

Remark: The accuracy of dust feed equipment shall be less than 5 % of average feed rate in change of dust feed rate at each 5 min.

- (d) Adjust the average dust feed rate at ± 5 % of designated feed rate.
- (5) As to the dust transfer tube between the dust feed equipment and the dust injector, use a tube difficult for dust to adhere on its wall and having such size as to be able to transfer the dust stably.

- (6) Use a dust injector shown in Appendix 3 Fig. 2. The compressed air pressure at air inlet side of dust injector shall be 1 bar {1 kgf/cm²}.

Remark: The dust injector of Appendix 3 Fig. 2 indicates the one capable of feeding the test dust at 40 g/min at maximum. In the case where the dust feed rate of not less than 40 g/min is required, use not less than two dust injectors.

- (7) Use the inlet tube shown in Appendix 3 Fig. 3. Make the sectional area of inlet tube, as a rule, same as that of air cleaner inlet. Allow the dust injector to be apart from the inlet tube as far as possible in the range where the fed dust does not leak outside the inlet tube.

- (8) Use the outlet tube shown in Appendix 3 Fig. 3. Make the sectional area of outlet tube same as that of air cleaner outlet.

Remark: In the case where the outlet shape of air cleaner is special, particular outlet tube shape may be required in some cases.

- (9) Use a pressure measuring device or pressure drop measuring device for measuring outlet static pressure and pressure drop having the accuracy specified in 4. (2).

- (10) Use an air flow meter having an accuracy specified in 4. (1).

Remark: Express the air flow rate by correcting to the standard condition shown in Appendix 4 relative to the variation of atmospheric pressure, temperature and relative humidity at the inlet of air flow meter.

- (11) Use the air flow control capable of maintaining air flow rate at $\pm 1\%$ of set value in either case of constant air flow rate operation and variable air flow rate operation.

- (12) Use the exhauster to flow air into the testing machine which is capable of holding the air flow rate and pressure characteristic required for test and has so sufficiently small pulsation of air flow as to be able to secure the measuring accuracy of air flow rate.

8. Air Flow Resistance Test

8.1 Purpose This test is performed for the purpose to obtain the air flow resistance by measuring outlet static pressure or pressure drop generated when air is allowed to flow in specimen air cleaner.

8.2 Test Conditions Flow air of rated air flow rate with air in test chamber for not less than 15 min until the mass of air cleaner becomes stable to accommodate the air cleaner for test environment.

8.3 Test Equipment The test equipment shall be as follows:

- (1) The test equipment of air cleaner assembly shall be in accordance with Figs. 7, 13 or 14 of Appendix 3. Attach the inlet tube and outlet tube with sealing all joint parts to prevent air leakage.

- (2) The test equipment for element unit shall be in accordance with Appendix 3 Fig. 8.

8.4 Air Cleaner Assembly Test Method The air cleaner assembly test shall be performed according to the following:

- (1) Let the test air flow rate be air flow rates of not less than five stages set at equal intervals in the range of designation agreed upon between the parties concerned with delivery taking the rated air flow rate as the reference. The test air flow rates in the case of setting to five stages shall be 50 %, 75 %, 100 %, 125 % and 150 % of the rated air flow rate, and in case of setting other than these, they shall be subjected to agreement between the parties concerned with delivery.

Remarks 1. Measure the wet type and oil bath air cleaners in the range where the oil carry-out is not generated.
For measurement, maintain the air flow rate until the outlet static pressure or pressure drop is stabilized.

2. As to the oil bath air cleaner, after preparing according to 16.3 (4), perform this test.

- (2) Record the environmental air pressure, temperature and relative humidity.
- (3) Measure the outlet static pressure or pressure drop.
- (4) Obtain the flow resistance according to 2. (15) of Appendix 1 and correct to the standard condition according to Appendix 4.
- (5) Record the test results according to the mode of Attached Table 3 or the mode similar thereto.

8.5 Element Unit Test Method The element unit test shall be in accordance with the following and, in addition, with 8.4.

- (1) Attach the element as shown in Appendix 3 Fig. 8, and measure the static pressure at the pressure taking opening of outlet tube to record it.
- (2) Detach the element, and measure the static pressure at the pressure taking out opening of outlet tube to record it.
- (3) Obtain the difference of measured values of (1) and (2), and correct the value to the standard condition to take it as the air flow resistance.

9. Efficiency Test

9.1 Purpose This test is performed for measurement of dust removing capacity of specimen air cleaner. This test may be performed at the same time as 10. Dust Holding Capacity Test.

9.2 Test Conditions The test conditions shall be as follows:

- (1) Perform this test at either a constant air flow rate or variable air flow rate.
- (2) Perform the measurement of efficiency at a constant air flow rate test at the air flow rate agreed between the parties concerned with delivery.
- (3) Perform the measurement of efficiency at variable air flow rate at flow rate variable cycle according to 9.6.
- (4) Perform the calculation of efficiency according to either absolute filter method or direct weighing method.
- (5) The kind of test dust shall be in accordance with 5.1. Make the mixing ratio of air when feeding test dust to test equipment relative to dust, hereinafter referred to as the "dust concentration", 1.0 g/m^3 , and keep it constant until the whole dust of dust feed equipment is fed. However, in the case where a special dust concentration is required, select it by taking the using conditions of air cleaner as the reference out of the values shown in Table 2.

Table 2. Special Dust Concentration

Unit: g/m^3

Using condition	Dust concentration
For dust light load	0.25, 0.5
For heavy dust load	2.0, 3.0

Remark: The dust concentration indicates the feeding dust amount per 1 m^3 of test air flow rate.

9.3 Test Equipment The test equipment shall be as follows:

- (1) The test equipment for air cleaner assembly shall be in accordance with Figs. 5, 10, 11 and 12 of Appendix 3.

In order to prevent air leakage, seal all joint parts and attach the inlet tube and outlet tube.

- (2) The test equipment for element unit shall be in accordance with Figs. 1, 4, 5 and 6 of Appendix 3.
- (3) The dust injector shown in Fig. 2 of Appendix 3 shall be used.

9.4 Types of Efficiency Tests The efficiency tests shall be of following three types. However, the intermediate efficiency test shall be performed, as required.

- (1) **Primary Efficiency Test** The test to measure the test dust when having fed it until reaching either one value of the following conditions.

- (a) The test dust amount for air cleaner to be used in ordinary dust condition shall be the value whichever is the larger when comparing "20 g" with "number of grams equal to the numerical value of six times the test air flow rate (m^3/min)".
- (b) The test dust amount of air cleaner to be used in a large dust amount condition shall be the value, whichever is the larger, when comparing "110 g" with "the required amount by specified dust concentration when the test time is made 30 min".
- (2) Intermediate Efficiency Test The test to measure the efficiency by air flow resistance set at the intermediate until reaching the test completion conditions from the primary air flow resistance.
- (3) Full Life Efficiency Test The test to measure the efficiency when having reached the test completion conditions.

9.5 Efficiency Test by Constant Air Flow Rate

9.5.1 Test Method (A) Absolute Filter Method This test shall be performed according to the following:

- (1) Accommodate ⁽⁷⁾ the specimen air cleaner for test environment, measure the mass at a unit not more than 1 g and at an accuracy of $\pm 1\%$ of preliminarily determined feed dust amount and record it.

Note ⁽⁷⁾ The gist of accommodation shall be in accordance with 8.2.

- (2) Measure the mass of absolute filter after the mass has been stabilized according to the gist of 5.2.3.
- (3) Record the pressures, temperatures and relative humidities of test chamber at the times of starting and completion of the test.
- (4) Prepare the test dust designated by 5.1 and measure the amount required for the test by using a suitable test container. Measure the mass of container and dust to the unit of 0.1 g and record.
- (5) Flow air to the test equipment, stabilize at test air flow rate, and measure the outlet static pressure or pressure drop to record.
- (6) Transfer the test dust from the dust container to dust feed apparatus and so regulate the dust feed speed so as to become the dust concentration selected according to 9.2 (5).
- (7) Regulate the compressed air pressure at air inlet side of dust injector at 1 bar $\{\text{kgf}/\text{cm}^2\}$, and flow air for dust feeding.

Remark: At this time the outlet static pressure or pressure drop may vary in some cases, and therefore confirm it to record.

- (8) Start the dust feed apparatus (at this time the test begins) and flow the dust into a specimen air cleaner. If the dust becomes insufficient during test, add the test dust to the dust feed apparatus.

- (9) At the designated time intervals (the number of measuring points until completion of test shall be not less than five points) measure the lapse of time and the outlet static pressure or pressure drop at the test air flow rate to record.
- (10) Continue the test until attaining respective test completion conditions for measuring primary, intermediate, and full life efficiencies, and measure the outlet static pressure or pressure drop at completion time to record. Thereafter, stop air of test equipment and dust injector.
- (11) In the case of test used of dust adhered on the outer surface of specimen air cleaner as well as of the chamber for test, collect carefully the remaining dust in the chamber for test at inlet side of specimen element and the like and in the test duct, and transfer into a dust container of which mass is measured preliminarily.
- (12) Remeasure the mass of dust container and subtract its mass from the mass recorded in (4).

Remark: This mass difference is the Feed Dust Amount to the specimen air cleaner.

- (13) Detach the specimen air cleaner from the test equipment so as not to spill the dust. Observe the leakage from the tightly sealed portion or abnormal condition and record. Measure the mass of specimen air cleaner at a unit not more than 1 g and at an accuracy of $\pm 1\%$ of feed dust amount. Subtract the mass measured in (1) from this mass.

Remarks 1. This mass difference is the Mass Increase of Specimen Air Cleaner.

2. In full life efficiency test, this mass increase is the Dust Holding Capacity of the specimen air cleaner.

- (14) Sweep down the dust adhering on the downstream side of specimen air cleaner on the absolute filter. Detach carefully the absolute filter, repeat the operation of (2) and measure the mass of absolute filter. Subtract the mass measured in (2) from this mass.

Remark: This mass difference is the Mass Increase of Absolute Filter.

- (15) Calculate the increase or decrease of feed dust amount according to the following formula. If the calculated value of α is in the range of 0.98 to 1.02, consider the test to be effective.

$$\alpha = \frac{A+C}{B}$$

where α : increase or decrease of feed dust amount

A: mass increase amount of specimen air cleaner (g)

B: feed dust amount (g)

C: mass increase amount of absolute filter (g)

(16) Calculate the efficiency according to the following formula:

$$\eta = \frac{A}{A+C} \times 100 \quad \text{or} \quad \eta = \frac{B-C}{B} \times 100$$

where η : efficiency (%)

A: mass increase amount of specimen air cleaner (g)

B: feed dust amount (g)

C: mass increase amount of absolute filter (g)

9.5.2 Test Method (B) Direct Weighing Method This test shall be performed according to the following:

- (1) In the case of being capable of using a large type balance of high accuracy, the direct weighing method may be used for performance test of specimen air cleaner.
- (2) As to this test, perform the test of air cleaner according to the procedures in absolute filter method of 9.5.1 excepting the operations of (2), (14), (15) and (16).
- (3) Calculate the efficiency according to the following formula:

$$\eta = \frac{A}{B} \times 100$$

where η : efficiency (%)

A: mass increase amount of specimen air cleaner (g)

B: feed dust amount (g)

9.6 Efficiency Test by Variable Air Flow Rate The purpose of this test is to measure efficiency by using variable air flow cycle modelled by matching the variation of suction air flow in the case where air cleaner is used in an actual internal combustion engine.

- (1) Perform this test instead of constant air flow test of 9.5 by matching the maximum air flow with the rated air flow and by using the variable air flow cycle shown in Figure.

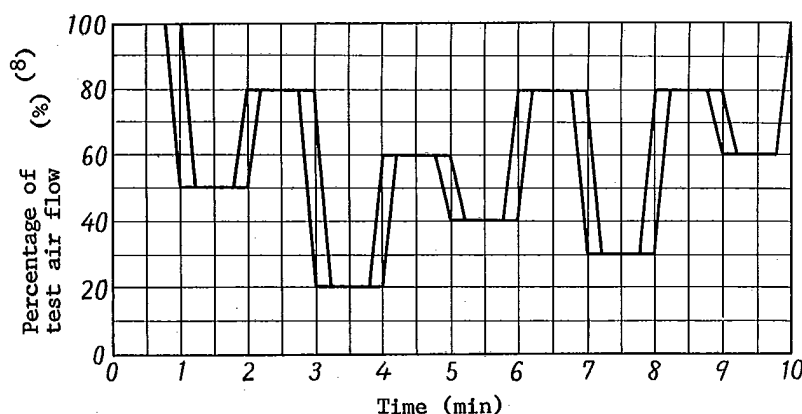
Remarks 1. Instead of the maximum air flow, the test may be performed by the air flow rate according to agreement between the parties concerned with delivery.

2. In the cases of oil bath air cleaner and large air cleaner, the test may be performed by changing the length of each part cycle of variable air flow cycle to 5 min instead of 1 min.

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- (2) Set the dust concentration so that it becomes the concentration specified in 9.2 (5) at the time of average air flow (60 % of the maximum air flow) at variable air flow cycle. Hold the dust feed speed at constant during the test.
- (3) Measure the outlet static pressure or pressure drop at the maximum test air flow in every variable cycle.
- (4) Perform the test according to conditions of efficiency test by a constant air flow except cases according to the following:
 - (a) Measure the outlet static pressure or pressure drop at the maximum test air flow at the completion time point of each cycle.
 - (b) Measure the efficiency at least after three cycles (after 30 min) if the length of each part cycle is each 1 min, and after each cycle (after 50 min) if the length of each part cycle is each 5 min, and further measure when reached the test completion conditions.

Figure. Variable Air Flow Cycle⁽⁹⁾



Notes (8) The percentage of test air flow indicates the ratio relative to the maximum air flow.

(9) The average air flow is 60 % of the maximum air flow.

10. Dust Holding Capacity Test

10.1 Purpose This test is performed for the purpose of measuring the whole mass of dust which the specimen air cleaner can collect until reaching the test completion conditions. This test may be performed at the same time as 9. Efficiency Test.

10.2 Test Conditions Test conditions shall be as follows:

- (1) Perform this test either at constant air flow or variable air flow.
- (2) Kind of test dust and dust concentration shall be in accordance with 9.2 (5).
- (3) Accommodate air cleaner for test environment according to 8.2.

10.3 Test Equipment The test equipment shall be in accordance with 9.3.

10.4 Test Method This test shall be performed according to the following:

- (1) Perform the test according to efficiency test by constant air flow of 9.5 or variable air flow of 9.6.
- (2) Draw a curve of air flow resistance increase relative to feed dust amount with taking the ratio of lapse of time to feed dust amount to specimen air cleaner as constant. The measured value of air flow resistance at each time interval shall be in accordance with 9.5.1 (9).
- (3) Calculate the feed dust amount at the time of completion of each time interval according to the following formula:

$$B_0 = \frac{T_0}{T} \times B$$

where B_0 : feed dust amount at completion time of each time interval (g)

B : feed dust amount (g)

T_0 : whole time until completion of each time interval (min)

T : whole time until test completion (min)

- (4) In the case where the test completion condition is air flow resistance, except the air flow resistance of test chamber.
- (5) Calculate the dust holding capacity according to the following formula:

$$D = A = A_2 - A_1 \quad \text{or} \quad D = B - C$$

where A : mass increase of specimen air cleaner (g)

A_1 : mass of air cleaner before test (g)

A_2 : mass of air cleaner after test (g)

B : feed dust amount (g)

C : mass increase of absolute filter (g)

D : dust holding capacity (g)

11. Rupture and Collapse Test

11.1 Purpose The purpose of this test is to perform measurement of capability for filter element to endure the designated pressure drop. The pressure drop at the time when the rupture of element is caused is taken as rupture or collapse pressure.