

Australian Standard™

**Air filters for use in general ventilation
and airconditioning**

Part 2: Methods of test



This Australian Standard was prepared by Committee ME-080, Air Filters. It was approved on behalf of the Council of Standards Australia on 7 March 2003 and published on 8 May 2003.

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Australian Chamber of Manufacturers
Australian Contamination Control Society
Australian Institute of Hotel Engineering
Australian Institute of Refrigeration Air Conditioning and Heating
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Air filters for use in general ventilation and airconditioning

Part 2: Methods of test

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PREFACE

This Standard was prepared by Standards Australia Committee ME-080, Air Filters, to supersede AS 1324.2—1996.

The objective of this Standard is to establish uniform comparative testing procedures, meaningful to users and manufacturers, for evaluating the performance of all air cleaning devices used in airconditioning and general ventilation to remove particulate matter. The Standard further establishes uniform specifications for equipment used to conduct such tests and a uniform method for reporting the performance obtained from the specified procedure.

Changes to the previous editions are the following:

- (a) Dynamic arrestance tests have been deleted and Test Dusts Nos 2 and 3 tests have been separated and designated as special tests for assessing particular filter applications.
- (b) Testing methodology and apparatus have been generally revised to improve the reproducibility of test results and to bring the test methods more in line with current European and American practices. This policy has been adopted in anticipation of an ISO International Standard being developed and adopted as a national Standard in Australia.

This Standard forms Part 2 of a two-part series of Standards that address general air filters. Part 1 of the series covers the application, performance and construction requirements for such filters.

The term ‘normative’ has been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of a Standard.

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STANDARDS AUSTRALIA

Australian Standard

Air filters for use in general ventilation and airconditioning

Part 2: Methods of test

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard provides test methods for laboratory or bench testing of air filters used in general ventilation and airconditioning systems. It also includes general information on test dusts, test rig and apparatus.

Test methods for filter applications are given in AS 1324.1.

NOTES:

- 1 Requirements of performance and construction of air filters for use in general ventilation and airconditioning are specified in AS 1324.1.
- 2 Methods for on-site testing of High Efficiency Particulate Air filters (HEPA filters) are specified in AS 1807 series. Performance, construction and methods of test for HEPA filters are specified in AS 4260.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- | | |
|------------|---|
| 1289 | Methods of testing soils for engineering purposes |
| 1289.3.6.3 | Method 3.6.3: Soil classification tests—Determination of the particle size distribution of a soil—Standard method of fine analysis using a hydrometer |
| 1324 | Air filters for use in general ventilation and airconditioning |
| 1324.1 | Part 1: Application, performance and construction |
| 1349 | Bourdon tube pressure and vacuum gauges |
| 1807 | Cleanrooms, workstations and safety cabinets—Methods of test |
| 2360 | Measurement of fluid flow in closed conduits |
| 2360.1.1 | Part 1.1: Pressure differential methods—Measurement using orifice plates, nozzles or Venturi tubes—Conduits with diameters from 50 mm to 1200 mm |
| 4260 | High efficiency particulate air (HEPA) filters—Classification, construction and performance |

1.3 GENERAL INFORMATION

The three performance characteristics of greatest interest to users and manufacturers of air cleaning equipment are the ability of the equipment to remove particulates from the air stream, the resistance to airflow, and the dust holding capacity before cleaning or replacement is required. Test methods for filter application are given in AS 1324.1.

A variety of methods are presented in this Standard but each can be grouped into either one of two categories, namely, destructive or non-destructive testing of an air filter. Both categories are used to determine the ability of equipment to remove particulates from the air stream.

Destructive tests involve challenging the test filter with a significant mass of test dust, of large particle size and this generally damages the filter. Destructive testing can determine the change in resistance for a specified amount of a particular contaminant, which may be considered when determining the operating time before cleaning or replacement is required.

Destructive tests include the use of Test Dusts Nos 2, 3 and 4.

Non-destructive tests involve minute quantities of test dust of submicrometre particle size, which do not significantly damage the filter. Non-destructive tests are usually employed for quality control.

Non-destructive tests include the use of Test Dust No. 1 (usually carried out in combination with a destructive test such as Test Dust No. 4).

1.4 DEFINITIONS

For the purposes of this Standard the definitions given in AS 1324.1 apply.

SECTION 2 INITIAL RESISTANCE

2.1 SCOPE

This Section sets out a test to determine the initial resistance created by the clean air filter operating at its rated airflow and various percentages of this rate.

2.2 APPLICATION

The initial resistance test shall be performed on clean filters after the mass stabilization test and before proceeding with the other tests.

2.3 PRINCIPLE

The loss of static pressure caused by the air filter at specified airflow rates is measured.

2.4 APPARATUS AND MATERIALS

The following items, which shall comply with Appendix A, are required:

- (a) Test air supply.
- (b) Test sample filter preparation.
- (c) Test rig.
- (d) Orifice plate manometer
- (e) Filter resistance manometer.

2.5 PROCEDURE

Airflows shall be measured using an orifice plate and manometer complying with the requirements of AS 2360.1.1. Filter resistance at the specified flow rates shall be measured using a manometer having an accuracy in accordance with Paragraph 6, Appendix A. All measurements shall be made under conditions of steady flow.

The procedure shall be as follows:

- (a) With the filter installed in the test duct, gradually increase the airflow from 0 to 40%, 60%, 80%, 100%, then 120% of specified test airflow, recording the filter resistance at each flow rate.
- (b) Gradually decrease the airflow from 120% to 100%, 80%, 60%, then 40% of specified test airflow, recording the filter resistance at each flow rate.

2.6 TEST REPORT

Test reports and graphical representation of results shall be in accordance with Section 8.

SECTION 3 MASS STABILIZATION

3.1 SCOPE

This Section sets out a test to determine the mass of carry-over, such as loss of oil, from viscous impingement type filters.

3.2 APPLICATION

The mass stabilization test shall be performed before any other test.

This method shall be used for normalizing a partially tested filter following a delay in excess of 12 h. During this procedure the airflow shall be set at 100%.

3.3 PRINCIPLE

The clean filter is subjected to the stipulated airflow rate until there is no further loss in mass.

3.4 APPARATUS AND MATERIALS

The following items, which shall comply with Appendix A, are required:

- (a) Test air supply.
- (b) Balance and weights.
- (c) Test sample filter preparation.
- (d) Test rig.
- (e) Orifice plate manometer
- (f) Filter resistance manometer.

3.5 PROCEDURE

The procedure shall be as follows:

- (a) Record the weight of the test filter and the test air temperature and RH.
- (b) Perform the Initial Resistance Test in accordance with Section 2, recording the time that the fan was started.
- (c) For clean filters, increase the airflow to 110%, then leave at this flow for 30 min. For normalizing, retain the airflow at 100% only and leave at this airflow for 30 min.
- (d) Switch off the fan, re-weigh the filter and record the loss of mass. Record test air temperature and RH.
- (e) If any loss, repeat Steps (c) and (d) for 30 min periods until a constant mass is attained.
- (f) Note and record any visible signs of carry-over, e.g., oil deposited on the wall of the duct.

3.6 TEST REPORT

Test reports shall be in accordance with Section 8.

SECTION 4 TEST DUST NO. 1 — EFFICIENCY TEST

4.1 SCOPE

This Section sets out a method to determine the submicrometre efficiency (hereafter referred to as ‘efficiency’) of a filter for Test Dust No. 1.

4.2 APPLICATION

This test should be done on the clean filter, and at the end of Test Dust No. 4 arrestance cycles.

NOTES:

- 1 The test would not normally be done at the end of the initial arrestance cycle.
- 2 With Test Dust No. 4, the test is not suitable if dust dislodges from the test filter and contaminates the downstream Test Dust No. 1 air sample.

An accuracy of $\pm 15\%$ of the observed penetration may be assumed with this Test Method. The maximum efficiency that may be reported with Test Dust No. 1 is 95%.

4.3 PRINCIPLE

A concentrated methylene blue solution is continuously atomized upstream of the test filter. The test air dries the aerosol to produce anhydrous methylene blue crystals. Such a suspension includes particles in the range $0.2\ \mu\text{m}$ to $3\ \mu\text{m}$ diameter and has a mass median diameter of $0.6\ \mu\text{m}$.

The efficiency of an air filter is principally determined by calculating the inverse ratio of the sample volumes used before and after the air filter to approximately match the stains produced on sampling papers clamped into the sampling air lines.

4.4 COMPOSITION

When Test Dust No. 1 is employed, the tests should be run on the clean filter, and after each arrestance test cycle.

4.5 NOTATION

The following applies to this test method:

C	= a constant depending on the concentration of the dust and on the nature of the sampling paper
I	= photometer reading
Idi	= photometer reading for the clean downstream sampling paper
Idf	= photometer reading for the dirty downstream sampling paper
Iui	= photometer reading for the clean upstream sampling paper
Iuf	= photometer reading for the dirty upstream sampling paper
L	= optical density
Ld	= the optical density of the downstream stain = $\log (Idi/Idf)$
Lo	= the optical density constant for the particular sampling paper
Lu	= the optical density of the upstream stain = $\log (Iui/Iuf)$
V	= volume

V_{di} = initial downstream volume reading at I_{di}

V_{ui} = initial upstream volume reading at I_{ui}

VCF = volume calibration factor

Suffix i = initial (clean sampling paper)

Suffix f = final (dirty sampling paper)

4.6 APPARATUS

4.6.1 General

The following, which shall comply with the requirements of Appendix A, are required:

- (a) Test air supply.
- (b) Test sample filter preparation.
- (c) Test duct.
- (d) Orifice plate manometer.
- (e) Compressed air supply.

NOTE: The No. 1 dust atomizer air pressure should be maintained at 210 ± 10 kPa throughout tests.

- (f) Regulator valve.
- (g) Pressure gauge.
- (h) Connections.
- (i) Wander lead.
- (j) Test dust No. 1.
- (k) The methylene blue atomizer.
- (l) Sample tubes.
- (m) Gas meters.
- (n) Photometer.
- (o) Sampling papers.

4.6.2 Air sample size

The test accuracy is only acceptable if the measured stains on sampling papers have optical densities between 0.2 and 0.5. Hence, the correct amount of air sample shall be drawn through the upstream and downstream sampling papers to obtain densities within a ± 0.10 tolerance.

4.7 PROCEDURE

4.7.1 Routine test preparation

Ensure the cleanliness of the rig. Insert sampling tubes and ensure alignment and sealing. Set the test filter in the test duct. Switch on the test duct fan and adjust airflow through the test to maintain $\pm 2\%$ of the specified airflow.

4.7.2 Zero efficiency test

At six monthly intervals, or following a long inactive period, a test to check the performance of the No. 1 sampling system shall be made. In this performance check a No. 1 efficiency test is run in the normal way except that no filtration device is installed in the test duct. This test shall give an average efficiency of $0\% \pm 2.5\%$. If it fails to do so, check all related equipment and rectify until the result complies. The results shall be recorded on a pro forma worksheet and kept on file. The test should normally be conducted after a gas meter calibration.

4.7.3 Test procedure

The procedure shall be as follows:

- (a) Turn on the photometer.
- (b) Rinse the atomizer and jar with clean hot water. Shake stock solution to mix thoroughly. Fill the atomizer jar to the correct level. (New stock solution is made by adding near boiling distilled water to clean powder, mixing thoroughly and allowing to cool. Heat improves solubility.) Top-up to the solution shall be in accordance with Item (n).
- (c) Connect pressure hoses to atomizer. Open atomizer valve and adjust pressure to 210 ± 5 kPa. Run atomizer for 5 min prior to first sampling.
- (d) Calibrate the photometer as necessary.
- (e) Boil a full kettle of water in readiness for steaming sample papers.
- (f) Place a sampling paper in the upstream sample holder. Measure the opacity and record it in the pro forma as '*I_{ui}*'. Insert holder in the upstream sampling hose assembly.
- (g) Repeat this last step for the downstream sampler, recording the opacity as '*I_{di}*'.
- (h) Record the initial volumes (*V_{ui}* and *V_{di}*) from the upstream and downstream volume meters.
- (i) Apply 210 ± 5 kPa pressure to the atomizer. Check that the flow rate is 0.133 to 0.15 L/s to ensure that jets are not blocked or damaged. During subsequent operation, the flow of compressed air shall not vary by more than 0.02 L/s of the value of the meter setting. When the atomization is uniform, start the suction pump and adjust the sampling rates to 0.46 to 0.93 L/s (between 3 and 4 times the duct velocity). Make final adjustments to equalize the heights of the manometer columns.
- (j) The correct sample volumes shall be drawn such that the stains on the upstream and downstream papers are of the same optical densities (by within ± 0.05). When the correct sample volumes have been drawn record the final meter volumes (*V_{uf}* and *V_{df}*).
- (k) Upstream and downstream sample papers shall be treated and processed simultaneously. The papers shall be steamed for at least 60 s to achieve a uniform stain and then dried for approximately 5 min in an oven preheated to 60°C. Measure and record the opacities as *I_{uf}* and *I_{df}* for the up and downstream papers respectively.
- (l) Calculate the optical densities (log of the ratio of opacities) for the upstream and downstream stains, then calculate the test filter efficiency in accordance with Clause 4.7.

- (m) Repeat Steps (f) to (l) using the same sample volumes until the values of $\log(I_{ui}$ and I_{uf}) for the original and filtered air respectively for any three tests agree with the average values within $\pm 5\%$. The cycle efficiency to be reported shall be the average of all completed tests. If this agreement cannot be achieved after five tests, then the causes of the scatter shall be determined and rectified and the whole procedure recommenced. If this agreement can not be achieved after a further five tests, this fact shall be recorded on the test report, together with all 10 values of the Test Dust No. 1 efficiency.
- (n) At the end of 8 h use, make up the solution to its original volume by the addition of 0.5% solution of methylene blue. This will restore the solution approximately to its original concentration of 1%. After 24 h operation the old solution shall be discarded and the reservoir refilled with fresh 1% solution of methylene blue.

4.8 CALCULATIONS

The following shall be calculated:

- (a) *Determination of optical density* Optical density shall be determined as follows:
- The optical density of the upstream stain, $L_u = \log(I_{ui}/I_{uf})$.
 - The optical density of the downstream stain, $L_d = \log(I_{di}/I_{df})$.
- (b) *Determination of efficiency* The efficiency calculation shall be determined in accordance with the following example pro forma and Equation 4(1):

No. 1 Dust calculations													
$L_o = 0.110$								$VCF = 0.9881$					
Input								Calculations					
V_{ui}	V_{di}	I_{ui}	I_{di}	V_{uf}	V_{df}	I_{uf}	I_{df}	V_u	V_d	L_u	L_d	%	OK?
1350	8484	896	892	1400	8585	311	308	50	101	0.4595	0.4625	49.5	OK
1400	8585	902	895	1450	8686	313	304	50	101	0.4604	0.4689	48.7	OK
1450	8686	895	894	1500	8787	312	306	50	101	0.4577	0.4658	48.8	OK
Cycle efficiency = 49%													

$$\text{Efficiency} = 100 \times \left[1 - \frac{V_u \times (L_d - L_o)}{V_d \times VCF \times (L_u - L_o)} \right] \quad \dots 4(1)$$

NOTE: The 'OK' flag indicates that the optical density is between 0.2 and 0.5 and that the downstream stain is within ± 0.10 of the upstream stain.

For particular atomizing condition and airflow rate, the optical density of the upstream stain is linearly related to the upstream air volume, as shown by the following equation:

$$L - L_o = C \times V \quad \dots 4(2)$$

- (c) *Determination of L_o* ' L_o ' shall be experimentally determined for each batch of sampling papers as follows:

Take six sampling papers from different parts of the batch and stain with different air sample volumes of unfiltered Test Dust No. 1 to obtain values of the optical density evenly distributed between 0.2 and 0.5. Tabulate the values of L and V , as in the example below, and calculate values for LV and V^2 .