PUBLISHED DOCUMENT

Environmental cleanliness in enclosed spaces – Guide to in situ high efficiency filter leak testing

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

Foreword

Publishing information

This Published Document is published by BSI and came into effect on 31 July 2007. It was prepared by Technical Committee LBI/30, *Cleanroom technology*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This Published Document supersedes PD 6609:2000, which is withdrawn.

Relationship with other publications

BS 5295:1989 (all parts) has been replaced by BS EN ISO 14644 (all parts). However, the withdrawn BS 5295:1989 contained information about in situ high efficiency filter testing using an oil aerosol challenge and a photometer that is not given in BS EN ISO 14644 (all parts). That information, which has been revised with respect to the new requirements in BS EN ISO 14644-3:2005, is published in this document.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

0 Introduction

Where high efficiency filters are fitted, it is important to ensure that the filter and its housing and sealing device do not permit the ingress of particles into a cleanroom or clean zone. This is checked by challenging the filter with an aerosol of particles dispersed upstream of the filter and scanning over the downstream face, frame and gasket of the filter to ensure that there are no leaks that exceed a specified level of penetration.

The object of the in situ leak test described in this document is to determine if the filter has been damaged between manufacture and installation, and during subsequent use.

In situ testing with oil aerosols might not be acceptable for some cleanroom applications where airborne chemical contamination needs to be controlled, as oil deposited on the filter will outgas. In such cases, an alternative method that uses inert particles and a particle counter can be used. This method is not discussed in this document but is described in **B.6.3** of BS EN ISO 14644-3:2005.

1 Scope

This Published Document provides information supplementary to the provisions of BS EN ISO 14644-3:2005. In particular, it gives recommendations and explanatory guidance for in situ leak testing of high efficiency filters using an oil aerosol challenge and photometer. It also provides guidance on the procurement of replacement filters (Annex A) and information that might be required in a test report (Annex B).

The guidance contained in this document is for the leak testing of high efficiency air filters that can be face scanned. The document does not provide information on other tests carried out on high efficiency filters installed in cleanrooms, such as pressure differentials, air supply volumes, and airflow uniformity.

2 Normative references

BS EN ISO 14644-3:2005, *Cleanrooms and associated controlled environments – Part 3: Test methods*

3 Requirements for testing

3.1 Aerosol injection

The filter integrity test relies on a homogeneous distribution of aerosol test challenge upstream and across the whole filter face. Homogeneous distribution is defined as a variation in concentration of less than ±15% in time about the average measured value. The upstream aerosol challenge should be measured as close as possible to the filter, and ideally not more than 50 mm from the upstream face.

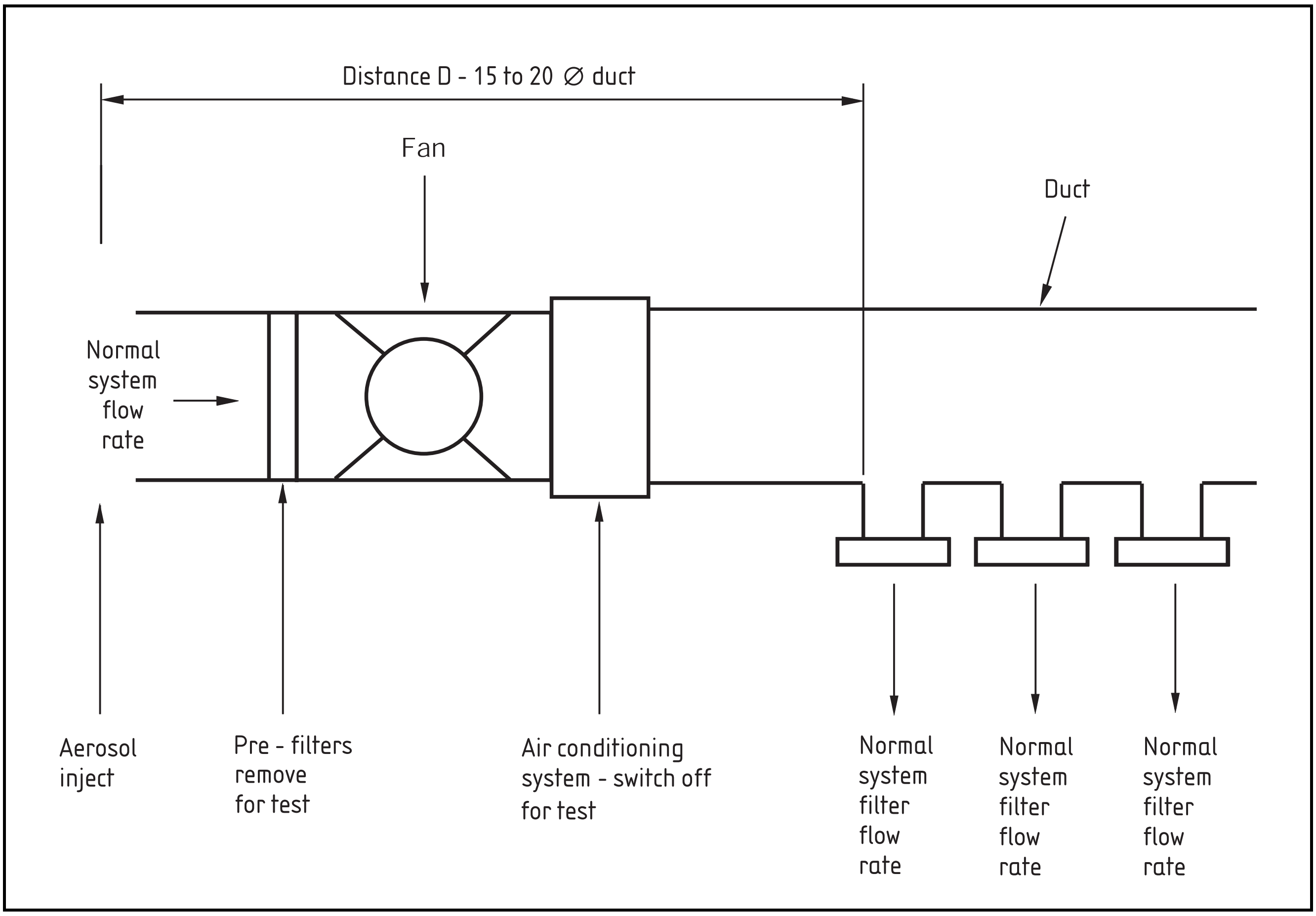
To ensure good mixing it is essential that the aerosol is injected correctly. For ducted systems, aerosol injection ports will normally be required. When injecting into long ducted systems with distribution legs along the main duct (see Figure 1), good mixing will not occur unless the distance *D* is at least 15 duct diameters. However the correct use of distribution sparge pipes may allow injection as near as one metre from the filter face to achieve homogeneous distribution of the challenge aerosol.

The aerosol injection point or port should be of sufficient size to accept the entry of the challenge aerosol and achieve the required upstream concentration. In some cases, oil aerosol injection pumps may be required to overcome the pressure in positive pressure ducts.

Where an aerosol challenge is injected upstream of an air conditioning unit, the refrigeration, heating and humidification circuits should be switched off to avoid attenuation of the aerosol challenge. Any pre-filters between the injection point and the high efficiency filter(s) should be removed prior to test.

The sample flow rate should always be maintained at the calibrated value of the sampling instrument being used. Where a filter is installed in a negative pressure extract duct and the photometer is unable to overcome the negative pressure in the duct then leaks will not be detected. To overcome this, the photometer may be used in a "differential sampling mode", if possible, where the exhaust of the photometer is returned to the exhaust duct.

Figure 1 **Diagram of an aerosol challenge to multiple filters via an air handling unit**



3.2 Aerosol challenge

Each filter requires a homogeneous oil aerosol challenge upstream of the filter of between 20 mg/m^3 and 80 mg/m^3 (µg/l) of air. This can be provided by means of a thermal generator or (a) Laskin nozzle(s). BS EN ISO 14644-3:2005 considers that the mass median particle diameter of the test aerosol should be between 0.5 µm and 0.7 µm with a geometric standard deviation of up to 1.7. This is a size distribution typical of that produced by a Laskin nozzle. However, it is known that the mass median diameter of particles produced by a thermal generator is likely to be below the size suggested in BS EN ISO 14644-3:2005, and closer to the most penetrating particle size (MPPS) of high efficiency filters. It is therefore likely that more leaks will be found when a thermal generator is used, but this is not considered a disadvantage.

The upstream aerosol concentration is the 100% challenge and the percentage penetration is the downstream concentration expressed as a percentage of the upstream concentration. The percentage leakage penetration L can be calculated (see Figure 2) as follows:

$$L = \frac{100Y}{X}$$

where:

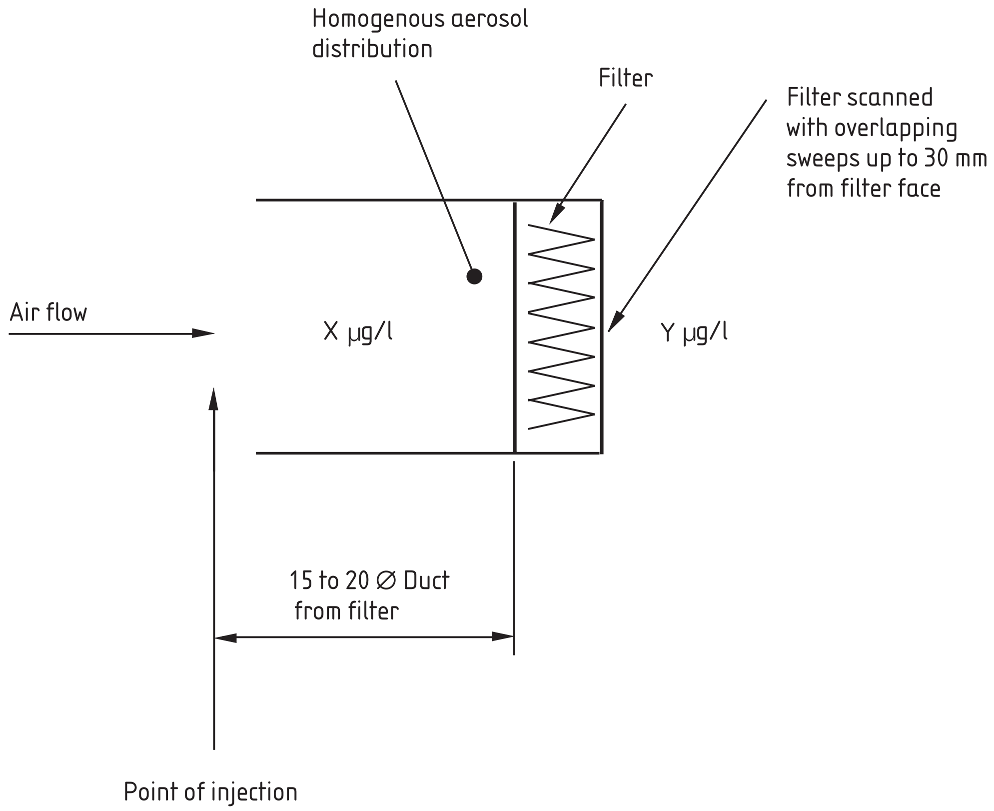
Y is the largest measured leak in mg/m^3 (µg/l), and

X is the average upstream challenge concentration in mg/m^3 (µg/l).

Prolonged exposure of filters to the challenge aerosol should be avoided. In the case of controlled environments that are served with multiple high efficiency filters, it is recommended that means be provided to challenge and test filters one at a time. Where such a provision is impractical, the upstream aerosol concentration may be reduced to a level agreed between the customer and the supplier, provided the downstream concentration at the pass/fail level is within the sensitivity of the photometer.

The upstream aerosol concentration should remain the same throughout the duration of the scan of each filter and should therefore be checked and recorded both at the start and upon completion of each filter scan.

Figure 2 **Diagram of aerosol filter testing**



3.3 System scanning

Systems that do not have the means of accessing the upstream concentration cannot be tested by the method described in this document.

A sampling probe should be used that ensures that the velocity of air being drawn into the opening of the probe is the same as the velocity of air coming from the filter face. This can be calculated in accordance with BS EN ISO 14644-3:2005 **B.6.2.4**. A variation in velocity of up to ±20% is acceptable.

The filter should be scanned at a distance of approximately 30 mm from the filter face using overlapping scans.

NOTE BS EN ISO 14644-3:2005 ***B.6.2.7*** *states that "designated leaks are deemed to have occurred where [there is] a reading greater than* 10^{-4} *(0.01%) of the upstream challenge aerosol concentration", but that "alternative acceptance criteria may be agreed between the customer and the supplier". BS EN ISO 14644-3:2005* ***B.6.1.2****b) states that an aerosol photometer can be used for MPPS penetrations equal to or greater than 0.003%. It has been well established that the use of linear photometers can readily measure aerosol penetrations down to 0.001%.*

The sealing device, housing and filter are all subject to the in situ test. Scans should therefore be made around the gasket seal, along the joints of the filter frame, along the bond between the filter pack and the frame, and over the whole area of the filter face.

A slow scanning velocity may improve sensitivity for finding leaks, and a fast scanning velocity may fail to find leaks. The filter should therefore be scanned at a velocity v (in cm/s) in accordance with the formula given in BS EN ISO 14644-3:2005 **B.6.2.5**, namely:

$$v = \frac{15}{W_p}$$

where W_p is the probe dimension at right angles to the scan direction.

3.4 Airflow through filters

Filter penetration varies with flow rate through the filter. If the airflow through the installed filter is higher than the airflow at which it was tested by the manufacturer, the filter penetration may increase above that to which the filter was manufactured, to a point where it gives an in situ test failure.

3.5 Repair of filters

BS EN ISO 14644-3:2005 **B.6.6** says that “leakage repair should only be acceptable by agreement between the customer and the supplier”. It should be noted that an effective repair at the gasket, and between the filter pack and frame, can often be achieved, but the repair of media leaks is difficult to achieve and, because of blockage, may have adverse effects on the uniformity of airflow. In a non-unidirectional cleanroom the air supply will quickly mix with room air and a less than perfect repair can be tolerated. However, in unidirectional flow, especially if the air is supplied directly to a critical area, the filter would normally be renewed. Where temporary repairs are made for expediency, e.g. to allow vital work to continue, a replacement filter needs to be installed at the earliest possible opportunity.

Annex A (informative) High efficiency filter specification table

A.1 High efficiency filter specification checklist

It is important when changing filters to choose the correct replacement filter, as failure to do this could affect the ability of the filter to pass the in situ leak test and could also affect the overall performance of the system to which the filter is fitted. Unambiguous specifications in relation to the following aspects should be clearly stated on all requisitions or orders to ensure compatibility with application and to avoid inappropriate filters being supplied:

a) application and orientation;

b) volumetric flow rate, uniformity of airflow and “clean” pressure drop;

c) pass/fail criteria for leakage and penetration with reference to the in situ test method to be used;

d) pass/fail criteria for leakage and penetration with reference to manufacturers’ tests (**A.2**);

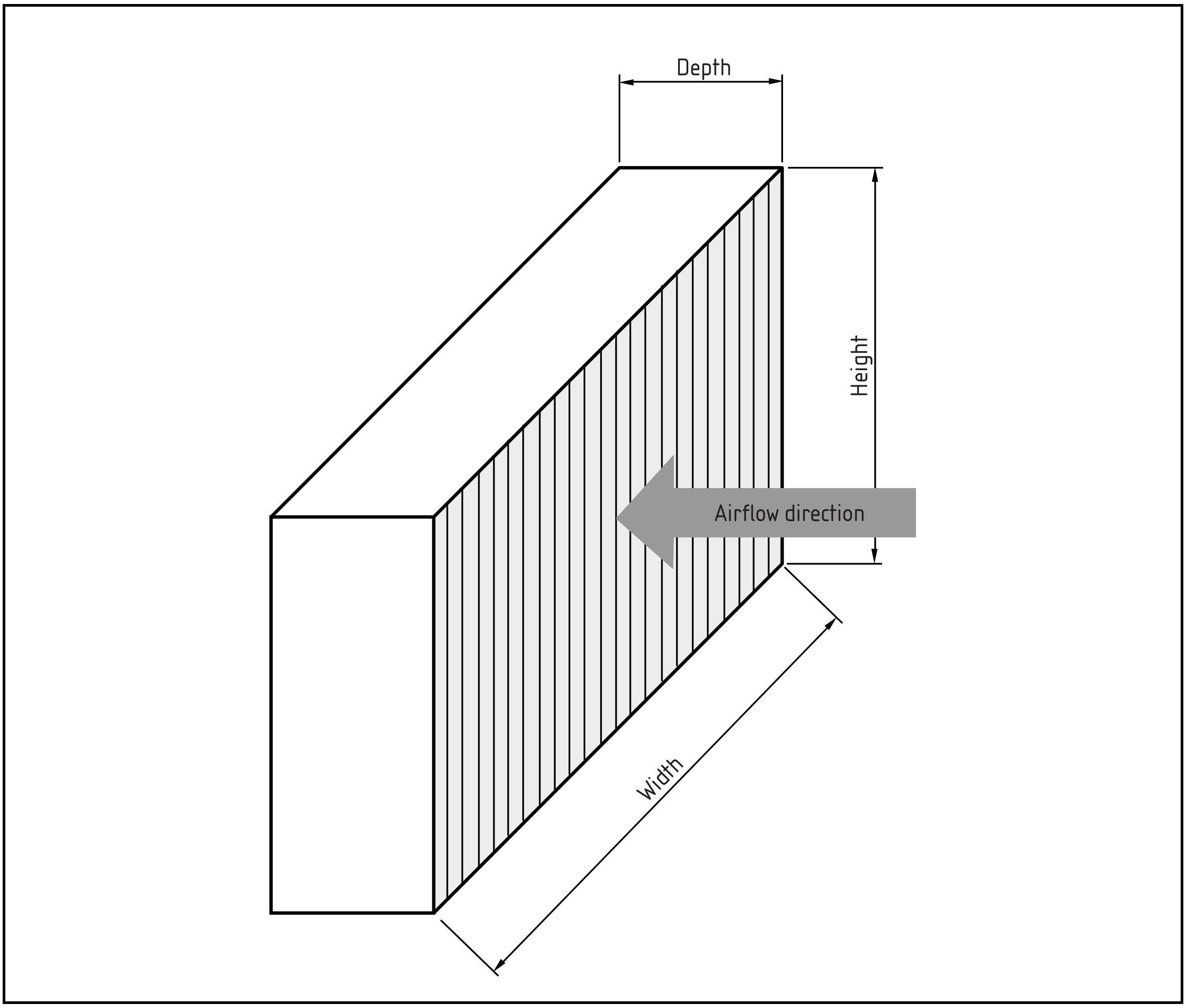
e) sealing arrangement;

f) size and form of construction.

When specifying the size of a standard type of filter, it is a commonly accepted practice to quote “height by width by depth”. The convention for filters is for height and width to define the dimensions of the face area of the filter, where the pleats are in the vertical or “height” direction, and for depth to define the dimension in the direction of airflow, as illustrated in Figure A.1. Failure to observe this system can result in a filter of inappropriate dimensions being supplied.

Table A.1 is a suggested high efficiency filter specification checklist. This can also be used as the basis for the manufacturer’s certificate of conformance where required.

Figure A.1 **Filter dimensions**



A.2 Manufacturers' high efficiency filter tests

Eurovent 4/4 (BS 3928:1969) specifies a volumetric test method commonly used by filter manufacturers for testing high efficiency filters. The Eurovent 4/4 test method uses an aerosol of sodium chloride with a relatively large mass median diameter of 0.7 µm. The Eurovent 4/4 test measures overall efficiency only and is not a scan test. Therefore a Eurovent 4/4 filter for use in a cleanroom should be subject to an additional scan test by the filter manufacturer, using a method similar to that used for the in situ test, to ensure that local penetrations are within specified limits.

BS EN 1822 (all parts) is a manufacturers' standard for the classification and testing of high efficiency air filters. Filters are classified in terms of overall and local efficiency at the most penetrating particle size (MPPS).

Filters tested to BS EN 1822 may have a suitable overall efficiency but too high a local penetration. An example of this is a BS EN 1822 H14 filter, which has a maximum overall efficiency of 99.995% and a maximum local penetration of 0.025%. This maximum local penetration may be too great to ensure that the filter passes the in situ test. It is therefore essential to inform the filter manufacturer of the type of in situ leak test to be carried out on the installed filter, and the maximum local penetration permitted, so that a suitable filter is provided.

Table A.1 **High efficiency filter specification**

This table is provided as a check list for assisting customers and suppliers to draw up a specification for a high efficiency filter that will be fit for purpose. A new specification sheet should be drawn up for every different size and type of filter

Application information		
Location and function, e.g. supply air filter in ceiling – see attached plan		
About the application		
Normal operating temperature	°C	
Maximum temperature	°C	
Operating humidity	%RH	

Safe removal method	**Tick**	**Comments**
Not applicable		
Disinfection/decontamination		
Encapsulation		
Bagging		

Filter disposal method	**Tick**	**Comments**
Solid general waste		
Contaminated waste		
Incineration		

Original filter supplier	**Manufacturer's code**	**Model/type**

Airflow (complete only one, i.e. either non-unidirectional or unidirectional)	
Non-unidirectional flow	
Volume (m^3/hr)	
Face velocity (m/s)	
Initial differential pressure (Pa)	

Unidirectional flow	
Airflow velocity 150 mm to 300 mm from filter face (m/s)	
Uniformity of airflow velocity across filter face (%±)	
Initial differential pressure (Pa)	

Table A.1 **High efficiency filter specification** (*continued*)

Manufacturer's filter test method				
BS EN 1822		**Filter class**	**Tick**	**Comments**
Volumetric efficiency				
	99.999995%	U17		
	99.99995%	U16		
	99.9995%	U15		
	99.995%	H14		
	99.95%	H13		
	99.5%	H12		
Eurovent 4/4 (BS 3928)		**Volumetric efficiency (%)**		

Manufacturer's leak test scan

NOTE To be carried out by the manufacturer with the object of ensuring that the filter will meet the specified criteria for the in situ leak test for local penetration after installation.

	Penetration %	**Comments**
BS EN 1822		
EN ISO 14644-3		
PD 6609		
Other		

In situ leak test method

NOTE In situ leak test to be carried out to verify that the filter meets the specified criteria for local penetration after installation.

	Penetration %	**Comments**
PD 6609		
EN ISO 14644-3		
Other		

Aerosol type	**Thermal generation (hot)**	**Laskin nozzle (cold)**	**Other**
Shell Ondina EL			
Durasyn 164 / Emery 3004			
Other (state type)			

Filter mechanical specification

Filter sizes	**Height** mm	**Width** mm	**Depth** mm
Filter outside case dimensions			
Filter cell (inside case) dimensions			

For filters with knife edge seals			
Height of knife edge (mm)			
Inset of knife edge from edge of filter (mm)			
Depth of gel channel (mm)			
Width of gel channel (mm)			

Table A.1 **High efficiency filter specification** (*continued*)

Frame material	**Tick one**	**Comments**
Particle board – MDF		
Plywood		
Chipboard		
Aluminium		
Galvanized steel		
Stainless steel (specify grade)		
Other (specify)		

Gasket	**Tick one**	**Comments**
Strip closed-cell neoprene		
One piece closed-cell neoprene		
Single pour “D” type		
Gel (specify type)		
Other (specify)		

Gasket location				
Side of filter	**Dirty**	**Clean**	**Both**	**Comments**
Thickness (mm)				

Airflow laminator	
Mesh guard (filter face protection)	
Thickness (mm)	
Diamond size (mm)	

Mesh guard material	
Stainless steel (specify grade)	
Steel unpainted	
Aluminium	
Powder coated steel	
Painted steel	
Powder coated stainless steel	
Other (specify)	

Separator (tick type)					
String		Kraft		Dimple	
Hot melt		Plastic		Polyurethane	
Aluminium		Other			

Filter media type (tick type)					
Glass		High Temp		PTFE Membrane	

Construction (tick type)			
Mini-pleat		Deep pleat with separators	
Deep pleat with no separator		Wedge, delta-V, other type (specify)	

Annex B (informative) In situ leak test report

This annex sets out a table that can be used for an in situ test report sheet. Table B is exclusively for the in situ leak test. Other tests on filters such as tests for differential pressure, airflow uniformity and air supply volumes should also be recorded and it may be useful to have a combined test report sheet for all tests.

The in situ leak test report should include the following information:

a) facility details;

b) date of test;

c) test method, test parameters, acceptance criteria;

d) instrumentation and calibration status;

e) measured upstream aerosol concentrations at the beginning and end of each test, and variation;

f) maximum downstream percentage local penetration measured per filter;

g) pass/fail test result;

h) corrective actions; and

i) name of tester(s) and testing qualification.

Table B.1 **In situ leak test report sheet**

Page 1	**IN SITU LEAK TEST REPORT**	**REPORT NUMBER :**	
Customer		**Test Supplier**	
FACILITY DETAILS			
Facility Identification Filter ID ISO Class Date of Test		Aerosol Injection Port ID Upstream Sample Port ID Test Standard / Method Maximum permitted penetration	
AEROSOL PHOTOMETER DETAILS			
Make/Model Number Serial Number Calibration Cert No. Date of Calibration Period of Validity of Calibration			

Page 2	IN SITU LEAK TEST REPORT	REPORT NUMBER :	

AEROSOL GENERATOR DETAILS

Make/Model Number

Serial Number

Cert of Conformity No.

Date of Certification

Period of Validity of Calibration

POSITIVE INJECTION PUMP DETAILS (when applicable)

Make/Model Number

Serial Number

TEST DATA

Upstream challenge concentration ______ μg/l

Rated air volume flow of filter ______ m^3/s

Actual air volume flow of filter ______ m^3/s

FILTER MEDIA SCAN DATA

Maximum measured penetration ______ %

PASS OR FAIL ______

FILTER FRAME AND GASKET SCAN DATA

Maximum measured penetration ______ %

PASS OR FAIL ______

Name of tester

Signature of tester

CORRECTIVE ACTION

Audited by

Signature of auditor

Bibliography

Standards publications

BS 3928:1969, *Method for sodium flame test for air filters (other than for air supply to I.C. engines and compressors)* (confirmed 2003)

BS 5295-1:1989, *Environmental cleanliness in enclosed spaces – Part 1: Specification for clean rooms and clean air devices* (withdrawn)

BS 5295-2:1989, *Environmental cleanliness in enclosed spaces – Part 2: Method for specifying the design, construction and commissioning of clean rooms and clean air devices* (withdrawn)

BS EN 1822-1, *High efficiency air filters (HEPA and ULPA) – Part 1: Testing flat sheet filter media*

BS EN 1822-2, *High efficiency air filters (HEPA and ULPA) – Part 2: Aerosol production, measuring equipment, particle counting statistics*

BS EN 1822-3, *High efficiency air filters (HEPA and ULPA) – Part 3: Classification, performance testing, marking*

BS EN 1822-4, *High efficiency air filters (HEPA and ULPA) – Part 4: Determining leakage of filter element (scan method)*

BS EN 1822-5, *High efficiency air filters (HEPA and ULPA) – Part 5: Determining the efficiency of filter element*

BS EN ISO 14644-1:1999, *Cleanrooms and associated controlled environments – Part 1: Classification of air cleanliness*

BS EN ISO 14644-2:2000, *Cleanrooms and associated controlled environments – Part 2: Specifications for testing and monitoring to prove continued compliance with ISO 14644-1*

BS EN ISO 14644-4:2001, *Cleanrooms and associated controlled environments – Part 4: Design, construction and start-up*

BS EN ISO 14644-5:2004, *Cleanrooms and associated controlled environments – Part 5: Operations*

BS EN ISO 14644-7:2004, *Cleanrooms and associated controlled environments – Part 7: Separative devices (clean air hoods, glove boxes, isolators and minienvironments)*

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