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Cleanrooms and associated controlled environments - Part 3:  
Test methods (ISO 14644-3:2005)

Salles propres et environnements maîtrisés apparentés -  
Partie 3: Méthodes d'essai (ISO 14644-3:2005)

Reinräume und zugehörige Reinraumbereiche - Teil 3:  
Prüfverfahren (ISO 14644-3:2005)

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Foreword

Endorsement notice

**ISO  
14644-3**

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**Cleanrooms and associated controlled environments —**

**Test methods**

Salles propres et environnements maîtrisés apparentés —





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## Foreword

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## **Introduction**

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# Cleanrooms and associated controlled environments —

## Test methods

**WARNING —** The use of this part of ISO 14644 may involve hazardous materials, operations and equipment. This part of ISO 14644 does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this part of ISO 14644 to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

### 1 Scope

### 2 Normative references

Ergonomics of the thermal environment — Instruments for measuring physical quantities

Cleanrooms and associated controlled environments — Part 1: Classification of air

Cleanrooms and associated controlled environments — Part 2: Specifications for testing

Cleanrooms and associated controlled environments — Part 4: Design, construction and

### 3 Terms and definitions

#### 3.1 General

##### 3.1.1

cleanroom

##### 3.1.2

clean zone

##### 3.1.3

installation

##### 3.1.4

separative device

### 3.2 Airborne particle measurement

#### 3.2.1

aerosol generator

#### 3.2.2

airborne particle

#### 3.2.3

count median particle diameter

CMD

**3.2.4  
macroparticle**

**3.2.5  
M descriptor**

**3.2.6  
mass median particle diameter  
MMD**

**3.2.7  
particle concentration**

**3.2.8  
particle size**

**3.2.9  
particle size distribution**

**3.2.10  
test aerosol**

**3.2.11  
U descriptor**

**3.2.12  
ultrafine particle**

### **3.3 Air filters and systems**

**3.3.1  
aerosol challenge**

**3.3.2  
designated leak**

**3.3.3  
dilution system**

**3.3.4  
filter system**

**3.3.5  
final filter**

**3.3.6  
installed filter system**

**3.3.7  
installed filter system leakage test**

**3.3.8  
leak**

**3.3.9  
scanning**

**3.3.10  
standard leak penetration**

### **3.4 Airflow and other physical states**

**3.4.1  
air exchange rate**

**3.4.2  
average airflow rate**

**3.4.3  
measuring plane**

**3.4.4  
non-unidirectional airflow**

**3.4.5  
supply airflow rate**

**3.4.6  
total airflow rate**

**3.4.7  
unidirectional airflow**

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uniformity of airflow**

### **3.5 Electrostatic measurement**

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**3.5.2  
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**3.5.4  
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-

**3.6.2  
anisokinetic sampling**

**3.6.3  
cascade impactor**

**3.6.4  
condensation nucleus counter  
CNC**

**3.6.5  
counting efficiency**

**3.6.6  
differential mobility analyzer  
DMA**

**3.6.7  
diffusion battery element**

**3.6.8  
discrete-particle counter  
DPC**

**3.6.9  
false count  
background noise count  
zero count**

**3.6.10  
flowhood with flowmeter**

**3.6.11  
iso-axial sampling**

**3.6.12  
isokinetic sampling**

**3.6.13  
particle size cutoff device**

**3.6.14  
threshold size**

**3.6.15  
time-of-flight particle size measurement**

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virtual impactor**

**3.6.17  
witness plate**

## **3.7 Occupancy states**

**3.7.1  
as-built**

**3.7.2  
at-rest**

**3.7.3  
operational**

## **4 Test procedures**

### **4.1 Cleanroom tests**

#### **4.1.1 Required test**

**Table 1 — Required test for installation**

Required tests	Reference in ISO 14644-3:2005			Referenced in
	Principle	Procedure	Apparatus	

#### **4.1.2 Optional tests**

**Table 2 — Optional tests for installation**

## 4.2 Principle

#### 4.2.1 Airborne particle count

#### 4.2.2 Airflow test

**4.2.3 Air pressure difference test**

**4.2.4 Installed filter system leakage tests**

**4.2.5 Airflow direction test and visualization**

**4.2.6 Temperature and humidity uniformity tests**

**4.2.7 Electrostatic and ion generator tests**

**4.2.8 Particle deposition test**

**4.2.9 Recovery test**

**4.2.10 Containment leak test**

## 5 Test reports

## Annex A

### **Choice of recommended tests of an installation and the sequence in which to carry them out**

#### **A.1 General**

#### **A.2 Test checklist**

**Table A.1 — Checklist of recommended tests and their sequence for a clean installation**

Selection of test procedure and s	Test procedure	Test procedure reference	Selection of test a	Test apparatus	Apparatus reference	Comments
	Airborne particle count for classification and test measurement					
	Airborne particle count for ultrafine particles					
	Airborne particle count for macroparticles					

T

T

T

Selection of test procedure and s	Test procedure	Test procedure reference	Selection of test a	Test apparatus	Apparatus reference	Comments
	<b>Humidity</b>					
	<b>Electrostatic and ion generator</b>					
	<b>Particle deposition</b>					
	<b>Recovery</b>					
	<b>Containment leak</b>					

## Annex B

### Test methods

#### B.1 Airborne particle count for classification and test measurement

##### B.1.1 Principle

##### B.1.2 Test procedure

###### B.1.2.1 General

###### B.1.2.2 Procedure for airborne particle count

##### B.1.3 Apparatus for airborne particle count

#### B.1.4 Test reports

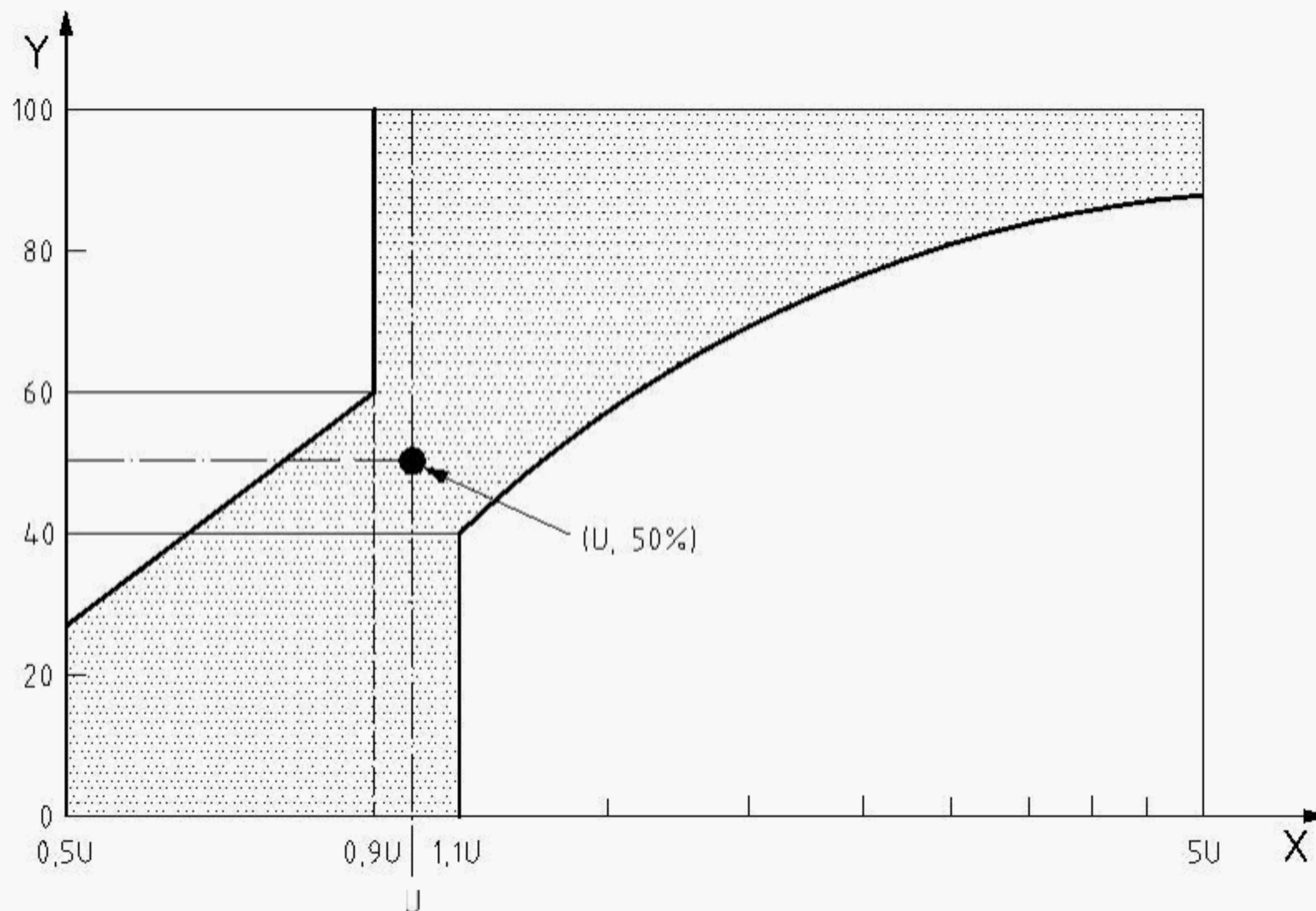
### B.2 Airborne particle count for ultrafine particles

#### B.2.1 Principle

##### B.2.1.1 General

##### B.2.1.2 Counting efficiency

50 % at the defined ultrafine particle size, shown as size "U". It includes a tolerance band of  $\pm 10\%$  of the ultrafine particle size, shown as sizes "1,1U" and "0,9U" in Figure B.1. The acceptable minimum and maximum



Key

Figure B.1 — Acceptability envelope for the counting efficiency of selected apparatus

#### B.2.1.3 Particle size cutoff device

**B.2.2 Procedure for ultrafine particle count**

**B.2.3 Apparatus for ultrafine particle count**

**B.2.4 Test reports**

**B.3 Airborne particle count for macroparticles**

**B.3.1 Principle**

**B.3.2 Sample handling considerations**

**B.3.3 Measurement methods for macroparticles**

**B.3.3.1 General**

**B.3.3.2 Macroparticle measurement with particle collection**

**B.3.3.2.1 Filter collection and microscopic measurement**

**B.3.3.2.2 Cascade impactor collection and measurement**

**B.3.3.3 Macroparticle measurement without particle collection**

**B.3.3.3.1 General**

**B.3.3.3.2 Discrete-particle counter (DPC) measurement**

**B.3.3.3.3 Time-of-flight particle size measurement**

**B.3.4 Procedure for macroparticle count**

**B.3.5 Test reports**

**B.4 Airflow test**

**B.4.1 Principle**

**B.4.2 Procedure for unidirectional airflow installation test****B.4.2.1 General****B.4.2.2 Supply airflow velocity****B.4.2.3 Uniformity of velocity within the cleanroom****B.4.2.4 Supply airflow rate measured by filter face velocity**

Q

Q

 $\Sigma$

**B.4.2.5 Supply airflow rate in air ducts**

**B.4.3 Procedure for non-unidirectional airflow installation test**

**B.4.3.1 General**

**B.4.3.2 Supply airflow rate measured at the inlet**

**B.4.3.3 Supply airflow rate calculated from filter face velocity**

**B.4.3.4 Supply airflow rate in air ducts**

**B.4.4 Apparatus for airflow tests**



#### B.5.4 Test reports

### B.6 Installed filter system leakage test

**WARNING —** The aerosol challenge can provide an unacceptable particulate or molecular contamination within some installations. Some test aerosols can create a safety hazard under certain circumstances. This part of ISO 14644 does not address any safety issues associated with these methods. It is the responsibility of the user to consult and apply appropriate safety practices, risk assessments and any regulatory limits prior to use of this part of ISO 14644.

#### B.6.1 Principle

##### B.6.1.1 General

applied to cleanrooms in “as-built” or in “at-rest” occupational states, and be undertaken when commissioning

##### B.6.1.2 Using an aerosol photometer

**B.6.1.3 Using a discrete-particle counter (DPC)**

**B.6.2 Procedures for installed filter system leakage scan test with an aerosol photometer**

**B.6.2.1 General**

**B.6.2.2 Choice of upstream aerosol challenge**

**B.6.2.3 Concentration of upstream aerosol challenge and its verification**

**B.6.2.4 Determination of probe size**

$$= \frac{q}{U}$$

U

W

U

U

$$= \frac{q}{U}$$

**B.6.2.5 Determination of scan rate**

S

**B.6.2.6 Procedure for installed filter system leakage scan test**

**B.6.2.7 Acceptance criteria**

**B.6.3 Procedure for installed filter system leakage scan test with a DPC**

**B.6.3.1 General**

**B.6.3.2 Conditions for aerosol**

**B.6.3.3 Concentration and verification of upstream aerosol**

**B.6.3.4 Determination of probe size**

**B.6.3.5 Procedure for installed filter system leakage scan test**

**B.6.3.6 Preparatory calculations and evaluation**

**B.6.3.6.1 Symbols and flow diagram of preparatory calculations and evaluation**

K

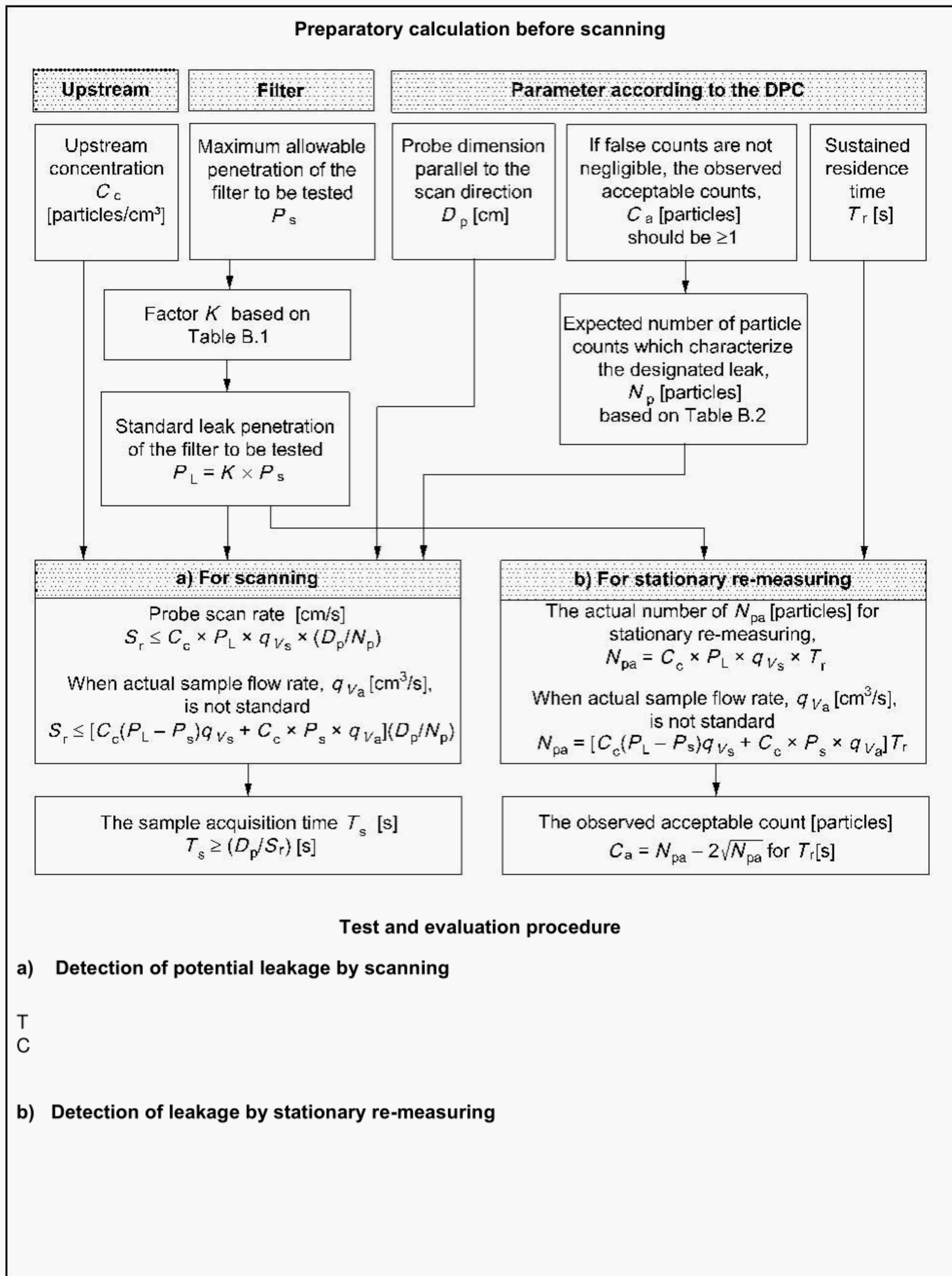


Figure B.2 — Flow diagram of preparatory calculations and evaluation

**B.6.3.6.2 S**

P

=

T

<b>Maximum allowable p</b>					
F					

C

**B.6.3.6.3 E**

C

T

Observed	Upper limit	Observed	Upper limit	

=  $\sqrt{\quad}$

**B.6.3.6.4 T**

u

**B.6.3.6.5 S**

C

N

=

=  $\sqrt{\quad}$ **B.6.3.6.6 Detection of potential leakage by scanning**C  
T

W —

**B.6.3.6.7 Detection of leakage by stationary re-measuring**

C

**B.6.3.7 Revision for non-standard flow rate**

P  
q

$$u = \frac{P}{q}$$

=

**B.6.3.8 Example of an application with evaluation**

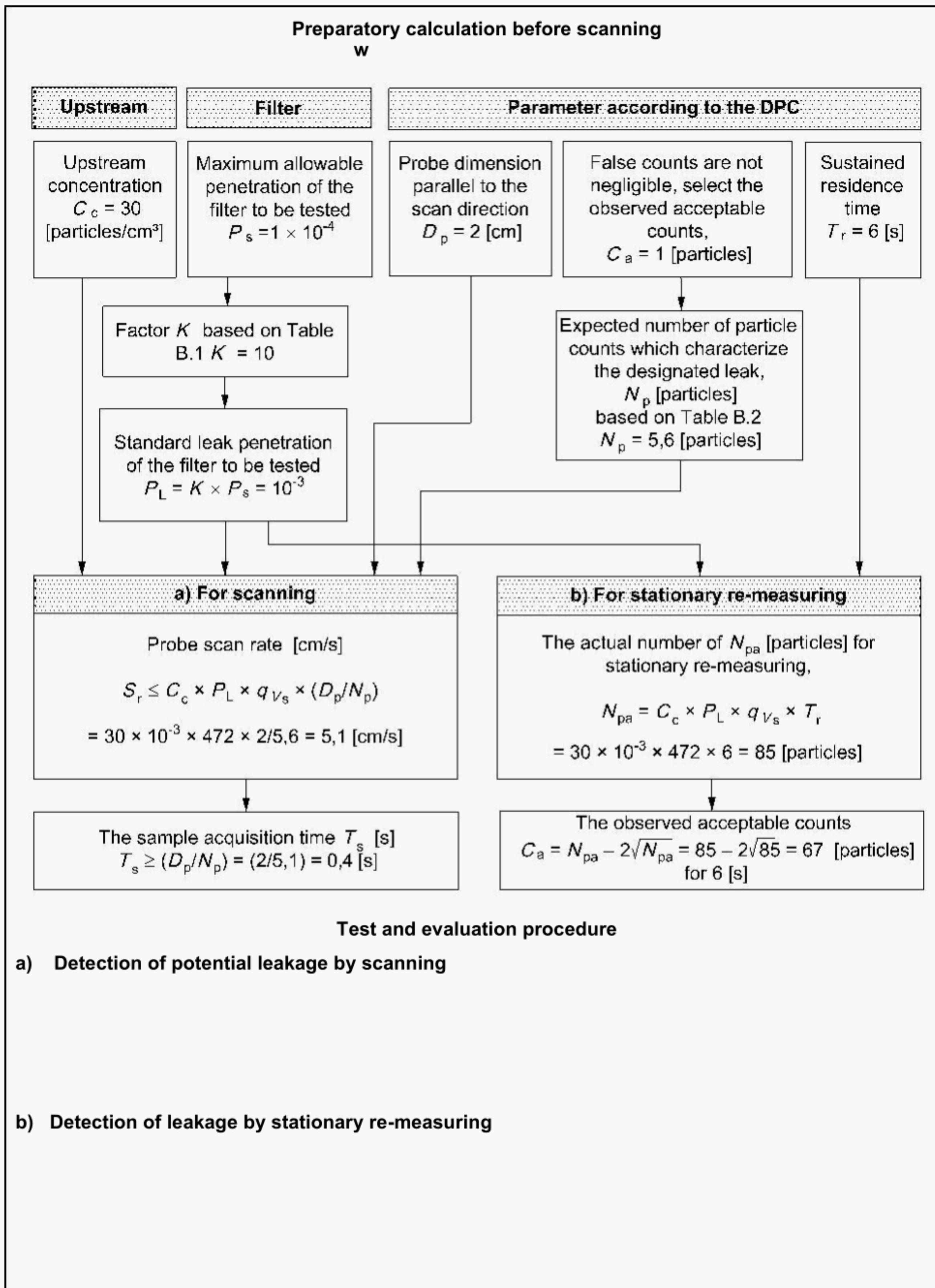


Figure B.3 — Flow diagram of evaluation procedure

**B.6.4 Procedure for overall leak test of filters mounted in ducts or air-handling units (AHUs)**

**B.6.5 Apparatus and materials for installed filter system leakage tests**

**B.6.5.1 A**

**B.6.5.2 D**

**B.6.5.3 S**

**B.6.5.4 S**

**B.6.5.5 S**

**B.6.6 Repairs and repair procedures**

**B.6.7 Test reports**

**B.7 Airflow direction test and visualization**

**B.7.1 Principle**

## B.7.2 Methods

### B.7.3 Procedures for airflow direction test and visualization

#### B.7.3.1 Tracer thread method

#### B.7.3.2 Tracer injection method

-

#### B.7.3.3 Airflow visualization method by image processing techniques

**B.7.3.4 Airflow visualization method by the measurement of velocity distributions**

**B.7.4 Apparatus used for airflow direction test and visualization**

**B.7.5 Test reports**

**B.8 Temperature test**

**B.8.1 Principle**

**B.8.2 Procedure for temperature test**

**B.8.2.1 General temperature test**

-

**B.8.2.2 Comprehensive temperature test**

**B.8.3 Apparatus for temperature test**

**B.8.4 Test reports**

**B.9 Humidity test**

**B.9.1 Principle**

**B.9.2 Procedure for humidity test**

**B.9.3 Apparatus for humidity test**

**B.9.4 Test reports**

**B.10 Electrostatic and ion generator tests**

**B.10.1 Principle**

**B.10.2 Procedures for electrostatic and ion generator tests**

**B.10.2.1 Procedure for electrostatic test**

**B.10.2.1.1 Measurement of surface voltage level**

**B.10.2.1.2 Measurement of the static-dissipative property**

**B.10.2.2 Procedure for ion generator test**

**B.10.2.2.1 General**

**B.10.2.2.2 Measurement of discharge time**

**B.10.2.2.3 Measurement of offset voltage**

**B.10.3 Apparatus for electrostatic and ion generator tests**

**B.10.4 Test reports**

**B.11 Particle deposition test**

**B.11.1 Principle**

**B.11.2 Procedure for particle deposition test**

**B.11.2.1 Collection of particles on witness plates**

**B.11.2.2 Counting and sizing collected particles**

$$D = \frac{N}{D}$$

D

### **B.11.3 Apparatus for particle deposition test**

#### **B.11.3.1 Witness plate material**

**B.11.3.2 Additional apparatus**

**B.11.4 Test reports**

**B.12 Recovery test**

**B.12.1 Principle**

**B.12.2 Cleanliness recovery performance**

**B.12.3 Procedure for recovery test**

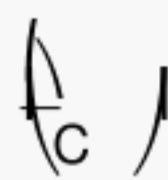
**B.12.3.1 Evaluation by 100:1 recovery time**

-

n

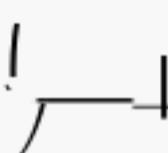
t

**B.12.3.2 Evaluation by recovery rate**

n      

n

-

n      —+     —)      —

#### B.12.4 Apparatus and measurement points for recovery test

##### B.12.4.1 A

##### B.12.4.2 D

##### B.12.4.3 i

#### B.12.5 Test reports

**B.13 Containment leak test**

**B.13.1 Principle**

**B.13.2 Procedures for containment leak test**

**B.13.2.1 Discrete-particle counter (DPC) method**

**B.13.2.2 Photometer method**

**B.13.3 Apparatus for containment leak test**

**B.13.3.1 A**

**B.13.3.2 D**

**B.13.4 Test reports**

## Annex C

### Test apparatus

#### C.1 Airborne particle count

C

.

Table C.1 — Specifications for the light-scattering discrete-particle counter

Item	Specification
	u

**C.2 Ultrafine particle count**C  
.  
2**Table C.2 — Specifications for condensation nucleus counter**

Item	Specification

C  
.  
.**Table C.3 — Specifications for DPC**

	U

C  
.  
2**Table C.4 — Specifications for particle size cutoff device**

Item	Specification

### C.3 Macroparticle count

C

C

3

.

**Table C.5 — Specifications for cascade impactor**

Item	Specification
	"cut-point" accuracy isW 90 %

C

.

**Table C.6 — Specifications for discrete-macroparticle counter**

Item	Specification

C  
.  
3  
.

**Table C.7 — Specifications for time-of-flight particle sizing apparatus**

Item	Specification

C  
.  
3

**Table C.8 — Specifications for piezo-balance impactor**

Item	Specification

**C.4 Airflow test****C.4.1 Air velocity meter****C.4.1.1 T****Table C.9 — Specifications for thermal anemometer**

Item	Specification

## C.4.1.2 U

**Table C.10 — Specifications for ultrasonic anemometer, 3-dimensional or equivalent**

Item	Specification

## C.4.1.3 V

**Table C.11 — Specifications for vane-type anemometer**

Item	Specification

## C.4.1.4 P

**Table C.12 — Specifications for Pitot-static tube and manometer**

Item	Specification

**C.4.2 Airflow meter**

C.4.2.1 F

**Table C.13 — Specifications for flowhood with flowmeter**

Item	Specification

C.4.2.2 O

r

C.4.2.3 M

v

**C.5 Air pressure difference test**

C

.

5

**Table C.14 — Specifications for electronic micromanometer**

Item	Specification

C

.

5

**Table C.15 — Specifications for inclined manometer**

Item	Specification

C  
.  
5

**Table C.16 — Specifications for mechanical differential pressure gauge**

Item	Specification

**C.6 Installed filter system leakage test****C.6.1 Aerosol photometers****C.6.1.1 L****Table C.17 — Specifications for linear aerosol photometer**

Item	Specification
	$\pm$
	u
	u

## C.6.1.2 L

**Table C.18 — Specifications for logarithmic aerosol photometer**

Item	Specification
	u
	u

C

C

.

6

C

.

C

**C.7 Airflow direction test and visualization**

C

**Table C.19 — Materials or particles used in tracer thread or injection methods**

Item	Description

**Table C.20 — Illumination light sources for airflow visualization**

Item	Description

C

C

**C.7.4 Aerosol generator****C.7.4.1 U****Table C.21 — Specifications for ultrasonic nebulizer**

Item	Specification

C.7.4.2 F

**Table C.22 — Specifications for fog generator**

Item	Specification

### C.8 Temperature test

6

•

c

6

### C.9 Humidity test

c

•  
6

1

8

#### C.10 Electrostatic and ion generator test

c

1

**Table C.23 — Specifications for a precision electrostatic voltmeter**

Item	Specification

**Table C.24 — Specifications for hand-type electrostatic voltmeter or electrostatic fieldmeter**

Item	Specification

C

.

**Table C.25 — Specifications for high resistance ohm-meter**

Item	Specification
	$\Omega$

C

.

**Table C.26 — Specifications for charged plate monitor**

Item	Specification

**C.11 Particle deposition test**C  
·  
1**Table C.27 — Specifications for particle fallout photometer**

Item	Specification

C  
·**Table C.28 — Specifications for surface particle counter**

Item	Specification
	u

C  
·  
1**Table C.29 — Specifications for PSL particle generator**

Item	Specification

**C.12 Recovery test**C  
·  
C  
2  
C  
·

**C.13 Containment leak test**

c

c

c

c

## Bibliography

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circular cross-section conduits running full — Part 3: Nozzles and Venturi nozzles

circular cross-section conduits running full — Part 4: Venturi tubes

C