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**Cleanrooms and associated  
controlled environments—  
Part 3: Test methods**

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## Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment of Japanese Industrial Standard by Japan Air Cleaning Association (JACA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

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**JIS B 9917** consists of the following 2 parts:

JIS B 9917-3 *Cleanrooms and associated controlled environments—Part 3: Test methods*

JIS B 9917-5 *Maintenance and cleaning in cleanroom operations*

# Cleanrooms and associated controlled environments—Part 3: Test methods

## Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **ISO 14644-3** published in 2005 by modifying its technical contents so as to reflect the reality of the evaluation being performed in Japan.

The portions with dotted underlines in this Standard are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with explanations is given in Annex JD.

## 1 Scope

This Standard specifies test methods for designated classification of airborne particulate cleanliness and for characterizing the performance of cleanrooms and clean zones.

Performance tests are specified for two types of cleanrooms and clean zones: those with unidirectional flow and those with non-unidirectional flow, in three possible occupancy states: as-built, at-rest and operational. The test methods recommend test apparatus and test procedures for determining performance parameters. Where the test method is affected by the type of cleanroom or clean zone, alternative procedures are suggested. For some of the tests, several different methods and apparatus are recommended to accommodate different end-use considerations. Alternative methods not included in this Standard may be used if based on agreement between customer and supplier. Alternative methods do not necessarily provide equivalent measurements.

**NOTE :** The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows:

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

The symbols which denote the degree of correspondence in the contents between **JIS** and the corresponding International Standard are IDT (identical), MOD (modified) and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and any revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent edition (including amendments) shall be applied.

JIS B 9920:2002 *Classification of air cleanliness for cleanrooms*

**NOTE :** Corresponding International Standard: ISO 14644-1:1999 *Cleanrooms and associated controlled environments—Part 1: Classification of air cleanliness* (MOD)

*JIS B 9921 Light scattering automatic particle counter*

*JIS Z 8122 Contamination control—Terminology*

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

### 3 Terms and definitions

For the purposes of this Standard, the terms and definitions in **JIS Z 8122** and the following apply.

#### 3.1 General

##### 3.1.1 cleanroom

room in which contamination is controlled, i.e. the concentration of airborne particles, airborne microorganisms and molecular contaminants is controlled below the restricted cleanliness level, the cleanliness required for materials, chemicals, water, etc. provided to the room is maintained and also the environmental parameters such as temperature, humidity and pressure are controlled as necessary

##### 3.1.2 clean zone

dedicated space in which contamination is controlled, and in which the concentration of airborne particles, airborne microorganisms and molecular contaminants is controlled below the restricted cleanliness level, the cleanliness required for materials, chemicals, water, etc. provided to the room is maintained and also the environmental parameters such as temperature, humidity and pressure are controlled as necessary

This zone may be open or enclosed, and may or may not be located within a cleanroom.

##### 3.1.3 separative device

equipment for creating assured levels of separation between the inside and outside of a defined volume

**NOTE :** It utilizes constructional and dynamic means.

Example: Clean booths, clean work stations, containment enclosures (cabinets), glove boxes, isolators and mini-environments.

#### 3.2 Airborne particle measurement

##### 3.2.1 aerosol generator

instrument capable of generating particulate matter having appropriate size range (e.g. 0.05  $\mu\text{m}$  to 2  $\mu\text{m}$ ) at a constant concentration, which may be produced by thermal, hydraulic, pneumatic, acoustic or electrostatic means

##### 3.2.2 airborne particle

solid or liquid object suspended in air, viable or non-viable, sized (for the purpose of this Standard) between 1 nm and 100  $\mu\text{m}$

**NOTE :** For classification purposes, refer to **JIS Z 9923:2002, 3.2.**

### **3.2.3 count median particle diameter, CMD**

median particle diameter based on the number of particles

NOTE : For the count median, one half of the particle number is contributed by the particles with a size smaller than the count median size, and one half by particles larger than the count median size.

### **3.2.4 macroparticle**

particle with an equivalent diameter greater than 5  $\mu\text{m}$

[See **JIS B 9920:2002, 3.2.4.**]

### **3.2.5 M descriptor**

measured or specified concentration of macroparticles per cubic metre of air, expressed in terms of the equivalent diameter that is characteristic of the measurement method used

NOTE : The M descriptor may be regarded as an upper limit for the averages at sampling locations (or as an upper confidence limit, depending upon the number of sampling locations used to characterize the cleanroom or clean zone). M descriptors cannot be used to define airborne particulate cleanliness classes, but they may be quoted independently or in conjunction with airborne particulate cleanliness classes.

[See **JIS B 9920:2002, 3.3.2.**]

### **3.2.6 mass median particle diameter, MMD**

median particle diameter based on the particle mass

NOTE : For the mass median, one half of mass of all particles is contributed by particles with a size smaller than the mass median size, and one half by particles larger than the mass median size.

### **3.2.7 particle concentration**

number of individual particles per unit volume of air

### **3.2.8 particle size**

diameter of a sphere that produces a response, by a given particle-sizing instrument, that is equivalent to the response produced by the particle being measured

NOTE : For discrete-particle-counting, light-scattering instruments, the equivalent optical diameter is used.

### **3.2.9 particle size distribution**

cumulative distribution of particle concentration as a function of particle size

### **3.2.10 test aerosol**

gaseous suspension of solid and/or liquid particles with known and controlled size distribution and concentration

### **3.2.11 U descriptor**

measured or specified concentration in particles per cubic metre of air, including the ultrafine particles [see **JIS B 9920:2002, 3.3.1**]

NOTE : The U descriptor may be regarded as an upper limit for the averages at sampling locations (or as an upper confidence limit, depending upon the number of sampling locations used to characterize the cleanroom or clean zone). U descriptors cannot be used to define airborne particulate cleanliness classes, but they may be quoted independently or in conjunction with airborne particulate cleanliness classes.

### **3.2.12 ultrafine particle**

particle with an equivalent diameter less than 0.1  $\mu\text{m}$

## **3.3 Air filters and systems**

### **3.3.1 aerosol challenge**

challenging of a filter or an installed filter system by test aerosol

### **3.3.2 designated leak**

maximum allowable penetration, which is determined by agreement between customer and supplier, through a leak, detectable during scanning of a filter system with discrete-particle counters

### **3.3.3 dilution system**

system wherein aerosol is mixed with particle-free dilution air in a known volumetric ratio to reduce concentration

### **3.3.4 filter system**

system composed of filter, frame and other support system or other housing

### **3.3.5 final filter**

filters in a final position before the air enters the cleanroom

### **3.3.6 installed filter system**

filter system mounted in the ceiling, wall, apparatus or duct

### **3.3.7 installed filter system leakage test**

test performed to confirm that the filters are properly installed by verifying that there is absence of bypass leakage in the installation, and that the filters and the grid system are free of defects and leaks

### **3.3.8 leak (of air filter system)**

penetration of contaminants that exceed an expected value of downstream concentration through lack of integrity or defects (of air filter system)

### **3.3.9 scanning**

method for disclosing leaks in filters and parts of units, whereby the probe inlet of a discrete-particle counter, etc. is moved in overlapping strokes across the defined test area

### **3.3.10 standard leak penetration**

leak penetration detected by a discrete-particle counter with a standard sample flow-rate when the sampling probe is stationary in front of the leak

NOTE : Penetration is the ratio of the particle concentration downstream of the filter to the concentration upstream.

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

#### **3.4.1 air exchange rate**

rate of air exchange expressed as number of air changes per unit of time and calculated by dividing the volume of air delivered in the unit of time by the volume of the space

#### **3.4.2 average airflow rate**

averaged volume of air per unit of time, to determine the air exchange rate in a cleanroom or clean zone

NOTE : Airflow rate is expressed in cubic metres per hour (m<sup>3</sup>/h).

#### **3.4.3 measuring plane**

cross-sectional area for testing or measuring a performance parameter such as the airflow velocity

#### **3.4.4 non-unidirectional airflow**

air distribution where the supply air entering the cleanroom or clean zone mixes with the internal air by means of induction

[See JIS B 9919:2004<sup>[40]</sup>, 3.8.]

#### **3.4.5 supply airflow rate**

air volume supplied into an installation from final filters or air ducts in unit of time

#### **3.4.6 total airflow rate**

air volume that passes through a section of a cleanroom or clean zone in unit of time

#### **3.4.7 unidirectional airflow**

controlled airflow through the entire cross-section of a cleanroom or clean zone with a steady velocity and approximately parallel streamlines

NOTE : This type of airflow results in a directed transport of particles from the cleanroom or clean zone.

[See JIS B 9919:2004<sup>[40]</sup>, 3.7.]

#### **3.4.8 uniformity of airflow**

unidirectional airflow pattern in which the point-to-point readings of velocities are within a defined percentage of the average airflow velocity

### **3.5 Electrostatic measurement**

#### **3.5.1 discharge time**

time required to reduce the voltage to the level, positive or negative, to which an isolated conductive monitoring plate was originally charged

### **3.5.2 offset voltage**

voltage that will accumulate upon an initially uncharged isolated conductive plate when that plate is exposed to an ionized air environment

### **3.5.3 static-dissipative property**

capability for reducing electrostatic charge on work or product surface, as a result of conduction or other mechanism to a specific value or nominal zero charge level

### **3.5.4 surface voltage level**

positive or negative voltage level of electrostatic charging on work or product surface, as indicated by use of suitable apparatus

## **3.6 Measuring apparatus and measuring conditions**

### **3.6.1 aerosol photometer**

light-scattering airborne particle mass concentration measuring apparatus, which uses a forward-scattered-light optical chamber to make measurements

### **3.6.2 anisokinetic sampling**

sampling condition in which the mean velocity of the air entering the sample probe inlet is significantly different from the mean velocity of the unidirectional airflow at that location

### **3.6.3 cascade impactor**

sampling device, which collects particles from an aerosol sprayed through a small nozzle or a slit using the principle of impaction upon a series of collector surfaces

NOTE : Each successive collector surface is exposed to a stream of aerosol through a smaller nozzle or a narrower slit, i.e. flowing at a higher velocity than was the previous one, thus allowing collection of smaller particles than the previous one. This device is also used as a measuring instrument.

### **3.6.4 condensation nucleus counter, CNC**

instrument that is capable of enlarging ultrafine particles by means of condensation for subsequent counting using optical particle counting techniques

### **3.6.5 counting efficiency**

ratio of the nominal concentration of microparticles in test air suctioned through the sample inlet of the discrete-particle counter to the actual concentration indicated on the counter, of such particles

### **3.6.6 differential mobility analyzer, DMA**

instrument for measuring the particle size distribution, based on the electrical mobility of particles

### **3.6.7 diffusion battery element**

individual component from a multi-stage particle size cutoff device, operating on the principle of diffusion to remove smaller particles from an aerosol stream

### **3.6.8 discrete-particle counter, DPC**

instrument having a means of displaying and recording the count and size of discrete particles (with a size discrimination) for specific air volume

NOTE : Normally, a light scattering airborne particle counter for clean spaces specified in JIS B 9921 is used.

### **3.6.9 false count**

count produced by a discrete-particle counter (DPC) when no particles of the measurable range size exist in the measured air

### **3.6.10 flowhood with flowmeter**

device with apparatus to directly measure the airflow volume at each final filter or air diffuser in an installation, set up to completely cover the filter or diffuser

### **3.6.11 iso-axial sampling**

sampling condition in which the direction of the airflow into the sample probe inlet is the same as that of the unidirectional airflow being sampled

### **3.6.12 isokinetic sampling**

sampling condition in which the mean velocity of the air entering the sample probe inlet is the same as the mean velocity of the unidirectional airflow at that location

### **3.6.13 particle size cutoff device**

device capable of removing particles smaller than those of interest that is attached to the inlet of a DPC or CNC

### **3.6.14 threshold size**

selected minimum particle size chosen for measuring a concentration of particles larger than or equal to that size

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

measurement of aerodynamic particle diameter determined by the time required for travelling the airflows with different velocities

NOTE : This measurement utilizes the particle velocity shift caused when a particle is introduced into the flow field with different velocity.

### **3.6.16 virtual impactor**

instrument to separate the particle sizing by inertial force to collide on the hypothetical (virtual) surface

NOTE : Large particles pass through the surface into a stagnant volume and small particles deflected with the bulk of the original airflow.

### **3.6.17 witness plate**

contamination-sensitive material of defined surface area used in lieu of direct evaluation of a specific surface that is either inaccessible or too sensitive to be handled

Material which uses a substitute surface instead of the actual specific surface.

### 3.7 Occupancy states

#### 3.7.1 as-built

condition where the cleanroom is complete with all services connected and functioning but with no production equipment, materials, or personnel present

[See **JIS B 9920:2002, 3.4.1.**]

#### 3.7.2 at-rest

condition where the cleanroom is complete with equipment installed and operating in a manner agreed upon by the customer and supplier, but with no personnel present

[See **JIS B 9920:2002, 3.4.2.**]

#### 3.7.3 operational

condition where the installation is functioning in the specified manner, with the specified number of personnel present and working in the manner agreed upon

[See **JIS B 9920:2002, 3.4.3.**]

## 4 Test procedures

### 4.1 Cleanroom tests

#### 4.1.1 Required test

An airborne particle count test (see table 1) shall be carried out in order to classify an installation in accordance with this Standard, at the time intervals specified in **JIS B 9920** and **ISO 14644-2**.

**Table 1 Required test for installation**

| Required tests                                                                                      | Reference in this Standard |             |                                                  | Reference in                             |
|-----------------------------------------------------------------------------------------------------|----------------------------|-------------|--------------------------------------------------|------------------------------------------|
|                                                                                                     | Principle                  | Procedure   | Apparatus                                        |                                          |
| Airborne particle count for classification and test measurement of cleanrooms and clean air devices | <b>4.2.1</b>               | <b>JA.2</b> | <b>JA.3</b> (see clause 5 of <b>JIS B 9921</b> ) | <b>JIS B 9920</b> and <b>ISO 14644-2</b> |

#### 4.1.2 Optional tests

Table 2 lists other tests appropriate for testing of an installation. These tests can be applied in each of the three designated occupancy states given in **3.7**. These tests may not be all-inclusive, nor may all of the tests be required for any given certification project. Tests and test methods should be selected in a manner agreed between the customer and supplier. Selected tests can also be repeated on a regular basis as part of a routine facility monitoring program (see **JIS B 9920** and **ISO 14644-2**). Guidelines for the selection of tests and a checklist of tests are given in Annex A. Test methods are outlined in Annex B. Test apparatus is described in Annex C.

The test methods described in Annex B are in outline form only. Specific methods should be developed to meet the needs of the particular application.

**Table 2 Optional tests for installation**

| Optional tests                                                                                                                                                                                                                                                                                                             | Reference in this Standard |             |             | Referenced in                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------|-------------|-----------------------------------|
|                                                                                                                                                                                                                                                                                                                            | Principle                  | Procedure   | Apparatus   |                                   |
| Airborne particle count                                                                                                                                                                                                                                                                                                    | <b>4.2.1</b>               | <b>B.1</b>  | <b>C.1</b>  | <b>JIS B 9921</b>                 |
| Airborne particle count for ultrafine particles                                                                                                                                                                                                                                                                            | <b>4.2.1</b>               | <b>B.2</b>  | <b>C.2</b>  | <b>JIS B 9920</b>                 |
| Airborne particle count for macroparticles                                                                                                                                                                                                                                                                                 | <b>4.2.1</b>               | <b>B.3</b>  | <b>C.3</b>  | <b>JIS B 9920</b>                 |
| Airflow test <sup>a)</sup>                                                                                                                                                                                                                                                                                                 | <b>4.2.2</b>               | <b>B.4</b>  | <b>C.4</b>  | <b>JIS B 9920 and ISO 14644-2</b> |
| Air pressure difference test <sup>a)</sup>                                                                                                                                                                                                                                                                                 | <b>4.2.3</b>               | <b>B.5</b>  | <b>C.5</b>  | <b>JIS B 9920 and ISO 14644-2</b> |
| Installed filter system leakage test                                                                                                                                                                                                                                                                                       | <b>4.2.4</b>               | <b>B.6</b>  | <b>C.6</b>  | <b>ISO 14644-2</b>                |
| Airflow direction test and visualization                                                                                                                                                                                                                                                                                   | <b>4.2.5</b>               | <b>B.7</b>  | <b>C.7</b>  | <b>ISO 14644-2</b>                |
| Temperature test                                                                                                                                                                                                                                                                                                           | <b>4.2.6</b>               | <b>B.8</b>  | <b>C.8</b>  | <b>JIS Z 8710</b> <sup>[30]</sup> |
| Humidity test                                                                                                                                                                                                                                                                                                              | <b>4.2.6</b>               | <b>B.9</b>  | <b>C.9</b>  | <b>JIS Z 8806</b> <sup>[31]</sup> |
| Electrostatic and ion generator test                                                                                                                                                                                                                                                                                       | <b>4.2.7</b>               | <b>B.10</b> | <b>C.10</b> |                                   |
| Particle deposition test                                                                                                                                                                                                                                                                                                   | <b>4.2.8</b>               | <b>B.11</b> | <b>C.11</b> |                                   |
| Recovery test                                                                                                                                                                                                                                                                                                              | <b>4.2.9</b>               | <b>B.12</b> | <b>C.12</b> | <b>ISO 14644-2</b>                |
| Containment leak test                                                                                                                                                                                                                                                                                                      | <b>4.2.10</b>              | <b>B.13</b> | <b>C.13</b> |                                   |
| Note <sup>a)</sup> This is a required test based on <b>JIS B 9920</b> and <b>ISO 14644-2</b> . These optional tests are not presented in order of importance. The order in which tests should be performed may be based upon the requirements of a specific document or after agreement between the customer and supplier. |                            |             |             |                                   |

## 4.2 Test items

### 4.2.1 Airborne particle count

This test is performed to determine air cleanliness and may consist of four parts as follows:

- a) cleanliness classification test (see Annex JA);
- b) airborne particle count (optional) (see **B.1**);
- c) ultrafine particle test (optional) (see **B.2**);
- d) macroparticle test (optional) (see **B.3**).

Tests **b**) to **d**) may be used for descriptive purposes or as the basis for a specified requirement, but cannot be used for classification purposes.

### 4.2.2 Airflow test

This test is performed to determine the supply airflow rate in a non-unidirectional cleanroom and the air velocity distribution in a unidirectional cleanroom. Typically, either airflow velocity or airflow rate testing will be performed, and results will be required in only one format: average velocity, average airflow rate or total airflow rate. Total airflow rate may, in turn, be used to determine the air exchange rate (air changes

per hour) for a non-unidirectional installation. The air velocity will be determined in unidirectional cleanrooms. Test procedures for the airflow test are given in **B.4**.

#### **4.2.3 Air pressure difference test**

The purpose of the air pressure difference test is to verify the capability of the cleanroom system to maintain the specified pressure differential between the installation and its surroundings. The air pressure difference test should be performed after the installation has met the acceptance criteria for airflow velocity or volume, airflow uniformity and other applicable tests. Details of the air pressure difference test are given in **B.5**.

#### **4.2.4 Installed filter system leakage tests**

These tests are performed to confirm that the final high efficiency air filter system is properly installed by verifying the absence of bypass leakage in the installation, and that the filters are free of defects (small holes and other damages in the filter medium and frame seal) and leaks (bypass leaks in the filter frame and gasket seal, leaks in the filter bank framework). These tests do not check the efficiency of the system. The tests are performed by introducing an aerosol challenge upstream of the filters and scanning downstream of the filters and support frame or sampling in a downstream duct. Two different leak detection techniques are given in **B.6**.

#### **4.2.5 Airflow direction test and visualization**

The purpose of this test is to confirm either the airflow direction or airflow pattern or both in regard to the design and performance specifications. If required, spatial characteristics of airflow in the installation may also be confirmed. Procedures for this test are given in **B.7**.

#### **4.2.6 Temperature and humidity uniformity tests**

The purpose of these tests is to demonstrate the capability of the cleanroom air-handling system to maintain air temperature and moisture (expressed as relative humidity or dew point) levels within the control limits over the time period specified by the customer for the area being tested. Procedures for these tests are given in **B.8** and **B.9**.

#### **4.2.7 Electrostatic and ion generator tests**

The purpose of these tests is to evaluate electrostatic voltage levels on objects, static-dissipative properties of materials and the performance of ion generators (i.e. ionizers) used for electrostatic control in installations. Electrostatic testing is performed to evaluate the electrostatic voltage level on work and product surfaces, and the static dissipative properties of floors, workbench tops, etc. The ion generator test is performed to evaluate the ionizer performance in eliminating static charges on surfaces. Procedures for these tests are given in **B.10**.

#### **4.2.8 Particle deposition test**

The purpose of this test is to measure the quantity (number or mass) or the effects (light scatter or area coverage) of particles deposited upon surfaces at any orientation. Some procedures for this test are given in **B.11**.

#### 4.2.9 Recovery test

The recovery test is performed to determine whether the installation is capable of returning to a specified cleanliness level within a finite time, after being exposed briefly to a source of airborne particulate challenge. This test is not recommended for unidirectional airflow installations. The procedure for this test is given in **B.12**.

When an artificial aerosol is used, residue contamination of the installation should be avoided.

#### 4.2.10 Containment leak test

This test is performed to determine if there is intrusion of unfiltered air into the cleanroom or clean zone(s) from outside the cleanroom or clean zone enclosure(s) through joints, seams, doorways and pressurized ceilings. The procedure for this test is given in **B.13**.

### 5 Test reports

The result of each test shall be recorded in a test report, and the test report shall include the following information:

- a) name and address of the testing organization, and the date on which the test was performed;
- b) number and year of publication of this Standard;
- c) clear identification of the physical location of the cleanroom or clean zone tested (including reference to adjacent areas if necessary), and specific designations for coordinates of all sampling locations;
- d) specified designation criteria for the cleanroom or clean zone, including the cleanliness classification, the relevant occupancy state(s), and the considered particle size(s);
- e) details of the test method used, with any special conditions relating to the test or departures from the test method, and identification of the test instrument and its current calibration certificate;
- f) test result, including data reported as specifically required in the relevant clause of Annex B or Annex JA, and a statement regarding compliance with the claimed designation;
- g) any other specific requirements defined relevant to the clause of Annex B or Annex JA for particular tests.

## Annex A (informative)

### Choice of recommended tests of a cleanroom and the sequence in which to carry them out

This Annex is to provide information on the choice of recommended tests of a cleanroom and the sequence in which to carry them out, and not to constitute a part of the provisions.

#### A.1 General

The test procedures described in this Annex may be used for demonstrating compliance with the performance criteria of a user-specified installation and for performing periodic testing.

The choice of tests may be based in part on factors such as the design of the installation, operational states and the required level of certification.

The sequence of tests should be determined beforehand between customer and supplier, and should be such as to minimize wasted effort in the event of non-compliance.

#### A.2 Test checklist

Table A.1 provides a checklist of tests and apparatus. Details of the test sequence should be decided upon by agreement between customer and supplier.

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

| Selection of test procedure and sequence <sup>a)</sup> | Test procedure                                                  | Test procedure reference | Selection of test apparatus <sup>b)</sup> | Test apparatus                     | Apparatus reference | Comments |
|--------------------------------------------------------|-----------------------------------------------------------------|--------------------------|-------------------------------------------|------------------------------------|---------------------|----------|
|                                                        | Cleanliness classification (required test)                      | Annex JA                 |                                           | Discrete-particle counter (DPC)    | <b>JIS B 9921</b>   |          |
|                                                        | Airborne particle count for classification and test measurement | <b>B.1</b>               |                                           | Discrete-particle counter (DPC)    | <b>C.1</b>          |          |
|                                                        | Airborne particle count for ultrafine particles                 | <b>B.2</b>               |                                           | Condensation nucleus counter (CNC) | <b>C.2.1</b>        |          |
|                                                        |                                                                 |                          |                                           | Discrete-particle counter (DPC)    | <b>C.2.2</b>        |          |
|                                                        |                                                                 |                          |                                           | Particle size cutoff device        | <b>C.2.3</b>        |          |

**Table A.1** (continued)

| Selection of test procedure and sequence <sup>a)</sup> | Test procedure                                                              | Test procedure reference          | Selection of test apparatus <sup>b)</sup> | Test apparatus                                     | Apparatus reference | Comments |
|--------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------|-------------------------------------------|----------------------------------------------------|---------------------|----------|
|                                                        | Airborne particle count for macroparticles                                  | <b>B.3</b>                        |                                           |                                                    | <b>C.3</b>          |          |
|                                                        | Airborne particle count for macroparticles with particle collection         | <b>B.3.3.2</b>                    |                                           | Microscopic measurement on collected filter paper  | <b>C.3.1</b>        |          |
|                                                        |                                                                             |                                   |                                           | Cascade impactor                                   | <b>C.3.2</b>        |          |
|                                                        | Airborne particle count for macroparticles without particle collection      | <b>B.3.3.3</b>                    |                                           | Discrete-particle counter (DPC)                    | <b>C.3.3</b>        |          |
|                                                        |                                                                             |                                   |                                           | Time-of-flight particle apparatus                  | <b>C.3.4</b>        |          |
|                                                        |                                                                             |                                   |                                           | Piezo-balance impactor                             | <b>C.3.5</b>        |          |
|                                                        | Airflow                                                                     | <b>B.4</b>                        |                                           |                                                    | <b>C.4</b>          |          |
|                                                        | Airflow velocity measurement in unidirectional airflow cleanroom            | <b>B.4.2.2</b> and <b>B.4.2.3</b> |                                           | Thermal anemometer                                 | <b>C.4.1.1</b>      |          |
|                                                        |                                                                             |                                   |                                           | Ultrasonic anemometer, 3-dimensional or equivalent | <b>C.4.1.2</b>      |          |
|                                                        |                                                                             |                                   |                                           | Vane-type anemometer                               | <b>C.4.1.3</b>      |          |
|                                                        |                                                                             |                                   |                                           | Pitot-static tubes and (digital) manometer         | <b>C.4.1.4</b>      |          |
|                                                        | Supply airflow velocity measurement in non-unidirectional airflow cleanroom | <b>B.4.3.2</b> and <b>B.4.3.3</b> |                                           | Thermal anemometer                                 | <b>C.4.1.1</b>      |          |
|                                                        |                                                                             |                                   |                                           | Ultrasonic anemometer, 3-dimensional or equivalent | <b>C.4.1.2</b>      |          |
|                                                        |                                                                             |                                   |                                           | Vane-type anemometer                               | <b>C.4.1.3</b>      |          |
|                                                        |                                                                             |                                   |                                           | Pitot-static tubes and (digital) manometer         | <b>C.4.1.4</b>      |          |
|                                                        | Total airflow rate measurement downstream of installed filters              | <b>B.4.3.2</b>                    |                                           | Integrating volume hood meter                      | <b>C.4.2.1</b>      |          |
|                                                        |                                                                             |                                   |                                           | Orifice meter                                      | <b>C.4.2.2</b>      |          |
|                                                        |                                                                             |                                   |                                           | Venturi meter                                      | <b>C.4.2.3</b>      |          |
|                                                        | Airflow rate measurement in supply air duct                                 | <b>B.4.2.5</b>                    |                                           | Integrating volume hood meter                      | <b>C.4.2.1</b>      |          |
|                                                        |                                                                             |                                   |                                           | Orifice meter                                      | <b>C.4.2.2</b>      |          |
|                                                        |                                                                             |                                   |                                           | Venturi meter                                      | <b>C.4.2.3</b>      |          |
|                                                        |                                                                             |                                   |                                           | Pitot-static tubes and (digital) manometer         | <b>C.4.1.4</b>      |          |

**Table A.1** (continued)

| Selection of test procedure and sequence <sup>a)</sup> | Test procedure                                          | Test procedure reference | Selection of test apparatus <sup>b)</sup> | Test apparatus                                              | Apparatus reference | Comments |
|--------------------------------------------------------|---------------------------------------------------------|--------------------------|-------------------------------------------|-------------------------------------------------------------|---------------------|----------|
|                                                        | Air pressure difference measurement                     | <b>B.5</b>               |                                           | Electronic micro-manometer                                  | <b>C.5.1</b>        |          |
|                                                        |                                                         |                          |                                           | Inclined manometer                                          | <b>C.5.2</b>        |          |
|                                                        |                                                         |                          |                                           | Mechanical differential pressure gauge                      | <b>C.5.3</b>        |          |
|                                                        | Installed filter leakage                                | <b>B.6</b>               |                                           |                                                             | <b>C.6</b>          |          |
|                                                        | Installed filter system leakage scan                    | <b>B.6.2</b>             |                                           | Discrete-particle counter (DPC)                             | <b>C.6.1</b>        |          |
|                                                        |                                                         |                          |                                           | Aerosol generator                                           | <b>C.6.2</b>        |          |
|                                                        |                                                         |                          |                                           | Aerosol source substances                                   | <b>C.6.3</b>        |          |
|                                                        |                                                         |                          |                                           | Dilution system                                             | <b>C.6.4</b>        |          |
|                                                        |                                                         |                          |                                           | Condensation nucleus counter                                | <b>C.2.1</b>        |          |
|                                                        | Test for filters mounted in ducts or air-handling units | <b>B.6.3</b>             |                                           | Discrete-particle counter (DPC)                             | <b>C.6.1</b>        |          |
|                                                        |                                                         |                          |                                           | Aerosol generator                                           | <b>C.6.2</b>        |          |
|                                                        |                                                         |                          |                                           | Aerosol source substances                                   | <b>C.6.3</b>        |          |
|                                                        |                                                         |                          |                                           | Dilution system                                             | <b>C.6.4</b>        |          |
|                                                        |                                                         |                          |                                           | Condensation nucleus counter                                | <b>C.2.1</b>        |          |
|                                                        | Airflow direction and visualization                     | <b>B.7</b>               |                                           | Visualization apparatus for tuft or tracer injection method | <b>C.7.1</b>        |          |
|                                                        |                                                         |                          |                                           | Thermal anemometer                                          | <b>C.7.2</b>        |          |
|                                                        |                                                         |                          |                                           | Ultrasonic anemometer 3-dimensional                         | <b>C.7.3</b>        |          |
|                                                        |                                                         |                          |                                           | Ultrasonic nebulizer                                        | <b>C.7.4.1</b>      |          |
|                                                        |                                                         |                          |                                           | Fog generator                                               | <b>C.7.4.2</b>      |          |
|                                                        | Temperature                                             | <b>B.8</b>               |                                           |                                                             | <b>C.8</b>          |          |
|                                                        | General temperature                                     | <b>B.8.2.1</b>           |                                           | Glass thermometer                                           | <b>C.8.1</b>        |          |
|                                                        |                                                         |                          |                                           | Thermometer                                                 | <b>C.8.2</b>        |          |
|                                                        |                                                         |                          |                                           | Resistance temperature device                               | <b>C.8.3</b>        |          |
|                                                        |                                                         |                          |                                           | Thermistor                                                  | <b>C.8.4</b>        |          |
|                                                        | Comprehensive temperature                               | <b>B.8.2.2</b>           |                                           | Glass thermometer                                           | <b>C.8.1</b>        |          |
|                                                        |                                                         |                          |                                           | Thermometer                                                 | <b>C.8.2</b>        |          |
|                                                        |                                                         |                          |                                           | Resistance temperature device                               | <b>C.8.3</b>        |          |
|                                                        |                                                         |                          |                                           | Thermistor                                                  | <b>C.8.4</b>        |          |

**Table A.1** (concluded)

| Selection of test procedure and sequence <sup>a)</sup>                                                                                        | Test procedure                  | Test procedure reference | Selection of test apparatus <sup>b)</sup> | Test apparatus                  | Apparatus reference | Comments |
|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------------|-------------------------------------------|---------------------------------|---------------------|----------|
|                                                                                                                                               | Humidity                        | <b>B.9</b>               |                                           | Humidity monitor, capacitive    | <b>C.9.1</b>        |          |
|                                                                                                                                               |                                 |                          |                                           | Humidity monitor, hair          | <b>C.9.2</b>        |          |
|                                                                                                                                               |                                 |                          |                                           | Dew point sensor                | <b>C.9.3</b>        |          |
|                                                                                                                                               |                                 |                          |                                           | Psychrometer                    | <b>C.9.4</b>        |          |
|                                                                                                                                               | Electrostatic and ion generator | <b>B.10</b>              |                                           |                                 | <b>C.10</b>         |          |
|                                                                                                                                               | Electrostatic                   | <b>B.10.2.1</b>          |                                           | Electrostatic voltmeter         | <b>C.10.1</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | High resistance ohmmeter        | <b>C.10.2</b>       |          |
|                                                                                                                                               | Ion generator                   | <b>B.10.2.2</b>          |                                           | Electrostatic voltmeter         | <b>C.10.1</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | High resistance ohmmeter        | <b>C.10.2</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | Charged plate monitor           | <b>C.10.3</b>       |          |
|                                                                                                                                               | Particle deposition             | <b>B.11</b>              |                                           | Witness plate                   |                     |          |
|                                                                                                                                               |                                 |                          |                                           | Binocular compound microscope   |                     |          |
|                                                                                                                                               |                                 |                          |                                           | Particle fallout photometer     | <b>C.11.1</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | Surface particle counter        | <b>C.11.2</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | Particle generator              | <b>C.11.3</b>       |          |
|                                                                                                                                               | Recovery                        | <b>B.12</b>              |                                           | Discrete-particle counter (DPC) | <b>C.12.1</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | Aerosol generator               | <b>C.12.2</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | Dilution system                 | <b>C.12.3</b>       |          |
|                                                                                                                                               | Containment leak                | <b>B.13</b>              |                                           |                                 | <b>C.13</b>         |          |
|                                                                                                                                               | DPC method                      | <b>B.13.2.1</b>          |                                           | Discrete-particle counter (DPC) | <b>C.13.1</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | Aerosol generator               | <b>C.13.2</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | Dilution system                 | <b>C.13.3</b>       |          |
|                                                                                                                                               | Photometer method               | <b>B.13.2.2</b>          |                                           | Photometer                      | <b>C.13.4</b>       |          |
|                                                                                                                                               |                                 |                          |                                           | Aerosol generator               | <b>C.13.2</b>       |          |
| Notes <sup>a)</sup> In the boxes of column 1 of table A.1, test planners can number the selected test methods according to the test sequence. |                                 |                          |                                           |                                 |                     |          |
| <sup>b)</sup> In the fourth column, test planners can select test apparatus according to the test method selected.                            |                                 |                          |                                           |                                 |                     |          |

## **Annex B (informative)**

### **Test methods**

This Annex is to provide information on test methods, and is not to constitute a part of the provisions.

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

##### **B.1.1 Principle**

Airborne particle count is carried out for the purpose of monitoring cleanrooms and measuring airborne particle concentrations of required locations. This test method specifies the measurement of airborne particle concentrations with size distributions having a threshold size between 0.1  $\mu\text{m}$  and 5  $\mu\text{m}$ .

##### **B.1.2 Test procedure**

###### **B.1.2.1 General**

The number of sample points, location selection, and the quantity of data required should be decided as required. **B.1** provides reference methods for air sampling at each sample point location.

Other appropriate methods of equivalent accuracy and which provide equivalent data may be used by agreement between customer and supplier.

NOTE : Where detailed information on cleanroom testing using a discrete-particle counter (DPC) is required or further information on DPC standards is required, **JIS B 9921** and the standard methods (references [2], [3], [4], [11], [23], [28]) may be referred to and used.

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

Install the DPC intake at the specified sampling location, and set up the DPC flow rate. In areas of unidirectional airflow, set the sampling probe inlet facing into the predominant direction of the airflow. A sampling probe should be selected to permit close to isokinetic sampling in areas with unidirectional flow<sup>[1]</sup>. The sample probe velocity should not differ from sampled air velocity by more than 20 %. In locations where sampled airflow being sampled is not controlled or predictable (e.g. non-unidirectional airflow), the inlet of the sampling probe shall be directed vertically upward.

The sampling system to be connected to the DPC sensor should be within 5 % in loss due to tubes, etc. and the tube length should be as short as possible. This should be given particular attention for sampling of particles larger than and equal to 1  $\mu\text{m}$ .

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

The counter should be the particle counter specified in **JIS B 9921**. The DPC should be capable of displaying or recording the particle count in those size ranges, and should have a valid calibration certificate, as described in **JIS B 9921**.

#### B.1.4 Test reports

By agreement between customer and supplier, the following information and data and the test report in clause 5 should be recorded:

- a) type of measurement;
- b) cleanliness classification of the cleanroom;
- c) occupancy state(s);
- d) sampling location(s);
- e) sampling protocol for classification or sampling plan for monitoring;
- f) particle size range(s) and counts;
- g) DPC inlet sampled flow rate and flow rate through the sensing chamber volume (flow rate of the sample to be measured);
- h) background noise count rate for the DPC;
- i) other data relevant for measurement.

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

#### B.2.1 Principle

##### B.2.1.1 General

This test method specifies the measurement of airborne particle concentrations with size distributions having threshold sizes smaller than  $0.1\ \mu\text{m}$ ; that concentration is referred to as the U descriptor<sup>[12]</sup>. Measurements can be made in a cleanroom in any of the three designated occupancy states. The measurements are made to define the concentration of ultrafine particles in the cleanroom in accordance with Annex D of **JIS B 9920**.

##### B.2.1.2 Counting efficiency

The counting efficiency of the system used to measure a U descriptor should fall within the shaded envelope region shown in figure B.1<sup>[12]</sup>. Here, the abscissa indicates the particle size to be measured ( $\mu\text{m}$ ), and the ordinate the counting efficiency (%) at a particle size threshold value U. The figure shows the counting efficiency characteristic range permitted when particles in the range of particle size  $0.5U$  to  $5U$  are measured at the particle size threshold value “U” on a base of the counting efficiency of 50 % at the particle size threshold value U. It includes a tolerance band of  $\pm 10\%$  of the ultrafine particle size, shown as sizes “ $0.9U$ ” and “ $1.1U$ ” in figure B.1. The acceptable minimum and maximum counting efficiencies for particles above and below the  $\pm 10\%$  size tolerance band are based on the calculated penetration of a diffusion element having at least 40 % penetration efficiency for particles 10 % larger than the defined ultrafine particle size and at least 60 % penetration efficiency for particles 10 % smaller than the defined ultrafine particle size.

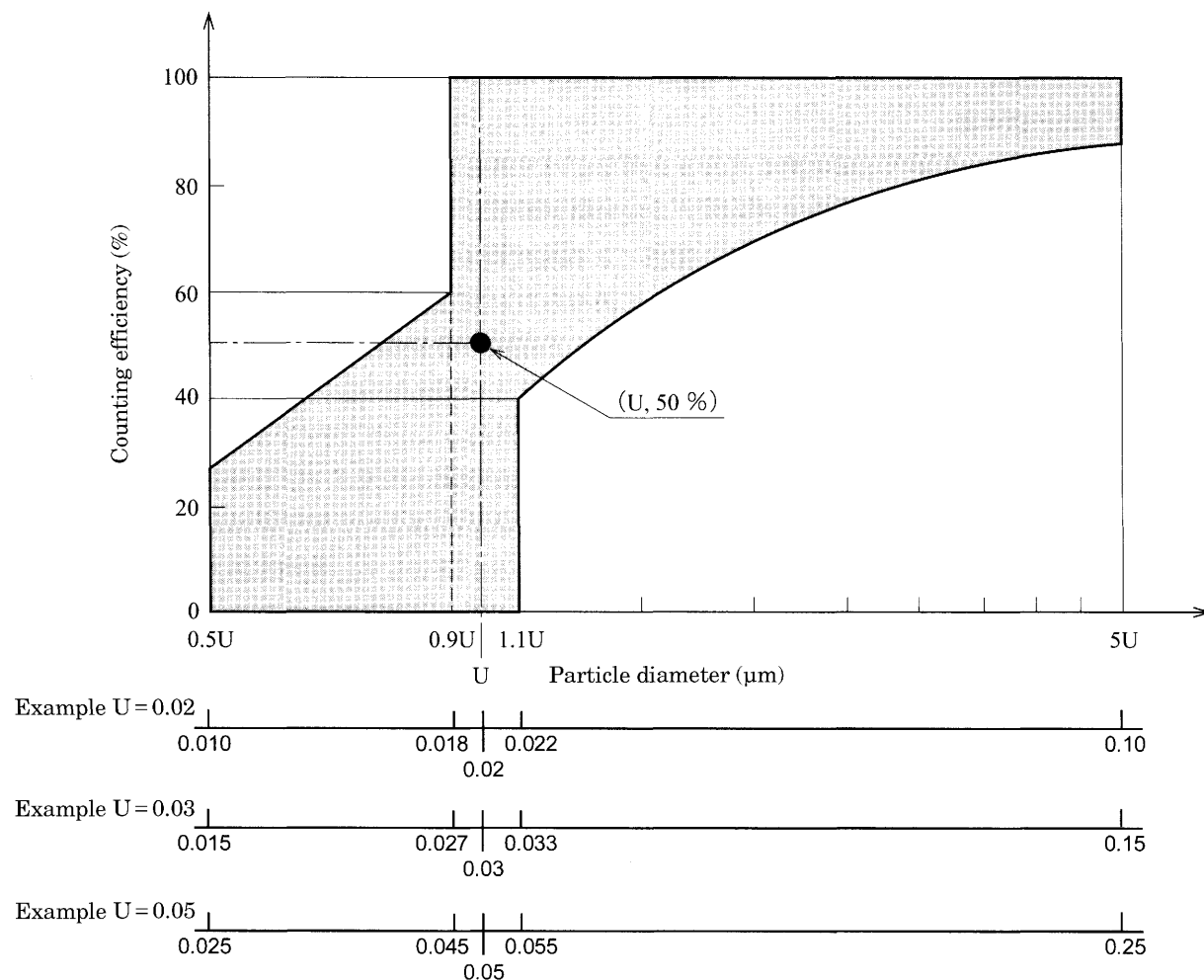


**Figure B.1 Acceptability envelope for the counting efficiency of selected apparatus**

If the DPC or condensation nucleus counter (CNC) has a counting efficiency curve that falls to the right of the shaded envelope of figure B.1, the DPC or CNC should not be used to measure or verify the  $U$  descriptor. If the curve falls to the left of the shaded envelope, the counting efficiency can be decreased by modifying it with a particle size cutoff device as described in **B.2.1.3**. In this case, the counting efficiency of the modified DPC or CNC becomes the product of the counting efficiency of the unmodified DPC or CNC and the fractional penetration of the particle size cutoff device.

### B.2.1.3 Particle size cutoff device

To achieve the desired counting efficiency characteristic required to measure or verify a  $U$  descriptor, a particle size cutoff device can be attached to the sample inlet of the DPC or CNC whose counting efficiency curve falls to the left of the shaded envelope of figure B.1. The counting efficiency curve of the combined DPC or CNC, sample inlet, and particle size cutoff device will be modified to fall within the required shaded envelope of figure B.1.

Particle size cutoff devices remove particles smaller than a defined size, reducing penetration in a well-defined and reproducible manner. A wide variety of sizes and configurations of particle size cutoff devices are available and acceptable, provided that

they produce the required penetration characteristics. As suitable particle size cutoff devices, diffusion battery elements and other such devices can be used. Penetration is a function of particle physical properties, device configuration and volumetric flow rate. Care is required with all particle size cutoff devices to ensure that they be used only at the flow rates for which they were designed and that they are installed so as to avoid accumulation of electrostatic charge which would lead to adhesion of particles. Charge accumulation can be minimized by ensuring that the particle size cutoff device is suitably electrically grounded.

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

Set up the sample inlet probe of the DPC or CNC (with the particle size cutoff device, if required). The sampling of ultrafine particles with a small sampling flow rate and long sampling tube can cause a significant diffusion loss. The sampling error due to ultrafine particles loss by diffusion should be no greater than 5 %. Calculate the U descriptor concentrations in the defined ultrafine particle size ranges, as agreed upon between customer and supplier, and report the data. Where information on stability of ultrafine particle concentration is required, make three or more measurements at selected locations at time intervals, as agreed upon between the customer and the supplier.

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

DPC as described in **C.2.2** or CNC as described in **C.2.1** is used. If a DPC is used, it should have a capability for accurate particle size definition up to at least 0.3  $\mu\text{m}$ . The threshold size counting efficiency for the DPC or CNC should be defined in accordance with figure B.1. If a DPC or CNC is used that is capable of detecting particles smaller than the desired size, a particle size cutoff device, with known particle size penetration performance, as described in **B.2.1.3**, should be used.

### **B.2.4 Test reports**

By agreement between customer and supplier, the following information and data should be recorded as described in clause 5 for measuring the U descriptor of the cleanroom:

- a) type of measurement: U descriptor measurement or monitoring;
- b) cleanliness classification of the cleanroom;
- c) occupancy state(s);
- d) sample point location(s);
- e) sampling plan for determination or sampling plan for testing, as specified;
- f) ultrafine particle size threshold defined for the U descriptor data;
- g) ultrafine particle measurement system inlet and sensing volume flow rates (sample flow rate to be measured);
- h) identification of the DPC or CNC and particle size cutoff device, if used, and the calibration status;

- i) background noise count rate for the DPC or CNC, when used;
- j) particle size cutoff device performance data, as required;
- k) other data relevant for measurement.

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

#### **B.3.1 Principle**

This test method describes the measurement of airborne particles with a threshold size larger than 5 µm in diameter (hereafter referred to as “macroparticles”). The concentration in this particle size range is indicated by M indicator<sup>[13]</sup>. Measurements can be made in a cleanroom in any of the three designated occupancy states. The measurements are made to define the concentration of macroparticles in clean areas in accordance with **JIS B 9920**, Annex D. The need for proper sample acquisition and handling to minimize losses of macroparticles in the sample handling operations is emphasized.

#### **B.3.2 Sampling handling considerations**

Careful sample collection and handling is required when working with macroparticles. For a complete discussion of the requirements for systems, which can be used for isokinetic or anisokinetic sampling and particle transport to the point of measurement, references [1] and [13] should be referred to.

#### **B.3.3 Measurement methods for macroparticles**

##### **B.3.3.1 General**

There are two general categories of macroparticle measurement methods. Comparable results may not be produced if different measurement methods are used. Correlation between different methods may not be possible for this reason. The particle size information produced by the various methods is summarized here:

##### **a) Measurement by collection**

- 1) filter collection and microscopic measurement (**B.3.3.2.1**) will report macroparticles using particle size based upon the agreed diameter;
- 2) cascade impactor collection and microscopic measurement [**B.3.3.2.2 a**)] will report macroparticles using particle size based upon the microscopist’s choice of reported particle diameter;
- 3) cascade impactor collection and weight measurement [**B.3.3.2.2 b**)] will report macroparticles using particle size based upon an aerodynamic diameter;

##### **b) Measurement of particles suspended in air**

- 1) DPC measurement (**B.3.3.3.2**) will report macroparticles using particle size based upon an equivalent optical diameter;
- 2) time-of-flight particle size measurement (**B.3.3.3.3**) will report macroparticles using particle size based upon an aerodynamic diameter.

### B.3.3.2 Macroparticle measurement with particle collection

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

Select a membrane filter and a holder or a pre-assembled aerosol monitor; a membrane filter with pore size of approximately  $0.8\ \mu\text{m}$  should be used. Label the filter holder to identify the filter holder location and installation. Connect the outlet to a vacuum source that will draw air at the required flow rate. If the sample location in which macroparticle concentration is to be determined is a unidirectional flow area, the flow rate should be established to permit isokinetic sampling into the filter holder or aerosol monitor inlet and the inlet should face into the unidirectional flow.

In un-unidirectional cleanrooms, the filter holder or aerosol monitor inlet should be located to face vertically upward. For cleanrooms operating at class 6 (see **JIS B 9920**) and cleaner, the sampled air volume should be no less than  $0.28\ \text{m}^3$ . For cleanrooms operating less clean than class 6, the sampled air volume should be no less than  $0.028\ \text{m}^3$ .

Remove the cover from the membrane filter holder or aerosol monitor and store in a clean location. Sample the air at the sample point locations as determined by agreement between the customer and supplier. If a portable vacuum pump is used to draw air through the membrane filter, the exhaust from that pump should be vented outside the cleanroom or through a suitable filter. After the sample collection has been completed, replace the cover on the filter holder or aerosol monitor. The sample holder should be transported in such a manner that the filter membrane is maintained in a horizontal position at all times and is not subjected to vibration or shock between the time the sample is captured and when it is analyzed. Count the particles on the filter surface (see reference [4]).

The measurement by optical microscopy is shown in Annex JB.

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

In the case of cascade impactors, the sampled airflow passes through a series of jets of decreasing orifice size. The larger particles are deposited directly below the largest orifices and smaller particles are deposited at each successive stage of the impactor. Two types of cascade impactors can be used for collection of macroparticles.

In one, the particles are deposited upon the surfaces of removable plates that are removed for subsequent weighing or microscopic examination. Sampling flow rates of  $0.000\ 47\ \text{m}^3/\text{s}$  ( $28.3\ \text{L}/\text{min}$ ) or more are typically used for this type of cascade impactor.

In the other type, the particles are deposited upon piezo-electric quartz microbalance mass sensors, which weigh the particles collected by each impactor stage. This cascade impactor type usually uses significantly smaller flow rates.

- a) For the first type of cascade impactor, the initial tare weight of each collection stage is recorded or a tare number of particles per unit area of each stage are counted before any measurements are made. The impactor is operated for a period of 10 min or more. At the end of that time, it is sealed and moved to the balance or microscope for evaluation. The collection stages are removed and the weight or number of particles accumulated upon each stage capable of collecting macroparticles is recorded. The macroparticle concentration is then defined as the total weight or number on the pertinent impactor stages divided by the total airflow, which was passed through the impactor.