INTERNATIONAL STANDARD 国际标准

Second edition 第二版
2019-08

ISO 14644-3

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

洁净室及相关受控环境-----
第 3 部分: 检测方法

Salles propres et environnements maîtrisés apparentés — Partie 3: Méthodes d'essai

Reference number ISO 14644-3:2019(E)

ISO 14644-3:2019(E)

Contents 目录

Foreword 前言

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

ISO（国际标准化组织）为全球各国标准化组织（ISO 成员）的联合会。起草制订国际标准的工作通常是通过 ISO 技术委员会完成的。各成员组织若对技术委员会的某个课题感兴趣，均有权参加该技术委员会的工作。国际上凡与 ISO 保持联系的政府的或是非政府的组织，均可参加此项工作。ISO 在电气技术标准化的各项事宜中，与国际电气技术委员会（IEC）有着紧密合作。

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

本文件起草及进一步维护依据程序为 ISO/IEC 指令第 1 部分。尤其要注意的是不同类 ISO 文件所需的批准标准是不同的。本文件根据 ISO/IEC 指令第 2 部分编辑规定起草。

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

请注意本文件的某些内容可能涉及专利权。ISO 不对识别任何或全部这类专利权负责。在文件制订过程中所识别的所有专利权详细信息将在前言和/或所收到的 ISO 专利声明清单中列出（参见 www.iso.org/patents）。

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

本文件中用到的所有商标名称仅为方便用户所提供的信息，并非背书或指定。

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

关于标准自愿属性的解释，ISO 专用术语的信息以及与符合性评估有关的表述，和 ISO 遵守 WHO 贸易技术壁垒（TBT）原则的信息，参见 www.iso.org/iso/foreword.html。

This document was prepared by ISO/TC 209, *Cleanrooms and associated controlled environments*.

本文件由 ISO/TC 209“洁净室和相关受控环境”起草。

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

所有对本文件的反馈或问题均应提交给用户所在国标准组织机构。在网站 www.iso.org/members.html 上可找到这些机构的完整清单。

This second edition of ISO 14644-3 cancels and replaces the first edition (ISO 14644-3:2005), which has been technically revised. The main changes compared to the previous edition are as follows:

本文件为 ISO14644-3 的第二版，取代第一版（ISO 14644:2005）。本版本在前版基础上进行了技术内容修订。与前版本相比，主要变化有：

— Clause B.7 has been simplified and corrected to address concerns over its complexity and noted errors;

— 简化第 B.7 条，纠正为解决其复杂质关切和所注意到的错误；

— guidance concerning classification of air cleanliness by airborne particle concentration has been moved to 14644-1[1]

— 对根据空气尘粒浓度进行空气洁净度分级相关的指南已转至 14644-1。

— the text of the whole document has been revised or clarified to aid in application.

— 整个文件正文内容进行了修订或澄清，以帮助应用。

A list of all parts in the ISO 14644 series can be found on the ISO website.

可在 ISO 官网上找到 ISO 14644 系列的所有部分。

Introduction 引言

Cleanrooms and associated controlled environments provide control of contamination to levels appropriate for accomplishing contamination-sensitive activities. Products and processes that benefit from the control of airborne contamination include those in such industries as aerospace, microelectronics, pharmaceuticals, medical devices, healthcare and food.

洁净室及相关受控环境通过将污染控制至适当水平来完成对污染敏感的活动。受益于空气尘粒污染控制的产品和工艺包括行业有如航空、微电子、药品、医疗器械、医疗和食品。

This document sets out appropriate test methods for measuring the performance of a cleanroom, a clean zone or an associated controlled environment, including separative devices and controlled zones, together with all associated structures, air treatment systems, services and utilities.

本文件设定了适当的方法测量洁净室、洁净区或相关受控环境的性能，包括隔离装置和受控区域，与所有相关构造一起、空气处理系统、服务和公用系统。

NOTE Not all cleanroom parameter test procedures are shown in this document. The procedure and apparatus for the test carried out for the air cleanliness classes by particle concentration and for macroparticles are provided in ISO 14644-1,[1] and specifications for monitoring air cleanliness by nanoscale particle concentrations are provided in ISO 14644-12.[8] The procedures and apparatus to characterize other parameters, of concern in cleanrooms and clean zones used for specific products or processes, are discussed elsewhere in other documents prepared by ISO/TC 209 [for example, procedures for control and measurement of viable materials (ISO 14698 series), testing cleanroom functionality (ISO 14644-4[3]), and testing of separative devices (ISO 14644-7[4])]. In addition, other standards can be considered to be applicable. Other cleanliness attribute levels can be determined using ISO 14644-8[5] (levels of air cleanliness by chemicals), ISO 14644-9[6] (levels of surface cleanliness by particle concentration) and ISO 14644-10[7] (levels of surface cleanliness by chemical concentration).

注：本文件并未展示所有洁净室参数检测程序。根据空气中微粒浓度进行洁净分级的测试方法和仪器已归入 ISO 14644-1 中，纳米级颗粒浓度空气洁净度监测标准归入 ISO 14644-12 中。确定其它与特定产品或工艺用洁净室和洁净区有关的参数的方法和仪器在 ISO/TC 209 起草的其它文件中另行讨论【例如，微生物控制和检测（ISO 14698 系列）、洁净间功能检测（ISO 14644-4），以及隔离装置检测（ISO 14644-7）】。另外，亦可考虑其它适用标准。其它洁净级别属性级别可采用 ISO 14644-8（根据化学物质确定的空气洁净度水平）、ISO 14644-9（根据颗粒浓度确定的表面洁净度水平）以及 ISO14644-10（根据化学物质浓度确定的表面洁净度水平）。

Cleanrooms and associated controlled environments —

Part 3:

Test methods

洁净间与相关受控环境----第 3 部分：检测方法

1 Scope 范围

This document provides test methods in support of the operation for cleanrooms and clean zones to meet air cleanliness classification, other cleanliness attributes and related controlled conditions.

本文件规定了支持洁净间和洁净区符合洁净级别、其它洁净属性和相关受控条件操作的检测方法。

Performance tests are specified for two types of cleanrooms and clean zones: those with unidirectional airflow and those with non-unidirectional airflow, in three possible occupancy states: as-built, at-rest and operational.

性能测试分为两种洁净间和洁净区：单向流和非单向流，和三种占有状态：空态、静态和动态。

The test methods, recommended test apparatus and test procedures for determining performance parameters are provided. Where the test method is affected by the type of cleanroom or clean zone, alternative procedures are suggested.

性能参数检测方法中提供了提供了检测仪器和检测程序建议。如果检测方法受到洁净室或洁净间类别影响，建议采用其它程序。

For some of the tests, several different methods and apparatus are recommended to accommodate different end-use considerations. Alternative methods not included in this document can be used by agreement between customer and supplier. Alternative methods do not necessarily provide equivalent measurements.

对于有些测试，建议采用不同方法和仪器以适合不同终端使用考量。如果客户与供应商之间达成协议，可使用本文件中未录入的替代方法。替代方法不必要提供等同的测量值。

This document is not applicable to the measurement of products or of processes in cleanrooms, clean zones or separative devices.

本文件不适用于洁净间、洁净区或隔离装置中产品或工艺的测量。

NOTE This document does not purport to address safety considerations associated with its use (for example, when using hazardous materials, operations and equipment). It is the responsibility of the user of this document to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

注：本文件无意解决其使用过程中的安全考量（例如，使用有害物料、操作和设备时）。本文件的使用者有义务建立适当的安全和卫生规范，在使用之前确定法规限度的适用性。

2 Normative references 引用标准

There are no normative references in this document.

本文件中未引用标准。

3 Terms and definitions 术语和定义

For the purposes of this document, the following terms and definitions apply.

本文件涉及术语和定义如下：

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

ISO 和 IEC 维护以下网址内的标准化所用术语数据库：

— ISO Online browsing platform: available at https://www.iso.org/obp

— ISO 在线浏览平台 https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

— IEC 电子百科 http://www.electropedia.org/

3.1 General terms 一般术语

3.1.1 Cleanroom 洁净间

room within which the number concentration of *airborne particles* (3.2.1) is controlled and classified, and which is designed, constructed and operated in a manner to control the introduction, generation and retention of particles inside the room

空气悬浮粒子数字浓度受控和分级的房间，其设计、建造和操作模式可控制引入、生成和滞留粒子于房间内。

Note 1 to entry: The class of airborne *particle concentration* (3.2.4) is specified.

注 1：空气悬浮粒子的级别已有规定。

Note 2 to entry: Levels of other cleanliness attributes such as chemical, viable or nanoscale concentrations in the air, and also surface cleanliness in terms of particle, nanoscale, chemical and viable concentrations might also be specified and controlled.

注 2：其它洁净属性水平如空气中化学物、微生物或纳米级浓度，以及表面洁净度方面的粒子、纳米级、化学物和微生物浓度亦可指定并受控。

Note 3 to entry: Other relevant physical parameters might also be controlled as required, e.g. temperature, humidity, pressure, vibration and electrostatic.

注 3：必要时亦可控制其它相关物理参数，如温度、湿度、压力、震动和静电。

[SOURCE: ISO 14644-1:2015, 3.1.1]

【来源：ISO 14644-1:2015, 3.1.1】

3.1.2 clean zone 洁净区

defined space within which the number concentration of *airborne particles* (3.2.1) is controlled and classified, and which is constructed and operated in a manner to control the introduction, generation and retention of contaminants inside the space

空气悬浮粒子数字浓度受控和分级的封闭空间，其设计、建造和操作模式可控制引入、生成和滞留粒子于该空间内。

Note 1 to entry: The class of airborne *particle concentration* (3.2.4) is specified.

注 1：空气悬浮粒子的级别已有规定。

Note 2 to entry: Levels of other cleanliness attributes such as chemical, viable or nanoscale concentrations in the air, and also surface cleanliness in terms of particle, nanoscale, chemical and viable concentrations might also be specified and controlled.

注 2：其它洁净属性水平如空气中化学物、微生物或纳米级浓度，以及表面洁净度方面的粒子、纳米级、化学物和微生物浓度亦可指定并受控。

Note 3 to entry: A clean zone(s) can be a defined space within a *cleanroom* (3.1.1) or might be achieved by a separative device. Such a device can be located inside or outside a cleanroom.

注 3：洁净区可以是一个洁净间内的封闭空间，亦可由一个隔离装置支持。此类装置可以安放在洁净间内外。

Note 4 to entry: Other relevant physical parameters might also be controlled as required, e.g. temperature, humidity, pressure, vibration and electrostatic.

注 4：其它相关物理参数亦可按要求进行控制，例如温度、湿度、压力、震动和静电。

[SOURCE: ISO 14644-1:2015, 3.1.2]

【来源：ISO 14644-1:2015, 3.1.2】

3.1.3 Installation 洁净设施

cleanroom (3.1.1) or one or more *clean zones* (3.1.2), together with all associated structures, air-treatment systems, services and utilities

洁净间或一个或多个洁净区，与其所有相关结构、空气处理系统、服务设施和公用系统一起称为洁净设施。

[SOURCE: ISO 14644-1:2015, 3.1.3]

【来源：ISO 14644-1:2015, 3.1.3】

3.1.4 separative device 隔离装置

equipment utilizing constructional and dynamic means to create assured levels of separation between the inside and outside of a defined volume

采用构造和动力学方法在密闭容积内外之间创建可靠隔离水平的设备。

Note 1 to entry: Some industry-specific examples of separative devices are clean air hoods, containment enclosures, glove boxes, isolators and mini-environments.

注 1：有些行业专用隔离装置例子有层流罩、隔离密封空间、手套箱、隔离器和微环境。

[SOURCE: ISO 14644-7:2004, 3.17]

【来源：ISO 14644-7:2004, 3.17】

3.1.5 Resolution 分辨率

smallest change in a quantity being measured that causes a perceptible change in the corresponding indication

引起可察觉对应显示的最小测量值。

Note 1 to entry: Resolution can depend on, for example, noise (internal or external) or friction. It may also depend on the value of a quantity being measured.

注 1：分辨率取决于，例如，噪声（内部或外部）或摩擦。亦可能取决于被测量值。

[SOURCE: ISO 14644-1:2015, 3.4.1]

【来源：ISO 14644-1:2015, 3.4.1】

3.1.6 Sensitivity 灵敏度

quotient of the change in an indication of a measuring system and the corresponding change in a value of the quantity being measured

测量系统显示变化值与被测量值对应变化值的比值。

3.2 Terms related to airborne particles 与空气悬浮粒子有关的术语

3.2.1 airborne particle 悬浮粒子

solid or liquid object suspended in air, viable or non-viable, sized between 1 nm and 100 µm

悬浮在空气中的、粒径从 1 nm 到 100µm 的液态或固态微生物或尘埃粒子。

Note 1 to entry: For classification purposes, refer to ISO 14644-1:2015, 3.2.1.

注 1：在分级时参考 ISO 14644-1:2015, 3.2.1。

3.2.2 count median particle diameter 计数中径

median particle diameter based on the number of particles

根据粒子数量得出的粒径中值

Note 1 to entry: 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.

注 1：粒径中值即一半的粒子粒径小于数量中值，一半的粒子粒径大于数量中值

3.2.3 mass median particle diameter 质量中径

median particle diameter based on the particle mass

根据粒子质量得出的粒径中值

Note 1 to entry: 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.

注 1：质量中径即所有粒子总质量的一半来自小于质量中值的粒子，另一半来自大于质量中值的粒子

3.2.4 particle concentration 粒子浓度

number of individual particles per unit volume of air

单位体积空气中的粒子个数

[SOURCE: ISO 14644-1:2015, 3.2.3]

【来源：ISO 14644-1:2015, 3.2.3】

3.2.5 particle size 粒径

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

在指定的粒子尺寸测定仪上，有相当于被测粒子的响应的球体的直径

Note 1 to entry: For light-scattering airborne-particle instruments, the equivalent optical diameter is used.

注 1：光散射尘埃粒子计数装置使用的当量光学直径

[SOURCE: ISO 14644-1:2015, 3.2.2]

【来源：ISO 14644-1:2015, 3.2.2】

3.2.6 particle size distribution 粒径分布

cumulative distribution of *particle concentration* (3.2.4) as a function of *particle size* (3.2.5)

粒子浓度的累积分布，是粒径的函数

[SOURCE: ISO 14644-1:2015, 3.2.4]

【来源：ISO 14644-1:2015, 3.2.4】

3.2.7 test aerosol 测试用气溶胶

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

具备已知和受控粒径分布和浓度的固体和/或液体粒子气态悬浮物

3.3 Terms related to air filters and systems 与空气过滤器和系统有关的术语

3.3.1 aerosol challenge 气溶胶测试

challenging of a filter or an *installed filter system* (3.3.6) by *test aerosol* (3.2.7)

用测试用气溶胶对过滤器或已安装的过滤器系统进行检测

3.3.2 designated leak 规定泄漏

maximum allowable penetration, which is determined by agreement between customer and supplier, through a *leak* (3.3.8), detectable during *scanning* (3.3.9) of a filter *installation* (3.1.3) with light-scattering airborne-particle counters (LSAPC) or *aerosol photometers* (3.6.2)

客户与建造商商定的最大允许穿透限值。用光散射粒子计数器（LSAPC）或气溶胶光度计对洁净室设施进行扫描时可检测到的泄漏。

3.3.3 dilution system 稀释系统

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

按已知容积比将进入的气溶胶与无粒子空气混合以降低气溶胶浓度的系统

3.3.4 filter system 过滤器系统

assembly composed of filter, frame and other support mechanism or other housing

由过滤器、框架及其他支撑装置或外壳所组成的系统

3.3.5 final filter 终端过滤

filter in a final position before the air enters the *cleanroom* (3.1.1) or *clean zone* (3.1.2)

处于空气进入洁净室前终端位置上的过滤器

3.3.6 installed filter system 已安装过滤系统

filter system (3.3.4) mounted in the ceiling, wall, apparatus or duct

已安装在天花板、墙壁、网管或设备上的过滤器系统

3.3.7 installed filter system leakage test 已安装过滤器检漏

test performed to confirm that the filters are properly installed by verifying that there is absence of bypass leakage of the filter *installation* (3.1.3), and that the filters and the grid system are free of defects and *leaks* (3.3.8)

为确认过滤器安装良好、没有向洁净室设施的旁路渗漏，过滤器及其框架均无缺陷和渗漏所做的检测

3.3.8 Leak 泄漏

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

（过滤器系统）因密封性欠佳或缺陷使污染物漏出，造成下风向浓度超出预期值

3.3.9 Scanning 扫描

method for disclosing *leaks* (3.3.8) in filters and parts of units, whereby the probe inlet of an *aerosol photometer* (3.6.2) or a light-scattering airborne-particle counter is moved in overlapping strokes across the defined test area

用气溶胶光度计或光散射粒子计数器的采样管、采取重叠的行程移过规定的检测区，以发现过滤器泄漏的方法

3.4 Terms related to airflow and other physical states 与气流和其它物理状态有关的术语

3.4.1 air change rate air exchange rate 换气率

rate expressing 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 *cleanroom* (3.1.1) or *clean zone* (3.1.2)

单位时间的换气率，以单位时间送入空气的体积除以空间的体积计算

3.4.2 measuring plane 测量截面

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

用来检测或测量风速等性能参数的横断面

3.4.3 non-unidirectional airflow 非单向流

air distribution where the supply air entering the *cleanroom* (3.1.1) or *clean zone* (3.1.2) mixes with the internal air by means of induction

送入洁净间/区的送风以诱导方式与区内空气混合的气流分布类型

[SOURCE: ISO 14644-1:2015, 3.2.8]

【来源：ISO 14644-1:2015, 3.2.8】

3.4.4 supply air volume flow rate 送风量

air volume per unit of time supplied into a *cleanroom* (3.1.1) or *clean zone* (3.1.2) from *final filters* (3.3.5) or air ducts

在单位时间内从风管或从终端过滤器送入洁净室设施的风量

3.4.5 total air volume flow rate 总风量

air volume per unit of time that passes through a section of a *cleanroom* (3.1.1) or *clean zone* (3.1.2)

单位时间内通过洁净室/区一部分的风量

3.4.6 unidirectional airflow 单向流

controlled airflow through the entire cross-section of a *cleanroom* (3.1.1) or a *clean zone* (3.1.2) with a steady velocity and airstreams that are considered to be parallel

通过洁净室/区整个断面的、风速稳定、大致平行的受控气流

[SOURCE: ISO 14644-1:2015, 3.2.7]

【来源：ISO 14644-1:2015, 3.2.7】

3.4.7 uniformity of velocity 流速均匀性

unidirectional airflow (3.4.6) pattern in which the point-to-point readings of velocity (speed and direction of airflow) are within a defined percentage of the average airflow velocity

单向流各点的风速读数（气流速度和方向）在指定的平均气流速度百分比内

3.5 Terms related to electrostatic measurement 与静电测量有关的术语

3.5.1 discharge time 放电时间

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

绝缘的导电监测板的电压降至原（正的或负的）充电电压所需的时间

3.5.2 offset voltage 补偿电压

voltage that accumulates on an initially uncharged isolated conductive plate when that plate is exposed to an ionized air environment

把未充电的绝缘导电板置于电离空气中时其上积累的电压

3.5.3 static-dissipative property 静电耗散特性

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

以传导或其它机理将工作表面或产品表面的静电荷降至额定零电荷或特定值的能力

3.5.4 surface voltage level 表面电压水平

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

用仪器测出的工作表面或产品表面的（正的或负的）静电电压水平

3.6 Terms related to measuring apparatus and measuring conditions 与测量仪器和测量条件有关的术语

3.6.1 aerosol generator 气溶胶发生器

apparatus capable of generating particulate matter having appropriate size range (e.g. 0,05 µm to 2 µm) at a constant concentration, which can be produced by thermal, hydraulic, pneumatic, acoustic or electrostatic means

能以加热、液压、气动、超声波音频、静电等方式生成浓度恒定、粒径范围适当（例如 0.05µm 至 2µm）的微粒物质的仪器

3.6.2 aerosol photometer 气溶胶光度计

light-scattering *airborne particle* (3.2.1) mass concentration measuring apparatus, which uses a forward-scattered-light optical chamber to make measurements

利用前散射光室测量空气悬浮粒子质量浓度的光散射测量仪

3.6.3 airflow capture hood with measuring device 风量罩

device with apparatus to completely cover the filter or air diffuser, and collect the air to directly measure the air volume flow rate

可完全罩住过滤器或空气导流器，采集空气后直接测量空气体积流速的装置

3.6.4 LSAPC light scattering airborne particle counter 光散射尘埃粒子计数器

apparatus capable of counting and sizing single *airborne particles* (3.2.1) and reporting size data in terms of equivalent optical diameter

可以对单个尘埃粒子进行计数和测量其尺寸，并报告当量光学直径数据的仪器

Note 1 to entry: The specifications for a particle counter are given in ISO 21501-4.

注 1：粒子计数器的标准在 ISO 21501-4 里。

[SOURCE: ISO 14644-1:2015, 3.5.1, modified — The term "light scattering discrete airborne particle counter" has been removed. Note 1 to entry has been reworded.]

【来源：ISO 14644-1:2015, 3.5.1，修订—删除术语“光散射离散悬浮粒子计数器”。注 1 重新表述】

3.6.5 witness plate 代测板

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

具有指定表面积的材料，用于替代对无法接近或过于灵敏不能直接测量的特定表面的直接评估

3.7 Terms related to occupancy states 与占有状态有关的术语

3.7.1 as-built 空态

condition where the *cleanroom* (3.1.1) or *clean zone* (3.1.2) is complete with all services connected and functioning but with no equipment, furniture, materials or personnel present

全部建成且设施齐备的洁净室/区，其所有动力均接通并在运行，只是没有生产设备、材料及人员

[SOURCE: ISO 14644-1:2015, 3.3.1]

【来源：ISO 14644-1:2015, 3.3.1】

3.7.2 at-rest 静态

condition where the *cleanroom* (3.1.1) or *clean zone* (3.1.2) is complete with equipment installed and operating in a manner agreed upon, but with no personnel present

在全部建成、设施齐备的洁净室/区中，已安装好的生产设备正在按客户和建造商商定好的方式运行，但场内没有人员

[SOURCE: ISO 14644-1:2015, 3.3.2]

【来源：ISO 14644-1:2015, 3.3.2】

3.7.3 Operational 动态

agreed condition where the *cleanroom* (3.1.1) or *clean zone* (3.1.2) is functioning in the specified manner, with equipment operating and with the specified number of personnel present

全部建成、设施齐备的洁净室/区正在以规定的模式运行，且现场有规定数目的人员正以商业的方式工作

[SOURCE: ISO 14644-1:2015, 3.3.3]

【来源：ISO 14644-1:2015, 3.3.3】

4 Test procedures 测试程序

4.1 Cleanroom tests 洁净间测试

4.1.1 General 通则

ISO 14644-1[1] shall be carried out in order to classify a cleanroom or clean zone by airborne particle concentration. Additional cleanliness attributes should be chosen if required (see Table 1).

洁净间/区按尘埃粒子浓度分级时，应按 ISO14644-1 要求执行。必要时可选择其它洁净度属性（参见表 1）。

NOTE Each standard contains specifications for test methods based on the characteristics of specific attributes, guidance on evaluating the test data and specifications for test apparatus.

注：每个标准均包括基于特定属性的指标的检测方法标准、对评估检测数据的指导以及检测仪器的标准。

Table 1 — Cleanliness attribute tests for cleanrooms and clean zones

表 1—洁净间/区的洁净度属性测试

General description	一般说明	Referenced in 参考
Levels of surface cleanliness by particle concentration	根据粒子浓度定义的表面洁净度级别	ISO 14644-9[6]
Levels of air cleanliness by chemical concentration	根据化学物浓度定义的空气洁净度级别	ISO 14644-8[5]
Levels of surface cleanliness by chemical concentration	根据化学物质浓度定义的表面洁净度级别	ISO 14644-10[7]
Monitoring air cleanliness by nanoscale particle concentration	根据纳米级粒子浓度监测空气洁净度	ISO 14644-12[8]

4.1.2 Supporting tests 支持性测试

Table 2 lists other appropriate tests that can be used for measuring the performance of a cleanroom or clean zone installation. These tests may be applied in each of the three designated occupancy states; refer to details in Annex B for suggested applications. These tests may not be all-inclusive. Also, they may not all be required for any given 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 routine monitoring or periodic testing. Guidelines for the selection of tests and a checklist of tests are given in Annex A. Test methods are outlined in Annex B.

表 2 所列出了可用于测量洁净间/区设施性能的其它适当测试。这些测试可用于 3 种规定的占用状态，详细建议应用参见附录 B。这些测试并非所有，亦可能并不是所有指定项目都会要求测试所有项目。测试项目和测试方法应由客户与供应商协定选择。所选择的测试项目亦可作为日常监测或定期测试的一部分定期重复。附录 A 中列出了测试选择指导以及测试检查清单。附录 B 列出了检测方法。

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

注：附录 B 中所述检测方法仅为纲要。可制订具体方法以满足特殊的应用需求。

Table 2 — Supporting tests

表 2—支持性测试

Supporting tests	支持性测试	Reference in ISO 14644-3 在 ISO 14644-3 里章节		
		Principle 原理	Procedure 方法	Apparatus 仪器
Air pressure difference test	压差测试	4.2.1	B.1	C.2
Airflow test	气流测试	4.2.2	B.2	C.3
Airflow direction test and visualization	气体流向测试和可视化	4.2.3	B.3	C.4
Recovery test	自净测试	4.2.4	B.4	C.5
Temperature test	温度测试	4.2.5	B.5	C.6
Humidity test	温度测试	4.2.6	B.6	C.7
Installed filter system leakage test	已安装过滤器系统泄漏测试	4.2.7	B.7	C.8
Containment leak test	封闭性泄漏测试	4.2.8	B.8	C.9
Electrostatic and ion generator tests	静电和离子发生器测试	4.2.9	B.9	C.10
Particle deposition test[a]	粒子沉降测试	4.2.10	B.10	C.11
Segregation test	隔离性测试	4.2.11	B.11	C.12

NOTE These supporting tests are not presented in order of importance or chronological order. The order in which tests are performed can be based on the requirements of a specific document or after agreement between the customer and supplier.

[a] The particle deposition test can also be considered a test for cleanroom performance in the operational state.

注：这些支持性测试并不是按重要性顺序或测试先后顺序列出。测试顺序可根据具体文件的要求，或在客户与供应商之间达成协议之后。

a-----在洁净间动态性能测试时应可考虑执行粒子沉降测试

4.2 Principle 通则

4.2.1 Air pressure difference test 压差测试

The purpose of the air pressure difference test is to verify the capability of the cleanroom air movement system to maintain the specified pressure differential between the cleanroom and its surroundings. The air pressure difference test should be performed after the cleanroom has met the acceptance criteria for airflow velocity or air volume flow rate, uniformity of velocity and other applicable tests. Details of the air pressure difference test are given in B.1.

压差检测的目的是验证洁净室通风系统维持其设施与其周围环境间规定压差的能力。压差检测应在洁净室设施已满足风速或风量、送风均匀性及其他适用检测的验收标准后进行的。压差检测的详细说明见 B.1。

4.2.2 Airflow test 气流测试

This test is performed to measure the supply airflow introduced into both unidirectional and non-unidirectional cleanrooms or clean zones. In unidirectional applications, the supply airflow velocity can be measured with individual point readings to allow for the measurement of velocity and determination of uniformity of velocity. The average of the individual velocity point readings may be used to calculate the supply airflow volume and air change rate (air changes per hour). In non-unidirectional applications, individual velocity point readings are typically not required as uniformity of velocity is generally not necessary. In these cases, airflow volume readings may be measured directly and then used in calculating the air change rate (air changes per hour) for the cleanroom or clean zone. Test procedures for the airflow test are given in B.2.

该测试是为了测量引入单向流和非单向流洁净间/区的送风气流。在单向气流中，送风流速可采用单点读数来测量，进而测量流速和确定流速均匀性。单点流速读数平均值可用于计算送风量和换气率

（每小时换气次数）。在非单向流系统中，一般不需要测量单点风速，因为一般不需要流速均匀。这种情况下可直接测量风量，然后用于计算该洁净间/区的换气率（每小时换气次数）。气流检测方法见 B.2。

4.2.3 Airflow direction test and visualization 气流方向和流型测试

The purpose of this test is to demonstrate that the airflow direction and its uniformity of velocity conform to the design and performance specifications. The airflow direction test can be conducted in the at-rest state to determine the basic cleanroom airflow patterns and can be repeated in the operational state simulating actual operations. Procedures for this test are given in B.3.

本测试的目的是证明气流方向及流速均匀性符合设计和性能标准。气流方向可在静态下测试，以确定洁净间基础气流形态，可在模拟实际操作的动态下重复本测试。测试方法见 B.3。

4.2.4 Recovery test 自净时间

The recovery test is performed to determine whether the cleanroom or clean zone 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. The procedure for this test is given in B.4. When an artificial aerosol is used, the risk of residue contamination of the cleanroom or clean zone should be considered.

自净时间测试是为了确定洁净室/区在短时暴露于空气悬浮粒子挑战源之后，在有限时间内恢复至指定洁净级别的能力。单向流系统不建议测试本项目。检测方法见 B.4。如果使用了人工气溶胶，则应考虑洁净室/区的残留污染风险。

4.2.5 Temperature test 温度测试

The purpose of this test is to verify the air temperature levels are 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.5.

本测试的目的是验证受测试区域内空气温度水平在客户指定的时间段内符合控制限度。测试方法见 B.5。

4.2.6 Humidity test 湿度测试

The purpose of this test is to verify moisture (expressed as relative humidity or dew point) levels are 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.6.

本测试的目的是验证受测试区域内空气湿度（表示为相对湿度或露点）水平在客户指定的时间段内符合控制限度。测试方法见 B.6

4.2.7 Installed filter system leakage tests 已安装过滤器系统泄漏测试

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 air filter installation, and that the filters are free of defects (small holes and other damage in the filter medium, frame, seal and leaks in the filter bank framework). These tests are not used to determine the efficiency of the filter medium. 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. Leak detection methods are given in B.7.

这项检测旨在验证洁净室设施不存在旁路渗漏，过滤器不存在缺陷（过滤器介质和密封框架上的小孔、其他损伤，以及过滤器边框泄漏），从而确认终端高效过滤器安装良好。这项检测不检查系统的效率。这项检测是这样进行的：在过滤器上风向引入检测气溶胶，并在过滤器的下风向对过滤器、其支撑架进行扫描，或在下风向的风管中采样。检漏方法见 B.7。

4.2.8 Containment leak test 封闭性泄漏测试

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.8.

本测试是为了确定是否有未过滤的空气从洁净间/区范围以外通过接头、接缝、门缝和有压力的天花板侵入洁净间/区。检测方法见 B.8。

4.2.9 Electrostatic and ion generator tests 静电和离子发生器测试

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 cleanrooms or clean zones. 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.9.

这些检测旨在评估物体上的静电电压、材料的静电耗散特性，以及在洁净室/区中进行静电控制所使用的离子发生器（即电离器）的性能。静电检测旨在评估工作表面和产品表面的静电电压，地面、工作台顶部的静电耗散特性等。离子发生器检测旨在评估离子发生器消除表面静电的性能。检测方法见 B.9。

4.2.10 Particle deposition test 粒子沉降测试

The purpose of this test is to verify the quantity and size of particles deposited from the air in the cleanroom onto a surface over an agreed period of time. Procedures for this test are given in B.10.

本项测试旨在测量洁净间内在协定的时间段内从空气中沉降至某个表面上的粒子的数量和尺寸。检测方法见 B.10。

4.2.11 Segregation test 隔离性测试

The purpose of this test is to assess the separation effectiveness achieved by a specific airflow, challenging the lesser classified area with particles and determining the particle concentration in the protected area at the other side of the segregation. Procedures for this test are given in B.11.

本项测试旨在评估指定气流的隔离有效性。测试使用粒子挑战低一级别的区域，并确定在隔断的另一边受保护区域的粒子浓度。测试程序见 B.11。

5 Test reports 测试报告

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

每项测试的结果均应记录在测试报告中，测试报告应包括以下信息：

a) the name and address of the testing organization, and the date on which the test was performed;

测试机构的名称和地址，以及执行每项测试的日期；

b) a reference to this document (ISO 14644-3:2019);

参考文件【ISO 14644-3:2019】

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;

清楚写明所测试洁净间/区物理位置【包括必要时引用邻近区域】，写明所有取样点位置坐标具体设置；

d) the specified designation criteria for the cleanroom or clean zone, including the ISO classification, the relevant occupancy state(s), and the considered particle size(s);

洁净间/区的指定设计标准，包括 ISO 级别、相关占用状态，以及所考虑的粒径；

e) the 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 apparatus and its current calibration certificate;

所用检测方法的详细说明，包括所有与检测有关的特殊条件或偏离检测方法的情况，写明测试仪

器的编号及其当前检定证书编号；

f) the test result, including data reported as specifically required in the relevant clause of Annex B, and a statement regarding compliance with the claimed designation;

测试结果，包括按附录 B 中相关条件所具体要求的应报告数据，以及关于是否符合所称设计要求的声明；

g) any other specific requirements defined relevant to the clause of Annex B for particular tests.

所有与粒子测试附录 B 条款有关的具体规定要求。

Annex A 附录 A
(informative 仅供参考)

Choice of supporting tests and checklist
支持性测试的选择和检查清单

A.1 General 通则

Special care should be taken when determining the sequence for carrying out tests for cleanroom, clean zone or controlled zone performance.

在确定洁净间/区或受控区域性能的检测顺序时应特别小心。

The selection and sequence of tests should be determined between customer and supplier and should detect noncompliance at the earliest stage possible and not compromise other tests in the sequence.

测试项目和测试顺序应由客户与供应商协定，应尽可能早发现不符合情况，并且不应影响后续其它测试。

A.2 Test checklist 测试检查清单

Table A.1 provides a checklist of tests and apparatus.

表 A.1 为测试和仪器的检查清单。

Table A.1 — Checklist of supporting tests

表 A.1—支持性测试检查清单

Selection of test procedure and sequence[a]	Test procedure	Test procedure reference	Selection of test apparatus[b]	Test apparatus	Apparatus reference	Comments
检测方法和顺序选择	检验方法	检测方法参照条款	检测仪器选择	检测仪器	检测仪器参照条款	备注
	Air pressure difference	B.1		Electronic micro-manometer	C.2.2	
				Inclined manometer	C.2.3	
				Mechanical differential pressure gauge	C.2.4	
	压差	B.1		电子微压计	C.2.2	
				倾斜式 U 形管压差计	C.2.3	
				机械式压差表	C.2.4	
	Airflow	B.2			C.3	
	气流	B.2			C.3	
	Uniformity of velocity within the cleanroom or clean zone (for unidirectional airflow)	B.2.2.2		Thermal anemometer	C.3.1.1	
				Three-dimensional ultrasonic anemometer, or equivalent	C.3.1.2	
				Vane-type anemometer	C.3.1.3	
				Tube array	C.3.1.5	
	洁净间/区内风速均匀性（单向流）	B.2.2.2		热感式风速计	C.3.1.1	
				三维超声风速仪	C.3.1.2	
				叶片式风速计	C.3.1.3	
				列管式	C.3.1.5	
	Supply airflow velocity (for unidirectional airflow)	B.2.2.3		Thermal anemometer	C.3.1.1	
				Three-dimensional ultrasonic anemometer, or equivalent	C.3.1.2	
				Vane-type anemometer	C.3.1.3	

Selection of test procedure and sequence[a] 检测方法和顺序选择	Test procedure 检验方法	Test procedure reference 检测方法参照条款	Selection of test apparatus[b] 检测仪器选择	Test apparatus 检测仪器	Apparatus reference 检测仪器参照条款	Comments 备注
				Tube array	C.3.1.5	
	送风流速（单向流）	B.2.2.3		热感式风速计	C.3.1.1	
				三维超声风速仪	C.3.1.2	
				叶片式风速计	C.3.1.3	
				列管式	C.3.1.5	
	Supply air volume flow rate measured by filter face velocity (for unidirectional airflow)	B.2.2.4		Thermal anemometer	C.3.1.1	
				Three-dimensional ultrasonic anemometer, or equivalent	C.3.1.2	
				Vane-type anemometer	C.3.1.3	
				Tube array	C.3.1.5	
	通过过滤器表面风速测量送风量流速（单向流）	B.2.2.4		热感式风速计	C.3.1.1	
				三维超声风速仪	C.3.1.2	
				叶片式风速计	C.3.1.3	
				列管式	C.3.1.5	
	Supply air volume flow rate in air ducts (for unidirectional airflow)	B.2.2.5		Orifice meter	C.3.2.3	
				Venturi meter	C.3.2.4	
				Pitot-static tubes and manometer	C.3.1.4	
				Thermal anemometer	C.3.1.1	
	风管中送风量与流速（单向流）	B.2.2.5		孔板流量计	C.3.2.3	
				文丘里流量计	C.3.2.4	
				皮托管与压力计	C.3.1.4	
				热感式风速计	C.3.1.1	
	Supply air volume flow rate measured at the inlet (for non-unidirectional airflow installation)	B.2.3.2		Airflow capture hood with measuring device	C.3.2.2	
	进口处计算送风量和风速	B.2.3.2		风量罩	C.3.2.2	
	Supply air volume flow rate calculated from filter face velocity (for non-unidirectional airflow i)	B.2.3.3		Thermal anemometer	C.3.1.1	
				Three-dimensional ultrasonic anemometer, or equivalent	C.3.1.2	
				Vane-type anemometer	C.3.1.3	
	从过滤器表面风速计算送风量和风速度	B.2.3.3		热感式风速计	C.3.1.1	
				三维超声风速仪	C.3.1.2	
				叶片式风速计	C.3.1.3	
	Supply air volume flow rate in air ducts (for non-unidirectional airflow)	B.2.3.4		Orifice meter	C.3.2.3	
				Venturi meter	C.3.2.4	
				Pitot-static tubes and manometer	C.3.1.4	
				Thermal anemometer	C.3.1.1	
	风管中的送风量和流速	B.2.3.4		孔板流量计	C.3.2.3	
				文丘里流量计	C.3.2.4	
				皮托管与压力计	C.3.1.4	
				热感式风速计	C.3.1.1	
	Airflow direction	B.3		Tracers	C.4.4.1	

Selection of test procedure and sequence[a]	Test procedure	Test procedure reference	Selection of test apparatus[b]	Test apparatus	Apparatus reference	Comments
检测方法和顺序选择	**检验方法**	**检测方法参照条款**	**检测仪器选择**	**检测仪器**	**检测仪器参照条款**	**备注**
	and visualization			Thermal anemometer	C.4.2	
				Three-dimensional ultrasonic anemometer, or equivalent	C.4.3	
				Aerosol generator	C.4.4	
				Ultrasonic nebulizer	C.4.4.2	
				Fog generator	C.4.4.3	
	气流方向和可视化	B.3		追踪器	C.4.4.1	
				热风速计	C.4.2	
				三维超声风速计，或等同者	C.4.3	
				气溶胶发生器	C.4.4	
				超声波净化器	C.4.4.2	
				发烟器	C.4.4.3	
	Recovery	B.4		Light-scattering airborne-particle counter (LSAPC	C.5.1	
				Aerosol generator	C.5.2	
				Aerosol source substances	C.5.3	
				Dilution system, equipment	C.5.4	
				Thermometer	C.6	
	自净	B.4		光散射悬浮粒子计数器（LSAPC）	C.5.1	
				气溶胶发生器	C.5.2	
				气溶胶源物质	C.5.3	
				稀释系统设备	C.5.4	
				温度计	C.6	
	Temperature	B.5		Expansion Thermometer	C.6 a)	
				Electrical Thermometer	C.6 b)	
				Thermomanometers	C.6 c)	
	温度	B.5		膨胀式温度计	C.6 a)	
				电子温度计	C.6 b)	
				热压力计	C.6 c)	
	Humidity	B.6		Dewpoint hygrometer	C.7 a)	
				Electrical conductivity variation hygrometer	C.7 b)	
	湿度	B.6		露点仪	C.7 a)	
				电导湿度计	C.7 b)	
	Installed filter system leakage	B.7			C.8	
	已安装过滤器系统检漏	B.7			C.8	
	Installed filter system leakage scan test with an aerosol photometer	B.7.2		Aerosol photometer	C.8.1	
				Aerosol generator	C.8.3	
				Test aerosol source substances	C.8.4	
	采用气溶胶光度计执行的已安装过滤器系统泄漏扫描测	B.7.2		气溶胶光度计	C.8.1	
				气溶胶发生器	C.8.3	
				测试用气溶胶源物质	C.8.4	

Selection of test procedure and sequence[a]	Test procedure	Test procedure reference	Selection of test apparatus[b]	Test apparatus	Apparatus reference	Comments
检测方法和顺序选择	检验方法	检测方法参照条款	检测仪器选择	检测仪器	检测仪器参照条款	备注
	试					
	Installed filter system leakage scan test with a LSAPC	B.7.3		Light-scattering airborne-particle counter (LSAPC)	C.8.2	
				Aerosol generator	C.8.3	
				Test aerosol source substances	C.8.4	
				Dilution system, equipment	C.8.5	
	采用 LSAPC 执行的已安装的过滤器系统泄漏扫描测试	B.7.3		光散射空气悬浮粒子计数器（LSAPC）	C.8.2	
				气溶胶发生器	C.8.3	
				测试用气溶胶源物质	C.8.4	
				稀释系统设备	C.8.5	
	Overall leak test of filters mounted in ducts or air-handling units	B.7.4		Aerosol photometer	C.8.1	
				Light-scattering airborne-particle counter (LSAPC)	C.8.2	
				Aerosol generator	C.8.3	
				Test aerosol source substances	C.8.4	
				Dilution system, equipment (LSAPC method only)	C.8.5	
	已安装在风管或空气处理单元内的过滤器整体泄漏测试	B.7.4		气溶胶光度计	C.8.1	
				光散射空气悬浮粒子计数器（LSAPC）	C.8.2	
				气溶胶发生器	C.8.3	
				测试用气溶胶源物质	C.8.4	
				稀释系统设备 （仅 LSAPC 方法）	C.8.5	
	Containment leak	B.8			C.9	
	控制区检漏	B.8			C.9	
	Light-scattering airborne-particle counter (LSAPC) method	B.8.2.1		Light-scattering airborne-particle counter (LSAPC)	C.9.1	
				Aerosol generator	C.9.2	
				Test aerosol source substances	C.9.3	
				Dilution system, equipment	C.9.4	
	光散射空气悬浮粒子计数器（LSAPC）方法	B.8.2.1		光散射空气悬浮粒子计数器（LSAPC）	C.9.1	
				气溶胶发生器	C.9.2	
				测试用气溶胶源物质	C.9.3	
				稀释系统设备	C.9.4	
	Aerosol photometer method	B.8.2.2		Aerosol generator	C.9.2	
				Test aerosol source substances	C.9.3	
				Aerosol photometer	C.9.5	
	气溶胶光度计方法	B.8.2.2		气溶胶发生器	C.9.2	
				测试用气溶胶源物质	C.9.3	
				气溶胶光度计	C.9.5	
	Electrostatic and	B.9			C.10	

Selection of test procedure and sequence[a]	Test procedure	Test procedure reference	Selection of test apparatus[b]	Test apparatus	Apparatus reference	Comments
检测方法和顺序选择	检验方法	检测方法参照条款	检测仪器选择	检测仪器	检测仪器参照条款	备注
	ion generator					
	静电和离子发生器	B.9			C.10	
	Electrostatic	B.9.2.1		Electrostatic voltmeter	C.10.1	
				High resistance ohm-meter	C.10.2	
				Charged plate monitor	C.10.3	
	静电	B.9.2.1		静电电压表	C.10.1	
				高电阻欧姆表	C.10.2	
				充电板监测仪	C.10.3	
	Ion generator	B.9.2.2		Electrostatic voltmeter	C.10.1	
				High resistance ohm-meter	C.10.2	
				Charged plate monitor	C.10.3	
	离子发生器	B.9.2.2		静电电压表	C.10.1	
				高电阻欧姆表	C.10.2	
				充电板监测仪	C.10.3	
	Particle deposition	B.10		Witness plate material	C.11.1	
				Wafer surface scanner	C.11.2	
				Particle fallout aerosol photometer	C.11.3	
				Surface particle counter	C.11.4	
				Particle deposition meter	C.11.5	
				Optical particle deposition monitor	C.11.6	
	粒子沉降	B.10		代测板	C.11.1	
				晶圆表面扫描仪	C.11.2	
				粒子辐射光度计	C.11.3	
				表面粒子计数器	C.11.4	
				粒子沉降计数器	C.11.5	
				光学粒子沉降监测器	C.11.6	
	Segregation test	B.11		Light-scattering airborne-particle counter (LSAPC)	C.12.1	
				Aerosol generator	C.12.2	
				Test aerosol source substances	C.12.3	
				Dilution system, equipment	C.12.4	
	隔离性测试	B.11		光散射悬浮粒子计数器（LSAPC）	C.12.1	
				气溶胶发生器	C.12.2	
				测试用气溶胶源物质	C.12.3	
				稀释系统设备	C.12.4	

[a] In the boxes of column 1, test planners can number the selected test methods according to the test sequence. In the fourth column, test planners can select test apparatus according to the test method selected.

在第 1 列中，测试计划者可根据检测顺序对所选检测方法进行编号
在第 4 列中，测试计划者可根据所选择的测试方法选择测试仪器

A.3 Planning for testing and verification 规划测试和核查

As a minimum, testing should be carried out:

至少应在以下时间执行测试：

a) in connection with classification according to ISO 14644-1;

与 ISO14644-1 进行分级有关时

b) at verification during start-up;

在启动中过程的核查中

c) at verification after failures have been identified and rectified;

在发现失败并修正之后的核查中

d) at verification after modification;

在改造之后的核查中

e) during periodic testing.

在定期测试中

A risk assessment should be performed to establish the appropriate intervals for periodic testing. Monitoring data, trend and test result should be used to confirm and, if appropriate, adjust time intervals for the selected tests.

应进行风险评估以确定定期测试的周期。监测数据、趋势和测试结果应用于确认以及（适当时）调整所选择测试的测试周期。

Annex B 附录 B

(informative 仅供参考)

Supporting test methods 支持性测试方法

B.1 Air pressure difference test 压差测试

B.1.1 General 概述

The purpose of this test is to verify the capability of the complete installation to maintain the specified pressure difference between the cleanroom and its surroundings, and between separate cleanrooms and clean zones within the installation.[18] This test is applicable in each of the three designated occupancy states, and can also be repeated on a regular basis as part of a routine facility monitoring program as described in ISO 14644-2[2].

本测试指在核查完整的设施维护洁净间与其周围环境之间，和设施内不同洁净间/区之间的指定压差的能力。该测试适用于三种指定的占用状态，亦可作为 ISO14644-2 日常设施监测计划的一部分进行定期测试。

B.1.2 Procedure for air pressure difference test 压差测试方法

It is recommended that the following items are confirmed before starting the measurement of differential pressure between rooms or between rooms and outside areas:

建议在开始测量不同房间或房间与外围区域之间压差之前确认以下项目：

— values and acceptable range of differential pressure between rooms should be defined;

— 应规定房间之间压差值和可接受范围

— supply air volume and balancing of the air handling unit supplies are within specifications;

— 送风量和空气处理单元送风平衡在指定标准内

— cleanroom components that could impact the differential pressure between rooms such as doors, windows, pass through, etc. should be closed. Permanent openings should be kept open during the test;

— 洁净间可能影响房间之间压差的装置如门、窗、传递柜等均应关闭。测试间可保持永久开放处打开

— the air handling system has been operated and the conditions have been stabilized;

— 空气处理系统已运行，且运行状况稳定

— extraction systems should be operating as agreed and specified.

— 通风系统按协定和指定条件运行

The pressure differences between each individual cleanroom, clean zone and the connected adjacent room(s) should be measured.

应测量每个独立洁净间/区和相邻连接房间之间的压差。

This will include measurement of the pressure difference between (a) classified room(s) connected to the non-classified surrounding environment.

其中会包括与非洁净周边环境相连接的洁净间之间的压差测量。

To avoid possible erroneous readings, the following should be considered:

为避免可能的读数错误，应考虑以下情况：

a) installation of permanent measuring points;

永久测量点的安装

b) measurements in the cleanroom and clean zone should not be taken near supply air inlets, return air outlets, air movement devices, doors and other localized high air velocity areas that may influence the local pressure at the measuring point;

洁净间/区内的压差不应在接近送风口、回风口、排气装置、门和其它局部高风速区域测量，这些地区测量可能影响测量点的局部压力

c) when the measured differential pressure is lower than an agreed value, direction of flow between rooms should be confirmed by flow visualization methods.

如果所测出的压差低于协定值，应腰身气流可视化方法确认房间之间的气流方向

B.1.3 Apparatus for air pressure difference test 压差测试仪器

Apparatus descriptions and measurement specifications are provided in C.2. An electronic micromanometer, inclined manometer, or mechanical differential pressure gauge can be used. The apparatus should have a valid calibration certificate.

仪器说明和测量规范见 C.2。可使用电子微压计、斜管压力计或机械压差计。仪器应具备有效检定证书。

B.1.4 Test reports 测试报告

By agreement between customer and supplier, the following information and data should be recorded as described in Clause 5:

根据客户与供应商之间的协定，应按第 5 条所述记录以下信息和数据：

a) type of tests and measurements, and measuring conditions;

测试类型和测量值以及测量条件

b) type designations of each measuring apparatus and apparatus used and its calibration status;

每个测量仪器和所使用仪器的设计类型及其检定状态

c) cleanliness classes of the rooms considered;

所考虑的房间的洁净级别

d) measuring point locations, when required the reference point location;

测量点位置，必要时给出参考点位置

e) occupancy state(s).

占用状态

B.2 Airflow test 气流测试

B.2.1 General 概述

The purpose of these tests is to measure airflow velocity and uniformity, and supply air volume flow rate in cleanrooms and clean zones. Measurement of velocity distribution is necessary in unidirectional airflow cleanrooms and clean zones, and supply air volume flow rate in non-unidirectional cleanrooms. Measurement of supply air volume flow rate is carried out to ascertain the air volume supplied to the cleanroom or clean zone per unit of time. The supply air volume flow rate is measured either downstream of final filters or in air supply ducts; both methods rely upon measurement of velocity of air passing through a known area, the air volume flow rate being the product of velocity and area. The choice of procedure should be agreed between customer and supplier.

本检测的目的是测量洁净室和洁净区内的风速均匀性及送风量。单向流洁净室或洁净区必须测量风速分布，而非单向流的洁净室和洁净区必须测量送风量。测量送风量是要查明单位时间内送到洁净设施内的风量。送风量或是在终端过滤器的下风向测量，或是在送风管中测量。两种方法都是测量穿过或来自一已知区域的空气体积流量。用风速与面积的乘积，即可计算出风量。应按客户和建造商的一致意见选择测量方法。

When measuring airflow velocity, the following conditions should be considered carefully:

测量风速时，应仔细考虑以下条件：

a) probe direction should be chosen appropriately under the consideration on the airflow velocity;

选择探头方向时要考虑气流速度

b) measurement should be conducted during sufficient time for repeatable readings and the average velocity or air volume flow rate should be recorded.

应有充分的时间执行测量以获得可重复的读数，应记录平均风速度或风量

B.2.2 Procedure for unidirectional airflow testing 单向流设施的检测方法

B.2.2.1 General 概述

The velocity of the unidirectional flow determines the performance of a unidirectional cleanroom. The velocity can be measured close to the face of the terminal supply filters, or within the room. This is done by defining the measuring plane perpendicular to the supply airflow and dividing it into measuring points (grid cells) of equal area[18].

可用单向流的风速来测定单向流洁净室的性能。可以在靠近终端送风过滤器表面的位置或是在室内测量风速。方法是规定出与送风气流成直角的测量截面，然后把其分成面积相等的测量点（方格单元）。

B.2.2.2 Supply airflow velocity 送风速度

The airflow velocity should be measured at approximately 150 mm to 300 mm from the filter face or entry plane.

应该在距过滤器表面或入口截面约 150 mm ~ 300 mm 的位置测量风速。

The number of measuring points (grid cells) is highly dependent upon the instrumentation used to perform the measurements, configuration of room infrastructure, location or process equipment and the design of the installed filter cell. The minimum number of measuring points (grid cells) should be determined by Formula (B.1):

测量点（方格单元）的数目很大程度取决于测量用仪器、房间基础设施参数、工艺设备的位置以及所安装过滤器单元的设计。应采用公式 B.1 计算最少测量点（方格单元）数目：

$$N = \sqrt{10 \times A} \qquad \text{(B.1)}$$

Where 其中

N is the minimum number of measuring points (grid cells; N should be rounded up to a whole number);

N 为最少测量点数目（方格单元，N 应向上修约至整数）

A is the measured area in m^2.

A 为所测量面积，单位 m^2

Where the average velocity is required for a zone with unidirectional airflow, the average velocity is calculated from Formula (B.2):

如果是单向流区，需要平均流速，则平均流速可用公式 B.2 计算：

$$V_a = (\sum V_n) / N \qquad \text{(B.2)}$$

Where 其中

V_a is the average velocity in m/s;

为平均流速度，单位 m/s

$\sum V_n$ is the sum of all the measured velocities (V_n) in m/s;

为所测得所流速【V_n】之和，单位 m/s

V_n is the measured velocity at each of the grid cell centres in m/s;

为每个方格单位中心所测得的流速，单位 m/s

N is the number of locations at which the velocities (V_n) were measured.

为测量流速【V_n】位置的数目

At least one point should be measured for each filter outlet or fan-filter unit.

每个过滤器出风口或 FFU 至少要有一个测量点。

If the measured data is to be used to determine airflow volume flow rate as in B.2.2.4 or uniformity of velocity as in B.2.2.3, then it can be advantageous to increase the number of measuring points (grid cells).

如果所测得的数据将被用于计算 B.2.2.4 中的风量速度或 B.2.2.3 中的流速均匀性，则增加测量点（方格单元）的数目会有好处。

For smaller areas, it can be necessary to increase the number of measuring points (grid cells) to improve the likelihood of detection of uneven airflow velocities.

如果面积更小，可能有必要增加测量点（方格单元）的数目以提高发现不平均风速的可能性。

The measuring time at each position should be sufficient to ensure a repeatable reading. Time-averaged values of measured velocities should be recorded for multiple locations.

各点的测量时长应足以确保计数可再现。记录多个位置上所测风速的时间平均值。

NOTE 1 If the supply airflow velocity is measured too close to the source, there is a risk of measurement error due to variable airflow distribution. If the supply airflow velocity is measured too far from the filter face, the measurement reading can be compromised.

注 1：如果送风风速测量点过于接近风源速度，则可能存在因风量分配差异导致的测量误差。如果送风风速测量点离过滤器表面太远，测量值计数可能受影响。

NOTE 2 A temporary barrier can be used to exclude disturbances to the unidirectional airflow.

注：可使用临时屏障排除单向流的扰动。

B.2.2.3 Uniformity of velocity within the cleanroom or clean zone 洁净室/区内风速均匀性

The uniformity of velocity can be measured according to B.2.2.2 or as agreed between customer and supplier.

可按 B.2.2.2 测量网速均匀性，或按客户与供应商双方约定方式测量。

NOTE When production apparatus and workbenches are installed, it is important to confirm that significant airflow variations do not occur.

注：如果已安装生产仪器和工作台，则确认不会发生重大的气流 波动非常重要。

The data to be used to determine the uniformity of velocity and maximum deviation, i.e. the velocity and its variation, should be agreed between customer and supplier.

用于计数风速均匀性和最大偏差（即风速及其差异性）的数据应由客户与供应商双方约定。

The standard deviation and mean average should be calculated from the velocity readings and the uniformity of velocity, U_V, obtained with Formula (B.3):

标准偏差和平均值应采用风速读数和风速均匀性 U_V，采用公式 B.3 计算获得：

$$U_V = [1 - (\sigma / V_a)] \times 100 \qquad (B.3)$$

Where 其中

σ is the standard deviation; 为标准偏差

V_a is the average velocity. 为平均风速

The maximum deviation of velocity, D_{max}, is calculated with Formula (B.4):

风速度最大偏差 D_{max} 采用公式 B.4 计算获得：

$$D_{max} = [(V_d - V_a) / V_a] \times 100 \qquad (B.4)$$

Where 其中

s_{max} is the maximum deviation in %; 为最大偏差，单位%

V_a is the average velocity; 为平均风速度

V_d is the reading with most variance from the average. 为与平均值最大差

B.2.2.4 Supply air volume flow rate calculated from the velocity measurement 采用风速计算送风量

The results of the airflow velocity test carried out in accordance with B.2.2.2 can be used to calculate the total supply air volume flow rate with Formula (B.5):

可使用按 B.2.2.2 测量所得的风速结果，采用公式 B.5 计算总送风量：

$$Q = \sum(V_n \times A_c) \qquad (B.5)$$

Where 其中

A_c is the cell area which is defined as the free area of the media divided by the number of measuring points (grid cells) in m^2; 为定义为介质自由面积的单元面积除以测量点（方格单元）数目，单位 m²

Q is the total air volume flow rate in m^3/s; 总风量，单位 m³/s

V_n is the airflow velocity at each cell centre in m/s; 每个单元中心的风速度，单位 m/s

$\sum$ is the summation for all cells. 所有单元的总和

NOTE The accuracy of the air volume flow rate, when calculated using this method can be influenced by many factors, such as; choice of test apparatus, choice of measuring locations, number of measuring points (grid cells), distance from filter face and calculation of open cell area.

注：如果采用此方法计算风量的准确性，则可能受到多个因素的影响，如测量仪器的选择、测量位置的选择、测量点（方格单元）的选择、离过滤器表面的距离以及开放单元面积的计算。

B.2.2.5 Supply air volume flow rate calculated from velocity measurement in air ducts 采用风管风速计算送风量

Supply air volume flow rate in ducts may be determined by using apparatus such as orifice meters, Venturi meters, pitot static tubes and anemometers.

风管中的送风量可以用孔板流量计、文丘里流量计和风速计等容积流量计测量。

In cases of the measurement by pitot static tubes and manometers or anemometers (thermal or vane type) for a rectangular duct, the measuring plane in the duct should be divided into measuring points (grid cells) of equal areas, and then the airflow velocity should be measured at the centre of each cell. The number of measuring points (grid cells) is agreed between customer and supplier. The air volume flow rate should be evaluated in the same way as defined in B.2.2.4. For a circular duct, the air volume flow rate by pitot static tubes may be determined by the procedure as typically described in ISO 5167-5[24].

如果用皮托静压管和测压计或风速计（热式或叶片式）对矩形风管进行测量，则应把风管中的测量截面划分为面积相等的测量点（方格单元），然后在单元的中心处测量风速度。测量点（方格单元）的数目由客户与供应商约定。应采用与 B.2.2.4 中所规定的相同方法对风量进行评估。如果是圆形风管，则可用 ISO 5167-5 中所述的一般方法用皮托静压管测量风量。

NOTE When measuring supply air volume flow rate, there can be differences between the measuring methods by filter face velocity and measurement in the air duct.

注：在测量送风量时，测量过滤器表面风速与测量风管风速可能存在差异。

B.2.3 Procedure for non-unidirectional airflow test 非单向流设施的检测方法

B.2.3.1 General 概述

In some cases, measurement of supply airflow velocity from individual outlets is necessary to determine the air volume flow rate from each outlet[18].

某些情况下，需要测量各个出风口的送风速度，以测定各送风口的风量。

B.2.3.2 Supply air volume flow rate measured using a capture hood 风量罩法测送风量

Because of the effect of local airflow turbulence and jet velocities issuing from an outlet, use of an airflow capture hood that captures all of the air issuing from each final filter or supply diffuser is recommended. The supply air volume flow rate is measured using an airflow capture hood with a measuring device, or the air velocity of the air exiting from an airflow capture hood multiplied by the effective area. The opening of airflow capture hood should be placed completely over the entire filter or diffuser, and the face of the hood should be seated against a flat surface to prevent air bypass and inaccurate readings. When an airflow capture hood with measuring device is adopted, the air volume flow rate at each final filter or supply diffuser should be measured directly at the discharge end of the hood.

由于送风口局部气流的扰动和喷射速度产生的效应，建议采用风量罩捕集所有从终端过滤器或送风散流器流出的空气。可以用配有计量计的风罩，或是用风量罩出风的风速乘以有效面积。风量罩的固定位置应该能完全覆盖住过滤器或散流器，其表面应该靠在一个平坦的表面上，防止空气因旁流产生不精确的读数。如采用风量罩测量各个终端过滤器或送风散流器的风量，则应该在风量罩的排风端直接测量。

The accuracy of the airflow capture hood should be verified to show that it gives accurate results for the type of air outlet being measured, and a correction factor should be applied if the results are not accurate. The correction factor is related to the flow. It corresponds to an in situ check and is based on the difference between the reference measurement in air ducts and the air outlet.

风量罩的准确度可进行验证，以证明其用于被测量的空气出口类型时可得出准确结果。如果结果不够准确，可采用校正因子。校正因子与流速有关，其对应于原位检查结果，来源于风管中标准测量值与出风口的测量值差异。

Also, in case an air outlet is fitted with (swirl) diffusers the airflow capture hood can be adapted for the flow type of the diffuser.

如果出风口装有【漩涡】散流器，风量罩可用于散流器的气流类型。

B.2.3.3 Supply air volume flow rate calculated by velocity measurement 采用风速计算送风量

Evaluation of the supply air volume flow rate without an airflow capture hood may be done with an anemometer downstream of each final filter. The supply air volume flow rate is determined from the airflow velocity multiplied by the corrected (free) area of exit. A temporary barrier may be used to exclude disturbances to the unidirectional airflow.

如果没有配备风罩，可以用各个终端过滤器下风向的风速计来评估送风量。用风速乘以出口校正（净）面积来测定送风量。可用幕帘隔断对单向气流的干扰。

For the number of measuring points (grid cells) and the calculation of supply air volume flow rate, refer to B.2.2.2 and B.2.2.4, respectively.

关于测量点的数目和送风量的计算，可分别参见 B.2.2.2 和 B.2.2.4。

If it is impossible to divide the plane into measuring points (grid cells) of equal areas, the average air velocity weighted by area may be substituted.

如果无法把平面划分为等面积的测量点（方格单元），也可以采用面积加权的平均风速。

The accuracy of the air volume flow rate, when calculated using this method can be in influenced by many factors, such as; choice of test apparatus, choice of measuring locations, number of measuring points (grid cells), distance from filter face and calculation of open cell area. Consideration should be given to these potential variations when performing this test.

采用本方法计算风量时，其准确性可能受到多个因素影响，如测量仪器的选择、测量位置的选择、测量点（方格单元）数目、到过滤器表面的距离以及开放性单元面积的计算。在执行此类测量时应考虑这些可能的变化。

B.2.3.4 Supply air volume flow rate calculated by velocity measurement in air ducts 采用风管中风速值计算送风量

Supply air volume flow rate in air ducts should be determined in the same way as defined in B.2.2.5.

风管中送风量应采用 B.2.2.5 中所规定的相同方式进行计算。

B.2.4 Apparatus for airflow tests 气流检测仪

Descriptions and measurement specifications of apparatus are provided in C.3. For airflow velocity measurements, ultrasonic anemometers, thermal anemometers, vane-type anemometers, or their equivalent, can be used.

仪器说明与测量技术条件参见 C.3。风速测量可使用超声波风速度、热风速计、叶片风速计或类似的仪器。

For supply air volume flow rate measurements, airflow capture hood, orifice meters, Venturi meters, pitot static tubes, averaging tube array and manometers, or their equivalent, can be used.

风量测量可使用孔板流量计、文丘里流量计、皮托静压管、平均管阵列和压力计或类似的仪器。

Airflow velocity measurements should be made with apparatus that is not affected by point-to-point velocity variation over small distances, e.g. a thermal anemometer can be used if small grid divisions are selected and additional measuring points (grid cells) are used. On the other hand, a vane anemometer can be used if it is sensitive enough and large enough to measure average air velocity over a range of variation.

进行风速测量所使用的仪器应不受短距离点对点速度变动的影响。例如，划分的格子小、测量点更多，就可以使用热风速计。另外，如其有足够的灵敏度和大小，也可以使用叶片流量计在一定变动范围内测量“平均”风速。

The apparatus chosen should have a valid calibration certificate.

所选择的测量仪器应具备有效的校正证书。

B.2.5 Test reports 测试报告

By agreement between customer and supplier, the following information and data should be recorded as described in Clause 5:

根据客户与供应商之间的协定，应按第 5 条所述记录以下信息和数据：

a) type of tests and measurements, and measuring conditions;

   测试类型与测试条件

b) type designations of each measuring apparatus used and its calibration status;

   仪器的名称与校正状况

c) measuring locations and the distance from the filter face;

   测量点和与过滤器表面的距离

d) occupancy state(s);

   占用状态

e) result of measurement;

测量结果

f) other data relevant for measurement.

其它与测量有关的数据

B.3 Airflow direction test and visualization 气流方向测试和可视化

B.3.1 General 概述

The purpose of airflow direction test and visualization is to demonstrate that the airflow direction and its uniformity of velocity conform to the design and performance specifications.

气流方向和可视化测试的目的是确认气流方向及其均匀性与设计和性能技术要求相符。

NOTE 1 Computational Fluid Dynamics (CFD) used as a predictive or analytical tool is not considered in this document.

注 1：本文件中不考虑使用计算机液体动力学（CFD）作为预测或分析工具。

NOTE 2 Tracer thread methods may not give a true indication of the direction of airflow due to the tracer material’s characteristics, e.g. weight of the thread.

注：示踪线方法可能因为示踪材料的特性而不能显示出气流的真实方向，例如线的重量。

B.3.2 Methods 方法

The airflow direction test and visualization can be performed by the following four methods:

下述 4 种方法可用于气流方向检测和可视化

a) tracer thread method;

示踪线法

b) tracer injection method;

示踪剂注入法

c) airflow visualization method by image processing techniques;

采用图像处理技术的气体流型可视化方法

d) airflow visualization method by the measurement of velocity distribution.

采用速度分布测量法的气体流形可视化方法

By methods a) and b), airflow in the cleanroom or clean zone is actually visualized by the use of fibre tracer thread, or tracer particles. Devices, such as video cameras, record the profiles. The fibre tracer thread or tracer particles should not be a source of contamination and should follow the airflow profile accurately. Other apparatus such as a tracer particle generator, and high intensity light source may be used for these methods.

用 a)和 b)法，实际上是用纤细示踪或微粒示踪物质来将洁净室设施中的气流可视化，采用记录装置如摄像机记录下资料。示踪线或示踪微料不应成为污染源，并能准确地跟随气流的流向。本方法中亦可使用示踪粒子发生器和高强度光源等其它仪器。

Method c) is used to demonstrate quantitatively the airflow velocity distributions in the cleanroom or clean zone. The technique is based on tracer particle image processing techniques using computers.

方法 c)用于量化呈现洁净室设施内气流速度的分布，它采用计算机示踪粒子图像处理技术。

Care should be taken to ensure that the personnel undertaking the test do not interfere with the airflow patterns being investigated.

应注意不让操作者干扰勘查中的气流。

NOTE 1 The airflow is affected by other parameters such as air pressure difference, air velocity, and temperature.

注 1：气流会受到其它参数如压差、流速和温度的影响。

NOTE 2 Appropriate airflow visualisation techniques best assess the effectiveness of air distribution in unidirectional airflow cleanrooms, clean zones and controlled zones. However, the method can also be used in non-unidirectional areas.

注 2：适当的气流可视化技术能最大程度地评估单向流洁净间/区和受控区域的气流分布效果。但是该方法亦可用于非单向流区域。

B.3.3 Procedures for airflow direction test and visualization 气流方向测试和可视化方法

B.3.3.1 Tracer thread method 示踪线法

The test is carried out by observation of tufts, e.g. silk threads, single nylon fibres or thin film tapes. These are set on the tip of support sticks or mounted on the crossing points of thin wire grids in the airflow. They provide visual indication of the airflow direction and fluctuations due to turbulence. Effective lighting will aid observation and recording of the indicated airflow.

该检测是通过观察如丝线、单根尼龙细线或薄膜带来实现的。将示踪线放置在支撑杆的端头或装在气流中细金属丝格栅的交叉点上，就可以直接观察出气流的方向和因干扰引起的波动。有效的照明有助于观察和记录显现的气流状况。

B.3.3.2 Tracer injection method 示踪剂注入法

The test is carried out by observation or imaging of the behaviour of tracer particles, which can be illuminated by high-intensity light sources. The test provides information about the airflow direction and uniformity of velocity in a cleanroom, clean zone or controlled zone. The tracer particles can be generated from materials such as de-ionized (DI) water, sprayed or chemically generated alcohol/glycol, etc. The source should be carefully selected to avoid contamination of surfaces.

该检测是通过对高强度淘汰照亮的示踪粒子的特性进行观察或制作成图像来实现的。该测试提供了洁净室设施内气流的方向性和均匀性的资料。可以用去离子水（DI）水、喷射或化学法生成的乙醇/正二醇等材料生成示踪粒子。要仔细选用适当的材料，以免污染表面。

The desired size of droplets should be considered when selecting the droplet generation method. Droplets should be large enough to be detected with the available image processing techniques, but not so large that gravitational or other effects result in their motion diverging from that of the airflow being observed.

选用液沆生成法时，要考虑小滴的粒径。小滴要大得图像处理技术能检测出来，但又不能过大而在运动过程中产生重力或其它效应，并偏离被观测的气流。

B.3.3.3 Airflow visualization method by image processing techniques 用图像处理技术进行气流可视化

Processing particle image data derived from the method described in B.3.3.2 on video frames or films provides quantitative characteristics of airflow by way of two-dimensional air velocity vectors in the area. The processing technique requires a digital computer with suitable interfaces and the appropriate software. For greater spatial resolution, devices such as a laser light sources can be used.

用 B.3.3.2 的方法将记录在摄像机或胶片上的粒子图像资料经过处理后，即可用区域内二维气流速度矢量显示气流的量化特性。该处理技术需用配有适当接口和软件的数字计算机。用激光光源等装置可以得到更大的空间分辨率。

B.3.3.4 Evaluation of airflow distribution by measurement of velocity distributions 通过测量速度分布进行气流可视化

The velocity distributions of airflow can be determined by setting air velocity measuring apparatus, such as thermal or ultrasonic anemometers, at several defined points in the cleanroom or clean zone under investigation. Processing of the measured data provides the information about the airflow distribution.

可以在被勘查的洁净室设施内的几个规定的点上设置风速测量仪，如热风速计或超声风速度，以测定

气流速度的分布。对测出的数据进行处理，就可得出气流分布的资料。

B.3.4 Apparatus used for airflow direction test and visualization 气流方向检测和可视化所用仪器

The apparatus used for the airflow direction test and visualization is different for each test method.

每种检测方法使用不同的气流方向检测和可视化仪器。

The apparatus suitable for each test method is given in C.4, Table B.1 and B.2.

C.4、表 B.1 和 B.2 中给出了每种检测方法的适用仪器。

Table B.1 — Materials or particles used in tracer thread or injection methods

表 B.2—示踪线或示踪物注入法所用物料或粒子

Item 材料	Description 描述
Material used in the tracer thread method	Silk thread, cloth, etc.
示踪线法中所用材料	丝线、布料等
Particulate method used in the tracer injection method	DI water or other fluid mist of 0,5 μm to 50 μm in diameter. Bubbles of neutral density in the air at the measuring location. Organic or inorganic test fog.
示踪物注入法中所用粒子	DI 水或其它直径为 0.5-50μm 的液体湿润物。空气中测量位置中性比重气泡。有机或无机测试用烟雾。
Image recording devices for recording the visualized pictures or images of tracer particles	Various devices, such as photographic cameras, video cameras, including high-speed or strobe or synchronized functions and image recording devices, used in flow visualization procedures.
记录可视化图像或示踪粒子的图像记录装置	气流可视化方法中所用各种装置，如摄像仪、照相机，包括高速或频闪或同步功能和图像记录装置

NOTE After flow visualization, it is generally necessary to re-clean the cleanroom or clean zone.

注：在气流可视化之后，通常需要重新清洁洁净区/间。

Table B.2 — Illumination light sources for airflow visualization

表 B.2—气流可视化照明光源

Item 材料	Description 描述
Various illumination light sources for contrasted observation or imaging of airflows	Tungsten lamp, fluorescent lamp, halogen lamp, mercury lamp, laser light sources (He-Ne, argon ion, YAG lasers, etc.) with or without stroboscope or synchronized devices to the recorders.
不同照度光源用于对比观察或气流成像	光纤钨丝灯、荧光灯、卤素灯、水银灯、激光灯源（氦-氖、氩离子、YAG 激光等），具有或不具有频闪装置或与记录仪同步的装置
Image-processing technique for quantitative measurement by flow visualization	Laser light sheet method, consisting of high-power laser sources (argon or YAG laser), optics including cylindrical lens, and a controller, where two-dimensional airflows are visualized.
通过气流可视化进行定量测量的图像处理技术	激光光片法，由高能激光光源（氩或 YAG 激光）组成，光路包括有柱面透镜和一个控制器，可以将二维气流可视化

B.3.5 Test reports 测试报告

By agreement between customer and supplier, the following information and data should be recorded as described in Clause 5:

根据客户与供应商之间的协定，应按第 5 条所述记录以下信息和数据：

a) type of tests, method of visualization and test conditions;

   测试类型、可视化方法和测试条件

b) type designations of each measuring apparatus used and its calibration status;

所用测量仪器的型号及其校正状况

c) visualization point locations;

可视化点位置

d) images stored on photographs or any other recording media, or raw data for each measurement, in the case of the image processing technique or the measurement of velocity distributions, if specified;

图像处理技术或速度分布测量中（如有要求时）相机或其它记录介质中所存贮的图像，或每个测量的原始数据

e) a plan of the exact location of all apparatus should accompany the flow visualization report;

气流可视化报告应随附所有仪器确切位置平面图

f) occupancy state(s).

占用状态

B.4 Recovery test 自净测试

B.4.1 General 概述

This test is performed to determine the ability of the installation to reduce the concentration of airborne particles by dilution. Cleanliness recovery performance after a particle generation event is one of the most important abilities of the installation. This test is only recommended for non-unidirectional airflow systems as the recovery performance is based on the dilution and mixing of the air found in non-unidirectional airflow systems, and not unidirectional airflow systems, where contamination is removed by the unidirectional flow of air. The recovery performance of a non-unidirectional cleanroom is affected by air distribution characteristics such as ventilation effectiveness, thermal conditions, and obstructions. The recovery test can be performed using an LSAPC or an aerosol photometer. When an artificial aerosol is used, the risk of residue contamination of the cleanroom or clean zone should be considered.

本项测试是用以确定设施通过稀释降低空气悬浮粒子的能力。设施在粒子发生事件之后恢复洁净度的能力是最重要的。本项测试仅建议用于非单向流系统，因为自净性能是基于非单向流系统的空气稀释和混合过程，而单向流中的污染是由空气垂直流动来清除的。非单向流洁净间的自净性能受到空气分布特性如通风效果、温度条件以及障碍物的影响。自净测试可使用 LSAPC 或气溶胶光度计进行。如果使用人工气溶胶，则应考虑洁净间/区内残留污染的风险。

B.4.2 Cleanliness recovery performance 洁净度自净性能

Recovery performance is evaluated by using the 100:1 or 10:1 recovery time and/or the cleanliness recovery rate. The 100:1 or 10:1 recovery time is defined as the time required for decreasing the initial concentration by a factor of 100 times (or 10 times). The cleanliness recovery rate is defined as the rate of change of particle concentration by time. It is possible to estimate both of these from the same particle concentration decreasing curve. The measured concentration levels used should be taken from inside the time range where the decreasing of particle concentration is described by a single exponential, indicated by a straight line on a semi-log chart (concentrations on the ordinate by the logarithmic scale, and the time values on the abscissa by the linear scale). Moreover, the test concentration should not be so high that coincident loss occurs, or so low that counting uncertainty occurs.

自净性能采用 100:1 或 10:1 的自净时间和/或洁净级别恢复速度来评估。100:1 或 10:1 自净时间定义为将初始浓度降低至 100 分之一（或 10 分之一）所需时间。洁净度恢复速度定义为粒子浓度随时间变化的速度。用相同的粒子浓度衰减曲线能够预测出上述两项结果。测量应该在这样的时间范围内进行，即粒子浓度用单一指数表述，该指数在半对数图（纵坐标上的浓度按对数刻度，横坐标上的时间值按线性刻度）上以直线标出。另外，检测浓度不应过高而引起重合损耗，也不应过低而引起计数偏差。

The purpose of the recovery time test is to evaluate an actual time interval for the concentration to reach target cleanliness level after the particle concentration in the cleanroom or clean zone has temporarily become higher due to planned maintenance shutdown, or unplanned plant failure. The purpose of evaluation by recovery rate is to establish the local ability to recover the cleanliness after the particle concentration around the measuring point has temporarily become higher. The slope of decreasing curve on a semi-log chart indicates this local ability.

自净时间测试的目的是评估因计划性维保关机，或计划外工厂故障后，洁净室/区内粒子浓度在暂时过高后达到目标洁净度水平浓度的实际时长。通过洁净度恢复速度进行评估的目的是了解测量点附近粒子浓度暂时变高之后恢复洁净度的局部能力。半对数图中衰减曲线的斜率表示该区域局部能力。

The 100:1 test is not recommended for ISO Classes 8 and 9.

不建议对 ISO 第 8 级和 9 级区域进行 100:1 测试。

NOTE The measurement of the recovery rate not only gives the recovery rate but the air change rate per unit of time at the location where the measurements were made. If the local air change rate at the location is compared to the overall air change rate in the cleanroom, the effectiveness of the ventilation system in providing clean air at the measuring location can be obtained.

注：恢复速度的测量不仅是给出恢复速度，还有测量点的单位时间的换气次数。如果将局部换气效数与洁净室内总体换气效数相比，则可以得出测量点通风系统提供洁净空气的效果。

B.4.3 Procedure for recovery test 自净测试方法

B.4.3.1 Selection of measuring points 选择测量点

Place the LSAPC probe in the working plane at appropriate location(s) (which can include critical locations or suspected worst-case locations). The measuring points and number of measurements should be determined between the customer and supplier. It can be inappropriate to choose measuring locations that give recovery performances not representative of the cleanroom, such as under an air terminal without a diffuser.

将 LSAPC 探头放置在工作截面适当位置（可包括关键位置或疑似最差情形位置）。测量点和测量次数应由客户与供应商协商确定。选择不能代表洁净间的自净性能测量点（例如在没有散流器的送风点下）是不恰当的。

B.4.3.2 Test method 测试方法

Care should be taken to avoid high airborne concentrations of particles that can cause coincidence error and contamination of the LSAPC optics. Before testing, calculate the concentration required to carry out the recovery test. If the concentration exceeds the maximum concentration of the LSAPC, where particle coincidence will occur, use a dilution system. Testing procedure:

应注意避免空气悬浮粒子浓度导致重叠误差，以及 LSAPC 光路污染。在测试之前，计算执行自净测试所需的浓度。如果该浓度超出 LSAPC 的最高浓度范围，则会发生粒子重叠，这时就使用稀释系统。测试方法：

a) set up the particle counter in accordance with the manufacturer's instructions and the apparatus calibration certificate;

   根据生产商说明书和仪器校正证书设置粒子计数器

b) the particle size used in this test should be less than 1 μm. It is recommended that the size channel used by the LSAPC corresponds to that of the maximum number concentration of the aerosol;

   本测试中所用粒子直径应小于 1μm，建议 LSAPC 所用的料径通道与气溶胶最大浓度数值相对应

c) the cleanroom area to be examined should be contaminated with an aerosol while the air-handling units are in operation;

   在 AHU 运行期间使用气溶胶污染待测洁净间

d) raise the initial particle concentration to more than 10 or 100 times depending on the target cleanliness level (see Note 1);

提高初始粒子浓度至目标洁净水平的 10 倍或 100 倍以上（参见注 1）

e) commence measurements at not more than 1 min intervals and record time and concentration.

以不超过 1 分钟的时间间隔进行测量，记录时间和浓度

f) The results of the decay of the logarithm of the particle concentration should be plotted against time to ensure that the results used are where the decay is exponential, i.e. the decay line is straight, and not at the beginning where the decay has not been established, or at the end where the background count in the cleanroom reduces the decay rate.

将粒子浓度对数衰减结果与时间作图，确保所用结果显示出的衰减为指数相关，即衰减为直线，且不是在衰减开始或洁净间背景计数降低衰减速度结束时

NOTE 1 The target cleanliness level can be either the design cleanliness level, the level established by testing according to ISO 14644-1 at the at-rest condition, or an alternative agreed cleanliness level, assuming that the level is at a point on the decay graph where the decay is exponential.

注：目标洁净度水平可以是设计洁净度水平，亦可是根据 ISO 14644-1 在静态时通过测试所得的洁净度水平，或协定的其它洁净度水平，此时假定该水平在衰减为指数相关时为衰减曲线上的一个点。

NOTE 2 If necessary, an alternative, but less convenient method, can be to turn off the ventilation system, add the test particles, mix with a room fan if needed, and turn on the ventilation system.

注：必要时，可采用替代的但不怎么方便的方法关闭通风系统，增加测试粒子，在房间里使用风扇加以混合（必要时），然后打开通风系统。

B.4.3.3 Evaluation by 10:1 or 100:1 recovery time 按 10:1 或 100:1 自净时间进行评估

Evaluation procedure: 评估方法：

a) note the time when the particle concentration reaches the 10× or 100× target concentration threshold (t_{10n} or t_{100n});

记录粒子浓度达到 10 倍或 100 倍目标浓度阈值的时间（t_{10n} 或 t_{100n}）

b) note the time when the particle concentration reaches the target cleanliness level, t_n;

记录粒子浓度达到目标洁净度水平的时间（t_n）

c) the 10:1 recovery time is represented by $t_{0,1} = (t_n - t_{10n})$;

计算 10:1 自净时间为 $t_{0,1} = (t_n - t_{10n})$

d) the 100:1 recovery time is represented by $t_{0,01} = (t_n - t_{100n})$.

计算 100:1 自净时间为 $t_{0,01} = (t_n - t_{100n})$

B.4.3.4 Evaluation by recovery rate 自净速度评估

Recovery performance can be determined from the slope of the particle concentration decreasing curve, as follows:

自净性能可从粒子浓度衰减曲线的斜率计算如下：

a) commence measurements and record time and concentration continuously. Sampling time should be as short as possible but sampling should be such that the count has statistical relevance. Time intervals between the samplings should be as short as possible;

连续测量并记录时间和浓度。取样时间应尽可能短，但取样应让计数具有统计学相关性。取样时间间隔应尽可能短。

b) plot the data of decreasing particle concentration on a semi-log chart (concentrations on the ordinate by the logarithmic scale, and the time values on the abscissa by the linear scale);

将衰减粒子浓度数据在半对数坐标纸上作图（浓度为对数刻度纵坐标，时间为线性刻度横坐标）

c) decide higher and lower concentration limits as to the decreasing curve measured is accepted as almost straight line;

确定衰减曲线几乎为直线范围内高低浓度限值

d) cleanliness recovery rate is obtained from the slope of the line between the higher and lower concentrations. The cleanliness recovery rate between two measurements is calculated from Formula (B.6):

洁净度自净速度从高低浓度之间的线性斜率中计算而得。2 次测量之间的洁净度自净速度采用公式 B.6 计算而得：

$$r = -2{,}3 \times \frac{1}{t1 - t0} \log\left(\frac{C_1}{C_0}\right) \quad [B.6]$$

Where 其中

C_0 is the higher concentration at t_0; 为时间 t_0 的高浓度

C_1 is the lower concentration at t_1. 为时间 t_1 的低浓度

R is the cleanliness recovery rate; 为洁净度自净速度

$t_1 - t_0$ is the time between measured concentration crosses C_0 and C_1; 为所测浓度 C_0 和 C_1 时间差

NOTE The ventilation effectiveness of a critical location or locations in the cleanroom can be determined by comparing the recovery rate at the location or locations with the overall recovery rate of the cleanroom. When the air and the contamination in the cleanroom are perfectly mixed at the start of the recovery test for the cleanroom, the overall recovery rate of a cleanroom is the same as the air change rate of the cleanroom. Therefore, the ventilation effectiveness can be obtained by comparing the recovery rate at the location or locations with the air change rate of the cleanroom.

注：洁净室内的关键位置通风效果可通过比较该位置与洁净间总体自净速度获得。如果洁净间内空气和污染在该房间自净测试开始时完全混合，则洁净间的总体自净速度与该洁净间的换气速度是相同的。因此，通风效果可通过比较该点的自净速度与该洁净间的换气速度获得。

To obtain comparable values of the recovery test, it is necessary to consider the influence of the temperature difference between incoming air and the recovery performance test point, which causes changes to the airflow in the cleanroom. This temperature difference can vary between the at-rest and as-built conditions, due to changes in the heat gains in the cleanroom, and between the different requirements for seasonal warming or cooling. The temperature differential between the incoming air and recovery test point should be measured.

为得到可比的自净测试值，有必要考虑进风和自净性能测试点之间温度差异的影响，这会导致洁净间气流变化。温度差异在静态和空态时可能会不一样，因为洁净间热量获取会有变化，并且季节性给暖或给冷要求不一样。应测量进风与自净测试点之间的温度差异。

B.4.4 Apparatus for recovery test 自净测试仪器

The apparatus listed below can be used for a recovery test:

下列仪器可用于自净测试：

— aerosol generator and artificially generated aerosol, which have the same characteristics as those described in C.5;

— 气溶胶发生器和人工生成的气溶胶，具有 C.5 所述相同特性

— light-scattering airborne-particle counter (LSAPC), which has the efficiency described in C.8;

— 光散射空气悬浮粒子计数器（LSAPC），其效率应符合 C.8 所述

— dilution system, if necessary, as described by C.5.4;

— C.5.4 所述的稀释系统（必要时）

— thermometer.

— 温度计

NOTE A recovery test can also be carried out using an aerosol photometer.

注：自净测试亦可使用气溶胶光度计进行。

B.4.5 Test reports 测试报告

By agreement between customer and supplier, the following information and data should be recorded as described in Clause 5:

根据客户与供应商之间的协定，应按第 5 条所述记录以下信息和数据：

a) type designations of each measuring apparatus used and its calibration status;

所用每件测量仪器的类型及其校正状态

b) number and location of measuring points;

测量点数目和位置

c) occupancy state(s);

占用状态

d) result of measurement.

测量结果

B.5 Temperature test 温度测试

B.5.1 General 概述

The purpose of this test is to verify the capability of the installation to maintain the air temperature level within the control limits and over the time period agreed between the customer and supplier for the particular area being tested. Refer to ISO 7726[28] and other related documents for details of suitable test methods.

本检测的目的是证明洁净设施的在特定被测区域内在客户与供应商协定的时间段维持空气温度在双方协定的控制限内的能力。适当检测方法详细信息参见 ISO 7726 和其它相关文件。

B.5.2 Apparatus for temperature test 湿度测试仪器

The temperature test should be performed using a sensor that has accuracy as defined in ISO 7726,[28] for example:

温度应采用具备 ISO 7726 所规定准确度的探头进行测试，例如：

a) thermometers;

温度计

b) resistance temperature devices;

电阻温度测量仪

c) thermistors.

热敏电阻

The apparatus should have a valid calibration certificate.

仪器应具备有效的校正证书

B.6 Humidity test 湿度测试

B.6.1 General 概述

The purpose of this test is to verify the capability of the installation to maintain the air humidity level (expressed as relative humidity or dew point) within the control limits and over the time period agreed between the customer and the supplier for the area being tested. Refer to ISO 7726[28] and other related documents for details of suitable test methods.

本测试的目的是验证设施在客户与供应商协定的时间段内在受测区域维护空气湿度水平（表示为相对湿度或露点）在控制限度内的能力。适当检测方法详细信息参见 ISO 7726 及其它相关文件。

B.6.2 Apparatus for humidity test 湿度测试仪器

Humidity tests should be performed using a sensor that has accuracy appropriate to the measurement as stated in ISO 7726[28].

湿度应采用具有 ISO7726 所要求适当准确度的探头进行测试。

Typical sensors are: 典型的探头有：

a) dielectric thin film capacitor humidity sensor;

   电介质薄膜电容器湿度探头

b) dew point sensor;

   露点探头

c) psychrometer.

   干湿球湿度计

B.7 Installed filter system leakage test 已安装过滤器系统检漏

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 document 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 document.

警示：气溶胶挑战可能会在某些洁净设施内产生不可接受的粒子或分子污染。有些测试用气溶胶可能在特定环境下产生安全性危害。本文件并不涉及任何与这些方法有关的安全性问题。用户在使用本文件之前有义务了解并实施适当的安全性规范、风险评估和任何法定限度。

B.7.1 General 概述

B.7.1.1 Methods 方法

These tests are performed to confirm that installed filter systems with integral efficiency of 99,95 % or higher at most penetrating particle size (MPPS) are properly installed by verifying the absence of bypass leakage in the installation, and that the filters are free of defects (small holes and other damage in the filter medium, frame, seal and leaks in the filter bank framework). Portions of the test methods given in B.7 have been adapted from IEST-RP-CC034.4[21].

本测试的目的是通过检查设施没有旁路泄漏来确认已安装的对最具穿透性粒子直径（MPPS）具有 99.95%或更高完整性效率的过滤器系统安装良好，过滤器无缺陷（过滤器介质、边框、密封有小孔和其它损伤，以及过滤器边框泄漏）。在 B.7 中所述测试方法已部分由 IEST-RP-CC34.4 采纳。

These tests are not used to determine the efficiency of the filter medium. The leak test establishes the level of leakage, relevant to the cleanliness performance of the installation. 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. The test is applied to cleanrooms and clean zones in as-built or in at-rest occupational states, and undertaken when commissioning new cleanrooms and clean zones, or when existing installations require re-testing, or after the high-efficiency air filters have been replaced.

本测试不用于确定过滤器介质的效率。检漏确定的是泄漏水平，与设施的洁净度性能有关。本测试是

在过滤器上游引入气溶胶，扫描过滤器下游和边框或在下游风管取样。该测试适用于空态或静态洁净间/室、新洁净室/区调试时，或现有设施需要重新测试，或在高效过滤器更换之后。

Two procedures for filter systems with ceiling, wall or apparatus mounted filters are described in B.7.2 and B.7.3. A procedure for duct mounted filters is described in B.7.4. The apparatus and methods are different, with the method described in B.7.2 measuring a mass concentration using an aerosol photometer and the method described in B.7.3 measuring numbers of particles using a LSAPC.

B.7.2 和 B.7.3 所述的是过滤器固定在天花板、墙面或设备上的过滤器系统的 2 种测试方法。B.7.4 所述的是过滤器安装在风管上的测试方法。它们采用不同的仪器和方法，B.7.2 方法中采用气溶胶光度计测量质量浓度，B.7.3 方法则采用 LSAPC 测量粒子数量。

B.7.1.2 Aerosol photometer method 气溶胶光度计法

The aerosol photometer method (B.7.2) may be used for testing:

气溶胶光度计法 B.7.2 可用于以下测试：

a) cleanrooms and clean zones with all types of air-handling systems;

装有任何类型空气处理系统的洁净室/区

b) installations where outgassing of oil-based volatile test aerosol deposited on the filters and ducts is not considered to be detrimental to products and/or processes and/or personnel within the cleanroom or clean zone.

设施排放油性挥发性测试用气溶胶并在过滤器上沉积，风管对洁净间/区内的产品和/或工艺和/或人员不会产生危害的

NOTE The aerosol photometer method can require a higher upstream aerosol concentration, when compared to the LSAPC method.

注：相比于 LSAPC 方法，气溶胶光度计方法可能需要上游有较高气溶胶浓度。

B.7.1.3 Light-scattering airborne-particle counter (LSAPC) method 光散射空气悬浮粒子计数器（LSAPC）方法

The LSAPC method (B.7.3) may be used for testing:

LSAPC 方法（B.7.3）可用于以下测试：

a) cleanrooms and clean zones with all types of air-handling systems;

将有任何类型空气处理系统的洁净间/区

b) installations where outgassing of oil-based volatile aerosol deposited on filters and ducts cannot be tolerated or where the use of solid aerosol is recommended.

设施排放油性挥发性测试用气溶胶并在过滤器上沉积，风管不能承受或推荐使用固体气溶胶的

NOTE 1 This method requires a series of calculations to set up the method and can also require the use of a diluter (see C.5.4). The calculations can be manual, through independent computers, instrument linked computers, or within automated adapted LSAPC instruments.

注 1：本方法要求进行一系列的计算来设计方法，亦可能需要使用稀释剂（参见 C.5.4）。计算可手动，可通过单独的计算机，可通过仪器连接的计算器或在可自动计算的 LSAPC 仪器内完成。

NOTE 2 This method can also be used with oil-based aerosol where outgassing can be tolerated.

注 2：本方法亦可用于可承受排放油性气溶胶的系统。

B.7.2 Procedure for installed filter system leakage scan test with an aerosol photometer 使用气溶胶光度计对已安装过滤器系统泄漏扫描测试方法

B.7.2.1 General 概述

Preparatory steps are contained in B.7.2.2, B.7.2.3, B.7.2.5 and B.7.2.6, acceptance criteria in B.7.2.4, the test procedure itself in B.7.2.7, and repair actions are to be found in B.7.6[17][18][21].

准备步骤在 B.7.2.2、B.7.2.3、B.7.2.5 和 B.7.2.6 中阐述，可接受标准在 B.7.2.4 中阐述，检测方法在 B.7.2.7 中阐述，修复措施则在 B.7.6 中阐述。

B.7.2.2 Determination of probe size 探头尺寸确定

It is desirable to choose a probe which has a rectangular inlet in sizes of D_p = 1 cm and W_p = 8 cm or a circular probe of diameter D_p = 3,6 cm. D_p is the probe dimension parallel to the scan direction, expressed in centimetres; W_p is the probe dimension perpendicular to the scan direction, expressed in centimetres.

最好选择 D_p = 1 cm 且 W_p = 8 cm 的矩形采样探头，或 D_p = 3,6 cm 的圆形探头。D_p 为平行于扫描方向的探头直径，单位 cm。W_p 为垂直于扫描方向的探头尺寸，单位 cm。

B.7.2.3 Determination of scan rate 扫描速度确定

The probe traverse scan rate, S_r, should be approximately 5 cm/s[21].

探头扫描速度 S_r 应为约 5 cm/s。

B.7.2.4 Acceptance criteria 可接受标准

While scanning, any indication of a leak equal or greater than the limit which characterizes a designated leak should be cause for holding the probe at the leak location. The location of the leak should be identified by the position of the probe that sustains the maximum reading on the aerosol photometer.

在扫描时，发现任何大于等于设计泄漏限度的泄漏情况时均应驻停探头在泄漏位置。应保持探头在气溶胶光度计稳定读出最大数字的位置识别泄漏点。

A leak detected in excess of 0,01 % of the upstream mass concentration is deemed to exceed the maximum allowable penetration. However, for filter systems of an integral efficiency at MPPS ≥99,95 % and less than 99,995 %, the acceptance criterion is 0,1 %.

检出泄漏率超出上游质量浓度的 0.01%时则认为超出最大可接受穿透率。但是，对于完整性效率 MPPS ≥99.95%小于 99.995%的过滤器系统，可接受标准为 0.1%。

If filter systems of an integral efficiency lower than 99,95 % at MPPS are to be tested, a different acceptance criterion are necessary, based on agreement between customer and supplier.

如果所测过滤器系统完整性效率低于 99.95%，则有必要根据客户与供应商之间的协议制订不同的可接受标准。

For actions to be taken to eliminate detected leaks, see B.7.6.

消除所检出的泄漏需采取的措施参见 B.7.6。

B.7.2.5 Choice of upstream aerosol challenge 上游气溶胶挑战的选择

An artificially generated aerosol by Laskin nozzle, thermal generator or similar should be introduced into the upstream airflow to achieve the required homogeneous challenge concentration. The mass median particle diameter for this production method is typically between 0,3 µm to 0,7 µm with a geometric standard deviation of up to 1,7.

将采用 Laskin 喷嘴、热生成器或类似方法人工制作的气溶胶引入上游气流，达到所需均匀性挑战浓度。此种气溶胶制作方法得到的质量介质粒子直径一般为 0.3-0.7µm，几何标准偏差最高 1.7。

NOTE A guide to aerosol source substances is given in C.8.4.

注：气溶胶源物质的指南参见 C.8.4。

B.7.2.6 Concentration of upstream aerosol challenge and its verification 上游气溶胶浓度及核查

The concentration of the aerosol challenge upstream of the filter should be between 1 mg/m^3 and 100 mg/m^3.

过滤器上游气溶胶的浓度应为 1-100 mg/m^3。

NOTE Not all photometers are capable of using 1 mg/m³ as the upstream challenge.

注：并不是所有光度计都能使用 1 mg/m³ 作为上游挑战浓度。

Appropriate measurements should be taken for the verification of the homogenous mixing of the added aerosol to the supply airflow. The first time a system is tested, it should be determined that sufficient aerosol mixing is taking place. For such validation, all injection and sampling points should be defined and recorded.

应采用适当的测量方法验证加入至送风气流中气溶胶混合均匀。系统首次测试时，应确定气溶胶已混合均匀。此类验证中，应规定并记录所有注入点和取样点。

The upstream aerosol concentration measurements taken immediately upstream of the filters should not vary more than ±15 % in time about the average measured value. Concentrations lower than the average reduce the sensitivity of the test to small leaks, while higher concentrations increase the sensitivity to small leaks. Further details as to how to conduct the air-aerosol mixing test should be agreed between customer and supplier.

过滤器上游直接测量的气溶胶浓度值不应超过平均测量值的±15%。浓度值低于平均值会降低对较小泄漏点的测试灵敏度。如何进行空气中气溶胶混合情况测试的更详细要求应由客户与供应商协商确定。

B.7.2.7 Procedure for installed filter system leakage scan test 已安装过滤器系统检漏扫描测试方法

Prior to performing this procedure, the airflow velocity test (B.2) should be carried out. Where installations are operated at different airflow velocities, the highest level should be selected for the filter system leakage scan test. The test is performed by introducing the specific challenge aerosol upstream of the filter(s) and searching for leaks by scanning the downstream side of the filter(s) and the grid or mounting frame system with the photometer’s probe as follows:

在执行本项测试之前，应测试气流速度（B.2）。如果设施以不同气流速度运行，则应选择最高水平用于过滤器系统检漏扫描测试。测试时，将指定的挑战气溶胶注入过滤器上游，用光度计探头扫描过滤器下游和格栅或安装边框系统查找是否有漏点：

a) measure the aerosol concentration upstream of the filters according to B.7.2.6. This aerosol concentration should be used as the upstream 100 % reference for the photometer. Downstream measurements is then displayed as percentage penetration of upstream concentration;

   按 B.7.2.6 测量过滤器上游的气溶胶浓度。该气溶胶浓度应作为上游 100%用于光度计对照。下游测量值显示为上游浓度的百分比穿透率；

b) the probe should then be traversed at a scan rate not exceeding 5 cm/s using overlapping strokes (1 cm recommended). The probe should be held in a distance of 3 cm or less from the downstream filter face or the frame structure;

   然后将探头以不超过 5 cm/s 的速度往返重叠（建议重叠 1cm）扫描。探头与下游过滤器表面或边框结构距离应为 3cm 或更小；

c) scanning should be performed over the entire downstream face of each filter, the perimeter of each filter, the seal between the filter frame and the grid structure, including its joints;

   扫描应覆盖每个过滤器的整个下游表面、每个过滤器的边缘、过滤器边框与格栅结构的密封处，包括其接口；

d) measurements of the aerosol upstream of the filters should be repeated at reasonable time intervals between and after scanning for leaks, to confirm the stability of the challenge aerosol concentration (see B.7.2.6).

   在检漏扫描之间和之后，应以合理时间间隔重复测量过滤器上游的气溶胶浓度，以确认挑战气溶胶浓度的稳定性（参见 B.7.2.6）。

B.7.3 Procedure for installed filter system leakage scan test with a LSAPC 采用 LSAPC 对已安装过滤器系统的扫描检漏测试方法

B.7.3.1 General 概述

Preparatory steps are contained in B.7.3.2 to B.7.3.7, test procedure in B.7.3.8 and B.7.3.9. acceptance criteria in B.7.3.4 and repair actions in B.7.6. An example of an application with evaluation is contained in B.7.3.10.

准备步骤在 B.7.3.2 至 B.7.3.7 中阐述，测试方法在 B.7.3.8 和 B.7.3.9 中阐述，可接受标准在 B.7.3.4 中阐述，修复措施则在 B.7.6 中阐述。评估应用实例放在 B.7.3.10 中。

This method has a two-stage approach:

本方法分为 2 步：

— Stage 1: the clean side of the filter should be scanned for a potential leak. During scanning with a LSAPC, detection of more than an acceptable count for given test conditions, N_a, in sample acquisition time, T_s, indicates the potential presence of a leak. In this case, the second stage should be performed. If there are no indications of potential leaks, further investigations are not necessary. The determination of N_a is described in B.7.3.5 and T_s is described in B.7.3.8.2. The procedure for stage 1 scan test is described in B.7.3.8.

— 第一步：扫描过滤器的清洁一边检查潜在泄漏。在使用 LSAPC 扫描期间，在取样时间（T_s）内使用指定测试条件（N_a）发现超出可接受计数值的点则表示可能出现泄漏。此时，应进入第二步。如果未发现泄漏指征，则不需要进一步调查。B.7.3.5 阐述了如何确定 N_a，B.7.3.8.2 阐述了如何确定 T_s。B.7.3.8 阐述了第一步扫描测试程序。

— Stage 2: the probe should be returned to the place of maximum particle count under each potential leak and a stationary re-measurement should be performed. During the stationary re-measurement with the LSAPC, detection of more than acceptable count for given test conditions, N_{ar}, in sustained residence time, T_r, indicates the presence of a leak. The determinations of N_{ar} and T_r are described in B.7.3.9.2. The procedure for stage 2 stationary re-measuring is described in B.7.3.9.

— 第二步：将探头返回至每个可能泄漏点下最大粒子计数值位置，停止移动，重新测量。在使用 LSAPC 驻停重新测量过程中，在取样时间（T_r）内使用指定测试条件（N_{ar}）发现超出可接受计数值的点则表示可能出现泄漏。B.7.3.9.2 阐述了如何确定 N_{ar} 和 T_r。B.7.3.9 阐述了第二步驻停重新测量方法。

B.7.3.2 Determination of probe size 探头尺寸的确定

The area of the probe size should ensure that the air velocity into the probe is the same as at the filter face, within a variation of ±20 %. The area of the intake probe can be calculated by means of Formula (B.7):

探头面积应确保进入探头的空气速度与过滤器表面的流速相同，其差异不超过±20 %。探头进气面积可使用公式 B.7 计算：

$$D_p \times W_p = Q_{va}/U \qquad \text{(B.7)}$$

Where 其中

D_p is the probe dimension parallel to the scan direction in cm; 为与扫描方向平等的探头尺寸，cm

Q_{va} is the sampling rate of the LASPC in cm^3/s; 为 LSAPC 取样速度，cm^3/s

U is the filter face velocity in cm/s. 为过滤器表面速度，cm/s

W_p is the probe dimension perpendicular to the scan direction, in cm; 垂直于扫描方向探头尺寸，cm

It is desirable to choose a probe which has a rectangular inlet in sizes of D_p = 1 cm and W_p = 8 cm or a circular probe of diameter D_o = 3,6 cm. Recommended probe dimensions are based on a sample flow rate, Q_{vs}, of 0,000 472 m^3/s (= 472 cm^3/s, 28,3 l/min or 1 CFM).

最好选择进口尺寸为 D_p = 1 cm 和 W_p = 8 cm 的探头矩形，或尺寸 D_o = 3.6 cm 的圆形探头。建议根

据样品流速 Q_{vs}，即 0,000 472 m^3/s （= 472 cm^3/s, 28,3 l/分钟或 1 CFM）选择探头尺寸。

If filter face velocity is unusually high (>1 m/s), a smaller dimension for the probe, D_p, can be calculated by use of Formula (B.7).

如果过滤器表面速度异常地高（>1 m/s），则可使用公式 B.7 计算得更小的探头尺寸 D_p。

For a circular probe, Formula (B.8) can be used to determine the value of D_p.

对于圆形探头，可使用公式 B.8 计算 D_p 值：

$$D_p = 2\times\sqrt{D_0\times W_s - W_s^{\,2}} \qquad \text{(B.8)}$$

Where 其中

D_p is the nominal probe dimension parallel to the scan direction, in cm;

为平行于扫描方面的名义探头尺寸，单位 cm

D_0 is the actual probe dimension (diameter), in cm;

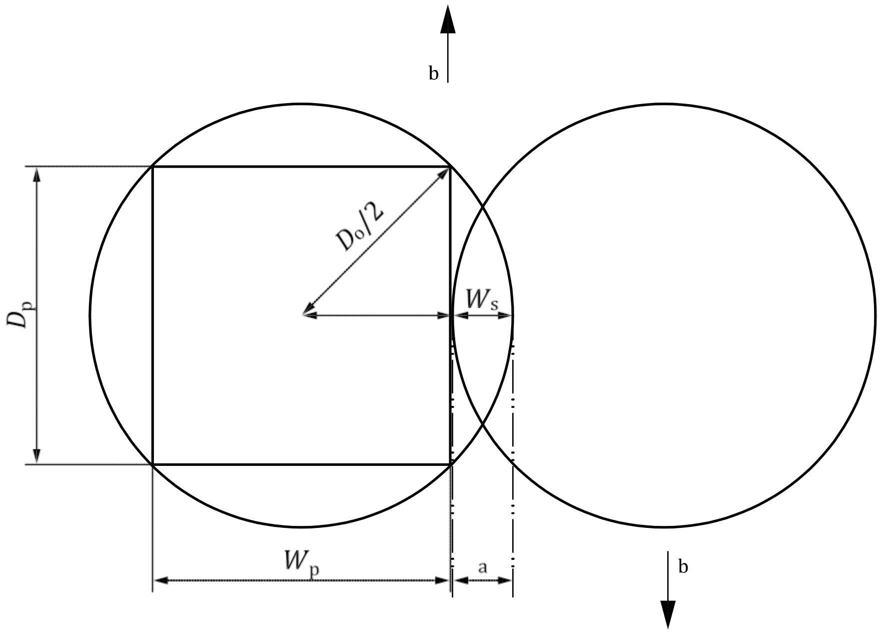
为实际探头尺寸（直径），单位 cm

W_s is the probe overlap dimension perpendicular to the scan direction, in cm.

为垂直于扫描方向的探头重叠尺寸，单位 cm

For a circular probe of a 3.6 cm, diameter, D_p, is 2.54 cm.

对于直径为 3.6cm 的圆形探头，D_p 为 2.54cm



Key 图中

a Overlap. 重叠

b Scan direction. 扫描方向

Figure B.1 — Circular probe dimensions diagram

图 B.1----圆形探头尺寸图

NOTE In order to scan the target surface area most efficiently, it is necessary to select W_s as D_p becomes equal to W_p. In case of circular probe with a diameter of 3,6 cm, the most efficient D_p is 2,54 cm.

注：为最有效地扫描目标表面面积，有必要选择为 D_p 等于 W_p 时的 W_s。如果圆形探头直径为 3.6cm，最有效的 D_p 为 2.54cm。

B.7.3.3 Determination of scan rate 扫描速度的确定

For a rectangular probe inlet size of D_p = 1 cm and W_p = 8 cm, the probe scan rate, S_r, is 5 cm/s or less. For a circular probe inlet diameter of 3,6 cm, the probe scan rate, S_r, is 12 cm/s or less.

如果矩形探头进口尺寸为 D_p = 1 cm 和 W_p = 8 cm，探头扫描速度 S_r,应为 5 cm/s 或更低。如果是圆形探头进口直径为 3.6cm，探头扫描速度可 S_r 应为 12 cm/s 或更低。

Where the upstream aerosol concentrations cannot be achieved, it is necessary to change the scan rate. The scan rate, S_r, in cm/s can be determined by assuming the sampling rate of the LSAPC is 0,000 472 m³/s and use Formula (B.9).

如果上游气溶胶浓度达不到，则有必要改变扫描速度。可假定 LSAPC 的取样速度为 0.000 472 m³/s，使用公式 B.9 计算扫描速度 S_r,单位为 cm/s。

$$S_r = C_c \times P_l \times 0{,}000\,472 \times \frac{D_p}{N_p} \tag{B.9}$$

Where 其中

C_c is the challenge aerosol concentration upstream of the filter in particles/m³;

为过滤器上游的挑战气溶胶浓度，单位个/ m³

N_p is the expected median of particle counts that characterize a designated leak in particles;

为预期粒子计数中值，表示规定粒子泄漏率

P_l is the maximum permitted penetration of the filter installation to be tested at 0,3 µm.

为待测过滤器设施的 0.3µm 粒子允许最大浓度

B.7.3.4 Particle size to be counted and acceptance criteria 待计数的粒子直径和可接受标准

The particle size to be counted should be equal to or greater than 0,3 µm.

待计数粒径应等于或大于 0.3µm。

While scanning, any indication of a leak should be cause for holding the probe at the leak location. The location of the leak should be identified by the position of the probe.

扫描时，发现任何泄漏表征时均应驻停探头于泄漏处。应通过探头位置识别泄漏点。

A leak detected in excess of 0,01 % of the upstream number concentration is deemed to exceed the maximum allowable penetration. However, for filter systems of an integral efficiency at MPPS ≥99,95 % and less than 99,995 %, the acceptance criterion is 0,1 %.

检出泄漏超出上游粒子浓度数的 0.01%时，则认为其超出允许最大穿透率。但是，对于完整效率 MPPS ≥99,95 %且低于 99.995%的过滤器系统，可接受标准为 0.1%。

If filter systems of an integral efficiency lower than 99,95 % at MPPS are to be tested, a different acceptance criterion is necessary, based on agreement between customer and supplier.

如果待测过滤器系统完整性效率 MPPS 低于 99.95%，则需要依据客户与供应商之间的协定采取不同的可接受标准。

B.7.3.5 Expected number of particle counts 预期粒子数目

The acceptable number of particle counts during the scanning (Stage 1) is N_a and it is desirable to select a N_a value of 0 or 1.

扫描中可接受的粒子数目（第一步）为 N_a，最好选择 N_a 值为 0 或 1.

The lower confidence limit will determine N_a. It can be calculated with Formula (B.10).

置信下限将确定 N_a 值。可采用公式 B.10 计算。

$$N_a = N_p - 2\sqrt{N_p} \quad \text{(B.10)}$$

where N_p is the expected median of particle counts that characterize a designated leak of particles.

其中 N_p 为预期粒子计数中值，确定粒子泄漏率。

It is the value N_p that is carried forward in Formula (B.9), and Formula (B.11) can be used to calculate N_p:

值 N_p 在公式 B.9 中有使用，公式 B.11 可用于计算 N_p：

$$N_p = (N_a + 2) + 2\sqrt{1 + N_a} \quad \text{(B.11)}$$

When $N_a = 0$, N_p is 4, and when $N_a = 1$, N_p is 5,83.

如果 $N_a = 0$，则 N_p 为 4，如果 $N_a = 1$，则 N_p 为 5.83.

NOTE Higher values of N_a and N_p can be selected if there are concerns with false positives being caused by a "bleed through" of particles in undamaged filter media.

注：如果不担心未受损过滤介质中粒子“渗漏”导致假阳性，可选择 N_a 与 N_p 中较高者。

B.7.3.6 Choice of upstream aerosol challenge 上游气溶胶的选择

An artificially generated polydisperse aerosol should be introduced into the upstream airflow to achieve the required homogeneous challenge concentration. The count median particle diameter for this production method is typically between 0,1 µm to 0,5 µm with a geometric standard deviation of up to 1,7. The median particle diameter for this production method is typically between 0,3 µm and 0,7µm with a geometric standard deviation of up to 1,7.

将人工生成的多分散体系气溶胶引入上游气流，达到所需的均匀挑战浓度。此种气溶胶生成方法所得到的计数粒径中值一般为 0.1-0.5µm，几何标准偏差最高 1.7。此种气溶胶生成方法所得粒径中值一般介于 0.3-0.7µm，几何标准偏差最高 1.7。

Alternatively, microspheres with an appropriate diameter can be used and an aerosol challenge.

亦可使用适当直径的微球作为气溶胶挑战。

Where an artificial aerosol cannot be introduced, atmospheric aerosol should be used as the upstream aerosol challenge.

如果不能引入人工气溶胶，则应使用大气气溶胶作为上游气溶胶挑战。

NOTE A guide to aerosol source substances is given in C.8.4.

注：C.8.4 提供了气溶胶源物质指南。

B.7.3.7 Concentration **of upstream aerosol challenge and its verification** 上游气溶胶挑战浓度及其确认

The concentration of the aerosol challenge upstream of the filter should be sufficiently high to achieve acceptable practical scan rates according to B.7.3.3. The concentration of aerosol challenge upstream of the filter is determined with Formula (B.12):

过滤器上游的气溶胶浓度应足够高，达到 B.7.3.3 中可接受实际扫描速度。过滤器上游的气溶胶挑战浓度采用公式 B.12 计算：

$$C_c \geq N_p \times S_r / (Q_{Vs} \times D_p \times P_L) \quad \text{(B.12)}$$

Where 其中

C_c is the challenge aerosol concentration upstream of the filter, in particles/m^3;

为过滤器上游气溶胶浓度，单位个/ m^3

D_p is the probe dimension parallel to the scan direction, in cm;

为平行于扫描方向的探头尺寸，单位 cm

P_l is the maximum permitted penetration of the filter installation to be tested at 0,3 μm.

为待测过滤器设施 0.3μm 粒子的允许最大穿透率

Q_{Vs} is the actual sample flow rate of the measuring apparatus, in m^3/s;

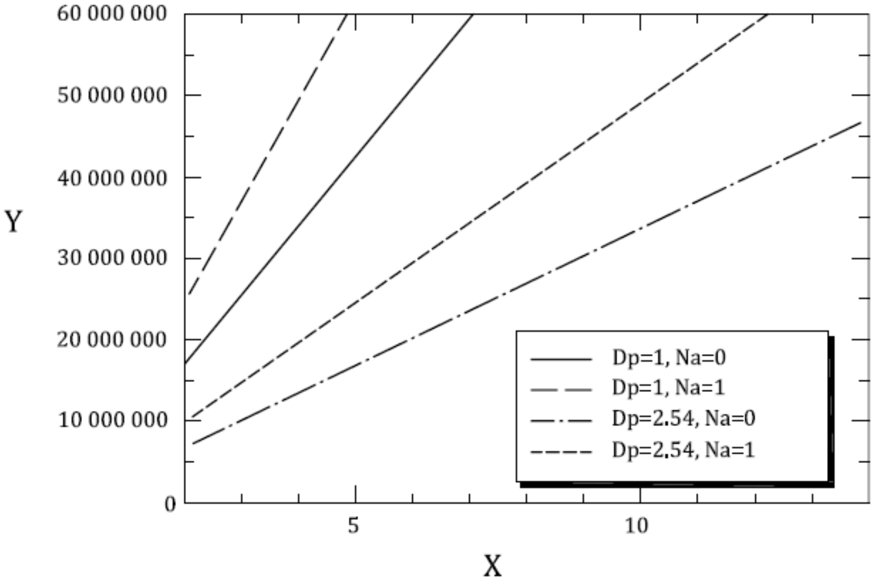
为测量仪器的实际样品流速，单位 m^3/s

S_r is the probe traverse scan rate, in cm/s;

为探头扫描速度，单位 cm/s

Based on the recommend probe size and scan rate as stated in B.7.3.2 and B.7.3.3, the concentration of aerosol challenge upstream of the filter can be selected from Figure B.2:

根据 B.7.3.2 和 B.7.3.3 中建议探头尺寸和所述扫描速度，可从图 B.2 中选择过滤器上游气溶胶浓度。



Key 坐标轴

X probe traverse scan rate, S_r in cm/s

探头扫描速度，S_r 单位 cm/s

Y challenge aerosol concentration, C_c in particles/m^3

挑战气溶胶浓度，C_c 单位个/m^3

Figure B.2 — Challenge aerosol concentration, C_c, for various probe traverse scan rate, S_r

图 B.2—挑战气溶胶浓度 C_c，为不同探头扫描速度 S_r

In most cases, generated aerosol should be added to the upstream aerosol challenge to reach the necessary high challenge concentration. To verify such high concentrations, a dilution system can be required to avoid exceeding the concentration tolerance of the LSAPC (coincidence error).

大多情形下，应将生成的气溶胶加入上游气溶胶挑战达到必要的高挑战浓度。为确认该高浓度，可使用稀释系统避免超出 LSAPC 的浓度可接受限（偶合误差）。

Challenge aerosol concentrations can be adjusted by changing the probe scan rate by use of Formula (B.9).

可使用公式 B.9 通过改变探头扫描速度调整挑战气溶胶浓度。

Appropriate measurements should be taken for verification of the homogenous mixing of the added aerosol to the supply airflow. The first time a system is tested, it should be determined that sufficient aerosol mixing is taking place. For such validation, all injection and sampling points should be defined and recorded.

应进行适当的测量对所加入至送风气流的气溶胶混合均一性进行验证。如果系统是首次测试，应确定气溶胶混合充分。对于此类验证，应规定并记录所有注入点和取样点。

The upstream aerosol concentration measurements taken immediately upstream of the filters should not vary more than ±15 % in time from the average measured value. Concentrations lower than the average will reduce the sensitivity of the test to small leaks, while higher concentrations increase the sensitivity to small leaks. Further details as to how to conduct the air-aerosol mixing test should be agreed between customer and supplier.

对过滤器上游接近点气溶胶浓度测量所得值不应超出平均测量值的±15 %。低于平均浓度的值会降低对较小泄漏的测试灵敏度，而高浓度则会提升对较小泄漏的测试灵敏度。更多关于如何进行空气气溶胶混合测试的详细信息应由客户与供应商协商确定。

When upstream aerosol concentrations vary over the time, these measurements should be continued during scanning for leaks in order to gain data for calculations with sequential downstream counts.

如果上游气浓胶浓度随时间变化，在检漏扫描期间应持续这些测量，以获得数据用于顺序下游计数值的计算。

B.7.3.7 Procedure for installed filter system leakage test, stage 1 scan test 已安装过滤器系统检漏方法，第一步扫描测试

B.7.3.7.1 General 概述

Prior to performing this procedure, the airflow velocity test (see B.2) should be carried out. Where installations are operated at different airflow velocities, the highest level should be selected for the filter system leakage scan test. The test is performed by introducing the specific challenge aerosol upstream of the filter(s) and searching for leaks by scanning the downstream side of the filter(s) and the grid or mounting frame system with the LSAPC probe as follows:

在执行本方法之前，应对气流速度（参见 B.2）进行测试。如果设施以不同气流速度运行，则应选择最高水平用于过滤器检漏扫描测试。测试时，将指定的挑战气溶胶注入过滤器上游，用 LSAPC 探头扫描过滤器下游和格栅或安装边框系统查找是否有漏点：

a) measurements of the aerosol upstream of the filters according to B.7.3.7 should be taken first to verify the aerosol concentration;

   根据 B.7.3.7 首先测量过滤器上游气溶胶，以确认气溶胶浓度

b) the probe should then be traversed at a scan rate not exceeding the value for S_r stated in B.7.3.3, using slightly overlapping strokes. The probe should be held in a distance of approximately 3 cm from the downstream filter face or the frame structure;

   将探头以不超过 B.7.3.3 所述速度移动扫描，扫描区域略有重叠。探头应

c) scanning should be performed over the entire downstream face of each filter, the perimeter of each filter, the seal between the filter frame and the grid structure, including its joints;

   应在每个过滤器的整个下游表面、每个过滤器的边缘、过滤器边框与格栅结构之间的密封，包括其接口进行扫描

d) measurements of the aerosol upstream of the filters should be repeated at reasonable time intervals between and after scanning for leaks, to confirm the stability of the challenge aerosol concentration (see B.7.3.7).

在检漏扫描期间和之后，应以合理时间间隔重复测量过滤器上游的气溶胶浓度，以确认挑战气溶胶浓度的稳定性

B.7.3.7.2 Measuring parameters for two scanning types 两类扫描的测量参数

Generally, LSAPCs are designed to count particles in a specific volume of sampled air. Many LSAPCs are not capable of outputting the data of particle counts during very short periods in continuous measurement.

一般来说，LSAPC 设计是用来对指定取样体积空气中粒子进行计数的。许多 LSAPC 在连续测量过程中无法在非常短的时间内输出粒子计数数据。

Thus, the conditions for $N_a = 0$ or $N_a = 1$ (N_a is acceptable count for given test conditions) should be chosen in the installed filter system leakage scan test with the LSAPC.

因此使用 LSACP 进行已安装过滤器系统扫描检漏时应选择 $N_a = 0$ 或 $N_a = 1$ 的条件（N_a 为指定测试条件下可接受计数值）。

Choosing this condition, leakage is verified with each count during the test, or with the period between counts.

选择此条件时，泄漏是通过测试期间每次计数，或在不同计数之间进行验证的。

If the apparatus is equipped to emit a sound for each count, leakage can be verified using this sound.

如果仪器可在每次计数时发声，则可使用此声音来验证存在泄漏。

If the apparatus can output the counts during very short periods in continuous measurement, any N_a is applicable. Absence of a leak is verified if the observed count is equal to or less than N_a at the time (D_p / S_r).

如果仪器可在连续测量期间在非常短的时间内输出计数结果，则可使用任意 N_a。如果在时间（D_p / S_r）所观察到的计数值等于或小于 N_a，则确认没有泄漏。

For reasonable test conditions, the following two scanning types can be selected:

测试条件合理时，可选择以下 2 类扫描方式：

a) Scanning type (a): Choosing $N_a = 0$ for 0,3 µm particles;

扫描类型（a）：选择 0,3 µm *粒子* $N_a = 0$

— suitable when the frequency of stationary re-measuring is predicted to be very small;

— 适合于驻停重新测量的频次预期非常低时

— type (a) test requires lower concentration for upstream than type (b);

— （a）类测试要求上游浓度比（b）类测试更低

— absence of a leak is verified if the count is 0; the scanning test can be continued.

— 如果计数值为 0，则证明无泄漏，可继续扫描测试

b) Scanning type (b): Choosing $N_a = 1$ for 0,3 µm particles;

扫描类型（b）：选择 0.3 µm *粒子* $N_a = 1$

— suitable when predicted that stationary re-measuring may be necessary;

— 适合于可能需要驻停重新测量的情况

— type (b) test requires higher concentration for upstream than type (a), however the influence of LSAPC count error is reduced;

— （b）类测试要求上游浓度比（a）类测试更低，但 LSAPC 计数器误差的影响会降低

— if the observed count is 0 or 1, absence of a leak is verified. The scanning test can be continued.

— 如果观察到的计数值为 1，则确认没有泄漏。可继续扫描测试

B.7.3.9 Procedure for stationary re-measuring 驻停重新测量方法

B.7.3.9.1 General 概述

The observation of a particle count larger than N_a indicates the potential presence of a leak, and the location should be checked by stationary re-measuring.

观察到粒子计数值大于 N_a 则显示可能存在泄漏，要采用驻停方法重新测量该点。

B.7.3.9.2 Detection of leakage by stationary re-measuring 驻停重新测量检漏

a) Observed counts smaller than N_{ar} [particles]: the observed counts for T_r, equal to or smaller than N_{ar} confirm an absence of leaks.

所观察的计数值小于 N_{ar}【个粒子】时：在时间 T_r 内所观察的计数值等于或小于 N_{ar}，则确认无泄漏。

b) Observed counts larger than N_{ar} [particles]: if the observed count exceeds N_{ar}, stationary re-measuring may be considered. If the observed count still exceeds N_{ar}, the filter should be considered to have a leak.

所观察的计数值大于 N_{ar}【个粒子】时：如果所观察的计数值超过 N_{ar}，可考虑驻停重新测量。如果所观察到的计数值仍超过 N_{ar}，则应考虑过滤器有泄漏。

B.7.3.9.3 Determination of measuring parameters for stationary re-measuring 驻停重新测量的测量参数确定

Recommended sustained residence time, T_r, is 10s.

建议驻停时长 T_r 为 10 秒。

The number of particle counts that characterizes the designated leak, N_{pr}, and acceptable count at stationary re-measuring, N_{ar}, are calculated with Formulae (B.13) and (B.14):

设计泄漏率的粒子计数值 N_{pr} 和驻停重新测量时可接受计数值 N_{ar} 采用公式 B.13 和 B.14 进行计算：

$$N_{pr} = C_c \times P_l \times Q_{VS} \times T_r \quad \text{(B.13)}$$

$$N_{ar} = N_{pr} - 2\sqrt{N_{pr}} \quad \text{(B.14)}$$

Where 其中

C_c is the challenge aerosol concentration upstream of the filter in particles/m^3;

为过滤器上游挑战气溶胶浓度，单位个/ m^3

D_p is the probe dimension parallel to the scan direction in cm.

为平行于扫描方向的探头尺寸，cm

N_{ar} is acceptable count at stationary re-measuring;

为驻停重新测量时可接受计数标准

N_{pr} is the number of particle counts which characterize the designated leak;

为设计泄漏率的粒子计数值

P_l is the maximum permitted penetration of the filter installation to be tested at 0,3 μm;

为待测过滤器设计的 0.3μm 粒子允许最大穿透率

Q_{VS} is the actual sample flow rate of the measuring apparatus in m^3/s;

为测量仪器的实际取样速度，m^3/s

T_r is the recommended sustained residence time(s);

为建议驻停时间

B.7.3.10 Example of an application with evaluation 评估应用举例

Examples of measuring parameters are shown in Table B.3. These tables give example parameters for D_p = 1 cm and W_p = 8 cm with a scan rate S_r = 5 cm/s, and a circular probe with diameter 3,6 cm and a scan rate S_r = 12 cm/s.

表 B.3 中列出的是测量参数例子。此表给出的是采用矩形采样头 D_p = 1 cm 以及 W_p = 8 cm ，扫描速度 S_r = 5 cm/s 时，和圆形采样头直径为 3.6cm，扫描速度 S_r = 12 cm/s 时的参数样例。

Table B.3 — Example of an application with evaluation

表 B.3—评估应用举例

Measuring parameters		Rectangular probe (1 cm × 8 cm)		Circular probe (diameter 3,6 cm)	
测量参数		矩形探头（1 cm × 8 cm）		圆形探头（直径 3.6cm）	
	Scanning type 扫描类型	type (a)	type (b)	type (a)	type (b)
P_l	Maximum allowable penetration of the filter system to be tested 待检过滤器系统的允许最大穿透率	0,000 1(0,01%)		0,000 1(0,01%)	
D_p	Nominal probe dimension parallel to the scan direction [cm] 平行于扫描方向的名义探头尺寸【cm】	1		2,54	
S_r	Probe traverse scan rate [cm/s] 探头扫描速度【cm/s】	5		12	
Q_{vs}	Sample flow rate of the measuring apparatus [m^3/s] 测量仪器取样速度【m^3/s】	0,000 472		0,000 472	
N_p	Expected number of particle counts that characterizes the designated leak corresponding to N_a [counts] – Stage 1 对应 N_a【计数】的指定泄漏率时规定粒子数目	4,0	5,83	4,0	5,83
N_a	Acceptable count during T_s at scan test [counts] – Stage 1 扫描测试【计数】中时间 T_s 可接受计数值---第 1 步	0	1	0	1
C_c	Challenge aerosol concentration upstream of the filter [particles/m^3] 过滤器上游的挑战气溶胶浓度【个/m^3】	423 728 814	617 584 746	400 373 682	583 544 642
N_{pr}	Expected number of particle counts during T_r = 10 s in the sustained residence time that characterizes the designated leak corresponding to N_{ar} [counts] – Stage 2 对应 N_{ar}【计数】的指定泄漏率时驻停时间 T_r = 10 秒内规定粒子数目—第二步	200,00	291,50	188,98	275,43

N_{ar}	Acceptable count during T_r = 10 s in the sustained residence time [counts] – Stage 2 (rounded) 驻停时间 T_r = 10 秒内可接受计数值【计数】--第二步（修约后）	171,72 (171)	257,35 (257)	161,48 (161)	242,24 (242)

B.7.4 Procedure for overall leak test of filters mounted in ducts or air-handling units (AHUs) 安装在风管内或空气处理单元（AHU）中的过滤器的总体泄漏率测试方法

This procedure may be used for evaluating the overall leakage of duct-mounted filters. This procedure may also be used to determine overall leakage of multistage filter arrays without individual stage tests. It is important to be aware that this procedure is significantly less sensitive at finding leaks than the method described in B.7.2 and B.7.3. The overall leakage test result is affected by the total airflow volume in the system, as the airflow volume increases more dilution of the leak occurs. Therefore, this test method should be used where duct-mounted filter installations serve less critical cleanroom areas and where scan testing of those same filter installations is not practical. If critical, the scan method should be adopted.

本方法可用于评估风管内安装的过滤器的总体泄漏率。本方法亦可用于确定多个过滤器阵列的总体泄漏率，而不需要单个测试。明白本方法发现泄漏的灵敏性远远低于 B.7.2 和 B.7.3 中所述方法非常重要。总体泄漏率测试结果受到系统中总体送风量的影响，因为气流量增加时会发生更多泄漏稀释。因此本测试方法应当用于那些支持较为不重要洁净间区域的风管内已安装过滤器设施，且无法对其进行扫描检漏的情况。如果是关键设施，则仍应使用扫描方法。

NOTE 1 This test is not designed to cover exhaust HEPA filter systems.

注：本测试并非用于排风 HEPA 过滤器系统。

The test is performed by introducing the challenge aerosol upstream of the filters installed remotely to the cleanroom or clean zone. The upstream particle concentration is first measured. The particle concentration of the filtered air is then measured, and compared to the upstream concentration to determine the total leakage or penetration of the filter installation[19].

进行本测试时，向远离洁净间/区的已安装过滤器上游引入挑战气溶胶。首先测量上游粒子浓度，然后测量已过滤空气中的粒子浓度，与上游浓度进行比较，确定该过滤器设施的总体泄漏率或穿透率。

The airflow velocity test (see B.2) for initial qualification should be done prior to performing this test. Measurements of the upstream aerosol concentration according to B.7.2.6 (aerosol photometer method) or B.7.3.7 (LSAPC method) should be taken first to verify the aerosol concentration and homogeneity.

初次确认时空气流速测试（参见 B.2）应在本测试之前完成。应先根据 B.7.26（气溶胶光度计方法）或 B.7.3.7（LSAPC 方法）测量上游气溶胶浓度，以验证气溶胶浓度和均匀性。

Measurement of downstream aerosol concentration should be carried out at locations where homogeneous mixing has occurred. If homogeneous mixing does not occur, a series of measurements should be taken at equally spaced locations in an agreed plane, between 30 cm and 100 cm downstream of the filter. This is a grid sampling method and the location and number of measurements should be agreed between the customer and the supplier.

下游气溶胶浓度应在均匀混合好的点进行测量。如果未混合均匀，则应在协定截面上距过滤器下游 30-100cm 处相同步距的点上进行一系列测量。此为网格取样方法，测量点和测量次数应由客户现供应商协商确定。

Measurements of the total aerosol challenge or particle concentrations upstream of the filters should be repeated at reasonable time intervals to confirm stability of the challenge aerosol source (see B.7.2.6 and B.7.3.7).

过滤器上游的气溶胶或粒子总浓度应以合理时间间隔重复测量，以确认挑战气溶胶源的稳定性（参见 B.7.2.6 和 B.7.3.7）。

Using a photometer, from the measured total challenge or concentration, the local penetration is measured as percentage penetration for each downstream location measurement. Using a LSAPC, from the measured particle challenge concentration, the local percentage penetrations should be calculated for each downstream location measurement for the particle size used. Each downstream percentage concentration should be lower than the percentage concentration specified, or as agreed between customer and supplier.

使用光度计，测量总体挑战浓度，测量每个下游位置的百分比穿透率。使用 LSAPC 时，测量粒子挑战浓度，计算所用粒径下每个下游位置的局部百分比穿透率。每个下游百分比浓度应低于规定的百分比穿透率，或低于客户与供应商协定的值。

Repairs or rectification of leaks may be made according to B.7.6 or by procedures agreed between the customer and the supplier.

可按 B.7.6 或客户与供应商之间协定对泄漏点进行修补或矫正。

NOTE 2 For applications, where ducted filters are required to be leak tested by scanning, the methods are described in B.7.2 and B.7.3.

注：如果需要对安装在风管中的过滤器进行扫描检漏，参见 B.7.2 和 B.7.3 中所述方法。

B.7.5 Apparatus and materials for installed filter system leakage tests 已安装过滤器系统检漏用仪器和材料

B.7.5.1 Aerosol photometer (see C.8.1), limited to use in instances where the background counts or concentrations are less than 10 % of that which characterizes a designated leak 气溶胶光度计（参见 C.8.1），限用于背景粒子数或浓度低于规定泄漏率 10%的情形

B.7.5.2 Light-scattering airborne-particle counter (LSAPC) (see C.8.2), limited to use in instances where the background counts or concentrations are less than 10 % of that which characterizes a designated leak. 光散射空气悬浮粒子计数器（LSAPC）（参见 C.8.2），限用于背景粒子数或浓度低于指定泄漏率的 10%的情况

B.7.5.3 Suitable pneumatic or thermal aerosol generator(s) to provide appropriate challenge aerosol concentration in the appropriate size range (see C.8.3). 适当的气动或热力学气溶胶发生器，提供具有适当粒径范围的适当挑战气溶胶浓度（参见 C.8.3）

B.7.5.4 Aerosol dilution system (see C.5.4). 气溶胶稀释系统（参见 C.5.4）

B.7.5.5 Aerosol source substances (see C.8.4). 气溶胶源物质（参见 C.8.4）

Apparatus specified in B.7.5.1 to B.7.5.3 should have a valid calibration certificate.

B.7.5.1 至 B.7.5.3 中所规定的仪器应具备有效的校正证书。

B.7.6 Repairs and repair procedures 维修和维修方法

Leakage repair should only be acceptable by agreement between the customer and the supplier. The method of repair should take into account any instructions from the apparatus manufacturer, or the customer.

只有当客户与供应商协定同意时，才可进行泄漏维修。维修方法应考虑设备生产商的说明书或客户要求。

In selecting materials for repair, outgassing and molecular deposition on products and processes should be considered.

在选择维修用材料时，应考虑放出气体和分子沉降在产品和工艺上的情况。

Detected leakage in filters, the sealant or the grid structure should be repaired.

检出过滤器泄漏时，应维修密封剂或格栅结构。

Repairs to filter or the grid support structure may be made using procedures agreed between the customer and supplier.

可使用客户与供应商协定的方法对过滤器或格栅支持结构进行维修。

After the repair has been completed and a suitable cure time has been allowed, the leak site should be rescanned for leaks using the defined method.

在完成维修并经过适当的放置时间之后，使用指定方法对泄漏处重新扫描检漏。

B.7.7 Test reports 测试报告

By agreement between the customer and supplier, the following information and data should be recorded as described in Clause 5:

根据客户与供应商之间的协定，应按第 5 条所述记录以下信息和数据：

a) test method: aerosol photometer or light-scattering airborne-particle counter (LSAPC);

测试方法：气溶胶光度计或光散射空气悬浮粒子计数器（LSAPC）

b) type designations of each measuring apparatus used and its calibration status;

所用的所有测量仪器型号及其校正状态

c) specification of the filter;

过滤器规格

d) any special condition or departures or both from this test method and any special procedures agreed between the customer and the supplier;

本方法任何特殊情况，或偏离本方法的情况，以及客户与供应商之间协定的任何特殊方法

e) measured upstream aerosol concentrations with their sample point locations and the corresponding time of measurement;

上游气溶胶浓度测量值，以及其取样点位置和对应测量时间

f) sample flow rate; and for LSAPC measurements, the particle size range;

样品流速，以及 LSAPC 测量中粒径范围

g) calculated average upstream aerosol concentration and its distribution;

计算所得上游气溶胶浓度平均值及其分布情况

h) calculated acceptance criteria applied for the downstream measurements;

计算所得的下游测量适用可接受标准

i) result of the downstream measurement for each clearly identified filter, area section or measuring location;

每个清楚标识的过滤器、区域部分或测量位置的下游测量结果

j) final result of the test for each defined location;

每个指定位置的最终测试结果

k) if there is no leakage, then test passed. Otherwise if there is leakage then report leak location, repair action and result of re-testing the location.

如果没有泄漏，则测试通过。否则应报告泄漏位置，修复措施以及该位置重新测试的结果

B.8 Containment leak test 密闭性泄漏测试

B.8.1 General 概述

This test is performed to determine if there is intrusion of contaminated air into the clean zones from surrounding non-controlled areas and to check pressurized ceiling systems for leaks.

本测试目的是确定是否有受污染的空气由外围非受控区域侵入洁净区，检查承压天花板系统的泄漏情况。

B.8.2 Procedures for containment leak test 密闭性泄漏测试方法

B.8.2.1 Light-scattering airborne-particle counter (LSAPC) method 光散射空气悬浮粒子计数器（LSAPC）方法

Measure the particle concentration outside the cleanroom enclosure immediately adjacent to the surface or doorway to be evaluated. This concentration should be greater than the cleanroom concentration by a factor of 10^3, and equal to at least ($3,5 \times 10^6$) particles/m^3 at the particle size to be measured. If the concentration is less, generate an aerosol to increase the concentration.

测量待评估表面或门口最近的洁净间密闭区外粒子浓度。其待测量粒子浓度应大于洁净间浓度 1000 倍，等于至少（3.5×10^6）个粒子/ m^3。如果浓度更低，制造气溶胶增加浓度。

To check for leakage through construction joints, cracks or service conduits, scan inside the enclosure at a distance of not more than 5 cm from the joint, seal or mating surfaces to be tested at a scan rate of approximately 5 cm/s.

检查结构接口、裂缝或服务用导管泄漏时，以 5cm/s 速度扫描密闭体内部，离接口处或被测接口、密封处或配合表面距离应小于 5cm。扫描密闭体内部，

To check for intrusion at open doorways, flow visualization methods are recommended.

检查打开门口的空气侵入情况时，建议使用气流可视化方法。

Record and report all readings greater than 10^{-2} times the measured external aerosol particle concentration at the appropriate particle size.

记录和报告适当粒径的所有大于倍所测外部气溶胶粒子浓度百分之一的读数。

NOTE The number and location of test points for this measurement are as agreed between customer and supplier.

注：本测量的测试点数目和位置应依据客户与供应商协定。

B.8.2.2 Aerosol photometer method 气溶胶光度计方法

Produce an aerosol outside the cleanroom or device in accordance with B.7.2.2 in concentration high enough to cause the aerosol photometer to exceed 0,1 %. A reading in excess of 0,01 % indicates a leak.

按 B.7.2.2 在洁净间或装置外面生成气溶胶，浓度应足够导致气溶胶光度计超出 0.1%。读数超出 0.01%时表示有泄漏。

To check for leakage through the construction joints, cracks or seams scan inside the enclosure at distance of not more than 5 cm from the joint, or seal surface to be tested, at a scan rate of approximately 5 cm/s.

检查结构连接处、裂缝或接缝处泄漏情况时，以 5cm/s 速度扫描密闭体内部，离接口处或被测密封表面距离应小于 5cm。

To check for intrusion at open doorways, measure the concentration inside the enclosure at a distance of 0,3 m to 1 m from the open door.

检查门口空气侵入情况时，在密闭体内部离打开的门 0.3-1m 处测量浓度。

Record and report all readings in excess of 0,01 % of the photometer scale.

记录和报告所有超出光度计刻度 0.01%的读数。

B.8.3 Apparatus for containment leak test 密闭性泄漏测试仪器

B.8.3.1 **Artificially generated aerosol source**, as described in B.7.5, with a valid calibration certificate; 人工生成气溶胶来源，按 B.7.5 所述，具有有效校正证书

B.8.3.2 **Light-scattering airborne-particle counter (LSAPC)**, as specified in C.8.2 (or **photometer**, as specified in C.8.1) with a valid calibration certificate and a lower particle size discrimination capability of 0,5 μm or smaller. 光散射空气悬浮粒子计数器（LSAPC），按 C.8.2 所规定（或光度计，按 C.8.1 指定），具有有效校正证书，粒径识别能力等于或低于 0.5μm。

B.8.4 Test reports 测试报告

By agreement between customer and supplier, the following information and data should be recorded as described in Clause 5:

根据客户与供应商之间的协定，应按第 5 条所述记录以下信息和数据：

a) type designations of each measuring apparatus used and its calibration status;

所有所用测量仪器的型号及其校正状态

b) data collection technique;

数据采集技术

c) measuring point locations;

测量点位置

d) occupancy state(s);

占用状态

e) result of measurement.

测量结果

B.9 Electrostatic and ion generator tests 静电和离子发生器测试

B.9.1 General 概述

This test consists of two parts. One is the electrostatic test and the other is the ion generator (ionizer) test. The purpose of the electrostatic test is to evaluate the level of electrostatic charge voltage on work and product surfaces, and the dissipation rate of electrostatic voltage of the floor, workbench top or other cleanroom or clean zone component. The static-dissipative property is evaluated by measuring surface resistance and leakage resistance on the surfaces. The ion generator test is performed to evaluate the performance of ion generators by measuring the discharge time of initially charged monitors, and by determining the offset voltage of isolated monitoring plates. The results of each measurement indicate the efficiency of eliminating (or neutralizing) static charges and the imbalance between the amount of generated positive and negative ions.

本测试由 2 部分组成。一部分这静电测试，另一部分为离子生器（离子化装置）测试。静电测试的目的是评估工作和产品表面的静电电压，以及地板、工作台表面或其它洁净间/区部件的静电消散速度。静电消散特性是通过测量表面电阻和表面泄漏电阻进行评估的。离子发生器测试是通过测量初始充电监测器的放电时间，确定孤立监测平板的补偿电压，来评估离子发生器的性能。每次测量的结果显示的是静电消除（或中和）效率，以及所生成的正负离子数量间的不平衡情况。

B.9.2 Procedures for electrostatic and ion generator tests 静电和离子发生器测试方法

B.9.2.1 Procedure for electrostatic test 静电测试方法

B.9.2.1.1 Measurement of surface voltage level 表面电压测量

The presence of positive or negative electrostatic charges on work and product surfaces is measured using an electrostatic voltmeter or fieldmeter.

工作和产品表面正/负静电荷情况采用静电电压计或场强计测量。

Adjust output of the electrostatic voltmeter or fieldmeter to zero by presenting the probe to face a grounded metal plate. The probe should be held such that the sensing aperture is parallel to the plate at a distance according to the manufacturer's instructions. The metal plate utilized for the zero adjustment should be of sufficient surface area for the required probe aperture size and proper probe-to-surface spacing.

将探头面向接地金属板表面，调节静电电压计或场强计输出为零。探头应与金属板平行，探头与金属板的感应距离应依据生产商说明书。调零用金属板的表面积要足够大以符合传感孔的尺寸要求并使探

头至表面有合适的间距。

To measure the surface voltage, place and hold the probe near the object surface whose charge is to be measured. The probe should be held in the same manner as for the zero adjustment. For a valid measurement, the surface area of an object should be sufficiently large, compared with the probe aperture size and probe-to-surface spacing.

记录下静电压计的读数。测量表面电压时，手持探头靠近待测物体表面。把持探头的方式应与进行零调整时相同。为了进行有效测量，相对于探头传感孔的尺寸和探头与表面的间距，物体应有足够大的表面积。

Record the readout of the electrostatic voltmeter.

记录静电电压读数。

The measuring point or object selected for measurement should be determined by agreement between the customer and supplier.

应该由客户和建造商协商选择测量点或测量物体。

B.9.2.1.2 Measurement of the static-dissipative property 静电消散特性测量

The static-dissipative property is evaluated by measuring surface resistance (resistance between different positions on the surface) and the leakage resistance (resistance between the surface and ground). These values are measured using a high-resistance meter.

通过测量表面电阻（表面不同位置之间的电阻）和漏电阻（表面和地面之间的电阻）来评估静电耗散特性。可用高电阻计进行这些测量。

Surface or leakage resistance is measured using electrodes that have appropriate weight and dimensions. These electrodes should be set at the correct distance from the surface during the measurement of surface resistance.

用重量和尺寸适当的电极测量表面电阻和漏电阻。测量表面电阻时，这些电极应与表面保持正确的距离。

Specific details of the test conditions should be agreed between customer and supplier.

检测条件的具体细节应该由客户和建造商议定。

B.9.2.2 Procedure for ion generator test 离子发生器测试

B.9.2.2.1 General 概述

The purpose of this test is to evaluate performance of bipolar ion generators. The test consists of measurements of both discharge time and offset voltage. The measurement of discharge time is performed to evaluate the efficiency of eliminating static charges using ion generators. Measurement of offset voltage is performed to evaluate imbalance of positive and negative ions in the ionized airflow from ion generators. An imbalance of ions can result in undesirable residual voltage.

本检测的目的是评估双极电离器的性能，包括放电时间和补偿电压的测量。测量放电时间是为了计算电离器消除静电荷的效率，测量补偿电压是为了评估电离器生成的离子流中正负离子的不平衡性。离子的不平衡会造成不良的残余电压。

These measurements are performed using conductive monitoring plates, an electrostatic voltmeter, and a timer and power source. (Sometimes apparatus consisting of those parts is known as a charged plate monitor.)

这些测量使用导电监测板、静电电压计和计时器及电源（有时把上述部分构成的仪器叫作充电板监测器）。

B.9.2.2.2 Measurement of discharge time 放电时间测量

This measurement is performed using monitoring plates that are (isolated conductive plates) of known capacitance (e.g. 20 pF). Initially the monitoring plate is charged to a known positive or negative voltage from a power source.

用具有已知电容（如 20pF）的监测板（绝缘的导电板）进行测量。开始时，用电源向监测板充电，达到已知的正或负的电压。

The change of static charge on the plate is measured while exposing the plate to the airflow that is ionized by the bipolar ion generators being evaluated. The change in plate voltage over time should be measured using an electrostatic voltmeter and a timer.

把板置于待评估的双极电离器的电离气流中，测量板上静电荷的变化。应该用静电压计和计时器测量板上电压随时间产生的变化。

Discharge time is defined as the time that is necessary for the static voltage on the plate to be reduced to 10 % of the initial voltage condition.

放电时间的定义是，板上静电荷减少到初始电压的 10%时所需时间。

Discharge time should be measured for both negative and positive charged plates.

正或负电压的充电板都应该测量放电时间。

Test point locations and results for acceptance criteria should be agreed between customer and supplier.

检测点的位置和验收标准结果应该由客户和建造商议定。

B.9.2.2.3 Measurement of offset voltage 补偿电压测量

Offset voltage is measured using a charged plate monitor mounted on an isolator. The charge on the isolated plate is monitored by an electrostatic voltmeter.

用安装在绝缘体上的充电板监测器测量补偿电压。用静电压计监测绝缘板上的电荷。

Initially, the plate should be grounded to remove any residual charge, and it should be confirmed that voltage on the plate is zero.

开始时板应接地，以消除残余电压，应该确认板上的电压为 0。

The offset voltage is measured by exposing the plate to the ionized airflow until the voltmeter readout becomes stable.

把板暴露于电离的气流中，直到电压计的读数稳定，此时测量补偿电压。

The acceptable offset voltage of an ion generator depends upon the electrostatic charge sensitivity of objects in the work area. The acceptable offset voltage should be determined by agreement between customer and supplier.

电离器可接受的补偿电压依工作区的物体对静电荷的敏感性而定。可接受的补偿电压应该由客户和建造商议定。

B.9.3 Apparatus for electrostatic and ion generator tests 静电和电离器测试仪器

B.9.3.1 Electrostatic voltmeter or electrostatic field meter, for measurement of the surface electrostatic voltage level for the electrostatic test; 静电电压计静电场强计，静电测试中测量表面静电电压

B.9.3.2 High resistance ohm meter, for measurement of the static-dissipative property for the electrostatic test; 高电阻欧姆计，静电测试中测量静电耗散特性

B.9.3.3 electrostatic voltmeter, or electrostatic field meter and conductive monitoring plate, or charged plate monitor for the ion generator test. 静电电压计，或静电场强计和电导监测板，或离子发生器测试中的充电板监测器

This apparatus is described in C.10. The apparatus should have a valid calibration certificate.

这些仪器在 C.10 中说明。仪器应具备有效校正证书。

B.9.4 Test reports 测试报告

By agreement between customer and supplier, the following information and data should be recorded as described in Clause 5:

根据客户与供应商之间的协定，应按第 5 条所述记录以下信息和数据：

a) type of tests and measurements, and measuring conditions;

 测试和测量类型以及测量条件

b) type designations of each measuring apparatus used and its calibration status;

 所用全部测量仪器的类型及其校正状态

c) temperature, humidity and other environmental data if relevant;

 温度、湿度和其它环境数据（如相关）

d) measuring point locations;

 测量点位置

e) occupancy state(s);

 占用状态

f) result of measurement;

 测量结果

g) other data relevant for measurement.

 与测量有关的其它数据

B.10 Particle deposition test 粒子沉降测试

B.10.1 General 概述

This test describes procedures and apparatus for measuring the particle deposition of particles that deposit from the air onto product or other critical work surface in a cleanroom or clean zone. The number of particles that deposit onto a given test surface area such as a witness plate, in a given time, are sized and counted using optical microscopes, electron microscopes, surface scanning apparatus, or real-time particle deposition rate detection device to obtain the particle deposition rate data. Particle deposition rate data should be reported in terms of mass, particle area or number of particles per unit surface area per unit of time.

本项检测说明的是，测定洁净室设施空气中沉降或可能沉降在产品上或工作表面上的粒子的粒径和数目的方法和仪器。用表面特性类似于所关注的有风险表面的代测板采集沉降的粒子，用光学显微镜、电子显微镜或表面扫描仪器确定粒径并计数。可以用粒子沉降光度计获得粒子沉降率的数据。应该以单位时间内的粒子质量或数量报告粒子沉降数据。

B.10.2 Procedure for particle deposition test 粒子沉降测试方法

B.10.2.1 Collection of particles on witness plates 代测板上粒子采集

The witness plate, which should be at the same electrical potential as the test surface, is placed in the same plane, and adjacent to the at-risk surface during the operational state. The at-risk surface is at the location of interest. The following procedures and methods should be followed when manipulating and collecting particles on witness plates or another test surface:

代测板应该放置在与测试表面处于同一个平面上，具有相同电势，并在操作过程中与风险表面相邻。风险表面为待测位置。操作代测板（或另一测试表面）和采集代测板（或另一测试表面）上粒子时应该遵循下述程序和方法：

a) verify that all cleanroom ventilation systems are functioning correctly, in accordance with operational requirements;

 验证洁净室的各个系统功能正常，符合运行要求。

b) identify each witness plate and clean to reduce the surface particle concentration to the lowest possible level. Determine the background concentration of particles on each witness plate before exposure;

各代测板要单独做出标识，并按要求进行清洁把表面粒子浓度减少到最低程度。测定每个代测板上粒子的背景浓度。

c) maintain 10 % of the witness plates as controls. These should be handled in exactly the same manner as the test witness plates;

保持 10%的代测板作对比用。这些板的处置方式要与检测用代测板完全相同，但是不予暴露。

d) transport all witness plates to the test locations in such a manner as to prevent particle contamination from the air or by surface contact;

把所有的代测板运到检测位置上。运送时要防止空气悬浮粒子污染板的表面。

e) expose the test witness plate adjacent to an at-risk surface in the cleanroom, such as where the product is exposed to airborne contamination;

让代测板暴露于洁净间内风险表面，例如产品暴露于空气悬浮粒子污染的地方

f) determine the time intervals for exposure of the test witness plates based upon the cleanroom air cleanliness and the particle counting apparatus. The exposure time should be from approximately one hour to the length of time necessary to obtain sufficient particle deposition to provide statistically valid data;

根据洁净间空气洁净度和粒子计数仪器确认代测板的暴露时长。暴露时间应从约 1 小时至所需时长以获得足够的粒子沉降，提供具有统计学意义的有效数据。

g) expose the witness plates during the operational state; it may be necessary to expose them during several manufacturing sessions to ensure that the plates are not used in unoccupied clean conditions where no product is exposed;

将代测板暴露于动态环境，可能有必要暴露在几轮生产过程中以确保代测表不会用于未被使用没有产品暴露的洁净条件

h) cover and collect the exposed witness plates after exposure and store in closed containers to protect from further contamination.

将暴露的代测板盖上并收集起来，把其存放在密封的容器中以防受到更多污染。

B.10.2.2 Counting and sizing collected particles 对已采集粒子计数和测径

Counting and sizing of particles collected on test surfaces should be carried out to obtain reproducible data that can be used to determine the cleanliness of the location being tested.

对采集在代测板上的粒子进行计数和计径，得到可以再现的数据，用于被测区域洁净度的分类。

When using a witness plate, the number of particles and their sizes can be determined by one of the following means:

如果使用的是代测板，则粒子数目和直径可采用以下方式之一进行测定：

a) optical light microscope with a calibrated linear or circular graticulate;

具有校正过的线形或圆形量板的光学显微镜

b) electron microscope with a calibrated grating with known line spacing;

具有已知线距经过校正的光栅的电子显微镜

c) surface scanner using size calibration information supplied by the manufacturer.

表面扫描仪，采用生产商提供的尺寸校正信息

When using a witness plate, the PDR can be calculated as follows:

如果使用的是代测板，PDR 可计算如下：

a) count and size the particles on the measurement area of the witness plates, including the control plates and categorize them in appropriate particle size ranges, based on the cumulative particle diameters;

   对代测板测量面积上粒子计数计径，包括控制板，根据累积粒子径将其分为适当粒径范围

b) subtract the values of the initial cleanliness of the witness plate from each test result;

   从测试结果中减去代测板初始洁净度值

c) calculate the net concentration in a given unit of measurement of surface area, and calculate the number that will deposit in a given time. When appropriate measurement units are used, this calculation yields a PDR in terms of the number of particles deposited per square metre per second.

   按指定表面积测量单位计算净浓度，计算指定时间内沉降数。如果使用的是恰当的测量单位，则该计算得出 PDR 为每秒每平方米沉降粒子数。

Where multiple test results are obtained, record the mean PDR value at each location and, if appropriate, its standard deviation.

如果得到多个检测结果，记录并平均每个位置的 PDR 值，及其标准偏差（适当时）。

B.10.3 Apparatus for particle deposition test 粒子沉降测试仪器

Various apparatus may be used for counting and sizing particles that have settled onto a test surface.

可使用不同仪器对沉降于测试表面的粒子进行计数与测径。

These fall into the following categories:

仪器分为以下几类：

a) light microscopes (particles larger than or equal to 2 µm);

   光学显微镜（大于等于 2 µm 的粒子）

b) electron microscopes (particles larger than or equal to 0,02 µm);

   电子显微镜（大于等于 0.02 µm 的粒子）

c) wafer surface scanner (particles larger than or equal to 0,01 µm);

   晶圆表面扫描仪（大于等于 0.01 µm 的粒子）

d) PDR detection device (particles larger or equal to 5 µm);

   PDR 检测仪（大于等于 5 µm 的粒子）

e) real-time PDR measurement device (particles larger than 15 µm).

   实时 PDR 测量装置（大于等于 15 µm 的粒子）

When choosing the counting and sizing apparatus, consideration should be given to the suitability to detect particles in the relevant size range. Other factors to be considered include the time required for sample collection and analysis. The apparatus used should have a valid calibration certificate.

在选择计数和计径仪器时，应考虑是否适合检出相关尺寸范围的粒子。其它需要考虑的因素包括样品采集和分析所需时间。所用仪器应具备有效校正证书。

B.10.4 Determination of sampling time and surface area 取样时间和表面积的计算

The lower the PDR, the larger the required exposed surface area, A, and exposure time, T. The product of $A \times T$ should be large enough to allow accurate determination of the PDR. A value of 20 is suggested for use with the largest particle of interest [see Formula (B.15)]:

PDR 越低，则所需暴露表面积 A 越大，暴露时间 T 越长。乘积 $A \times T$ 应足够大，使得可准确测量 PDR。测量最大粒子时建议 A 值采用 20【参见公式 B.15】：

$$A \times T \geq 20 \qquad (B.15)$$

Where 其中

A is the area of exposed surface; 为暴露表面积

T is exposure time. 暴露时长

B.10.5 Test reports 测试报告

By agreement between customer and supplier, the following information and data should be recorded:

经客户与供应商协定，应记录以下信息和数据：

a) type of tests and measurements, measuring conditions, and occupancy state;

测试和测量类型、测量条件和占用状态

b) type designations of each measuring apparatus used and its calibration status;

所用测量仪器的类型及其校正状态

c) measuring point locations;

测量点位置

d) result of measurement.

测量结果

B.11 Segregation test 隔离测试

B.11.1 General 概述

This test describes the procedures and apparatus required for assessment of the protective effect of a specific segregating airflow. Testing can be either across a doorway or across the perimeter of an area with a higher classification or a specific purpose different than the surrounding area. The test is performed by generating an airborne aerosol in the lesser classified area, measuring this as the reference concentration and counting the particle concentration just across the perimeter in the protected area. The test can be performed at various selected locations along the perimeter under assessment.

本测试阐述的是评估特定隔离用气流的保护效果的方法和仪器。测试可穿过门口或穿越更高级别洁净区边缘，或与周围区域不同的具体目的。测试中，在低级别区域生成气溶胶，测定气溶胶浓度应为标准浓度，然后测量穿过被保护区域边缘粒子浓度。

This test should be preceded by a classification of air by particles test in the surroundings as well as the protected area to determine the baseline particle concentration level. The challenging particle concentration should be of sufficient level to be able to assess the protection factor.

本测试应先对周围环境和受保护区域通过空气悬浮粒子计数进行洁净分级，以确定基准粒子浓度水平。挑战粒子浓度应具有足够浓度水平，可评估保护因子。

NOTE Airflow direction test and visualization can be performed to identify the perimeter of the protected area.

注：可测试气流方向和可视化从而识别受保护区域的边缘。

B.11.2 Procedure 方法

B.11.2.1 Generation of reference concentration 参考浓度的计算

To challenge the protective airflow in the surroundings, a sufficient number of particles should be generated. Recommended test aerosol particles are described in C.5.3. The mean particle size should be 0.5 µm and greater unless an alternative size is agreed between customer and supplier. In order to be sufficient, the following should be considered:

为挑战周围环境的保护性气流，应生成足够数目的粒子。建议测试用气溶胶粒子在 C.5.3 中阐述。平

均粒径应为 0.5μm 或更大，客户与供应商之间另有协定者除外。为确保足够浓度，应考虑以下要点：

a) verify that all cleanroom systems are functioning correctly, in accordance with an agreed occupancy state;

核查是否所有洁净间系统依协定的占用状态正常运行

b) to establish the challenging concentration, the protective effect to be verified should be used to calculate the number of challenging particles based on the anticipated particle concentration within the protected zone. This anticipated concentration should at least be 10 times the baseline count in the point to be verified.

为确定挑战浓度，应使用要验证的保护效果，根据被保护区域内期望粒子浓度来计算挑战粒子。该期望浓度应至少 10 倍于待验证点的基准粒子数

B.11.2.2 Equipment geometry 设备几何形状

Test equipment geometry should be determined. The probe(s) in the protected area should not be more than 0,1 m from the determined air barrier. The challenge concentration probe in the lesser classified area should not be more than 1 m from the determined air barrier (between aerosol generator and air barrier). The aerosol generator should be positioned approximately 1 m to 1,5 m from the challenge concentration probe.

应确定测试设备的几何形状。受保护区域的探头离待测气障不应大于 0.1m。低级别区域的挑战浓度探头离待测气障不应大于 1m（气溶胶生成器与气障之间）。气溶胶生成器应放置在离挑战浓度探头约 1-1.5m 处。

NOTE The number of locations where the protected effect is determined depends of the perimeter, the form of the protected area and agreement between the customer and supplier.

注：保护效果测定点数目取决于受保护区域的边缘和形状，以及客户和供应商之间的协定。

B.11.2.3 Procedure of measurement 测量方法

a) The sample times should be determined based on ISO-14644-1:2015, A.4.4.

取样时间应根据 ISO-14644-1：2015，A.4.4 确定。

b) Begin the generation of particles in the lesser classified side of the air barrier assuring that the momentum of the challenge leaving the test apparatus does not overpower the air barrier.

在气障的低级别一边开始生成粒子，确保给测试仪器的挑战动力不会突破气障。

c) Record particle concentration in the lesser classified area at each probe(s). A minimum of three 1-minute measurements should be taken.

记录低级别区域里每个探头处的粒子浓度。至少应记录三次 1 分钟测量结果。

NOTE A dilution device can be required when measuring the high concentration.

注：在测量高浓度时可能需要有稀释装置。

d) record the particle concentration in the protected area at each probe(s). A minimum of three 1-minute measurements should be taken.

记录受保护区域内每个探头处粒子浓度。至少应记录三次 1 分钟测量结果。

B.11.2.4 Calculating the protection index 保护系数计算

The protection index is calculated with Formula (B.16):

保护系数采用公式 B.16 计算如下：

$$PI_X = -\log\left(C_X / C_{Ref}\right) \qquad (B.16)$$

Where 其中

C_{Ref} is the reference particle concentration, expressed in p/m^3, for particles ≥0,5 µm (challenge concentration) of the nearest reference particle counter, (guidance value: >5 × 10^6/m^3).

为最近标准粒子计数器（挑战浓度）≥0.5μm 粒子标准浓度，表示为 p/m^3（指导值为>5×10^6/m^3）

C_X is the average particle concentration at measuring point x, expressed in p/m^3, for particles ≥0,5 μm;

为测量点 X 的≥0.5μm 粒子平均浓度，表示为 p/m^3

PI_X is the protection index;

为保护系数

B.11.3 Test reports 测试报告

By agreement between the customer and supplier, the following information and data should be recorded as described in Clause 5:

根据客户与供应商之间的协定，应按第 5 条所述记录以下信息和数据：

a) designation of the type of each measuring apparatus used and its calibration status;

所用各种测量仪器的设计及其校正状态

b) data collection technique;

数据采集技术

c) measuring point locations;

测量点位置

d) occupancy state(s);

占用状态

e) result of measurement.

测量结果

Annex C 附录 C
(informative 仅供参考)
Test apparatus 测试仪器

C.1 General 概述

Annex C describes the measuring apparatus that should be used for the recommended tests given in this document.

附录 C 阐述的是本文件中建议测试所用测量仪器。

Data given in Tables C.1 to C.9 indicate the minimum necessary requirements for each item of apparatus. Items are listed and numbered to correspond with Annex B. Those responsible for planning tests can refer to Annex C for the selection of test apparatus and to Annex A for a checklist of recommended tests of an installation and the sequence in which to carry them out. Measuring apparatus should be chosen subject to agreement between the customer and supplier.

表 C.1-C.9 列出的数据是每种仪器所需最低要求。检测项目列出顺序与编号与附录 B 相对应。负责规划测试者可参考附录 C 选择测试仪器，参考附录 A 查看对某个设施的建议测试清单，以及测试执行顺序。测量仪器选择应符合客户与供应商之间的协定。

This annex does not prevent the use of improved apparatus as it becomes available. Alternative test apparatus can be appropriate and may be used subject to agreement between customer and supplier.

本附录并不妨碍使用改进过的仪器（如有）。替代测试仪器可能是适用的，可根据客户与供应商之间的协定使用。

Test apparatus should be selected with measurement limits and range that are appropriate for its application. The apparatus should also be calibrated with calibration points covering the range of its intended use. All test apparatus sensitivity (3.1.7) should be 1.

所选择测试仪器应具备适合其用途的测量限度与范围。仪器校正点应覆盖其既定用途的范围。所有测试仪器灵敏度（3.1.7）应为 1。

Minimum requirements for test apparatus are given in this annex with a requirement specified for maximum permissible error. Below is an explanation of how the maximum permissible error for an air velocity meter can be estimated.

本附录提供了测试仪器的最低要求，以及允许最大误差要求。以下为如何估测空气流速表允许最大误差的解释。

There are at least three contributions to the maximum permissible error:

允许最大误差至少有三个因素：

— the expanded calibration uncertainty (given in the calibration certificate);

— 扩展校正不确定度（在校正证书里提供）

— the sum of the random errors' absolute values (after correcting for systematic errors, random errors[29] still remain. Each of these give rise to variations in repeated observations of the quantity to be measured);

— 随机误差绝对值总和（在纠正了系统误差之后，随机误差仍然存在。每个误差均会增加待测量重复观察的波动）

— yearly drift.

— 年度飘移

For the purpose of this example, the expanded calibration uncertainly has been given as 0,025 m/s, the sum of the random errors is 0,03 m/s and the yearly drift is 0,005 m/s.

本例中，所解释的校正不确定度给定为 0.025m/s，随机误差之和为 0.03m/s，年度飘移为 0.005m/s。

Adding these three contributions gives 0,06 m/s. Assuming the errors are symmetric around 0, this gives the values for the limits of error (maximum permissible errors) of ±0,06 m/s.

将上述三项相加得到 0.06m/s。假定误差对称点约为 0，则其误差限值（允许最大误差）为±0.06m/s。

NOTE This value of 0,06 m/s is not an uncertainty. Instead, the limits of error indicate the interval inside which the measurement error is permitted to be[29].

注：此值 0.06m/s 并不是不确定度。相反，误差限表示的是允许测量误差在此范围之内。

C.2 Air pressure difference test 压差测试

C.2.1 General 概述

The minimum requirements for the air pressure difference test apparatus are given in Table C.1.

空气压差测试仪器最低要求见表 C.1。

Table C.1 — Air pressure difference test apparatus

表 C.1—空气压差测试仪器

Item 项目	Minimum requirements 最低要求
Measuring limits	N/A
测量范围	无
Resolution	0,5 Pa (0 Pa–49,9 Pa) 1,0 Pa (≥50 Pa)
分辨率	0.5 Pa（1-49.9 Pa） 1.0 Pa（≥50 Pa）
Maximum permissible error	The greater of 2 Pa or 5 % of reading (Mechanical gauges can be used for continuous monitoring reference but not for testing due to potential errors)
允许最大误差	2 Pa 与读数的 5%，取大者 （机械式压力表可用于连续监测参考，但由于潜在误差不能用于测试）

C.2.2 Electronic manometer, to display or output the value of the air pressure difference between a cleanroom or clean zone and its surroundings by detecting the change of electrostatic capacitance or electronic resistance due to the displacement of a diaphragm.

电子压差计，通过检测由于隔膜移位引起的静电电容或电子电阻变化，显示或输出洁净间/区与其周围环境之间的压差。

C.2.3 Inclined manometer, to measure the air pressure difference between two points, by detecting with the eye amplitude inclined scales which indicate the small pressure head (height) in a gauge tube filled with liquid such as water or alcohol. Care shall be taken when using this type of measuring device. It should be level and used in a fixed position.

斜管压差计，通过肉眼验看灌有液体如水或乙醇的测量管中指示最小压力头（高度）的倾斜面刻度测量压差。使用此类测量装置时小心。应保持水平并在固定后使用。

C.2.4 Mechanical differential pressure gauge, to measure the air pressure difference between two areas by detecting the movement distance of a needle connected with a mechanical gear or magnetic linkage to the displacement of a diaphragm. Care shall be taken when using this type of measuring device. It should be level and used in a fixed position.

机械压差表，通过检测与机械齿轮相连或磁性连接至隔膜移位的针移动距离，测量两区域之间压差。使用此类测量装置时小心。应保持水平并在固定后使用。

Careful consideration should be given to selecting the appropriate gauge range when using this apparatus.

使用此类仪器时应小心选择适当的仪器测量范围。

C.3 Airflow test 气流测试

C.3.1 Air velocity meter 风速计

C.3.1.1 General 概述

The minimum requirements for the air velocity test apparatus are given in Table C.2.

气流速度测试仪器最低要求见表 C.2。

Table C.2 — Air velocity test apparatus

表 C.2—气流速度测试仪器

Item 项目	Minimum requirements 最低要求
Measuring limits	N/A
测量范围	无
Resolution	0,01 m/s (0,20 m/s–0,99 m/s) 0,1 m/s (≥1,00 m/s)
分辨率	0.01 m/s（0.20-0.99 m/s） 0.1 m/s（≥1.00m/s）
Maximum permissible error	0,1 m/s (0,20 m/s–1,00 m/s) 10 % of reading (>1,00 m/s)
允许最大误差	0.1 m/s（0.20-1.00 m/s） 读数的 10%（>1.00 m/s）

C.3.1.2 Thermal anemometer, to calculate air velocity by measurement of the heating power necessary to maintain the electrically heated sensor, exposed to the airflow, at a fixed temperature.

热压力计，通过测量维持暴露于气流中电子加热探头处于固定温度所需的热量计算空气流速。

C.3.1.3 Three-dimensional ultrasonic anemometer, or equivalent, to measure air velocity by sensing the shift of sound frequency (or acoustic velocity) between separated points in the measured airflow.

三维超声风速计，或等同者，通过感应被测气流中不同点声波频率（或声音速度）波动测量空气速度。

C.3.1.4 Vane-type anemometer, to measure air velocity by counting the revolution rate of the vanes in the airflow.

叶片式风速计，通过计算气流中叶片转速测量空气速度。

C.3.1.5 Pitot-static tubes and manometer, to measure air velocity from the difference of total and static pressures at a position in the airflow.

皮托管和压力计，通过气流中某点的总压和静压之差测量气流速度。

C.3.1.6 Tube array, to measure air velocity from the difference of total and static pressures at a position in the airflow. Averaging airflow grids use multiple tube arrays to simultaneously measure airflow on a grid and provide an average velocity, using an electrical multi-meter manometer.

管阵列，通过气流中某点的总压和静压之差测量气流速度。采用电子多米压力计，使用多管阵列同时测量方格中气流，计算平均气流，得到平均速度。

C.3.2 Airflow meter 气流计

C.3.2.1 General 概述

The minimum requirements for the air volume flow rate test apparatus are given in Table C.3.

风量测试仪器最低要求见表 C.3。

Table C.3 — Air volume flow rate test apparatus

表 C.3—风量测试仪器

Item 项目	**Minimum requirements 最低要求**
Measuring limits	N/A
测量范围	无
Resolution	0,001 m^3/s
分辨率	0.001 m^3/s
Maximum permissible error	0,01 m^3/s (0 m^3/s–0,1 m^3/s) 10 % of reading (>0,1 m^3/s)
允许最大误差	0.01 m^3/s（0-0.1 m^3/s） 读数的 10%（> 0.1m^3/s）

C.3.2.2 **Airflow capture hood with measuring device**, to measure air volume flow rate from an area over which there can be variations in airflow, providing an integrated air volume from that area. The total airflow is collected and concentrated so that the velocity at the measuring point represents the cross-sectional average velocity from the total area.

风量罩，测量从其上方流出的空气体积流量。如果该面积控制的是总风量，局部气流可能有波动。收取并集中总气流，使得测量点的速度可代表总面积的横截面平均速度。

C.3.2.3 **Orifice meter**, refer to ISO 5167-2[22].

孔板流量计参见 ISO5167-2。

C.3.2.4 **Venturi meter**, refer to ISO 5167-4[23].

文丘里流量计，参见 ISO 5167-4

C.4 Airflow direction test and visualization

C.4.1 **Apparatus, materials and accessories for airflow direction test and visualization**, see Tables B.1 and B.2. 气流方向和可视化用仪器、物料和附件参见表 B.1 和 B.2。

C.4.2 **Thermal anemometer**, see C.3.1.1.

热感式风速计，参见 C.3.1.1

C.4.3 **Three-dimensional ultrasonic anemometer**, or equivalent, see C.3.1.2.

三维超声气风速计，或等同者，参见 C.3.1.2

C.4.4 **Aerosol generator**. 气溶胶发生器

C.4.4.1 General 概述

Aerosol generators for tracers in flow visualization may also be referred to B.3.4. Some application examples, such as particle generators and ultrasonic nebulizers are given below.

气流可视化示踪物用的气溶胶发生器亦可参见 B.3.4。一些应用例子，如粒子生成品和超声雾化器列出如下。

C.4.4.2 **Ultrasonic nebulizer**, to generate aerosols (mist), employing focused sound waves to aerosolize a liquid (e.g. DI water) into fine droplets.

超声雾化器，生成气溶胶（烟雾），使用超声波将液体（例如 DI 水）雾化成细液滴。

C.4.4.3 **Fog generator**, to generate aerosols (mists). A thermally produced aerosol of DI water/glycols/alcohols.

烟雾生成器，产生气溶胶（烟雾）。通过加热生成 DI 水/乙二醇类/乙醇类的气溶胶。

C.5 Recovery test 自净测试

C.5.1 **Light-scattering airborne-particle counter (LSAPC),** capable of counting and sizing single airborne particles and reporting size data in terms of equivalent optical diameter.

光散射空气粒子计数器（LSAPC）：可计数并测量单个空气中颗粒并报告等同光学直径的粒径数据。

Refer to ISO 14644-1[1].

参见 ISO 14644-1.

C.5.2 **Aerosol generator**, capable of generating particles within the size range 0,1 µm–1,0 µm at a constant concentration, which may be generated by thermal, hydraulic, pneumatic, acoustic, chemical or electrostatic method.

气溶胶生成器：能生成浓度恒定粒径为 0,1 µm–1,0 µm 范围的颗粒，可采用加热、液化、充气、自然生成、化学或静电方法生成。

C.5.3 **Test aerosol source substances**. Typically, the following substances are used to generate test aerosols, liquid or solid test aerosol for generating by spraying or atomizing into the atmosphere:

生成气溶胶的物质：一般来说，可使用以下物质生成检测用气溶胶，采用喷雾或自动化方式让液体或固体检测气溶胶进入空气：

a) poly-alpha olefin (PAO) oil, 4 centistokes PAO; 聚 α-烯烃（PAO）油

b) dioctyl sebacate (DOS); 癸二酸二辛酯（DOS）

c) di-2-ethyl hexyl sebacate (DEHS); 癸二酸二异辛酯（DEHS）

d) dioctyl (2-ethyl hexyl) phthalate (DOP[1]) (e.g. CAS No. 117-81-7[2]); 邻苯二甲酸酯（DOP）（例如 CAS 号 117-81-7）

e) food quality mineral oil (e.g. CAS No. 8042-47-5); 食品级矿物油（例如 CAS 号 8042-47-5）

f) paraffin oil (e.g. CAS No. 64742-46-7); 石蜡（例如 CAS 号 64742-46-7）

g) microspheres with an appropriate diameter. 直径适当的微球

If the required concentration can be achieved, atmospheric aerosol may also be used.

如果可达到所需浓度，亦可使用大气气溶胶

C.5.4 **Dilution system, equipment**, in which the aerosol is mixed with clean air in a known volumetric ratio to reduce concentration. 稀释系统/设备，气溶胶在其中与洁净空气以已知体积比例混合以降低浓度。

C.6 Temperature test 温度测量

The temperature test should be performed using a sensor that has accuracy as defined in ISO 7726,[28] for example:

温度测量应使用符合 ISO7726 所要求准确度的探头。

a) expansion thermometers; 热膨胀温度计
   1) liquid expansion thermometer; 液体热膨胀温度计
   2) solid expansion thermometer; 固体热膨胀温度计

b) electrical thermometers; 电子温度计
   1) variable resistance thermometer, including; 可变电阻温度计，包括
      - platinum resistor; 铂电阻

[1] In certain countries, the us e of DOP for filter testing is discouraged on safety grounds. 在有些国家，出于安全考虑，不鼓励在过滤器测量中使用 DOP。

[2] CAS No., Chemical Abstract Service Registry Number, substances have been registered in Chemical Abstract, issued by American Chemical Society[14]. CAS 号，化学文摘服务登记编号，已在化学文摘登记过的物质会由化学文摘协会发放编号。

- thermistor; 热电偶

2) thermometer based on the generation of an electromotive force (thermocouple); 基于生成电动势的温度计（热电偶）

c) thermomanometers (variation in the pressure of a liquid as a function of temperature). 热压力表（液体压力变化为温度函数）

The minimum measurement resolution requirement for the apparatus is 20 % of the allowable temperature range for the difference between the set point temperature and the permissible range of variation allowed from that set point.

对于设定温度与允许波动范围之间差异，仪器仪表的最低测量分辨率应为允许温度范围的 20%。

NOTE The requirement of range, accuracy, etc., depends on the purpose of the cleanroom or clean zone.

注：范围、准确度等要求取决于洁净间或洁净区的用途。

ISO 7726[28] is for a general purpose.

ISO7726 用于一般用途。

C.7 Humidity test 湿度测量

Humidity tests should be performed using a sensor that has accuracy appropriate to the measurement as stated in ISO 7726[28].

湿度测量应使用符合 ISO7726 所要求适当准确度的探头。

Typical sensors are: 典型探头有：

a) dewpoint hygrometers (e.g. psychrometer); 露点湿度计（例如干湿球湿度计）

b) electrical conductivity variation hygrometer; 电导率变化湿度计

1) lithium chloride hygrometer; 氯化锂湿度计

2) capacitance hygrometer. 电容湿度计

The minimum measurement resolution for the apparatus should be 20 % of the allowable relative humidity range for the difference between the set point humidity and the permissible range of variation allowed from that set point.

对于设定湿度与允许波动范围之间差异，仪器仪表的最低测量分辨率应为允许湿度范围的 20%。

NOTE The requirement of range, accuracy, etc., depends on the purpose of the cleanroom or clean zone.

注：范围、准确度等要求取决于洁净间或洁净区的用途。

ISO 7726 is for a general purpose.

ISO7726 用于一般用途。

C.8 Installed filter system leakage test 已安装系统检漏

C.8.1 Aerosol photometer, to measure the mass concentration of aerosols in milligrams per cubic meter (mg/m^3). The aerosol photometer uses a forward scattered-light optical chamber to make this measurement. This apparatus may be used to measure filter leak penetration directly.

气溶胶光度计，测量气溶胶的质量浓度，单位为毫克每立方米（mg/m^3）。气溶胶光度计使用前向散射光光学箱进行此测量。该仪器可用于直接测量过滤器泄漏穿透率。

The minimum requirements for the aerosol photometer are given in Table C.4.

气溶胶光度计最低要求参见表 C.4。

Table C.4 — Aerosol photometer

表 C.4—气溶胶光度计

Item 项目	Minimum requirements 最低要求
Measuring limits	0,000 1 mg/m³ to 100 mg/m³
测量范围	0.0001-100 mg/m³
Resolution	0,000 1
分辨率	0.0001
Maximum permissible error	10 % for the selected range
允许最大误差	所选范围的 0.%

Sample probe tubing dimensions (length and internal diameter) should comply with manufacturer's recommendations.

样品探头管道尺寸（长和内径）应符合生产商的建议。

NOTE Sample probe inlet dimensions are detailed in B.7.2.2.

注：样品探头进口尺寸详细信息见 B.7.2.2。

C.8.2 Light-scattering airborne-particle counter (LSAPC), see C.5.1. 光散射空气悬浮粒子计数器（LSAPC），参见 C.5.1。

C.8.3 Aerosol generator, see C.5.2. 气溶胶生成器，参见 C.5.2。

C.8.4 Test aerosol source substances, see C.5.3. 测试用气溶胶源物质，参见 C.5.3。

C.8.5 Dilution system, equipment, see C.5.4. 稀释系统，设备参见 C.5.4。

C.9 Containment leak test 密闭泄漏测试

C.9.1 Light-scattering airborne-particle counter, see C.5.1. 光散射空气悬浮粒子计数器参见 C.5.1。

C.9.2 Aerosol generator, see C.5.2 气溶胶生成器参见 C.5.2。

C.9.3 Aerosol source substances, see C.5.3. 气溶胶源物质参见 C.5.3。

C.9.4 Dilution system, see C.5.4. 稀释系统参见 C.5.4。

C.9.5 Aerosol photometer, see C.8.1. 气溶胶光度计参见 C.8.1.

C.10 Electrostatic and ion generator test 静电和离子发生器测试

C.10.1 Electrostatic voltmeter, to measure the average voltage (potential) in a small area by sensing the intensity of the electrical field at an electrode inside a probe through a small aperture in the probe.

静电电压计，用于测量

The minimum requirements for an electrostatic voltmeter are given in Table C.5.

静电电压表最低要求参见表 C.5。

Table C.5 — Specification for electrostatic voltmeter

表 C.5—静电电压表标准

Item 项目	Minimum requirements 最低要求
Measuring limits	±(1–20) kV
测量范围	±(1–20) kV
Resolution	10 V (1 kV–20 kV)
分辨率	10 V (1 kV–20 kV)
Maximum permissible error	10 % of reading
允许最大误差	读数的 10%

C.10.2 High resistance ohm-meter, to measure the resistance of insulation materials and components by sensing leakage current from a device applying high voltage to a device under test.

高阻欧姆表，通过感应从施加高压的装置流向待测装置的泄漏电流测量绝缘材料和部件的电阻。

The minimum requirements for the high resistance ohm-meter are given in Table C.6.

高阻欧姆表的最低要求见表 C.6。

Table C.6 — Specifications for high resistance ohm-meter

表 C.6—高阻欧姆表标准

Item	**项目**	**Minimum requirements**	**最低要求**
Measuring limits	测量限度	1 000 Ω to 20 GΩ	1000Ω 至 20 GΩ
Resolution	分辨率	0,01 MΩ	0.01 MΩ
Maximum permissible error	最大允许误差	5 % of each full scale	满刻度的 5%
Test voltage	测试电压	DC 100 V to 1 000 V	直流 100-1 000 V

C.10.3 Charged plate monitor, to measure the neutralizing properties of an ionizer or ionization system. The minimum requirements for the charged plate monitor are given in Table C.7.

充电板监测器，测量离子发生器或离子化系统的中和特性。充电板监测器的最低要求见表 C.7。

Table C.7 — Specifications for charged plate monitor

表 C.7—充电板监测器标准

Item	**项目**	**Minimum requirements**	**最低要求**
Measuring limits	测量限度	±5 kV	±5 kV
Resolution	分辨率	0,1 V (<100 V) 1,0 V (>99 V)	0.1 V (<100 V) 1.0 V (>99 V)
Maximum permissible error	最大允许误差	5 % of full scale	满刻度的 5%

C.11 Particle deposition test 粒子沉降测试

C.11.1 Witness plate material. Depending on particle size to be detected and means of measurement the following may be used:

代测板材料，根据待测粒径和测量方法，可使用以下材料：

a) micro-porous membrane filters;

微孔膜过滤器

b) double-sided adhesive tape;

双面胶带

c) petri dishes;

皮氏培养皿

d) petri dishes containing a contrasting colour (black) polymer, such as polyester resin;

装有对照颜色（黑色）聚合物的皮氏培养皿，如聚合树脂

e) photographic film (sheet);

胶片

f) microscope slides (plain or with evaporated metal film coating);

显微镜载玻片（平片或蒸发金属膜涂层片）

g) glass or metal mirror plates;

玻璃或金属镜片

h) semiconductor wafer blanks;

半导体片坯片

i) glass photo mask substrates;

玻璃光掩膜基片

j) transparent plastic plate.

透明塑料板

The surface smoothness of the witness plate should be appropriate for the size of the particles that are counted to ensure that the particles are easily visible. The selected witness plate material should be electrostatic neutral. The means of measurement employed should be capable of resolving and measuring the smallest particle size to be enumerated. Witness plates that need to be transparent should be free of defects.

代测板的表面光滑度应与待测粒子的粒径相适，保证粒子易于看到。所选择的代测板材料应为静电中性。采用的测量手段应该能分辨并测量最小的粒径。透明代测板应无瑕疵。

Particle deposition can be determined by measuring the area coverage of deposited particles or by counting (and sizing) of particles deposited on the witness plate during exposure. Particle deposition measurement can be divided into particle sizes within the air cleanliness level range (0,1 µm to 5,0 µm) and macro particles (larger than or equal to 5 µm).

粒子沉降率可通过测量沉降粒子的表面覆盖率或计算暴露期间沉降在代测板上的粒子数目获得。粒子沉降 率测量可分为空气洁净度水平范围内粒径（0.1-5.0 µm）和大粒子（大于等于 5µm）。

Table C.8 — Particle deposition measurement by surface analyser

表 C.8—表面分析仪测量粒子沉降

Item	项目	Minimum requirements	最低要求
Measuring limits	测量限度	Surface number concentration: 1/cm^2 to 10^6/cm^2 Particle size: 0,1 µm to 5 µm	表面数量浓度： 1/cm^2 to 10^6/cm^2 粒径： 0.1 µm to 5 µm
Resolution	分辨率	Particle size: 0,1 µm	粒径： 0.1 µm
Maximum permissible error	最大允许误差	Particle size: 1 µm	粒径： 1 µm

Table C.9 — Particle deposition measurement macro particles test apparatus

表 C.9—大粒子测试仪器测量粒子沉降

Item	项目	Minimum requirements	最低要求
Measuring limits	测量限度	Area coverage: 1 m^2/ m^2 to 5 000 10^{-6} m^2/ m^2 Particle size: ≥5 to ≥500 µm	面积： 1 m^2/ m^2 to 5 000 10^{-6} m^2/ m^2 粒径： ≥5 to ≥500 µm
Resolution	分辨率	Area coverage: 10 10^{-6} m^2/ m^2 Particle size: 10 µm	面积： 10 10^{-6} m^2/ m^2 粒径： 10 µm
Maximum permissible error	最大允许误差	Area coverage: 20 10^{-6} m^2/ m^2 Particle size: 20 µm	面积： 20 10^{-6} m^2/ m^2 粒径： 20 µm

C.11.2 **Wafer surface scanner,** to measure particles using a laser scanner and microscopic or electromicroscopic imaging devices to size the detected particles.

晶片表面扫描仪，

C.11.3 **Particle fallout aerosol photometer**, to measure total scattered light from particles sediment upon dark glass collection plates, and reports these data in terms of a sedimentation factor that is related to the concentration of sediment particles that would deposit upon critical surfaces.

粒子沉降气溶胶光度计，测量暗色玻璃采集板上沉降粒子的总散射光，将数据报告为沉降因

子。沉降因子与可沉降在关键表面的沉降粒子浓度有关。

Calibration is carried out by fluorescent particles 4µm and 10 µm or polystyrene microsphere of 90 µm and 45 µm nominal. Measured area is <2 cm^2.

采用 4 µm 和 10 µm 的荧光粒子或名义粒径 90µm 和 45µm 的聚苯乙烯微球校正。被测面积 <2cm^2。

C.11.4 **Surface particle counter**, to measure the number (and size) of single particles deposited on a surface by scattered light.

表面粒子计数器，通过散射光测量沉积在表面的单个粒子数量（和粒径）。

Measured area is 0,2 cm^2 to 3 cm^2. Measured area can be increased by scanning. Size resolution is 0,1 µm to 25 µm depending on selected optical system.

被测面积为 0.2-3cm^2，被测面积可通过扫描增加，根据所选光学系统不同，粒径分辨率为 0.1-25 µm。

C.11.5 **Particle deposition meter**, to determine the number of particles and their size on a glass witness plate. The glass is illuminated from below. A coordinate table is used to scan a relevant area. Vision software can be used to determine the particle size distribution. From the particle size distribution, the measuring surface and the exposure time, the particle deposition rate can be determined.

粒子沉降计，确定玻璃代测板上粒子数目与粒径。从玻璃下面提供照明。使用坐标工作台扫描相关区域。可使用视觉软件确定粒径分布。根据粒径分布情况、测量表面积和暴露时间可确认粒子沉降率。

C.11.6 **Optical particle deposition monitor** An optical system detects particles on an inclined surface by examining the change of the interference pattern of an extended laser beam. Measuring surfaces from 10 cm^2 to 100 cm^2 can be achieved. An example of a commercial apparatus has a detection surface of 60 cm^2. Particles ≥20 µm can be detected. The particle deposition result is given on the projected horizontal surface.

光学粒子沉降监测仪，通过检查延伸激光束的干扰模式变化检测斜面上粒子的光学系统。测量面积可达 10-100cm^2。商用仪器有检测面积达 60 cm^2 者。可检出直径≥20 µm 的粒子。粒子沉降结果以投影水平面给出。

C.12 Segregation test 隔离性测试

C.12.1 Light-scattering airborne-particle counter, see C.5.1. 光散射空气悬浮粒子计数器，参见 C.5.1。

C.12.2 Aerosol generator, see C.5.2. 气溶胶生成品，参见 C.5.2。

C.12.3 Aerosol source substances, see C.5.3. 气溶胶源物质，参见 C.5.3.

C.12.4 Dilution system, see C.5.4. 稀释系统，参见 C.5.4。

Bibliography 参考文献

[1] ISO 14644-1:2015, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness by particle concentration*

ISO 14644-1:2015，洁净间与相关受控环境—第一部分：根据粒子浓度对空气洁净度分级

[2] ISO 14644-2, Cleanrooms and associated controlled environments — Part 2: Monitoring to provide evidence of cleanroom performance related to air cleanliness by particle concentration

ISO 14644-2，洁净间与相关受控环境---第二部分：

[3] ISO 14644-4, Cleanrooms and associated controlled environments — Part 4: Design, construction and start-up

ISO 14644-4，洁净间与相关受控环境—第四部分：设计、建筑与启动

[4] ISO 14644-7:2004, Cleanrooms and associated controlled environments — Part 7: Separative devices (clean air hoods, gloveboxes, isolators and mini-environments)

ISO 14644-7:2004，洁净间与相关受控环境—第七部分：隔离装置（洁净空气罩、手套箱、隔离器和微环境）

[5] ISO 14644-8, Cleanrooms and associated controlled environments — Part 8: Classification of air cleanliness by chemical concentration (ACC)

ISO 14644-8，洁净间与相关受控环境—第八部分：

[6] ISO 14644-9, Cleanrooms and associated controlled environments — Part 9: Classification of surface cleanliness by particle concentration

ISO 14644-9，洁净间与相关受控环境—第九部分：

[7] ISO 14644-10, Cleanrooms and associated controlled environments — Part 10: Classification of surface cleanliness by chemical concentration

ISO 14644-10，洁净间与相关受控环境—第十部分：

[8] ISO 14644-12, Cleanrooms and associated controlled environments — Part 12: Specifications for monitoring air cleanliness by nanoscale particle concentration

ISO 14644-12，洁净间与相关受控环境—第十二部分：

[9] ASME N510-1989, Testing of Nuclear Air-Treatment Systems

ASME N510-1989，核空气处理系统的测试

[10] ASTM F24-00, Standard Method for Measuring and Counting Particulate Contamination on Surfaces

ASTM F24-00，表面粒子污染测量与计数标准方法

[11] ASTM F50-92, Standard Practice for Continuous Sizing and Counting of Airborne Particles in Dust Controlled Areas and Clean Rooms Using Instrument Capable of Detecting Single Sub-Micrometre and Larger Particles

ASTM F50-92，使用可检测单个微米以下和更大粒子检测仪器对尘埃受控区域和洁净间内空气悬浮粒子进行连续尺寸测量与计数的标准规范

[12] ASTM F312-97, Standard Test Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters

ASTM F312-97，从膜过滤器上航空流体用显微镜测量微料尺寸和计数的标准测试方法

[13] ASTM F1471-93, Standard Test Method for Air Cleaning Performance of a High-Efficiency Particulate Air-Filter System

ASTM F1471-93，高效粒子空气过滤器系统的空气清洁性能标准测试标准

[14] Chemical Abstracts Service Registry, Columbus, Ohio, US: American Chemical Society

化学文摘服务注册处，美国哥伦布：美国化学协会

[15] EN 1822-2, High efficiency air filters (HEPA and ULPA) — Part 2: Aerosol production, measuring equipment, particle counting statistics

EN 1822-2，高效空气过滤器（HEPA 和 ULPA）--第二部分：气溶胶生成、测量设备，粒子计数统计

[16] EN 1822-4, High efficiency air filters (HEPA and ULPA) — Part 4: Determining leakage of filter element (scan method)

EN 1822-4，高效空气过滤器（HEPA 和 ULPA）--第四部分：过滤器元件检漏（扫描方法）

[17] IEST-RP-CC001 6:2016, HEPA and ULPA Filters

IEST-RP-CC001 6:2016，HEPA 和 ULPA 过滤器

[18] IEST-RP-CC006 3:2004, Testing Cleanrooms

IEST-RP-CC006 3:2004，测试洁净间

[19] IEST-RP-CC007 3:2016, Testing ULPA Filters

IEST-RP-CC007 3:2016，测试 ULPA 过滤器

[20] IEST-RP-CC021 4:2016, Testing HEPA and ULPA Filter Media

IEST-RP-CC021 4:2016，测试 HEPA 和 ULPA 过滤器介质

[21] IEST-RP-CC034 4:2016, HEPA and ULPA Filter Leak Tests

IEST-RP-CC034 4:2016，HEPA 和 ULPA 过滤器检漏

[22] ISO 5167-2, Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 2: Orifice plates

ISO 5167-2，将压差装置插入全面运行的环形截面管道中测量流体速度—第二部分：节流孔板

[23] ISO 5167-4, Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 4: Venturi tubes

ISO 5167-4，将压差装置插入全面运行的环形截面管道中测量流体速度—第四部分：文丘里管

[24] ISO 5167-5, Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 5: Cone meters

ISO 5167-5，将压差装置插入全面运行的环形截面管道中测量流体速度—第五部分：圆锥计

[25] No JACA 24:1989, Standardization and Evaluation of Clean Room Facilities

JACA 24:1989，洁净间设施标准化和评估

[26] JIS B 9921, Light scattering automatic particle counter. Japanese Industrial Standards Committee

JIS B 9921，光散射悬浮粒子自动计数仪，日本行业标准委员会

[27] SEMI E14-93, Measurement of particle contamination contributed to the product from the process or support tool

SEMI E14-93，工艺或支架工具对产品粒子污染的测量

[28] ISO 7726, Ergonomics of the thermal environment — Instruments for measuring physical quantities

ISO 7726，热力学环境的工效学—测量物理量值的仪器

[29] Evaluation of measurement data – Guide to the expression of the expression of uncertainty in measurement, JCGM 100:200, corrected version 2010, (GUM)

测量数据评估—测量不确定度表述指南，JCGM 100：200，2010 年修正版本（GUM）