

Technical Information Report

AAMI TIR42: 2021

Evaluation of particulate
associated with vascular
medical devices

Evaluation of particulate associated with vascular medical devices

Approved 31 March 2021
by **AAMI**

Abstract: This document provides information for defining appropriate test methods, determining the source of particulate, assessing the clinical risk of particulate, and establishing product particulate limits. Particulate could arise from many sources including materials, environment, and clinical use. This TIR is intended to offer guidance to the medical device industry when evaluating the tendency for medical devices to release particulate, identifying particulate sources, applying analytical methods for particulate testing, and developing particulate limits based on clinical risk.

Keywords: acute, coating, emboli, hydrophilic, light microscopy, light obscuration, literature review, medical device, particle, particle counting, particulate limits, particulate matter, risk, simulated use, test method, validation

AAMI Technical Information Report

A technical information report (TIR) is a publication of the Association for the Advancement of Medical Instrumentation (AAMI) Standards Board that addresses a particular aspect of medical technology.

Although the material presented in a TIR may need further evaluation by experts, releasing the information is valuable because the industry and the professions have an immediate need for it.

A TIR differs markedly from a standard or recommended practice, and readers should understand the differences between these documents.

Standards and recommended practices are subject to a formal process of committee approval, public review, and resolution of all comments. This process of consensus is supervised by the AAMI Standards Board and, in the case of American National Standards, by the American National Standards Institute.

A TIR is not subject to the same formal approval process as a standard. However, a TIR is approved for distribution by a technical committee and the AAMI Standards Board.

Another difference is that, although both standards and TIRs are periodically reviewed, a standard must be acted on—reaffirmed, revised, or withdrawn—and the action formally approved usually every five years but at least every 10 years. For a TIR, AAMI consults with a technical committee about five years after the publication date (and periodically thereafter) for guidance on whether the document is still useful—that is, to check that the information is relevant or of historical value. If the information is not useful, the TIR is removed from circulation.

A TIR may be developed because it is more responsive to underlying safety or performance issues than a standard or recommended practice, or because achieving consensus is extremely difficult or unlikely. Unlike a standard, a TIR permits the inclusion of differing viewpoints on technical issues.

CAUTION NOTICE: This AAMI TIR may be revised or withdrawn at any time. Because it addresses a rapidly evolving field or technology, readers are cautioned to ensure that they have also considered information that may be more recent than this document.

All standards, recommended practices, technical information reports, and other types of technical documents developed by AAMI are voluntary, and their application is solely within the discretion and professional judgment of the user of the document. Occasionally, voluntary technical documents are adopted by government regulatory agencies or procurement authorities, in which case the adopting agency is responsible for enforcement of its rules and regulations.

Comments on this technical information report are invited and should be sent to AAMI, Attn: Standards Department, 901 N. Glebe Road, Suite 300, Arlington, VA 22203.

Published by
AAMI
901 N. Glebe Road, Suite 300
Arlington, VA 22203
www.aami.org

© 2021 by the Association for the Advancement of Medical Instrumentation

All Rights Reserved

Publication, reproduction, photocopying, storage, or transmission, electronically or otherwise, of all or any part of this document without the prior written permission of the Association for the Advancement of Medical Instrumentation is strictly prohibited by law. It is illegal under federal law (17 U.S.C. § 101, *et seq.*) to make copies of all or any part of this document (whether internally or externally) without the prior written permission of the Association for the Advancement of Medical Instrumentation. Violators risk legal action, including civil and criminal penalties, and damages of \$100,000 per offense. For permission regarding the use of all or any part of this document, complete the reprint request form at www.aami.org or contact AAMI at 901 N. Glebe Road, Suite 300, Arlington, VA 22203. Phone: +1-703-525-4890; Fax: +1-703-276-0793.

Printed in the United States of America

ISBN 978-1-57020-787-7

Contents

Page

Committee representation	iv
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Definitions	1
4 Introduction	2
5 Key characteristics for evaluation of particulate	2
6 Sources of particulate	3
7 Particulate evaluation test methods	7
8 Literature review	12
9 Considerations for establishing quantitative limits for product particulate	22
Annex A Summary of particulate characterization technologies	30
Bibliography	34

Tables

Table A.1—Primary particulate quantitation and sizing technologies	30
Table A.2—Additional particulate quantitation and sizing technologies	31
Table A.3—Particulate chemical identification technologies	32

Committee representation

Association for the Advancement of Medical Instrumentation

Medical Device Particulates Committee

This technical information report (TIR) was developed by the AAMI Medical Device Particulates Committee. Approval of the TIR does not necessarily imply that all committee members voted for its approval.

At the time this document was published, the **AAMI Medical Device Particulates Committee** had the following members:

Cochairs: Terry Irwin, MBA, CMQ/OE
Dinesh Patwardhan, PhD

Project Leader: Eleni Whatley, PhD

Members: Susanne Anderson, NAMSA
August Baur, Centurion Sterilization Services
Kendahl Bennis, Boston Scientific
Martin Boehm, Shire/Takeda Pharmaceuticals
Lindsey Borton, MPH, Smiths Medical
Carolyn Braithwaite-Nelson, Spectranetics/Philips
Alina Bridges, Mayo Clinic
Amitabh Chopra, Camarillo, CA
James Conti, PhD, Dynatek Labs
Lydia Edgewater, W.L. Gore & Associates
Paul Fioriti, B. Braun Medical
Dan Floyd, CISS-EO, DuPont Tyvek Medical and Pharmaceutical Protection
Doug Harbrecht, Sterility Assurance Ltd.
Stephanie Hsia, Medtronic Neurovascular
Yin Hu, MD, University Hospitals of Cleveland
Terry Irwin, Edwards Lifesciences
Allan Kimble, DuPuy Synthes USA/Johnson & Johnson
Stan Lam, PhD, Stryker Neurovascular
Rashi Mehta, West Virginia University Hospitals
Rupal Mehta, Rush University Medical Center
Tonya Morris, BS, Nelson Laboratories/Sotera Health
Dinesh Patwardhan, U.S. Food and Drug Administration/CDRH
Christin Pawleski-Hoell, Raumedic Inc.
Sandi Schaible, WuXi Apptec Inc.
Kyle Timme, Cook Research
Craig Weinberg, PhD, Biomedical Device Consultants & Laboratories
Neal Zupec, Baxter Healthcare Corporation

Alternates: Brian Choules, PhD, Biomedical Device Consultants & Laboratories
Robert John Evjen, Boston Scientific
Siddharth Loganathan, Stryker Neurovascular
Gerald McDonnell, PhD, Johnson & Johnson
Nicholas Packet, DuPont Tyvek Medical and Pharmaceutical Protection
Elaine Strobe, PhD, Dynatek Laboratories
Carl Swanson, NAMSA
Eleni Whatley, PhD, U.S. Food and Drug Administration/CDRH
Preston Zook, Nelson Laboratories/Sotera Health

NOTE Participation by federal agency representatives in the development of this technical information report does not constitute endorsement by the federal government or any of its agencies.

Foreword

This technical information report was developed by the AAMI Medical Device Particulates Committee. The objective is to provide technical information that will assist medical device manufacturers in determining acceptable levels of particulate on medical device products used to deliver or implant into the vasculature, or both.

The following verbal forms are used within AAMI documents to distinguish requirements from other types of provisions in the document:

- “shall” and “shall not” are used to express requirements;
- “should” and “should not” are used to express recommendations;
- “may” and “may not” are used to express permission;
- “can” and “cannot” are used as statements of possibility or capability;
- “might” and “might not” are used to express possibility;
- “must” is used for external constraints or obligations defined outside the document; “must” is not an alternative for “shall.”

Suggestions for improving this recommended practice are invited. Comments and suggested revisions should be sent to Standards, AAMI, 901 N Glebe Road, Suite 300, Arlington, VA 22203 or standards@aami.org.

NOTE This foreword does not contain provisions of the AAMI TIR42, *Evaluation of acute particulate generation associated with vascular medical devices* (AAMI TIR42:2021), but it does provide important information about the development and intended use of the document.

Introduction

This Technical Information Report (TIR) addresses the particulate matter on limited duration and implantable medical devices, and on accessory devices used in the vascular system during the delivery and implantation or exposure and removal of such devices. Unintentional particulate matter on medical devices can be a quality control issue because of the manufacturing environment or a device design–related issue. Sources of particulate in the manufacturing environment might include glove powders, lint and other fibers, paper particles, packaging materials, paint particles, and many other materials. Release of particulate during use is a characteristic of medical devices that may be addressed in product development. Particulate consisting of device materials can arise because of friction, abrasion, or dissolution, and can have significant effects on patient outcome.

Evaluation of particulate associated with vascular medical devices

1 Scope

1.1 General

This document addresses particulate released from intravascular medical devices that have direct contact with circulating blood. It is intended to assist intravascular medical device manufacturers in defining appropriate test methods, determining the source of particulate, assessing the clinical risk of particulate, and establishing product particulate limits.

1.2 Inclusions

This document specifically includes particulate that could be acutely released into the vasculature from intravascular medical devices and accessories used with the devices. This might include particulate as a result of manufacturing, packaging, materials, coatings, and acute device use. This document only addresses particulate that might be released during acute intravascular device use, i.e., from introduction to device and accessory withdrawal.

1.3 Exclusions

This document does not address particulate released after removal of a non-implantable device or after removal of an implant's delivery system and accessories, i.e., chronic particulate release from an implanted device such as due to wear. It excludes intentional therapies in the form of particulate, for example drug coatings on balloons and embolization microspheres or beads, though their delivery systems are included.

This document specifically excludes particulate arising from the operating room or clinical environment in which the device is used.

This document does not address patient-generated particulate, such as those originating from plaque, that might be produced before, during, or following an acute device procedure. Liquids, such as lubricating fluids, are not considered to be particulate in the context of this document.

Routine monitoring of particulate levels on the device due to unintended changes in the manufacturing process or environment are not discussed in this document.

2 Normative references

There are no normative references in this document.

3 Definitions

For the purposes of this technical information report, the following terms and definitions apply.

3.1

acute application

time frame during device delivery, or exposure to the device, up until all accessories have been removed during typical procedures

NOTE Typical acute procedures usually last 2 hours or less. However, for the purposes of this document, acute procedures can last up to 24 hours.

3.2

fiber

minute piece of matter with defined physical boundaries and a length to width ratio (i.e., aspect ratio) of at least 10:1

3.3

particle

minute piece of matter with defined physical boundaries

[SOURCE: ISO 16197 [1] and ISO 14644 [2].]

3.4

particulate

3.5

particulate matter

mobile particles and/or fibers present on or arising from the use of a medical device

NOTE Liquids and gas bubbles, whether miscible or immiscible, are not considered particulate. Hydrogels or other highly solvated materials, which consist primarily of solvent in a polymer matrix, are included.

3.6

visible particulate

particulate matter 100 microns or larger

4 Introduction

In presentation of a medical device to patients, it is important to minimize the unintentional particulate matter present on the device or released from the device during clinical use that can interact with the patient during therapy. Extraneous particulate matter from a device has been indicated to present a safety risk to patients, in some instances, as described in Sections 8 and 9 of this document.

Due to the absence of comprehensive and definitive clinical safety data, generally accepted particulate size ranges and particulate count limits that aid patient safety have yet to be established for intravascular devices. This is due to the fact that setting specific limits is complicated by varied patient thresholds to emboli due to a broad array of medical conditions and comorbidities, the vast array of vascular beds with different sizes in the human anatomy, and the benefit(s) of the device to the patient. This TIR has not overcome this obstacle but recommends general approaches to generate limits based on benefit/risk principles. These approaches require assumptions with appropriate rationale by the device manufacturer to set particulate limits.

5 Key characteristics for evaluation of particulate

5.1 Identity

The chemical composition of particulate might be an important consideration when investigating and characterizing potential sources of the particulate matter. The identification of particulate matter is usually conducted through analytical techniques as discussed in Section 7 and Annex A below. It might be important to consider the identity (e.g., material type, chemical composition, etc.), source, and potential toxicity of each type of particulate. It is not expected that all particulate need to be identified, but efforts at identification should be undertaken when appropriate (e.g., when particulate levels have exceeded limits, large or atypical particulate, such as in color, shape, or morphology, is found, or as necessary to better derive the source of particulate).

5.2 Size

The size of particulate can be important because particulate can block blood vessels, however criticality of size might vary depending on vasculature and risk. Manufacturers should determine what sizes are appropriate based on their device considerations and the vascular area for which a device will be used. It is often useful to describe particulate size ranges (generally three or more) to quantify the number of particulate falling into these specified groupings.

5.3 Shape

The shape of particulate matter can have important effects. Understanding particulate shape is important not only to determine the source, but to also understand added risks posed by the introduction of these particulate to the vascular system. For example, fibers might be a unique concern because the three dimensions will be very different (fibers are defined as having an aspect ratio of $\geq 10:1$). Counting and characterization methods might not distinguish fibers in the same way, and the biological effects of fibers can be different from round particles having the same surface area or dimension. If the presence of fibers is suspected, it might be useful to employ multiple characterization methods. Appropriate methods (e.g., microscopy) should be used to characterize the shape of particulate shed by intravascular medical devices in order to ensure particulate counting methods are appropriate.

5.4 Quantity

The allowable quantity of particulate matter depends on a variety of factors including chemical composition, potential toxicity, shape, and size. Particulate count limits are not recommended in this TIR because of the absence of comprehensive and definitive clinical data and the benefits of the device should be weighed with the particulate risks. See Section 9 for more detail on strategies for establishing particulate limits.

6 Sources of particulate

6.1 Baseline identification of particulate contaminants

Effective control of particulate matter starts early in the product and manufacturing development process. As a result, initial characterization of particulate matter released from the device should be performed as early as possible in the product development process and compared to the proposed particulate limits for the device. When the device design reaches a state of maturity where human use is being considered or if the device is already available for human use, a program should be initiated to measure and identify the burden of particulate matter on the device. It can be helpful for this program to include development of a list of all materials associated with the device as well as possible contaminants from the manufacturing process and environment, by documenting and identifying, when needed, (e.g., by Fourier transform infrared spectroscopy):

- a) materials used in the device;
- b) materials used during manufacturing, such as gowns, gloves, hair covers, and shoe covers;
- c) materials of manufacture for machine parts such as valves, gaskets, and belts;
- d) reagents used, such as lubricants, cleaning agents, and processing agents;
- e) packaging materials and processes;
- f) environmental contaminants.

This list is an important tool that can be used later to help identify sources of particulate matter.

Based on the risk assessment, if potentially harmful particulate matter is found (e.g., large quantities of particulate, large-sized particulate, or particulate of a harmful material/chemical composition), and the related risk cannot be appropriately mitigated, the device design, manufacturing process, cleaning, and/or preparation processes might need to be modified to reduce particulate levels. If the characterization data demonstrates acceptable levels of particulate when compared to the proposed device particulate limits, then product and manufacturing control limits (a.k.a. alert and action limits) may be established using the available data.

6.2 Control of particulate sources

Unintended particulate matter can originate from a variety of sources that include the medical device itself, its packaging, and the manufacturing environment. The table below provides an overview of common particulate sources and typical methods that are applied to evaluate, reduce and/or control the particulate source.

Particulate Source	Evaluation and Control Method
6.2.1 Product Design The control or minimization of particulate matter starts during device design and development. This TIR does not address particulate released by wear or degradation after implantation of a device, though this risk should be considered in the design of a device.	
6.2.1.1 Materials and Coatings Materials Particulate can be released from the materials used in the device. Consideration should also be made for wear of those materials during use. Coatings In addition, coated devices (e.g., hydrophilic, hydrophobic, antithrombotic, polymer, etc.) can shed more particulate than uncoated devices. The amount of particulate released from a coating depends on its physical and chemical properties, such as chemical composition, structure, and coating/attachment method. Hydrophilic coatings have been reported to delaminate and/or shed particulate [3]-[9]. Hydrophilic and/or hydrophobic coatings can separate (e.g., peel, flake, shed, delaminate, slough off) from medical devices and potentially cause serious patient injury.	6.2.1.2 Evaluation and Control Method During device design, consideration should be given to the particulate levels associated with device materials or components. These considerations may include: a) requirements for cleanliness of the materials or components from the selected supplier; b) ease of cleaning materials and components; c) tendency of the material to shed particulate, such as when flexed, heated, aged, or rubbed against packaging materials or against another device in use; d) tendency of the material (if the material easily becomes statically charged, or if it is tacky) to attract particulate from the environment; e) composition and amount (thickness, length) of coatings and how they might relate to particulate generation when used intravascularly and in challenging clinical scenarios;
6.2.1.3 Design Configuration The number of parts in the device and the way those parts interact with each other during use can have a large effect on the number and size of particulate released during use. Parts that rub together or interfere with each other are more likely to release particulate than those with no contact. In addition, the complexity of a single part in the design can affect how easily that part can be cleaned to remove particulate prior to and during assembly. A vascular device's interaction with accessory devices (e.g., guidewires, introducer sheaths, etc.) can also contribute to particulate generation and shedding. Inappropriate labelled sizing or mismatch of accessories during use can result in high frictional forces which can increase the likelihood of particulate generation.	6.2.1.4 Evaluation and Control Method Generation of particulate can be reduced by a) minimizing the use of surfaces that rub together, such as o-ring seals and threaded connections; b) minimizing complexity of the design; c) designing for ease of cleaning; d) ensuring appropriate labeled dimensions.
6.2.1.5 Packaging Because packaging is either in direct contact with the device or in close proximity to the device, there is potential for transfer of particulate matter to the device. This potential is especially true of the following: a) paper packaging; b) chipboard backing cards, forms, or holders; c) instructions for use; d) rough edges on polymeric containers; e) elastomeric fixtures;	6.2.1.6 Evaluation and Control Method The potential of each packaging component to transfer particulate should be considered during package design. Particulate contribution from packaging should be minimized. Control of particulate matter should include the packaging materials.

Particulate Source	Evaluation and Control Method
f) hinged packaging; and g) hypotubes or other components designed with a snug fit to the device.	
6.2.1.7 Shelf Life	6.2.1.8 Evaluation and Control Method
Most medical devices have a shelf life claim. The level of particulate released by the device can be affected by the amount of time that elapses between manufacture and use. Changes in material properties occurring during the aging process can lead to increased particulate release during use. Examples are a) environmental stress cracking of embrittled parts; b) environmental stress cracking of molded parts with residual stress; c) oxidative and drying effect on materials, especially films and coatings; and d) delamination of material layers.	Assessment of device particulate should be considered for accelerated and real-time shelf life studies. These studies should also incorporate samples exposed to the maximum number of allowed sterilization exposures (e.g., double sterilization). Discussion of aging protocols can be found in AAMI TIR17, ASTM F1980, and ANSI/AAMI/ISO 11607-1.
6.2.2 Manufacturing Manufacturing controls should manage five areas of concern: component or raw materials, manufacturing processes, manufacturing equipment, manufacturing personnel, and manufacturing environment. The effect of particulate should also be considered during changes in manufacturing processes or materials.	
6.2.2.1 Components and Raw Materials	6.2.2.2 Evaluation and Control Method
Components and raw materials might be a significant source of particulate.	The integration of the components into the manufacturing process should take into consideration the amount of the components' particulate burden and the steps implemented to reduce it. Components and raw materials that present a high potential source of particulate should be cleaned before being introduced into a clean manufacturing environment. Material and component cleaning should be validated to ensure particulate levels are acceptable. Examples of component cleaning include sonication and agitating with detergents or soaps.
6.2.2.3 Manufacturing Processes	6.2.2.4 Evaluation and Control Method
Consideration should be given to manufacturing steps that might generate or increase the level of particulate such as a) grinding; b) polishing; c) cutting; d) stamping; e) spraying; f) sonication; g) surface modification (e.g., coatings, etchings); h) drying;	The manufacturing process should have adequate controls to ensure particulate matter that will inappropriately affect the finished product, either directly or indirectly, is not released during the process or is removed as part of the manufacturing process. Such processes should be segregated from other manufacturing operations and followed by adequate cleaning procedures. Optimization of manufacturing steps can be considered to reduce particulate matter, when possible. For devices with coatings, optimization of coating processes can help improve coating adhesion and overall integrity to help reduce the amount of particulate shedding.

Particulate Source	Evaluation and Control Method
i) packaging, transport, and storage of subassemblies; j) hand operations.	
6.2.2.5 Manufacturing Equipment	6.2.2.6 Evaluation and Control Method
In addition to the manufacturing operation performed by equipment, the equipment itself and related utilities can generate particulate. Equipment used in the manufacturing operation should be appropriate for the environment in which it is used.	Equipment that generates large quantities of airborne particulate in a clean manufacturing environment should be vented or otherwise mitigated (e.g., filtered) to ensure the manufacturing environment does not become contaminated. Micro-controlled environments can be used to control the environments in which molded components are manufactured. Compressed gases used in the manufacturing process that vent into the manufacturing areas should meet the quality requirements for particulate of the manufacturing areas. Equipment that sheds particulate such as those with moveable parts that contact each other and shed material should be avoided in clean manufacturing environments.
6.2.2.7 Manufacturing Personnel	6.2.2.8 Evaluation and Control Method
Sources of particulate from personnel include, for example, skin cells, hair, cosmetics, clothing fibers, and soil from clothing and shoes.	Gowning and other personnel practices should be established and maintained to ensure that personnel are not contributing particulate to the product or manufacturing environments. These practices may include, for example, gowns, gloves, sleeve covers, hair covers, beard covers, face covers, shoe covers, smocks, or complete jumpsuits and face shields. The use of cosmetics is not recommended in manufacturing areas. The number of personnel in a given area can be restricted to reduce the contribution of particulate from personnel. See ISO 14644-5 for personnel operations considerations.
6.2.2.9 Manufacturing Environment	6.2.2.10 Evaluation and Control Method
There is the potential for the manufacturing environment to introduce particulate to the medical device. The manufacturing environment should be adequate to control the levels and type of particulate and to prevent the generation of product particulate matter. The cleanliness level of the manufacturing environment depends on the requirements of the device.	If it is required that the manufacturing environment be controlled, refer to the ISO 14644 series. As recommended in these documents, action and alert levels should be established. AAMI TIR52 can also be referenced.
6.2.3 Sterilization	6.2.4 Evaluation and Control Method
Effects of sterilization on particulate generation will differ by the modality used. The following are potential physical effects of sterilization on the device: a) moist heat, ethylene oxide, or chemical vapor-sterilization parameters (e.g., temperature, humidity and pressure) might result in material changes such as deformation, corrosion or liberation of particulate; b) irradiation—scission of polymer chains might result in embrittlement, cracking, or oxidative stress.	The potential effect of the sterilization process on the generation of particulate should be considered in the selection of sterilization method, materials, components, and packaging.

Particulate Source	Evaluation and Control Method
6.2.5 Shipping and Distribution	6.2.6 Evaluation and Control Method
The amount of particulate released by a device can be significantly affected during transit of the packaged device from the manufacturer to the end user. Vibration and effects caused by stacking and/or dropping can be anticipated during transit. Additionally, potential pressure stress can occur during airborne transport. Anticipation of these effects will account for movement and rubbing of parts in the package. Each of these factors can affect the amount and type of particulate released from the device and from the device packaging onto the device. Temperature extremes might also affect particulate generation and should be considered.	Evaluation of particulate on devices in their finished carton configuration after environmental conditioning and shipping simulation should be conducted. See ASTM D4169, ASTM D7386 and/or International Safe Transit Association (ISTA) 2A and 3A. The impact of package and carton configuration should be considered when determining appropriate testing.
6.2.7 Clinical Application and Use	6.2.8 Evaluation and Control Method
During clinical use of the device, particulate matter can be released from the device or due to interactions of the device with ancillary components (e.g., guiding catheter, guidewire).	Evaluation of particulate generation from the device is recommended to be performed under conditions representative of the clinical use (i.e., simulated use conditions and at physiological temperature of $37 \pm 2^\circ\text{C}$) unless a suitable justification can be made. Refer to Section 7 for further details.

6.3 In-process visual inspection for particulate

In-process visual inspections can be used to limit visible particulate matter present on the medical device. These inspections should be performed with the naked eye or 2.5X magnification, with appropriate justification. If visible particulate matter is detected, it might be appropriate to remove particulate matter as part of the validated manufacturing process. Other validated methods to ensure visible particulate matter is limited on the device can be appropriate.

7 Particulate evaluation test methods

7.1 General considerations for particulate evaluation

Appropriate evaluation of the quantity, sizing, and identification of particulate shed from vascular medical devices is a systematic process that requires multiple steps. The first step is to generate an appropriate simulated use model for testing. Once complete, various counting and sizing methods can be employed as well as analytical techniques for determination of source. The sections below outline these steps along with considerations for testing.

7.1.1 Test environment controls

Particulate testing should be carried out in a controlled environment (e.g., a class 100 laminar flow cabinet) that limits the introduction of extraneous particulate matter. The analyst should gown with the appropriate clothing (e.g., hair nets, non-shedding polyester coats, and particle-free gloves) to reduce the risk of particulate contamination. All equipment and supplies used in the evaluation should be reasonably free of contaminants, as appropriate. Glassware should be washed with a detergent solution, followed by a thorough rinse using particle free or filtered fluid.

Collection of particulate matter at one facility while performing primary sizing and counting at another facility is not recommended due to the potential for introduction of test artifacts (e.g., due to settling, agglomeration, or breaking up of particulate matter). If this approach is employed, the validation should account for all aspects of this process (e.g., shipping, time from collection to analysis, packaging, collection container, temperature variation).

7.1.2 Test article

The test article should be representative of the finished device, as intended for clinical use and should undergo all manufacturing processes including single or multiple sterilization cycles (as applicable). When sampling, a product should be contained in its usual packaging and tested after removal from its packaging. If the device comes in multiple sizes, testing should be conducted on various device sizes to ensure that the testing is representative of the entire