
**Ophthalmic implants — Irrigating
solutions for ophthalmic surgery**

*Implants ophtalmiques — Solutions d'irrigation pour la chirurgie
ophtalmique*

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Foreword

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.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

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Ophthalmic implants — Irrigating solutions for ophthalmic surgery

1 Scope

This International Standard defines requirements with regards to safety for the intended performance, design attributes, preclinical and clinical evaluation, sterilization, product packaging, product labelling and the information supplied by the manufacturer.

This International Standard applies to ophthalmic irrigating solutions (OISs), used during ophthalmic surgery. These solutions do not provide any primary immunological, pharmacological or metabolic function.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10993-1:—¹⁾, *Biological evaluation of medical devices — Part 1: Evaluation and testing*

ISO 10993-2:1992, *Biological evaluation of medical devices — Part 2: Animal welfare requirements*

ISO 11607:2002, *Packaging for terminally sterilized medical devices*

ISO 13408-1:1998, *Aseptic processing of health care products — Part 1: General requirements*

ISO 14155-1, *Clinical investigation of medical devices for human subjects — Part 1: General requirements*

ISO 14155-2, *Clinical investigation of medical devices for human subjects — Part 2: Clinical investigation plans*

ISO 14630:1997, *Non-active surgical implants — General requirements*

ISO 14971-1:1998, *Medical devices — Risk management — Part 1: Application of risk analysis*

ISO 15223:2000, *Medical devices — Symbols to be used with medical device labels, labelling and information to be supplied*

EN 868-1:1997, *Packaging materials and systems for medical devices which are to be sterilized — Part 1: General requirements and test methods*

EN 1041:1998, *Information supplied by the manufacturer with medical devices*

EN 12442-1:2000, *Animal tissues and their derivatives utilized in the manufacture of medical devices — Part 1: Analysis and management of risk*

1) To be published. (Revision of ISO 10993-1:1997)

3 Terms and definitions

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

3.1 delivery system
sealed container in which the product is supplied and any additional components provided to introduce the product into the eye

3.2 ophthalmic irrigating solution (OIS)
aqueous solution that is physiologically compatible with the intraocular environment and functions solely by mechanical means

NOTE It does not provide any primary immunological, pharmacological or metabolic function.

4 Intended performance

The intended performance of the product shall be defined by the manufacturer. The intended performance shall include the general requirements for the intended performance of non-active surgical implants outlined in ISO 14630.

The extent to which the intended performance has been achieved shall be determined, taking into account published standards, published clinical and scientific literature, validated test results, preclinical evaluation and clinical trials.

5 Design attributes

5.1 General

The general requirements for non-active surgical implants outlined in ISO 14630 shall apply.

5.2 Concentration of the components

The concentration of each component material in the finished product shall be determined and documented, and the concentration of each component shall be expressed as weight of material per unit volume of solution. Since the testing methodology may affect the actual concentration reported, the standard physical or chemical techniques utilized shall be described and documented. Wherever possible, components shall comply with stated compendial standards.

5.3 Water used

The purity of the water used shall be Water for Injections (e.g. see [3]).

5.4 Characterization of the finished product

5.4.1 General

The manufacturer shall describe and document the physical characteristics that affect the performance of the OIS efficacy in ophthalmic surgery.

NOTE These physical properties should be measured at the conditions expected and relevant at the time of use.

5.4.2 pH and buffering capacity

The pH of the finished product shall be determined and documented with a calibrated pH meter at $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.

NOTE The pH of the product should be close to that of the aqueous humour (pH 7,38) in order to prevent damage to the corneal endothelial cells. *In vitro* studies have shown that the pH range tolerated by the endothelium narrows as exposure time increases.

A suitable method shall be used to determine buffering capacity. An example of a suitable method is given in Annex A. The products shall be classified as in Table 1.

Table 1 — Classification according to pH and buffering capacity

Group	Base buffering capacity (mol/l per pH)	Acid buffering capacity (mol/l per pH)	pH range
Essentially unbuffered	< 0,000 5	< 0,004	6,5 to 8,5
Moderately buffered	0,000 5 to 0,005	0,004 to 0,04	6,7 to 8,2
Buffered	> 0,005	> 0,04	7,2 to 7,6

5.4.3 Chemical and biological contaminants

Potentially hazardous chemical or biological contaminants and impurities shall be determined by a risk analysis. For raw materials of biological origin, these contaminants may include proteins, nucleic acids or other biological materials. Contaminants of the finished product that are potentially hazardous either to the tissues of the eye or systemically, shall be identified, whenever possible, and their concentrations in the finished product reported.

Contaminants shall be determined using standard analytical methods when available, and all methods shall be described. Limits for identified contaminants shall be set and included. Testing for the biological effects of these contaminants during evaluation of biological safety may be required if the risk analysis determines it necessary.

5.4.4 Osmolality

The manufacturer shall determine and document the osmolality range of the OIS. Osmolality of the finished product shall be not less than 200 mosm/kg or greater than 400 mosm/kg. Osmolality shall be determined using either a vapour pressure osmometer or a cryoscopic osmometer.

5.4.5 Spectral transmittance

The spectral transmittance of the finished product shall be recorded over the range 300 nm to 1 100 nm. Results shall be presented graphically, plotting % transmission against wavelength.

5.4.6 Particulates

5.4.6.1 General

There is a potential for adverse events to take place as a result of particles of certain sizes and characteristics in the finished product.

Particulate contamination of OISs consists of extraneous, mobile undissolved particles other than gas bubbles, unintentionally present in the solutions.

A risk assessment shall evaluate the potential for contamination by, or formation of, particulates in the product during manufacture as well as the conditions expected during transport and storage, and during use of the product and the hazards associated with these.

In multi-component products (i.e. where there are two or more separate parts of a product that have to be mixed prior to use) tests shall be applied to the mixed product.

5.4.6.2 Visible particles

The OIS shall be essentially free of visible particles. The method described in Annex B shall be used to determine this.

5.4.6.3 Subvisible particles

Either the light obscuration test method given in Annex C or the microscopic test method given in Annex D shall be used to determine the subvisible particulate level for OISs with the corresponding limits of each method as given below.

The following limits shall apply for the light obscuration test method described in Annex C:

- No more than 50 particles equal to or greater than 10 μm per ml of OIS;
- No more than 5 particles equal to or greater than 25 μm per ml of OIS;
- No more than 2 particles equal to or greater than 50 μm per ml of OIS.

The following limits shall apply for the microscopic test method of Annex D:

- No more than 25 particles equal to or greater than 10 μm per ml of OIS;
- No more than 2,5 particles equal to or greater than 25 μm per ml of OIS;
- No more than 1 particle equal to or greater than 50 μm per ml of OIS.

NOTE The light obscuration test method of Annex C is based on light blockage. Amorphous, semiliquid or otherwise morphologically indistinct materials contribute to light obscuration and therefore contribute to the particle count. In the microscopic test method of Annex D, amorphous, semiliquid or otherwise morphologically indistinct materials appear as stain or discolouration on the surface of the membrane filter, and are not counted as particles. To compensate for this difference, the limits for the microscopic test method are one half those for the light obscuration method.

6 Design evaluation

6.1 General

The OIS shall be evaluated to demonstrate that the intended performance is achieved. The requirements for evaluation of non-active implants outlined in ISO 14630 shall apply.

6.2 Preclinical evaluation of biological safety

6.2.1 General

The procedure for evaluation of biological safety of an OIS shall commence with an assessment of risk, carried out and documented in accordance with ISO 14971-1. The results of the risk analysis shall determine the tests required to evaluate the biological safety of the OIS.

For OISs containing material of animal origin the risk analysis and management requirements outlined in EN 12442-1 shall apply.

NOTE 1 During the risk assessment the manufacturer should take into account the interaction with other ophthalmic products.

For all OISs the requirements for evaluation of biological safety specified in ISO 10993-1 shall apply.

NOTE 2 Based upon the typical clinical applications, OISs are categorized as "Implant devices, tissue/bone". The tests for this and other categories of devices identified in Table 1 of ISO 10993-1:1997 are for guidance only. They do not represent maximum or minimum test requirements.

NOTE 3 It may be possible to combine biocompatibility tests, thereby reducing the number of animals required for testing. Multiple tests can be conducted simultaneously in a single animal provided that the test animal is not subjected to undue pain or distress.

In addition to the biocompatibility tests identified in ISO 10993-1 and by the risk analysis, all of the following tests shall be considered in the selection of tests to evaluate the biological safety of an OIS.

6.2.2 Bacterial endotoxins test

The OIS shall be evaluated for the presence of bacterial endotoxins using the Limulus Amebocyte Lysate (LAL) test, in accordance with USP 24 [5] or an equivalent, validated test procedure. Any product that exceeds a bacterial endotoxin limit of 0,5 endotoxin units (EU) per ml fails the test.

6.2.3 Intraocular irritation and inflammation

If the risk assessment indicates that it is necessary to undertake tests for intraocular irritation, inflammation, intraocular pressure and other local events, such tests shall be conducted in a suitable animal model in accordance with Annex E. The choice of animal species shall be justified and documented. The animal welfare requirements as described in ISO 10993-2 shall apply.

The animal testing shall mirror the intended clinical use as closely as possible.

The study design should assess the intraoperative and postoperative ocular irritation and inflammation of the ophthalmic surgery, with comparative use of the OIS under evaluation and a control OIS that has already been proven to be non-irritating and non-inflammatory in clinical use for five years. The volume of OIS used shall simulate the intended use, accounting for ocular volume differences between the human eye and that of the animal model.

The post-surgical irritation and inflammation shall be monitored and graded in accordance with Annex E. Based upon the risk management plan, appropriate evaluation at appropriate times may include corneal pachymetry and slit lamp biomicroscopy. All adverse effects shall be documented.

The OIS shall show ocular irritation and inflammation results less than or equal to the control OIS, or it shall be excluded from clinical use.

6.3 Clinical evaluation

If clinical evaluation and risk assessment identify the need for a clinical investigation, Annex F shall be considered. In addition, the general requirements concerning clinical investigations of medical devices for human subjects specified in ISO 14155-1 and ISO 14155-2 shall apply.

7 Sterilization

Whenever possible, the product shall be terminally sterilized in its final container. The requirements for sterilization of non-active surgical implants outlined in ISO 14630 shall apply.

Ethylene oxide shall not be used to sterilize the OIS solution and, unless justified, not to sterilize the primary container either. In case of justification and use for the latter, ethylene oxide and related contaminants may diffuse into the solution, for which the following limits shall then apply:

- ethylene oxide: less than 20 µg/ml
- ethylene chlorohydrin: less than 100 µg/ml

NOTE 1 It has been found that the requirements determining acceptable limits for ethylene oxide residuals specified in ISO 10993-7 are inadequate for devices in contact with highly sensitive tissues, such as those of the eye. For this case AAMI TIR No. 19 provides additional guidance to the application of ISO 10993-7.

For OISs that are not terminally sterilized, but aseptically processed, ISO 13408-1 shall apply. The process shall be demonstrated to comply with a contamination rate limit of 10^{-3} by a validated media fill study.

NOTE 2 ISO 13408-1 specifies the general requirements for, and offers guidance on, processes, programmes and procedures for the validation and control of aseptically processed health care products. ISO 13408-1 particularly applies, but is not limited to, the processing of aqueous solutions, and is thus relevant to the preparation of OISs. Future parts of that International Standard will address specialized processes, such as filtration and lyophilization.

8 Product stability

The manufacturer shall define and state the shelf life of the product. Real time or accelerated shelf life testing shall be performed to demonstrate that the finished product remains within specifications for a period of the labelled shelf life under expected conditions of transport and storage. Real time testing shall reflect normal storage temperature and temperature fluctuations and the relative humidity shall be controlled within $60\% \pm 20\%$. In accelerated testing the temperature shall not exceed 45 °C and the relative humidity shall be at least 40 %. The parameters that shall be followed during shelf life studies are the pH, osmolality, particulate levels, sterility (using EP, JP or USP [5-8]), colour and clarity, plus any other factors identified by risk analysis as crucial to safe use of the product.

The established shelf life of the OIS shall be re-validated if a risk assessment identifies any change in manufacture that may affect the stability of the product.

NOTE Changes in the composition of the product, source materials, material suppliers, manufacturing conditions, including the sterilization process, package design or package materials may affect the shelf life of the product.

9 Packaging

9.1 Protection from damage during storage and transport

The packaging requirements for medical devices outlined in ISO 11607 and ISO 14630 shall apply.

9.2 Maintenance of sterility in transit

OISs shall be packaged in such a way that they remain sterile or below the contamination rate specified, as applicable, within the limits specified for conditions of transport, storage and handling. The sterile packaging requirements outlined in EN 868-1 shall apply.

10 Information supplied by the manufacturer

The general requirements for information provided by the manufacturer of medical devices specified in EN 1041 shall apply together with the following particular requirements. Symbols may be used instead of text, where appropriate. When symbols are used the requirements of ISO 15223 shall apply.

The labelling shall contain information on whether the OIS is buffered and if so give information on the buffer type and capacity.

If the product is vulnerable to damage by exposure to environmental elements, there shall be clear warning signs on the shipping container.

NOTE The batch number and expiration date may be provided on a self-adhesive label.

A package insert shall be included within the storage container, provided in such a way that it can be removed and read without damaging the sterile barrier.

The minimum information required on the storage container, package insert, sterile barrier and primary container is listed in Table 2.

Table 2 — Information supplied by the manufacturer

Information	Storage container	Package insert	Sterile barrier (if present)	Primary container
Name of the manufacturer or authorized representative	x	x	x	x
Address of the manufacturer or authorized representative	x	x		
Trade name of product	x	x	x	x
Brief description of the chemical composition of the product and the volume supplied	x	x		
Conditions for storage	x	x		
Indications for use		x		
Contra-indications for use		x		
Warnings, precautions and known interactions with other ocular products		x		
Statement that the contents are for single use only	x	x	x	x
Statement "Sterile" and the method(s) of sterilization of the product and primary container	x	x	x	x
Statement "Do not use if sterile barrier is breached"		x	x	x
Expiration date	x		x	x
Information on whether the OIS is buffered and if so information on the buffer type and capacity		x		
Buffering category (see Table 1)		x		
Batch number preceded by the word "LOT"	x		x	x
NOTE The batch number, expiration date and sterility data need not be provided on the sterile barrier if that is transparent and the required information can be read directly from the primary container without breaching the seal.				

Annex A (informative)

Example of a suitable method for pH measurement and buffer capacity determination

A.1 General

This annex gives an example of a suitable method for pH measurement and buffer capacity determination.

A.2 Equipment and reagents

A.2.1 10-ml burette, capable of accurately delivering titrant in 0,1 ml increments.

A.2.2 Stirring plate.

A.2.3 Stirring bar.

A.2.4 Sodium hydroxide, 0,005 N volumetric standard.

A.2.5 Hydrochloric acid, 0,01 N volumetric standard.

A.3 Methodology

Sodium hydroxide and hydrochloric acid solutions are prepared and standardized using compendial methods and diluted to the desired concentration prior to use.

To a flask add 25 ml (V_s) of sample and with a calibrated glass pH electrode measure the pH (pH_1). Using the 10 ml burette (A.2.1), add sufficient HCl volumetric standard titrant to give a pH change of 1,0 pH unit (pH_2). Record the volume (V_t) of titrant added. Repeat with a second aliquot of sample using the NaOH volumetric standard as the titrant.

Calculate the buffer capacity using the following formula:

$$\frac{V_t \times N}{V_s \times (\text{pH}_2 - \text{pH}_1)}$$

where N is the normality of the titrant in question.

Report both buffer capacity against acid and buffer capacity against base in units of mol/l per pH.

For solutions with significant buffer capacity, the sample volume may be adjusted to give a suitable volume of titrant.

Annex B (normative)

Particulate contamination: visible particulates

B.1 General

The test is intended to provide a simple procedure for the visual assessment of the OIS as regards visible particles.

B.2 Apparatus

The apparatus consists of a viewing station comprising:

- B.2.1 a mat black panel**, of appropriate size, held in a vertical position.
- B.2.2 a non-glare white panel**, of appropriate size, held in a vertical position next to the black panel.
- B.2.3 an adjustable lamp holder**, fitted with a suitable light source and a suitable light diffuser.

Any appropriate visible light source is acceptable, provided that the intensity of the illumination at the viewing point is greater than 2 000 lx. Higher illumination is preferable for containers of coloured glass and plastic.

B.3 Method

Remove any adherent labels from the container and wash and dry the outside. Gently swirl the container ensuring that air bubbles are not introduced, and observe and count visible particulates for 5 s in front of the white panel. Repeat the procedure in front of the black panel. Document the sum of the counts for both the white and the black panels as the particulate contamination level of the OIS.

Annex C (informative)

Light obscuration test method for particulate contamination: subvisible particles

C.1 General

This annex describes a light obscuration test method for particulate contamination in the case of subvisible particles.

C.2 Apparatus

C.2.1 General

The apparatus is an electronic, liquid-borne particle counting system that uses a light-obscuration sensor with a suitable sample feeding system. A variety of this type of devices is commercially available. The operator needs to ensure that the operating parameters of the instrumentation are appropriate to the required accuracy and precision of the test result. The operator needs to be adequately trained.

C.2.2 Sensor concentration limits

The apparatus used shall have a concentration limit to the maximum number of particles per ml identified, which is greater than the concentration of the particles expected in the test specimen. The vendor-certified concentration limit is specified as that count level at which coincidence counts due to simultaneous presence of two or more particles in the sensor view volume comprise less than 10 % of the counts collected for 10 µm particles.

C.2.3 Sensor dynamic range

The dynamic range of the apparatus used (range of size of particles that can be accurately sized and counted) shall include the smallest particle size to be enumerated in the test article.

C.2.4 Particle-free water

Water to be used is passed through a filter having a porosity of 1,2 µm or finer.

C.2.5 Calibration

Calibrate the apparatus using dispersions of suitable spherical particles of known sizes between 10 µm and 25 µm in monodisperse suspensions. Disperse these standard suspensions in particle-free water to obtain an appropriate concentration of particulates. Take care to avoid aggregation of particles during dispersion.

C.3 Methodology

C.3.1 General precautions

Carry out the test under conditions of limited particulate contamination, preferably in a laminar-flow cabinet.

Very carefully wash the glassware and filtration equipment to be used, except for the membrane filters, with a warm detergent solution and rinse with abundant amounts of particle-free water to remove all traces of detergent. Immediately before use, rinse the equipment from top to bottom, outside and then inside, with particle-free water.

Take care not to introduce air bubbles into the prepared sample to be examined, especially when fractions of the prepared sample are being transferred to the container in which the determination is to be carried out.

C.3.2 Control test

In order to check that the environment is suitable for the test, that the glassware is properly cleaned and that the water to be used is particle-free, carry out the following test. Determine the particulate contamination of 5 samples of particle-free water each of 5 ml, in accordance with the method described below. If the number of particles of 10 µm or greater exceeds 25 for the combined 25 ml, the precautions taken for the test are not sufficient. Repeat the preparatory steps until the control test is passed.

C.3.3 Method

Multipacked OISs, which require mixing prior to use, are mixed as directed on the labelling thus ensuring thorough mixing of the separate components.

Mix the contents of the sample by slowly inverting the container 25 times. If necessary, carefully remove the sealing closure. Clean the outer surfaces of the container opening using a jet of particle-free water and remove the closure, avoiding contamination of the contents. Eliminate gas bubbles by allowing to stand for 2 min.

Remove four portions, each of $5 \text{ ml} \pm 0,2 \text{ ml}$ and count the number of particles equal to or greater than 10 µm and 25 µm. Disregard the result obtained for the first portion, and calculate and document the average number of particles for the prepared sample under examination.

Annex D (informative)

Microscopic test method for particulate contamination: subvisible particles

D.1 Introduction

This test enumerates subvisible, essentially solid, particulate matter in OIS products on a per-volume basis, after collection on a microporous membrane filter. In performing the microscopic assay, no attempt is made to enumerate amorphous, semiliquid or otherwise morphologically indistinct materials that have the appearance of a stain or discolouration on the membrane surface. Such materials show little or no surface relief and present a gelatinous or film-like appearance.

D.2 Test apparatus

D.2.1 Microscope

Use a compound binocular microscope that corrects for changes in interpupillary distance by maintaining a constant tube length, and with an objective and eyepiece combination that provides a magnification of $100 \times \pm 10 \times$. The lense has $10 \times$ nominal magnification, a planar achromat or better in quality, with a minimum numerical aperture of 0,25. In addition, the lense is compatible with an episcopic illuminator attachment. The eyepieces have $10 \times$ magnification. In addition, one eyepiece is designed to accept and focus an eyepiece graticule. The microscope has a mechanical stage capable of holding and traversing the entire circular area of a 25 mm or 47 mm membrane filter.

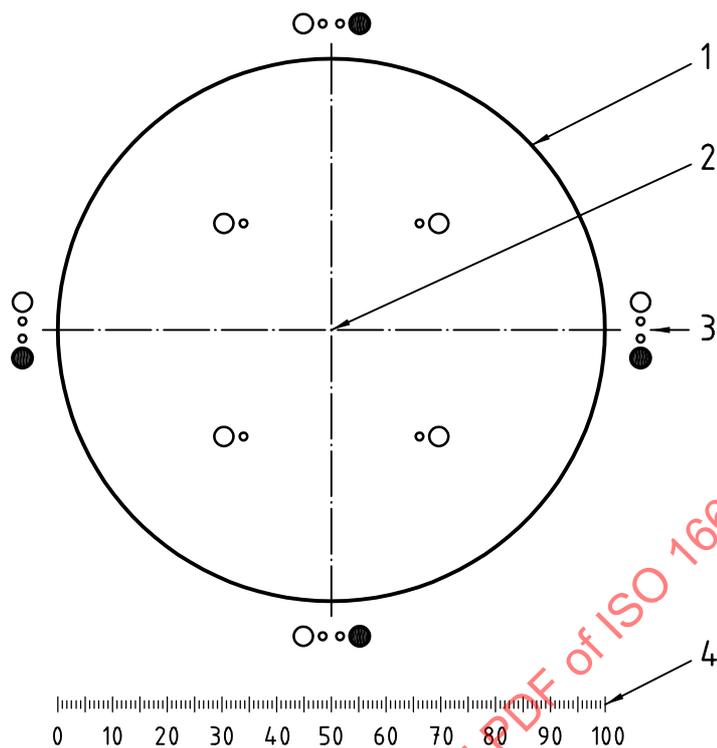
D.2.2 Illuminators

Two illuminators are required. One is an external, focusable auxiliary illuminator adjustable to give incident oblique illumination at an angle of 10° to 20° . The other is an episcopic brightfield illuminator built into the microscope. Both illuminators have sufficient capacity to provide a bright, even source of illumination and may be equipped with blue daylight filters to decrease operator fatigue during use.

D.2.3 Circular diameter graticule

Use a circular diameter graticule (see Figure D.1) matched to the microscope objective and eyepiece such that the sizing circles are within 2 % of the stated size at the plane of the stage.

The large circle divided by crosshairs into quadrants is designated the graticule field of view (GFOV). Transparent and black circles having $10 \mu\text{m}$ and $25 \mu\text{m}$ diameters at $100 \times$ are provided as comparison scales for particle sizing.



Key

- 1 GFOV circle
- 2 cross hairs
- 3 reference circles
- 4 linear scale

Figure D.1 — Circular diameter graticule

D.2.4 Micrometer

Use a stage micrometer, graduated in 10 μm increments and certified by an appropriate standardizing agency.

D.2.5 Filtration apparatus

Use a filter funnel suitable for the volume to be tested, having a minimum diameter of about 21 mm. The funnel is made of plastic, glass or stainless steel. Use a filter support made out of a stainless steel screen or sintered glass as the filtration diffuser. The filtration apparatus is equipped with a vacuum source, a solvent dispenser capable of delivering solvents filtered at 1,2 μm or finer retention rating at a range of pressures from 70 kPa to 550 kPa, and membrane filters (25 mm or 47 mm non-gridded or gridded, black or dark grey, of suitable material compatible with the product, with a porosity of 1,0 μm or finer). Use blunt forceps to handle the membrane filters.

D.3 Method

D.3.1 Preparation details

D.3.1.1 Test environment

A laminar flow hood or other laminar airflow enclosure, having a capacity sufficient to envelope the area in which the analysis is prepared, with HEPA-filtered air having not more than 100 particles (0,5 μm or larger)/ft³

(3 500 particles/m³). For the blank determination, supply a 50 ml volume of filtered-distilled or deionized water. Apply vacuum, and draw the entire volume of water through the membrane filter. Remove the membrane from the filter funnel base, and place atop a strip of double-sided tape in a Petri slide or Petri dish. After allowing the membrane to dry, examine it microscopically at a magnification of 100 ×. If not more than 20 particles 10 μm or larger in size and 5 particles 25 μm or larger are present within the filtration area, the background particle level is sufficiently low for performance of the microscopic assay.

Throughout this procedure, it is preferable to use powder-free gloves and thoroughly cleaned glassware and equipment. Prior to conducting the test, clean the work surfaces of the laminar flow enclosure with an appropriate solvent. Rinse glassware and equipment successively with a warm, residue-free solution of detergent, hot water, filtered-distilled or deionized water, and filtered isopropyl alcohol. Prior to use, filter the distilled or deionized water and the isopropyl alcohol with filters having a porosity of 1,2 μm or finer.

Perform the rinsing under the laminar flow enclosure equipped with HEPA filters. Allow the glassware and filtration apparatus to dry under the hood, upstream of all other operations. Preferably, the hood is located in a separate room that is supplied with filtered air and maintained under positive pressure with respect to the surrounding areas.

D.3.1.2 Microscope preparation

Place the auxiliary illuminator close to the microscope stage, focusing the illuminator to give a concentrated area of illumination on a filter membrane positioned on the microscope stage. Adjust the illuminator height so that the angle of incidence of the light is 10° to 20° to the horizontal. Use the internal episcopic brightfield illuminator with fully-opened field and aperture diaphragms. Centre the lamp filament, and focus the microscope on a filter containing particles. Adjust the intensity of reflected illumination until particles are clearly visible and show pronounced shadows. Adjust the intensity of episcopic illumination to the lowest setting, then increase the intensity of the episcopic illumination until shadows cast by particles show the least perceptible decrease in contrast.

D.3.1.3 Operation of circular diameter graticule

The relative error of the graticule is initially determined with a certified stage micrometer. To accomplish this, align the graticule micrometer scale with the stage micrometer so that they are parallel. Compare the scales, using as large a number of graduations on each as possible. Read the number of graticule scale divisions, GSD, compared to stage micrometer divisions, SMD. Calculate the relative error using the formula:

$$100 \frac{\text{GSD}-\text{SMD}}{\text{SMD}}$$

A relative error to within ± 2 % is acceptable. The basic technique of measurement applied with the use of the circular diameter graticule is to mentally transform the image of each particle into a circle and then compare it to the 10 μm and 25 μm graticule reference circles. The sizing process is carried out without superimposing the particle on the reference circles; particles are not moved from their locations within the graticule field of view (the large circle) for comparison to the reference circles. Use the inner diameter of the clear graticule reference circles to size white and transparent particles. Use the outer diameter of the black opaque graticule reference circles to size dark particles. Rotate the graticule in the right-hand microscope eyepiece so that the linear scale is located at the bottom of the field of view, bringing the graticule into sharp focus by adjusting the right-hand eyepiece dioptre ring while viewing an out-of-focus specimen. Focus the microscope on a specimen, looking through the right-hand eyepiece only. Then, looking through the left-hand eyepiece, adjust the left-hand eyepiece dioptre to bring the specimen into sharp focus.

D.3.1.4 Preparation of filtration apparatus

Wash the filtration funnel, base and diffuser in a solution of liquid detergent and hot water. Rinse with hot water. Apply a second rinse with filtered-distilled or deionized water using a pressurized jet of water over the entire exterior and interior surfaces of the filtration apparatus. Repeat the pressurized rinse procedure using filtered isopropyl alcohol. Finally, using the pressurized rinser, rinse the apparatus with filter distilled or deionized water.

Remove a membrane filter from its container, using ultracleaned blunt forceps. Use a low pressurized stream of filtered purified water to wash both sides of the filter thoroughly by starting at the top and sweeping back and forth to the bottom. Assemble the cleaned filtration apparatus with the diffuser on top of the filtration base, placing the clean membrane filter on top of the diffuser. Place the funnel assembly on top of the filtration base, and lock it into place.

D.3.2 Test procedure

D.3.2.1 Test preparations

Prepare the test specimens in the following sequence. Outside of the laminar enclosure, remove outer closures, sealing bands and any loose or shedding paper labels. Rinse the exteriors of the containers with filter distilled or deionized water as directed under D.3.1.1. Protect the containers from environmental contamination until analysed. Withdraw the contents of the containers under test in a manner least likely to generate particles that could enter the sample. Contents of containers with removable stoppers may be withdrawn directly by removing the closures. Sampling devices having a needle to penetrate the unit closure may also be used. Products packaged in flexible plastic containers may be sampled by cutting the medication or administration port tube, or a corner, from the unit using a suitably cleaned razor blade or scissors.

The number of test specimens should be adequate to provide a statistically sound assessment of whether a batch or other large group of units represented by the test specimens meets or exceeds the limits. If the volume in the container is less than 25 ml, test a solution pool of 10 or more units. Single small-volume units may be tested if the individual unit volume is 25 ml or more. For large-volume solutions, single units are tested.

For small-volume solutions containing a volume of 25 ml or more and tested singly and for large-volume solutions, the entire solution volume is tested. For large-volume solutions or for small-volume solutions where the individual unit volume is 25 ml or more, fewer than 10 single units may be tested, based on the definition of an appropriate sampling plan.

D.3.2.2 Product determination (liquid preparations)

Thoroughly mix the units to be tested by inverting them 20 times. Open the units in a manner consistent with the generation of the lowest possible numbers of background particles. For products less than 25 ml in volume, open and combine the contents of 10 or more units in a cleaned container. Filter large-volume units individually. Small-volume units having a volume of 25 ml or more may be filtered individually.

Transfer to the filtration funnel the total volume of a solution pool or of a single unit, as applicable, and apply vacuum. If the volume of solution to be filtered exceeds the volume of the filtration funnel, add, stepwise, a portion of the solution until the entire volume is filtered.

After the last addition of solution, begin rinsing the walls of the funnel by directing a low-pressure stream of filter distilled, or deionized water in a circular pattern along the walls of the funnel, and stop rinsing the funnel before the volume falls below about one-fourth of the fill level. Maintain the vacuum until all the liquid in the funnel is gone.

Remove the filtration funnel from the filtration base while maintaining vacuum, then turn the vacuum off and remove the filter membrane using blunt forceps. Place the filter in a Petri dish or similar container, secure it in place with double-sided tape and label with sample identification. Allow the filter to air-dry in the laminar-flow enclosure with the cover ajar.

D.3.3 Enumeration of particles

D.3.3.1 General

The microscopic test described in this section is flexible in that it can count, in particles per ml, specimens containing 1 particle per ml as well as those containing significantly higher numbers of particles per ml.

D.3.3.2 Total count procedure

In performance of a total count, the graticule field of view (GFOV) defined by the large circle of the graticule is ignored, and the vertical cross hair is used. Scan the entire membrane from right to left in a path that adjoins but does not overlap the first scan path. Repeat this procedure, moving from left to right to left until all particles on the membrane are counted. Record the total number of particles that are 10 µm or larger and the number that are 25 µm or larger, calculate the particle count, in particles per ml, for the units tested using the formula

$$\frac{P}{V}$$

where

P is the total number of particles counted;

V is the volume, in millilitres, of the solution tested.

Correct for the dilution factor, if applicable, to obtain the number of particles in the OIS as supplied.

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