



**International
Standard**

ISO 7544

**Rolling bearings — Test and
assessment methods for cleanliness**

Roulements — Méthodes d'essai et d'évaluation de la propreté

**First edition
2024-09**

STANDARDSISO.COM : Click to view the full PDF of ISO 7544:2024

STANDARDSISO.COM : Click to view the full PDF of ISO 7544:2024



COPYRIGHT PROTECTED DOCUMENT

© ISO 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

| | Page |
|--|-----------|
| Foreword | v |
| Introduction | vi |
| 1 Scope | 1 |
| 2 Normative references | 1 |
| 3 Terms and definitions | 1 |
| 4 Symbols and abbreviated terms | 2 |
| 5 Main steps of cleanliness inspection | 2 |
| 6 Equipment and accessories | 3 |
| 6.1 Equipment for extraction..... | 3 |
| 6.1.1 Equipment for pressure-rinsing method..... | 3 |
| 6.1.2 Equipment for ultrasonic method..... | 4 |
| 6.2 Equipment for filtration..... | 5 |
| 6.3 Auxiliary accessories..... | 7 |
| 6.4 Equipment for analysis..... | 8 |
| 6.4.1 Gravimetry..... | 8 |
| 6.4.2 Light-optical analysis..... | 8 |
| 7 Blank value | 8 |
| 8 Test lot | 8 |
| 8.1 General..... | 8 |
| 8.2 Test lot size..... | 8 |
| 9 Extraction | 9 |
| 9.1 General..... | 9 |
| 9.2 Test fluid..... | 9 |
| 9.3 Pressure-rinsing method..... | 9 |
| 9.3.1 General..... | 9 |
| 9.3.2 Parameters for pressure-rinsing extraction..... | 9 |
| 9.3.3 Procedure for pressure-rinsing extraction..... | 10 |
| 9.4 Ultrasonic method..... | 10 |
| 9.4.1 General..... | 10 |
| 9.4.2 Parameters for ultrasonic extraction..... | 10 |
| 9.4.3 Procedure for ultrasonic extraction..... | 11 |
| 10 Filtration and drying | 11 |
| 10.1 General..... | 11 |
| 10.2 Analysis filter..... | 11 |
| 10.3 Procedure for filtration..... | 11 |
| 10.4 Procedure for drying..... | 12 |
| 11 Analysis | 12 |
| 11.1 Gravimetry..... | 12 |
| 11.2 Light-optical analysis..... | 12 |
| 12 Test report | 13 |
| 13 Escalation | 13 |
| Annex A (informative) Explanations on “cleanliness” of rolling bearings | 14 |
| Annex B (informative) Pressure-rinsing parameters | 19 |
| Annex C (informative) Occupational health, safety and environment | 21 |
| Annex D (informative) Example of a test report | 22 |
| Annex E (informative) Escalation strategy | 23 |

STANDARDSISO.COM : Click to view the full PDF of ISO 7544:2024

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.

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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

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.

This document was prepared by Technical Committee ISO/TC 4, *Rolling bearings*.

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.

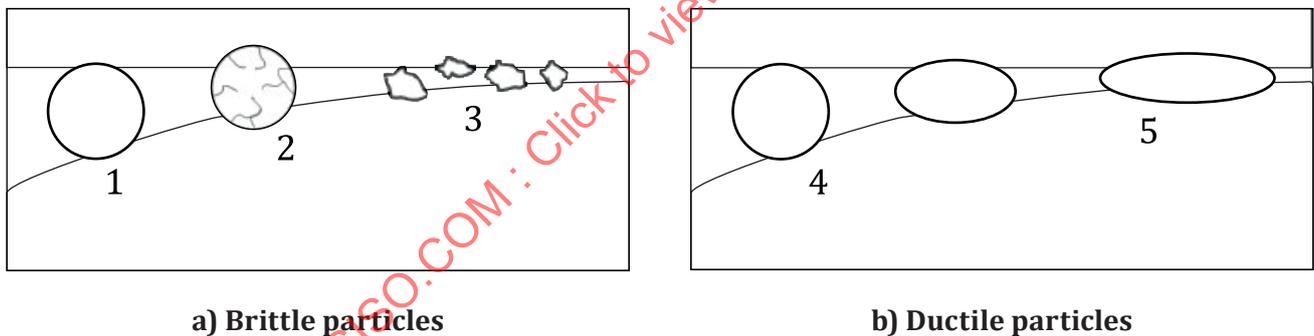
Introduction

This document is based on ISO 16232. However, the inspection and evaluation methods in ISO 16232 cannot be directly transferred to the rolling bearings industry, because of the different uses of rolling bearings in a wide variety of applications. This document has been prepared to describe a common and general approach for the inspection of cleanliness of rolling bearings.

The cleanliness requirements on rolling bearings increase steadily. The cleanliness of rolling bearings has a direct influence on achieving reliable performance, especially in association with vibration and noise, as well as the life of rolling bearings according to ISO 281. Therefore, the cleanliness of rolling bearings is necessary to a certain level. Various test and assessment methods of rolling bearing cleanliness lead to differences in inspection and assessment results. To avoid incomparable inspection results, the extraction procedure, the test fluid and the parameter settings for the test equipment are described in this document.

[Figure 1](#) shows that the type of contaminant particle is crucial in determining the particle size and counting. After several times of over rolling, brittle particles break into small pieces as shown in [Figure 1 a\)](#); in comparison to the measured thickness, their effective size is reduced significantly. Ductile particles can be deformed as shown in [Figure 1 b\)](#).

Particulate contaminants (debris), entrapped into the contact between the rolling elements and the raceways, are the main cause for surface-initiated damages, which produce many rolling bearings failures. Subject to the elastic properties of the rolling element and raceway materials, entrapped particles, under the heavily loaded contacts, deform mainly in the inlet zone and remain nearly the same as they pass through the Hertzian contact zone, leaving the indentations on the mating surfaces. It seems clear that brittle particles, like corundum (Al_2O_3) and silicon carbide (SiC), tend to fracture and break into smaller pieces during the entrainment into the contact. Ductile particles, like copper, plastics and textile fibres are heavily deformed during the entrainment and extruded subsequently from the contact, as shown in [Figure 1](#); see Reference [9] for further information.



Key

- 1 initial deformation
- 2 debris fracture
- 3 fragments entering contact
- 4 debris starting to deform
- 5 elastic deformation closure around flattened particle giving dents on mating surfaces

Figure 1 — Deformation mechanisms of brittle and ductile particles

This document does not give the cleanliness limits for rolling bearings. The cleanliness required for a specific application is dependent on many factors. Cleanliness limits can be agreed between the supplier and customer.

Rolling bearings — Test and assessment methods for cleanliness

1 Scope

This document specifies procedures and equipment for cleanliness inspections of rolling bearings. It describes, in particular, test methods and assessment techniques.

This document is applicable to the test and assessment of various types of open bearings and capped bearings before grease filling, as well as the test and assessment of rolling bearing parts.

This document is not applicable for linear motion rolling bearings.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 5593:2023, *Rolling bearings — Vocabulary*

ISO 16232:2018, *Road vehicles — Cleanliness of components and systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5593, ISO 16232 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

component

rolling bearing, *rolling bearing part* (3.3) or subunit of a rolling bearing

3.2

extraction curve measurement

procedure for verifying the efficiency and suitability of extraction parameters by repeating the extraction a maximum of six times in an identical manner with the same test object

3.3

rolling bearing part

individual part comprising a rolling bearing but excluding all accessories

Note 1 to entry: The main rolling bearing parts are outer ring, inner ring, rolling elements and cage (if necessary, further parts of the rolling bearing like shield, seal etc.).

[SOURCE: ISO 5593:2023, 3.2.1.1, modified — Note 1 to entry has been added.]

3.4

surface

exterior area and interior area of the *component* (3.1)

3.5

controlled surface

surface (3.4) of the rolling bearings or rolling bearing parts that is subject to a cleanliness requirement

4 Symbols and abbreviated terms

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

| | |
|--------------------|--|
| A | unit of reference “1 000 cm ² controlled surface” when specifying the CCC |
| CCC | component cleanliness code |
| CCC _a | component cleanliness code for all particles |
| CCC _m | component cleanliness code for shiny (metallic) particles without fibres |
| CCC _o | component cleanliness code for other particles without fibres |
| CCC _{wof} | component cleanliness code for all particles without fibres |
| D | nominal outside diameter, in millimetres (mm) |
| m | residue mass (net mass of particle load), in milligrams (mg) |
| m ₁ | initial mass (tare mass of analysis filter), in milligrams (mg) |
| m ₂ | final mass (gross mass, i.e. total mass of occupied analysis filter), in milligrams (mg) |
| P _U | power of ultrasonic device, in watts (W) |
| V _B | filling quantity of test vessel, in litres (l) |
| V _U | filling quantity of bath, in litres (l) |
| x | particle size, e.g. 150 µm ≤ x < 200 µm, in micrometres (µm) |
| φ _U | power density of the ultrasonic bath, in watts per litre (W/l) |

5 Main steps of cleanliness inspection

The cleanliness inspection is made with the following steps (see [Figure 2](#)):

- a) selection - taking the test lot for analysis;
- b) extraction - removing the particles from the test component;
- c) filtration - of the particles;
- d) analysis - of the particles;
- e) documentation - of the inspection parameters and results.

The cleanliness inspections shall be performed using the materials and equipment described in this document and in a suitable environment by skilled staff; for more information, see ISO 16232. The test environment shall be in accordance with ISO 16232:2018, 11.2.4.

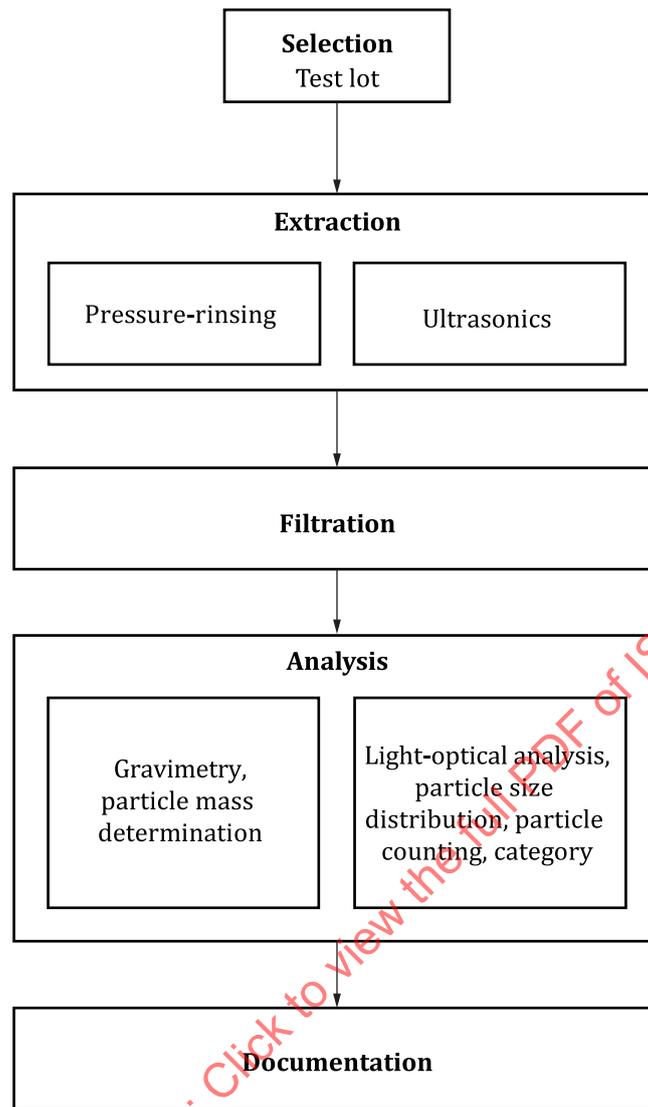


Figure 2 — Main steps of cleanliness inspection

To compare inspection results reliably, the same test fluid, extraction procedure and analysis parameter shall be applied.

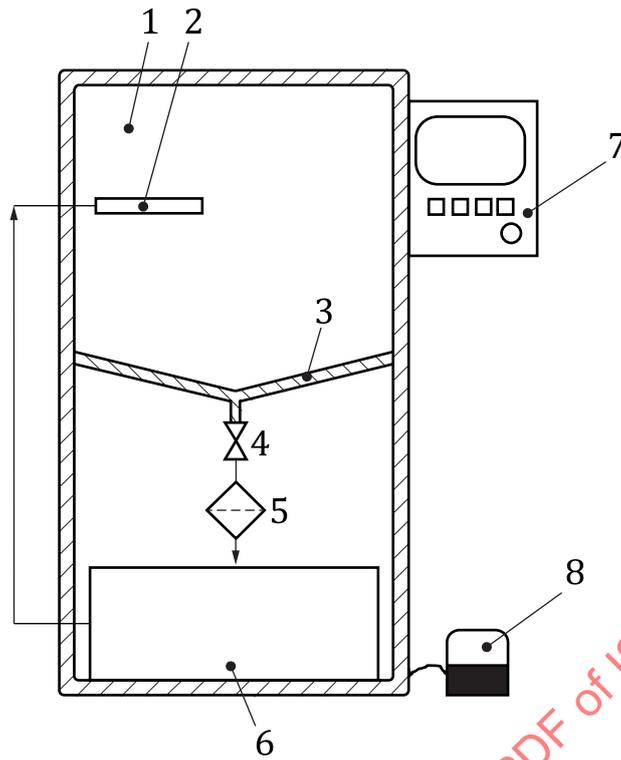
For further information about the analysis of the particles and the documentation, see [Annex A](#) and [Annex D](#).

6 Equipment and accessories

6.1 Equipment for extraction

6.1.1 Equipment for pressure-rinsing method

A schematic diagram of a pressure-rinsing cabinet is shown in [Figure 3](#). Other equipment such as open cabinets, pressure vessels with a spraying gun, or laboratory wash bottles can also be used.



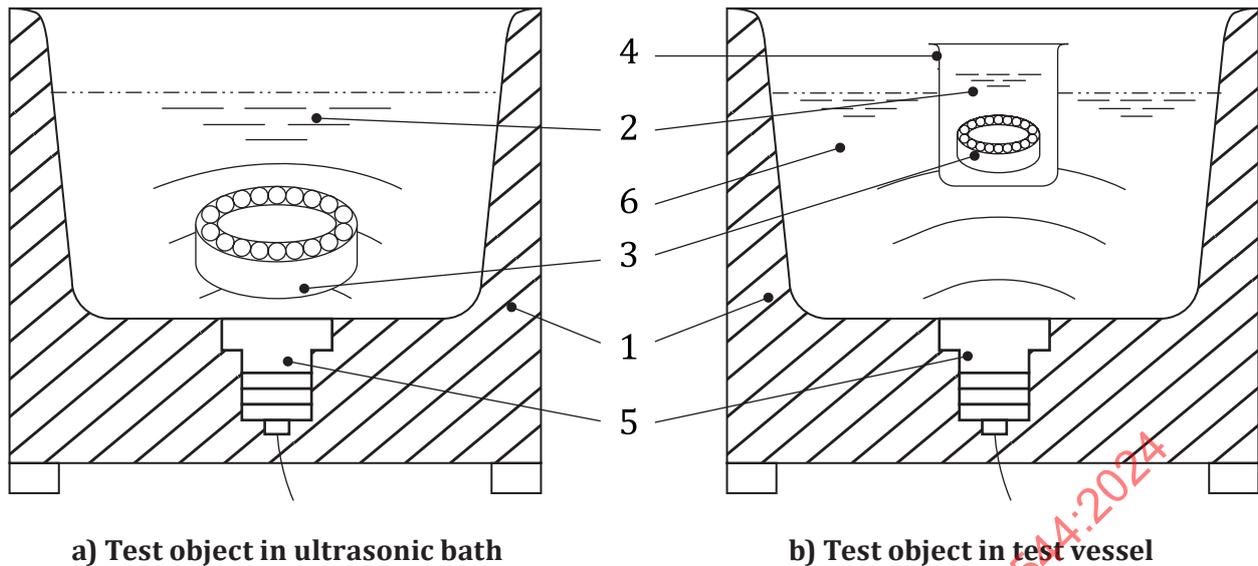
Key

- | | | | |
|---|-------------------------------------|---|---|
| 1 | extraction chamber (clean air area) | 6 | media supply with |
| 2 | manual pressure-rinsing nozzles | — | test fluid |
| 3 | collection trough | — | purification filter |
| 4 | stop cock | — | pump or pressure supply |
| 5 | analysis filter | 7 | controls for rinsing programs with emergency stop |
| | | 8 | foot switch |

Figure 3 — Example of a pressure-rinsing cabinet

6.1.2 Equipment for ultrasonic method

A schematic diagram of an ultrasonic bath is shown in [Figure 4](#). Other equipment like extraction cabinets that uses the ultrasonic extraction method can also be used.



Key

- 1 tank
- 2 test fluid
- 3 test object
- 4 vessel
- 5 ultrasound transducer
- 6 water (e.g. tap water)

NOTE 1 With increasing frequency of the ultrasonic, the related wavelength decreases.

NOTE 2 The distance between sound source and rolling bearings at a frequency of 40 kHz is more than 38 mm. At a frequency of 35 kHz, the distance is more than 43 mm.

Figure 4 — Schematic diagram of ultrasonic bath

The test object is direct in the bath [see [Figure 4 a](#)]. The power density of the ultrasonic bath, φ_U , is calculated according to [Formula \(1\)](#).

$$\varphi_U = \frac{P_U}{V_U} \tag{1}$$

The test object is in test vessel [see [Figure 4 b](#)]. The power density of the ultrasonic bath, φ_U , is calculated according to [Formula \(2\)](#).

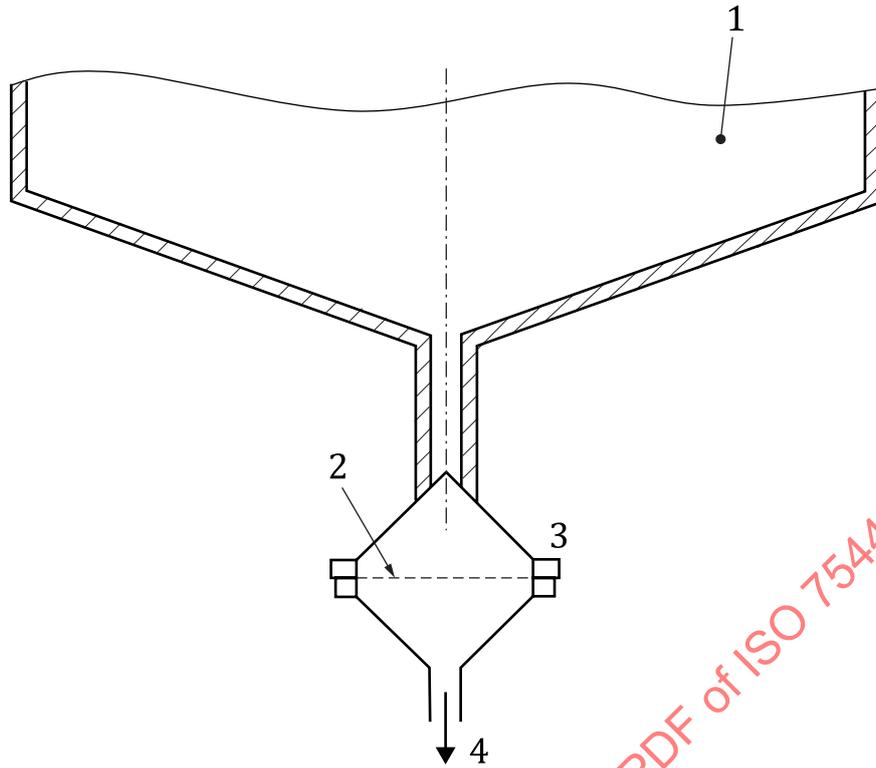
$$\varphi_U = \frac{P_U}{V_U + V_B} \tag{2}$$

6.2 Equipment for filtration

In general, the equipment for filtration comprises the following parts:

- analysis filter;
- equipment for filtration.

The schematic diagram of the direct filtration is shown in [Figure 5](#).

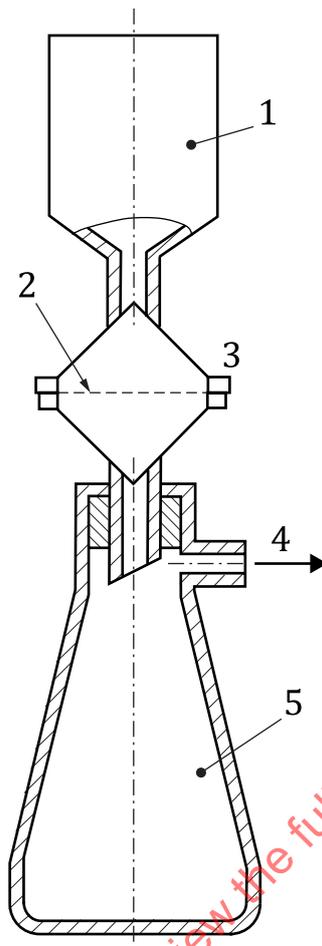


Key

- 1 ultrasonic bath or pressure-rinsing cabinet
- 2 analysis filter
- 3 filter holder
- 4 vacuum source

Figure 5 — Schematic diagram of direct filtration

The separate filtration shall be realized according to [Figure 6](#).



Key

- 1 filter funnel
- 2 analysis filter
- 3 filter holder
- 4 vacuum source
- 5 vacuum flask

Figure 6 — Schematic diagram of separate filtration

6.3 Auxiliary accessories

The following accessories shall be used for the testing:

- analysis filter tweezers;
- disposable synthetic gloves;
- laboratory wash bottle for rinsing;
- stainless steel crucible tongs or tweezers for parts handling;
- timer;
- Petri dishes or similar with cover slip;
- glass or stainless vessels for components.

6.4 Equipment for analysis

6.4.1 Gravimetry

An analytical balance, with resolution at least 0,1 mg, shall be used methodologically for the analysis of the test lot.

6.4.2 Light-optical analysis

The following devices and equipment shall be used for the procedures listed.

- a) Measuring the largest particle
 - 1) stereo microscope with ocular scale or measuring software included;
 - 2) object micrometre or length standard with certificate.
- b) Determining the particle size distribution
 - 1) automatic stereo microscope;
 - 2) particle scanner that can determine at least 50 µm particle size;
 - 3) filter frames or other suitable aids for fixation of the analysis filter;
 - 4) particle standard with certificate.

7 Blank value

The blank value shows the cleanliness level of the whole testing environment. For this purpose, the cleanliness test is made without the test object, but in the same way as with the test object. The threshold values and more detailed information can be found in ISO 16232. The blank value shall be regularly checked and documented.

The measuring results shall be documented as proof of a clean measuring environment. For reference or gauge measurements, a blank value measurement is necessary.

8 Test lot

8.1 General

The cleanliness test shall be made with a test lot from one production batch or one delivery. The test lot shall have an overall surface of at least 1 000 cm²; the number of test objects shall be selected accordingly.

The surface of each rolling bearing or rolling bearing part can be found in the drawing; if not present, the supplier shall be inquired.

The test lot shall only be taken with disposable synthetic gloves so as not to influence the measuring result. The test lot shall be taken from the original packaging directly before extraction. The particles remaining in the packaging shall not be considered in the evaluation, i.e. the packaging shall not be cleaned, however, special observation shall be reported.

NOTE If the components are preserved with a hardly removable (waxy) preservative, the test can be made before the preservation.

8.2 Test lot size

If the surface area is not known, choose the recommended test lot size specified in [Table 1](#).

If the surface area is known, choose the number of pieces in such a way that at least 1 000 cm² are tested.

Table 1 — Test lot size for cleanliness test

| Analysis method | Rolling bearings | | | Rolling bearing parts ^a | | |
|---|-------------------|-------------------------|-------------------|---|---|--|
| | $D \leq 80$ mm | $80 < D \leq 200$ mm | $D > 200^b$ mm | $D \leq 80$ mm | $80 < D \leq 200$ mm | $D > 200^b$ mm |
| Gravimetry and light-optical analysis | 5 pieces | 3 pieces | 1 piece | Equivalent to 5 pieces of rolling bearing | Equivalent to 3 pieces of rolling bearing | Equivalent to 1 piece of rolling bearing |
| ^a Includes balls, rollers, cages, shields, seals, etc. ^b If the rolling bearing or rolling bearing parts surface is much larger than 1 000 cm ² , it is optional to test only a segment of the rolling bearing or rolling bearing part. | | | | | | |

9 Extraction

9.1 General

The choice of the extraction method and test fluid significantly influences the measuring results. The threshold values of the cleanliness test shall be defined in accordance with the extraction method and the test fluid.

NOTE 1 Results of different methods are not comparable. In case of incomparable results, the choice of the extraction method is subject to agreement between the supplier and customer.

NOTE 2 There is a risk of false brinelling in components with the ultrasonic extraction method.

9.2 Test fluid

The test fluid used should be pre-filtered appropriately, see [Clause 7](#):

- aqueous surfactant solution; or
- mixture of hydrocarbons with a low aromatic content, e.g. isoparaffinic mixture.

The mixture of hydrocarbons with a low aromatic content shall have a flash point between 40 °C to 100 °C, preferably between 55 °C to 100 °C.

NOTE 1 Test results with different test fluids are not always comparable.

NOTE 2 Hydrocarbon test fluid is commonly used for rolling bearings testing due to economic reasons.

For information about occupational health, safety and environment, see [Annex C](#).

9.3 Pressure-rinsing method

9.3.1 General

For components, an extraction curve measurement is not absolutely required if the parameters mentioned under [9.3.2](#) are used. Otherwise an extraction curve measurement shall be made in accordance with ISO 16232.

9.3.2 Parameters for pressure-rinsing extraction

The pressure-rinsing extraction parameters shall be in the following ranges:

- nozzle diameter from 1,5 mm to 3,0 mm;
- flow rate depending on the nozzle diameter from 0,4 l/min to 2,5 l/min;

- rinsing volume depending on the flow rate and the rinsing duration from 2,0 l/1 000 cm² to 6,0 l/1 000 cm²;
- pressure-rinsing duration depending on the rinsing volume and flow rate shall not be below 2 min/1 000 cm².

NOTE 1 The values given above are not intended to be starting parameters.

A full-jet nozzle with a round cross-section shall be used.

The distance between jet nozzle and the component for analysis shall be not more than 15 cm.

Some examples of possible pressure-rinsing parameter are shown in [Annex B](#).

Intermediate values for pressure-rinsing parameters can be found in [Annex B](#).

NOTE 2 In [Figure B.1](#), see also the borderline where there is a risk of aerosol formation.

9.3.3 Procedure for pressure-rinsing extraction

For pressure-rinsing extraction, the following procedure applies:

- before starting the test, it shall be ensured that the equipment is sufficiently clean;
- if direct filtration is used, put the analysis filter into the filter holder;
- place the test object(s) into the extraction chamber;
- rinse the test object(s) evenly from all sides under turning with the specified volume;
- remove the test object(s) and rinse the extraction chamber and all other equipment used thoroughly;
- all quantities of liquid used for extraction and rinsing shall be sent for filtration;
- if direct filtration is used, remove the analysis filter.

9.4 Ultrasonic method

9.4.1 General

Rolling bearings and rolling bearing parts of a nominal outside diameter, D , up to 240 mm can be cleaned with ultrasound. Rolling bearing parts that release particles, for example, from the component material or from coatings, are not suitable for ultrasonic method.

For standard rolling bearings, an extraction curve measurement is not required if the parameters mentioned under [9.4.2](#) are used. Otherwise an extraction curve measurement shall be made in accordance with ISO 16232.

9.4.2 Parameters for ultrasonic extraction

For ultrasonic extraction, the following parameters shall be applied:

- test fluid filling depth to exceed the test objects by at least 10 mm;
- power density of at least 10 W/l;
- frequency of 35 kHz to 40 kHz;
- extraction time of 3 min \pm 10 s; a longer extraction time may be used in special applications, as per agreement between the supplier and customer.

NOTE The values given above are not intended to be starting parameters.

9.4.3 Procedure for ultrasonic extraction

For ultrasonic extraction, the following procedure applies:

- before starting the test, it shall be ensured that the equipment is sufficiently clean;
- put the test object(s) directly into the ultrasonic bath [see [Figure 4 a](#)], or into the test vessel [see [Figure 4 b](#)];
- fill up the ultrasonic bath [see [Figure 4 a](#)], or fill the test vessel [see [Figure 4 b](#)] to the correct level with test fluid;
- position the test object(s) or the test vessel in the centre of the ultrasonic bath with the correct distance to the sound-emitting surface;
- perform the ultrasonic cleaning;
- remove the test object(s) one by one from the test fluid;
- rinse the test object(s) with fresh test fluid from a laboratory wash bottle under turning to reach all surfaces;
- filter the extraction fluid via a filtering unit;
- rinse the whole required equipment;
- all quantities of liquid used for extraction and rinsing shall be sent for filtration;
- remove the analysis filter.

10 Filtration and drying

10.1 General

The purpose of the filtration is to separate the particles extracted from a component that are in the extraction fluid on an analysis filter surface in order to make them accessible for analysis. Vacuum filtration is usually used for this as it provides fastest results.

10.2 Analysis filter

A 5 µm mesh filter (e.g. made of polyester or polyamide) should be used as the analysis filter. Other analysis filters with various pore sizes (e.g. 0,8 µm, 1,2 µm or 10 µm) may be used.

NOTE 1 Different analysis filter structures (e.g. grid, foamed) and pore sizes can lead to non-comparable results.

NOTE 2 If necessary, cascading of filters can be used.

10.3 Procedure for filtration

For filtration, the following procedure applies:

- determine the initial mass (m_1), if gravimetry is required (see [11.1](#));
- place the analysis filter into the filter holder using tweezers;
- apply the filtration funnel or, if cabinet is used, close the filter holder;
- filter the extraction liquid;
- thoroughly rinse all surfaces wetted by the extraction liquid using the rinsing medium;
- remove the filtration funnel or, if cabinet is used, open the filter holder;

- transfer the analysis filter to a clean Petri dish or similar implement using tweezers.

During the filtration, the analysis filter shall not be overloaded and the particles on the analysis filter shall be homogeneously distributed and shall not overlap in case of particle counting, see ISO 16232:2018, 8.6.

10.4 Procedure for drying

For drying, the following procedure applies:

- the analysis filter in the Petri dish or similar implement should be partly covered during the drying and cooling process;
- for gravimetry, the analysis filter shall be dried in a suitable drying cabinet at a suitable temperature and duration to evaporate the liquid (e.g. for hydrocarbon test fluid at 105 °C for 30 minutes) and shall be cooled for approximately 30 minutes in a desiccator. For information about occupational health, safety and environment, see [Annex C](#);
- for particle counting, the analysis filter should be dried to ensure a reliable measurement.

11 Analysis

11.1 Gravimetry

The mass of the extracted particle load is determined by weighing the analysis filter before and after filtration:

- determine the initial mass m_1 (tare mass);
- determine the final mass m_2 (gross mass);
- calculate the residue mass m (net mass) according to [Formula \(3\)](#):

$$m = m_2 - m_1 \quad (3)$$

NOTE For further information, see ISO 16232:2018, 9.2.2.

11.2 Light-optical analysis

This evaluation procedure is based on ISO 16232:2018, 9.2.3.

The evaluation is made:

- on the analysis filter after filtration and drying;
- with an automatic stereo microscope. The evaluation system shall distinguish between shiny (mostly metallic) and non-shiny (mostly non-metallic) particles;
- in the selected magnification at least 10 pixels shall be imaged. For particles smaller than 50 µm, a better resolution is necessary;
- with a stereo microscope for assessment of individual particles, e.g. size, shape and material.

NOTE The smaller the particles, the more uncertain the metal detection. Below 50 µm, no metal detection is practical.

Similar techniques, such as scanner evaluations, may be used if they fulfil the requirements for this method.

12 Test report

The test report shall contain at least the following information:

- reference to this document;
- customer, if required;
- designation of the tested objects;
- controlled surface;
- reference to the test method;
- equipment for pressure rinsing method, if necessary;
- type and quantity of test fluid used;
- test report number;
- identification of the test objects;
- documentation of additional information, if necessary;
- date of cleanliness test;
- analysis filter including structure, pore size and material;
- name of the operator;
- any deviations from the procedure;
- any unusual features observed.

An example of a test report is shown in [Annex D](#).

13 Escalation

As the cleanliness tests are time-consuming and involve manual tasks, much fewer of the cleanliness tests can be carried out compared to other quality tests (e.g. dimensional accuracy). Therefore, established methods from quality management cannot effortlessly be transferred to the cleanliness test. The cleanliness of components is often subject to significantly higher variations than other technical properties. Cleanliness limit values are not tolerance limits. If a cleanliness value does not meet the specification, it does not mean that the system will fail.

When a limit value is exceeded, a double-check should be performed first. The test conditions and the testing equipment shall be carefully checked. Then an inspection shall be performed on a second component from the same batch (if it is possible).

If limits are also exceeded during the double-check, the escalation strategy described in [Annex E](#) is suggested.

Annex A (informative)

Explanations on “cleanliness” of rolling bearings

A.1 General

The cleanliness of components is subject to much higher variations than purposely produced features. This applies both to the number of particles (gravimetry or as numbers in particle size classes) and, in particular, to the length of the largest particle. The reason for this is that contaminant particles are not manufactured in a defined way but rather occur spontaneously in a very large range.

This is valid for each type of contamination occurring during the production process or during transport and storage. When rolling bearings are machined, particles occur in very broad ranges of lengths, widths, thicknesses and shapes. Some of them later can be found as residual contaminant particles on components. An industrial particle cleaning system can efficiently reduce the overall contamination of components; but the prevailing range of variation can be reduced only to a limited extent.

The residual magnetism of all random components for analysis should be within the defined limits, e.g. ≤ 3 A/cm, as it has an influence on the cleanliness.

A.2 Determination of particle sizes and particle counting

It is recommended to use a particle counting device which is able to measure the length and width of particles automatically. As an option, the software also can distinguish between shiny and non-shiny particles. In practice, it can be assumed that shiny particles are made of metal. For details, see ISO 16232:2018, 9.2.3.4.

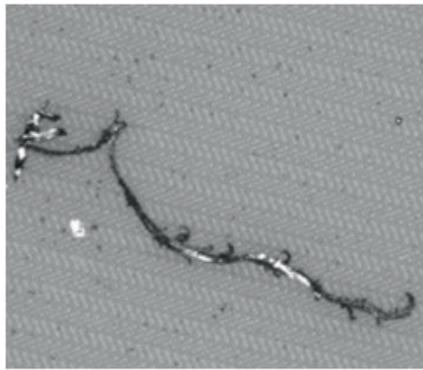
NOTE Manual counting is possible but considered to be impracticable.

A.3 Microscopy

The three biggest particles should be visually determined by size and material.

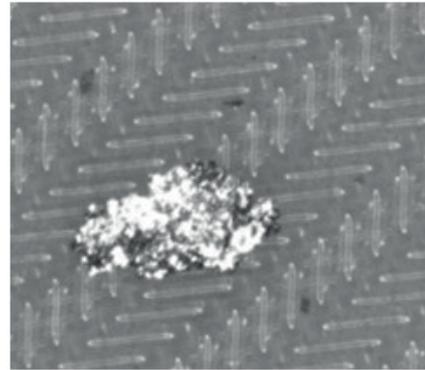
A.4 Examples of shiny (metallic) particles

[Figure A.1](#) shows examples of typical shiny (metallic) particles and their sizes (length and width).



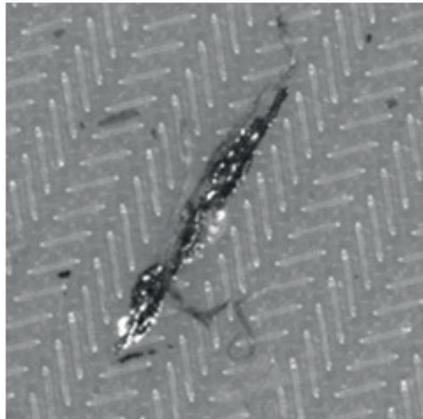
0 1 000 μm

a) Length 3 036 μm, width 607 μm



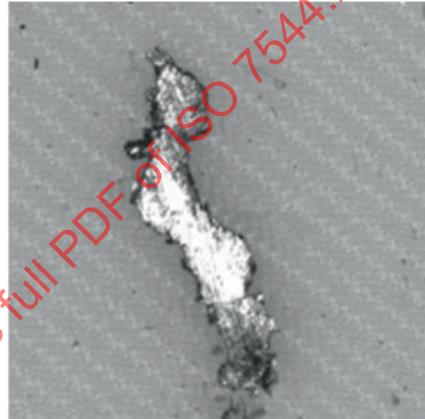
0 200 μm

b) Length 374 μm, width 199 μm



0 500 μm

c) Length 702 μm, width 112 μm



0 1 000 μm

d) Length 1 640 μm, width 403 μm

Figure A.1 — Examples of shiny (metallic) particles and their sizes

A.5 Regulation for component cleanliness codes (CCC)

A.5.1 Explanations regarding CCC

According to ISO 16232, the CCC defines the number and length of particles on a surface of a defined size.

The classes (B, C, D, E, F, etc.) of particle sizes are defined in [Table A.1](#).

Light-optical systems determine the length and/or width of individual particles. The particles are also classified into a specified length or width interval (or size class).

NOTE See ISO 16232:2018, 10.8.3 for further information.

Table A.1 — Size class of particles

| Size class | Size x in μm |
|------------|---------------------------|
| B | $5 \leq x < 15$ |
| C | $15 \leq x < 25$ |
| D | $25 \leq x < 50$ |
| E | $50 \leq x < 100$ |
| F | $100 \leq x < 150$ |
| G | $150 \leq x < 200$ |
| H | $200 \leq x < 400$ |
| I | $400 \leq x < 600$ |
| J | $600 \leq x < 1\ 000$ |
| K | $1\ 000 \leq x < 1\ 500$ |
| L | $1\ 500 \leq x < 2\ 000$ |
| M | $2\ 000 \leq x < 3\ 000$ |
| N | $3\ 000 \leq x$ |

[Table A.2](#) gives an example of documentation showing particle size distribution with the inspection result.

Table A.2 — Example documentation of particle size distribution with inspection result

| Size class ^a | | | | | | | | | |
|---|--------------------------|--------------------------|--------------------------|--------------------------|----------------------------|------------------------------|------------------------------|------------------------------|-------------------|
| E | F | G | H | I | J | K | L | M | N |
| Particle count per 1 000 cm² (x = particle size in μm) | | | | | | | | | |
| 50 $\leq x <$ 100 | 100 $\leq x <$ 150 | 150 $\leq x <$ 200 | 200 $\leq x <$ 400 | 400 $\leq x <$ 600 | 600 $\leq x <$ 1 000 | 1 000 $\leq x <$ 1 500 | 1 500 $\leq x <$ 2 000 | 2 000 $\leq x <$ 3 000 | 3 000 $\leq x$ |
| Inspection result of counted particles | | | | | | | | | |
| 3 562 | 1 815 | 782 | 115 | 52 | 30 | 3 | 2 | 1 | 0 |
| Cleanliness level^b | | | | | | | | | |
| 12 | 11 | 10 | 7 | 6 | 5 | 2 | 1 | 0 | 00 |
| ^a See Table A.1 . ^b See Table A.3 . | | | | | | | | | |

The corresponding simplified component cleanliness code is then expressed as follows:

$$\text{CCC} = \text{A (E12/F11/G10/H7/I6/J5/K2/L1/M0/N00)}$$

When a letter “A” precedes the bracket, the specification is related to a surface of 1 000 cm²:

E12 stands for:

- a) E (size class) = particle length between 50 μm up to less than 100 μm ;
- b) 12 (cleanliness level) means that the number of particles up to and including 4 000 particles is admissible.

A.5.2 Number of particles

[Table A.3](#) defines the number of particles in particle concentration classes according to ISO 16232:2018, Table 9.

Table A.3 — Particle concentration classes

| Cleanliness level | Particle count (per 1 000 cm ² or 100 cm ³) up to and including |
|-------------------|--|
| 00 | 0 |
| 0 | 1 |
| 1 | 2 |
| 2 | 4 |
| 3 | 8 |
| 4 | 16 |
| 5 | 32 |
| 6 | 64 |
| 7 | 130 |
| 8 | 250 |
| 9 | 500 |
| 10 | 1 × 10 ³ |
| 11 | 2 × 10 ³ |
| 12 | 4 × 10 ³ |
| 13 | 8 × 10 ³ |
| 14 | 16 × 10 ³ |
| 15 | 32 × 10 ³ |
| 16 | 64 × 10 ³ |
| 17 | 130 × 10 ³ |
| 18 | 250 × 10 ³ |
| 19 | 500 × 10 ³ |
| 20 | 1 × 10 ⁶ |
| 21 | 2 × 10 ⁶ |
| 22 | 4 × 10 ⁶ |
| 23 | 8 × 10 ⁶ |
| 24 | 16 × 10 ⁶ |

SOURCE: ISO 16232:2018, Table 9.

A.5.3 Distinction of component cleanliness codes (CCC) for rolling bearings

Ball bearings (point contact) and roller bearings (line contact) should have different requirements of component cleanliness codes (CCC).

The definition of required component cleanliness codes (CCC) significantly depends on a number of factors, for example:

- design (e.g. ball bearing, roller bearing);
- dimensions (e.g. diameter of rolling element, rolling bearing size);
- application condition (e.g. load, speed).

The following codes are recommended:

CCC_m = A(.....) Shiny (**m**etallic) particles without fibres;

CCC_o = A(.....) **O**ther particles without fibres.

Other codes can be agreed upon, for example:

$CCC_a = A(\dots)$ All particles;

$CCC_{wof} = A(\dots)$ All particles **without** fibres.

STANDARDSISO.COM : Click to view the full PDF of ISO 7544:2024

Annex B (informative)

Pressure-rinsing parameters

This annex describes pressure-rinsing parameters. Some examples of possible pressure-rinsing parameters are shown in [Table B.1](#). Other possible values for pressure-rinsing parameters can be found in [Figure B.1](#).

Table B.1 — Examples of pressure-rinsing parameters for round full-jet nozzle

| Example | Nozzle diameter mm | Flow rate l/min | Rinsing volume l/1 000 cm ² | Rinsing duration min/1 000 cm ² |
|---------|-----------------------|--------------------|---|---|
| A | 1,5 | 0,4 | 2,0 | 5 |
| B | 2,0 | 1,6 | 5,0 | 3,1 |
| C | 2,5 | 1,0 | 6,0 | 6 |
| D | 2,5 | 1,5 | 6,0 | 4 |
| E | 3,0 | 1,5 | 4,5 | 3 |

[Figure B.1](#) is a parameter variation diagram for determining the resultant pressure and likelihood of aerosol formation under varying nozzle diameter and flow rate conditions. For more information, see ISO 16232:2018, 7.4.3.1.