INTERNATIONAL STANDARD

ISO 16232-4

First edition
2007-06-01

Road vehicles — Cleanliness of components of fluid circuits —

Part 4: Method of extraction of contaminants by ultrasonic techniques

Véhicules routiers — Propreté des composants des circuits de fluide — Partie 4: Méthode d'extraction des contaminants par ultrasons

Reference number
ISO 16232-4:2007(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

ISO 16232-4 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 5, *Engine test*.

ISO 16232 consists of the following parts, under the general title *Road vehicles — Cleanliness of components of fluid circuits*:

— *Part 1: Vocabulary*

— *Part 2: Method of extraction of contaminants by agitation*

— *Part 3: Method of extraction of contaminants by pressure rinsing*

— *Part 4: Method of extraction of contaminants by ultrasonic techniques*

— *Part 5: Method of extraction of contaminants on functional test bench*

— *Part 6: Particle mass determination by gravimetric analysis*

— *Part 7: Particle sizing and counting by microscopic analysis*

— *Part 8: Particle nature determination by microscopic analysis*

— *Part 9: Particle sizing and counting by automatic light extinction particle counter*

— *Part 10: Expression of results*

Introduction

The presence of particulate contamination in a fluid system is acknowledged to be a major factor governing the life and reliability of that system. The presence of particles residual from the manufacturing and assembly processes will cause a substantial increase in the wear rates of the system during the initial run-up and early life, and may even cause catastrophic failures.

In order to achieve reliable performance of components and systems, control over the amount of particles introduced during the build phase is necessary, and measurement of particulate contaminants is the basis of control.

The ISO 16232 series has been drafted to fulfil the requirements of the automotive industry, since the function and performance of modern automotive fluid components and systems are sensitive to the presence of a single or a few critically sized particles. Consequently, ISO 16232 requires the analysis of the total volume of extraction liquid and of all contaminants collected using an approved extraction method.

The ISO 16232 series has been based on existing ISO International Standards such as those developed by ISO/TC 131/SC6. These International Standards have been extended, modified and new ones have been developed to produce a comprehensive suite of International Standards to measure and report the cleanliness levels of parts and components fitted to automotive fluid circuits.

This part of ISO 16232 defines procedures for the removal and collection of contaminants from components using ultrasonic bath or an ultrasonic probe so that their cleanliness can be evaluated.

The cleanliness level of a component, as determined according to this method, depends to a large extent on the test parameters (e.g. the frequency, the power and duration of the ultrasound and the type of application, bath or sonotrode). It is advisable that all parameters be included in the inspection document and rigorously followed by the test staff.

Road vehicles — Cleanliness of components of fluid circuits —

Part 4:
Method of extraction of contaminants by ultrasonic techniques

1 Scope

This part of ISO 16232 describes the principles of extraction of contaminants from a component either by immersion in an ultrasonic bath or by applying ultrasonic vibrations directly via sonotrodes. It is preferably applied to small and medium sized components of various geometry of which both internal and/or external surfaces have to be examined (e.g. joint seals, gears, etc). It is also applicable to small parts to be analysed in batches.

This method can be used on its own or in association with other methods of extraction described in the ISO 16232 series.

NOTE 1 The suitability of this method for complex geometries – e.g. tiny bores or large cavities with small openings – is decided on a case by case basis.

NOTE 2 Depending on the shape of the components, this method can be used also for batches containing multiple layers of components provided that there is no obstruction to the extraction of contaminants from the surface and their subsequent transfer into the test liquid. Small compact parts of large number are cleaned in a single layer.

Unless otherwise specified, this part of ISO 16232 deals with particulate contamination only. It does not, therefore, cover appearance defects or contamination by liquid or gaseous materials. It covers the amount and the nature of residual particles resulting from manufacturing processes and from the environment.

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 16232-1, *Road vehicles — Cleanliness of components of fluid circuits — Part 1: Vocabulary*

ISO 16232-2, *Road vehicles — Cleanliness of components of fluid circuits — Part 2: Method of extraction of contaminants by agitation*

ISO 16232-3, *Road vehicles — Cleanliness of components of fluid circuits — Part 3: Method of extraction of contaminants by pressure rinsing*

ISO 16232-5, *Road vehicles — Cleanliness of components of fluid circuits — Part 5: Method of extraction of contaminants on functional test bench*

ISO 16232-6, *Road vehicles — Cleanliness of components of fluid circuits — Part 6: Particle mass determination by gravimetric analysis*

ISO 16232-7, *Road vehicles — Cleanliness of components of fluid circuits — Part 7: Particle sizing and counting by microscopic analysis*

ISO 16232-8, *Road vehicles — Cleanliness of components of fluid circuits — Part 8: Particle nature determination by microscopic analysis*

ISO 16232-9, *Road vehicles — Cleanliness of components of fluid circuits — Part 9: Particle sizing and counting by automatic light extinction particle counter*

ISO 16232-10:2007, *Road vehicles — Cleanliness of components of fluid circuits — Part 10: Expression of results*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16232-1 apply.

4 Principle

The contaminants are extracted from the surface of the component by ultrasound. The cleaning effect is due to the cavitation, which creates micro-bubbles that implode close to the particles which are then expelled from and transferred to the extraction liquid for subsequent analysis.

NOTE 1 In case of an active component, the particles are extracted from the entire controlled surface of the component by traversing liquid.

NOTE 2 Several operating parameters influence the extraction efficiency, e.g. power density, operating time and medium, the placement and orientation of the component in relation to the ultrasonic source and the material the component is made of.

5 Equipment

5.1 General

The equipment used shall neither alter nor modify the size distribution of the extracted particles.

5.2 Test liquid

The test liquid shall be compatible with all the materials in the component, with the liquid used in the final system and with the test equipment, including seals, membrane filters and clean-up filters. A test liquid of low viscosity ($\leqslant 5\ mm^2/s$) and having the capability of removing (or dissolving) oil and grease is recommended. It should be filtered to attain the requirements of 6.3.3.

SAFETY PRECAUTIONS — In case a tested component will be reclaimed for final use, application of incompatible test liquid may cause hazardous damage.

5.3 Test component container

A closed container should be used for the transfer of the component from the place of sampling to the place of particle extraction. This container shall be appropriate to the shape of the component and made of material compatible with the test liquid. Its degree of cleanliness shall comply with the blank requirements specified in 6.3.3.

5.4 Ultrasonic equipment

5.4.1 Ultrasonic bath

The ultrasonic bath should be made of stainless steel. The principal characteristics of the ultrasonic equipment (notably power, frequency, and dimensions of the bath) shall be specified in the test report and the inspection document. In general, by applying transducers to the floor or to the wall surfaces of the bath, it is possible to achieve a high degree of homogeneous sonic distribution and therefore a homogeneous cleaning effect.

If the extraction liquid is in direct contact with the ultrasonic bath, the latter shall be processed like a collection container.

5.4.2 Sonotrodes

Another possibility for transferring ultrasonic energy to the test liquid is by using sonotrodes. These are mechanical elements that transmit ultrasound and transfer it to the test liquid to be sonically treated. The mass and geometry of these elements are aligned with the frequency of the ultrasound. For this application they are usually rod-shaped and made of titanium and most of the ultrasonic energy is radiated via the tip.

Sonotrodes are used in the extraction procedures for such internal geometries as through-boring, blind holes and channels which are less suitable for cleaning in an immersion ultrasonic bath.

NOTE Due to the high power densities that can be attained using sonotrodes, great care has to be taken to avoid cavitation damage to component(s) under test.

5.5 Pressure rinsing liquid dispenser

The pressure liquid dispenser is a device that provides clean test liquid specified in 5.2 at a pressure and flow rate capable of extracting the contaminants in an effective manner. The dispenser can also be used to rinse the test equipment and all other items.

NOTE This device can be the same as the one used for providing the test liquid.

5.6 Vacuum suction system

If necessary, use an assembly consisting of a source of vacuum, a vacuum flask previously cleaned and a flexible tube of suitable dimensions and shape for recovery of the extraction liquid and any particles that have accumulated in the component under examination.

5.7 Collection equipment

The collection equipment shall allow effective draining of contaminants. A conical base is preferred.

It shall be cleaned to achieve the requirements of 6.3.3.

It is possible for contaminants remaining on the equipment to be transferred to the sample and thus be erroneously included as part of the particles removed from the component. All collection equipment shall be cleaned and covered before use in order to limit contamination from the environment.

5.8 Sampling containers

The sampling containers (glassware, etc.) required for transferring the extraction liquid from the collection equipment to the analysis equipment shall be cleaned to achieve the requirements of 6.3.3.

5.9 Environmental conditions

The cleanliness of the environment where the extraction is performed shall be consistent with the presumed cleanliness of the component to test. This requirement may result in the test being carried out in a laboratory or controlled workplace. The suitability of the environment is validated when performing the blank test.

5.10 Health and safety

5.10.1 Local Health and Safety procedures shall be followed at all times, any equipment shall be operated in accordance with the manufacturer's instruction and personal protection equipment used where appropriate.

5.10.2 Chemicals used in the procedures can be harmful, toxic or flammable. Good laboratory practices shall be observed in the preparation and use of these chemicals. Care shall be taken to ensure compatibility of the chemicals with the materials used (refer to each Material Safety Data Sheet [MSDS]). Follow the precautions for safe handling and usage as described in the MSDS available from the supplier.

5.10.3 Volatile liquids; care shall be taken with flammable liquids to ensure that they are used in accordance with the MSDS, at temperatures below the stated flash point and away from potential sources of ignition. Appropriate precautions should be taken to avoid inhalation of fumes from these solvents. Always use suitable protective equipment.

5.10.4 Electrical; appropriate care should be applied in the use of electrical power.

5.10.5 Disposal; all liquids and substances shall be disposed of in accordance with local environmental procedures. In the event of spillage it shall be cleaned-up in the manner detailed in the MSDS.

6 Procedure

6.1 Handling and storage

During handling and storage of test components, it shall be ensured that no contaminants are deposited on or removed from controlled surfaces.

To prevent loss of particles during transport it may be necessary to seal openings of the test components, e.g. with suitable plugs.

6.2 Extraction procedure set-up and validation

6.2.1 The number of components to be analysed shall be chosen so as to measure a significant amount of contaminants that complies with the requirements for a blank (see 6.2.15 NOTE 3).

6.2.2 If the break-in of the component is part of its manufacturing process, the extraction procedure should be agreed between parties and included in the inspection document because break-in may alter its initial cleanliness level.

6.2.3 If the particles that are detached during transportation of the test component and/or particles from the packaging are to be included in the cleanliness inspection, as agreed upon between parties, they shall be collected using the appropriate extraction method (e.g. low pressure rinsing). This agreement shall be included in the inspection document.

6.2.4 The effectiveness of the ultrasonic method depends on the following, non-exhaustive list of parameters: the frequency, the power and duration of the ultrasonic vibrations and the type of application – bath or sonotrode (see Annex A for practical information). A synopsis of the operations to perform is given in Annex B. The detailed description of operating conditions and equipment used in application of this standard to extract the contaminants from the component by ultrasonic techniques constitutes the extraction procedure. This procedure shall be established for each component and shall be both agreed between parties and

included in the inspection document. Details of the procedure shall be reported on a suitable data sheet (for an example of extraction procedure data sheet see Annex C).

6.2.5 If needed for reporting results and if not specified, determine the controlled and/or controlled surface area of the component volume under examination (see Annex B of ISO 16232-10:2007). Report and/or specify their values in the inspection document.

6.2.6 Before starting to set up or validate any extraction protocol/equipment, it is necessary to perform an initial blank test to know the cleanliness of the equipment. This is performed after cleaning the equipment and the initial blank shall exhibit values stated in 6.3.3.

NOTE Conditioning and cleaning serves the purpose of obtaining a suitable cleanliness level of the inspection set-up. It is recommended that a basic procedure for conditioning the inspection set-up be defined. For example, by performing a cleanliness analysis of a defined volume of liquid after the cleaning procedure of the set-up, it can be determined whether the inspection environment is suitable for carrying out a validation procedure.

6.2.7 If necessary, demagnetise the component and/or clean those external surfaces which are not involved in the cleanliness test.

6.2.8 The external surface should be cleaned in a physically different place from where extraction is to be carried out. Ensure that no contaminants are deposited on or removed from controlled surfaces. For example, if the component is of large size, a tank for example, clean only those external surfaces which might contribute to contamination during the extraction process.

6.2.9 If necessary, remove all covers and other plugs fitted for transport of the component. If the component contains a shipment liquid, empty it out, measure its volume and analyse its contaminants according to Clause 7.

NOTE Removal of plugs might generate contaminants to unavoidably contribute to the original contamination.

6.2.10 If dismantling is necessary to obtain access to all the surfaces to be inspected, do so with care.

NOTE Any operation of dismantling might generate particles which could be added to or lost from the original amount of particles.

6.2.11 Extraction procedure using an ultrasonic bath.

6.2.11.1 If it is only the external surface of the component that is subject to the inspection process and if the component has no hollow parts opening to the exterior, proceed as indicated in 6.2.11.4. If it does have such hollow parts, carefully close their openings and proceed to 6.2.11.4.

6.2.11.2 If the internal and external surfaces of the component are the parts subject to the inspection process, proceed as described in 6.2.11.4.

6.2.11.3 If it is only the internal surface of the component that is subject to the inspection process, carefully rinse its external surface without rinsing particles into the controlled surface, fill it completely with test liquid, close it hermetically and then proceed as indicated in 6.2.11.4.

NOTE The process of closing or sealing the component may generate or introduce particles.

6.2.11.4 Completely immerse the component in a suitable container e.g. a glass beaker containing clean test liquid, or hang the component directly in the ultrasonic bath containing a suitable volume of clean test liquid.

If several surfaces of the component are to be tested, repeat ultrasonic treatment for each individual controlled surface. It may be necessary to turn the component with the surface under test facing toward the ultrasonic transducers.

6.2.11.5 Subject the component or its container to ultrasonic treatment at the power and frequency and for the duration specified in the inspection document.