
**Road vehicles — Cleanliness of
components of fluid circuits —**

Part 5:

**Method of extraction of contaminants on
functional test bench**

iTeh STANDARD PREVIEW
Véhicules routiers — Propreté des composants des circuits de fluide —
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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 16232-5 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*:

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- 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 liquid 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 a flow of test liquid in conditions as close as possible to the ones components are actually used in 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 parameters of the test such as the capacity of the test bench to reproduce the operating conditions and the requirements of the component (e.g. flow conditions, duration of flowing, etc). All parameters are included in the cleanliness specification and in the inspection document and it is advisable that they be rigorously followed by the test staff.

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Road vehicles — Cleanliness of components of fluid circuits —

Part 5:

Method of extraction of contaminants on functional test bench

1 Scope

This part of ISO 16232 describes the principles of extraction of contaminants by test on a laboratory functional test bench with the test liquid flowing under pressure or under vacuum. It is applicable to both active and passive components through which the fluid can easily flow.

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 pressure rinsing*

ISO 16232-4, *Road vehicles — Cleanliness of components of fluid circuits — Part 4: Method of extraction of contaminants by ultrasonic techniques*

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 component shall be installed on a validated test bench which simulates the component's functional operation. The motion of the liquid under known conditions detaches the contaminants from the controlled surfaces and transfers them to the test liquid, for subsequent analysis. The motion of the test liquid is achieved either by pressure or by vacuum. In the case of an active component, depending on the function principle, the component shall be actuated either by an external device or by the moving liquid.

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 ($\leq 5 \text{ mm}^2/\text{s}$) 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.

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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 Test set up

Use a test set-up that enables the component to operate at its acceptable flow rate, temperature and pressure as agreed between parties and included in the inspection document. A typical test set-up schematic is shown in Annex A.

In Annex A, all circuit components shown are given as examples. The extraction circuit shall be designed so as to fulfil the requirements of the extraction procedure.

The design of the test set-up and the components selected are critical to the accuracy, repeatability and reproducibility of measurements, and the basic rules are:

- the components shall neither alter nor modify the size distribution of the particles
- the components shall not encourage the settlement of particles during its operation and be so designed to quickly and effectively cause the particles to be re-entrained after periods of stoppage.

5.5 Pressure rinsing liquid dispenser

The pressure liquid dispenser is a device that provides a 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.

5.6 Collection equipment

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

The collection equipment shall be cleaned to achieve the requirements of 6.3.3.

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

5.7 Sampling containers

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

5.8 Environmental conditions

The cleanliness of the environment of the place 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.

5.9 Health and safety

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5.9.1 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.

5.9.2 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.

5.9.3 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.

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

5.9.5 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

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

6.1.2 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 contaminant.

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 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 For active components, it may be necessary to operate them in order to pass the test liquid through during the extraction procedure. In this case, the initial contamination level may be altered. The extraction conditions should be agreed upon between parties and included in the inspection document.

6.2.5 The effectiveness of the contaminant extraction on a functional test stand depends on the following, non exhaustive list of parameters: flow rate, duration of flow, test liquid, liquid viscosity, etc. 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 flow the test liquid through the component 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). An example of operating protocol is given in Annex A.

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

6.2.7 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. 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.

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

6.2.9 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.

6.2.10 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.

6.2.11 If dismantling is necessary to obtain access to all the surface 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.

6.2.12 Clean the test liquid, in the following manner, so that it complies with 6.3.3.

- a) Ensure that the test component can be by-passed either by valving or by connecting the two ports usually occupied by the test component. Bring in the clean-up filter. Annex A gives further guidance.
- b) For pressure flushing, circulate the test liquid through the clean-up filter until the required blank value (6.3.3) is obtained.
- c) For vacuum flushing either connect a secondary pump to circulate the extraction liquid around the circuit or clean in batches by drawing volumes through the clean-up filter into a suitable clean container. Continue until the required cleanliness value (6.3.3) is obtained.

Care in fitting and removing both the pipe and component for test shall be undertaken so not to contribute significant particles

6.2.13 Extract the contaminants using an appropriate operating protocol (e.g. as described in Annex A.2).

6.2.14 Collect all the extraction liquid in the sampling container. Rinse the inner surface of the sampling container with clean rinsing liquid in order to collect any remaining particles for subsequent analysis.

NOTE 1 As a function of the level of contamination observed in the extraction liquid, it may be necessary to divide the total volume among several sampling containers to facilitate their subsequent analysis, to avoid clogging of a membrane filter during filtration, the saturation of an APC or overlapping of particles in the case of microscopic counting.

NOTE 2 Instead of collecting in a container, the extraction liquid may also be directed through a membrane filter connected directly to the outlet of the test bench.

6.2.15 Analyse the extraction liquid as specified in Clause 7 and label the result obtained as S_1 .

6.2.16 Repeat operations 6.2.12 to 6.2.15 twice more on the same component, using a different clean container for collecting each extraction liquid sample and label the results obtained as S_2 and S_3 .

6.2.17 Validate the contaminant extraction procedure to ensure its efficacy as follows:

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- a) for each of the three samples taken in 6.2.15 and 6.2.16, establish the total mass of contaminants and/or the total number of particles. For the particle count, this is applicable to the total number of particles larger than the smallest particle size specified in the inspection document. This particle size shall be chosen to enable counting of a significant number of particles.
- b) divide the result of the last sample by the sum of all the values obtained in 6.2.17 a);
- c) if the value obtained is less than or equal to 10 % of this sum the end-point is reached and the extraction is completed.

NOTE 1 This procedure enables the extraction curve to be drawn and the end-point ($\leq 0,10$) to be demonstrated, (see Figure 1).

NOTE 2 The cleanliness level of the component is the sum of the extractions.

NOTE 3 In some cases (for example: a very low contamination level, difficulties in extracting particles, inappropriate blank level, etc.) the extraction curve may not be of the form seen in Figure 1. If this is the case, it is ensured that all extraction parameters have been properly investigated.

d) If the value obtained is $> 0,10$ a further extraction is necessary. Repeat stages 6.2.12 to 6.2.15 until the last sample (S_n) produces a result $\leq 0,10$ of the total of the samples ($S_n \leq \frac{10}{100} \sum_{i=1}^n S_i$).

6.2.18 If six extractions have been performed without reaching a value $\leq 0,10$, then the extraction parameters are not suitable and shall be modified. Repeat operations 6.2.13 to 6.2.17 with new parameters on a new component.

6.2.19 If this criterion is not fulfilled set up a new extraction protocol and validate it according to 6.2 or apply another extraction method as defined in ISO 16232-2, ISO 16232-3 or ISO 16232-4.