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Road vehicles — Cleanliness of components of fluid circuits —

Part 10: Expression of results

Véhicules routiers — Propreté des composants des circuits de fluide —

Partie 10: Expression des résultats

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Contents

Page

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 16232-10 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 5, *Engine tests*.

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/SC 6. 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 rules for expressing these cleanliness levels when measured by the methods defined in ISO 16232-6, ISO 16232-7, ISO 16232-8 and ISO 16232-9.

Users of the ISO 16232 series introducing this coding system are encouraged to inform the ISO/TC 22/SC 5 secretariat of any problems met, through their national standards organization.

Road vehicles — Cleanliness of components of fluid circuits —

Part 10:
Expression of results

1 Scope

This part of ISO 16232 defines the rules and the forms of expression and presentation of the results of measurements of particulate cleanliness of components for the fluid circuits of motor vehicles. It also defines a cleanliness coding system for simplifying the reporting and communication of particulate contamination data.

This part of ISO 16232 also defines the rules to be used for specifying cleanliness requirements.

This part of ISO 16232 does not concern the expression of particulate cleanliness of fluids.

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

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*

3 Terms and definitions

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

4 Principles

Particulate contamination, as measured in the whole volume of extraction fluid used in one of the methods of extraction and analyses described in ISO 16232 series, is quantified:

- per component;
- to a reference surface of 1 000 cm^2 of wetted surface of a component;
- to a reference volume of 100 cm^3 of wetted volume of a component.

The level of particulate contamination can be expressed by the total mass, by the particle-size distribution (number of particles per size class) possibly combined with the nature of particles or by the dimension of the largest particle(s) found. Data can also be combined, e.g. total mass and largest particle.

Cleanliness levels shall only be compared if they are in the same measurement units, i.e. either per 1000 cm^2 of wetted surface area or 100 cm^3 of wetted volume.

The cleanliness levels expressed per component shall never be compared one with the other. They shall only be used to compare a result to a specification.

Annex A gives recommendation for using the appropriate Component Cleanliness Code (CCC) codification.

NOTE In view of the different physical principles used to evaluate the size of the particles (e.g. a microscope or a light extinction automatic particle counter), the particulate contamination level measured on the same extraction sample can be different.

5 Expression of results of gravimetric analysis

5.1 Necessary data

The expression of the results of a gravimetric analysis requires knowledge of the following characteristics:

1) wetted volume (V_C) or wetted surface area (A_C) or V_C/A_C ratio of the component (see Annex B for an example);

2) number of components analysed if the contaminants are collected from more than one component;

3) total mass (mg) of contaminants collected by extraction.

NOTE There is no relationship between the gravimetric analysis results and the other contamination analysis results (e.g. particle counting).

5.2 Expression of results

5.2.1 Mass per component (m_{Cp})

Let n be the number of components analysed and m the total mass of contaminants collected, then:

$$m_{Cp} = \frac{m}{n} \text{ mg per component}$$

When low weight or/and small components are analysed, the result can be expressed as the mass of contaminants for n components. This is written as:

$$m_{\mathrm{Cp}} = m \text{ mg for } n \text{ components}$$

NOTE The cleanliness level reported by the mass per component varies arbitrarily depending on both, the size of the part and amount of its contamination.

5.2.2 Mass per unit surface area of component (m_A)

If A_{C} is the wetted surface area of the component (cm^2) and m the total mass (mg) of contaminant collected, then:

$$m_A = \frac{m \times 1\,000}{A_{\mathrm{C}}} \text{ in mg/1 000 cm}^2 \text{ of component}$$

5.2.3 Mass per unit volume of component (m_V)

If V_{C} is the wetted volume of the component (cm^3) and m the total mass (mg) of contaminant collected, then:

$$m_V = \frac{m \times 100}{V_{\mathrm{C}}} \text{ in mg/100 cm}^3 \text{ of component}$$

6 Expression of results of particle size distribution analysis - Component Cleanliness Code, CCC

6.1 Necessary data

To present the data from the extraction tests in this form and obtain the CCC requires the information detailed in 5.1 and the following:

— all or part of the counting size intervals chosen from Table 1 as specified in the inspection document;

— wetted volume (V_{C}) or wetted surface area (A_{C}) or $V_{\mathrm{C}}/A_{\mathrm{C}}$ ratio of the component (see Annex B for an example);

— number of components analysed if the contaminants are collected from more than one component;

— the numbers of the particles extracted from the component(s) analysed in each of the specified size ranges.

6.2 Size classes

The particles are counted in all or part of the size ranges defined by an inclusive lower size (called x_1) and an exclusive higher one (called x_2) among those listed in Table 1.

Each size range is labelled by a letter which defines a size class.

Table 1 — Size classes for particle counting

Size class	Size x (µm)
B	$5 \leqslant x < 15$
C	$15 \leqslant x < 25$
D	$25 \leqslant x < 50$
E	$50 \leqslant x < 100$
F	$100 \leqslant x < 150$
G	$150 \leqslant x < 200$
H	$200 \leqslant x < 400$
I	$400 \leqslant x < 600$
J	$600 \leqslant x < 1\,000$
K	$1\,000 \leqslant x$

NOTE According to individual requirements, size ranges may be combined and/or left out.

Table 2 — Definition of the cleanliness level of a component

Number of particles per 100 cm^3 or per 1 000 cm^2		Cleanliness level
More than	Up to and including	
0	0	00
0	1	0
1	2	1
2	4	2
4	8	3
8	16	4
16	32	5
32	64	6
64	130	7
130	250	8
250	500	9
500	1×10^3	10
1×10^3	2×10^3	11
2×10^3	4×10^3	12
4×10^3	8×10^3	13
8×10^3	16×10^3	14
16×10^3	32×10^3	15
32×10^3	64×10^3	16
64×10^3	130×10^3	17
130×10^3	250×10^3	18
250×10^3	500×10^3	19
500×10^3	1×10^6	20
1×10^6	2×10^6	21
2×10^6	4×10^6	22
4×10^6	8×10^6	23
8×10^6	16×10^6	24

NOTE In the test report, it is advisable that the raw number of particles also be noted.

6.3 Contamination level

The level of particulate contamination of a component in a given particle size class is expressed by the number specified in Table 2 as a function of the number of particles counted on the component with respect to the geometrical unit (100 cm^3 or 1 000 cm^2) chosen.

6.4 Component Cleanliness Code (CCC)

6.4.1 The Cleanliness Code of Components (CCC) is written as a sequence, enclosed in parentheses and separated by slashes, of alphanumerical pairs specifying all or several of the size classes from Table 1 and their level of contamination given by Table 2.

The capital letters A or V printed before the parentheses explains if the code refers either to 1 000 cm^2 of wetted surface area or to 100 cm^3 of wetted volume of the component.

6.4.2 When the CCC refers to the whole size ranges all letters of Table 1 and corresponding levels are written: for instance

CCC = V (B20/C16/D18/E12/F12/G12/H8/I0/J0/K00)

6.4.3 When the CCC refers to some size classes, only the relevant letters and corresponding levels are written: for instance

CCC = V (C16/D18/E12/F12/G12/J0)

means that there was no requirement (or no results) for cleanliness data at size ranges B,H, I and K.

6.4.4 When several successive size classes are at the same cleanliness level, they are reported by their letters side by side and the relevant level is written after the last letter: e.g. : .../EFG12/...

CCC = V (C16/D18/EFG12/H8/J0)

means that between 2 000 and 4 000 particles (level 12) are in three size ranges $50 \leqslant x < 100$ (size E), $100 \leqslant x < 150$ (size F) and $150 \leqslant x < 200$ (size G) µm and that there is no requirement or data for size B, I and K.

6.4.5 When the cleanliness level relates to a size range broader than the ones of Table 1, i.e. it covers several consecutive size classes, it is labelled by the letters of the lower and higher sizes linked by an hyphen (-) followed by the relevant level, e.g.: ...../G-J20/.....

CCC = V (C16/D18/EF12/G-J20)

means between 500×10^3 and 10^6 particles (level 20) between 150 and less than 1 000 µm (sizes G to J) and no requirement or data at other sizes.

CCC = V (G-K20)

means between 500×10^3 and 10^6 particles (level 20) greater than 150 µm (sizes G to K) and no requirement or data at other sizes.

CCC = V (G-K00)

means no particle (level 00) greater than 150 µm (sizes G to K) and no requirement or data at other sizes.

Other examples are given in Annex C.

6.4.6 Alternative transitional expression of cleanliness

Due to some existing practice, Annex D gives an alternative transitional expression of cleanliness.