BRITISH STANDARD

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16232-1:2007

Road vehicles — Cleanliness of components of fluid circuits —

Part 1: Vocabulary

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BSI
British Standards

National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Part 1: Vocabulary

Véhicules routiers — Propreté des composants des circuits de fluide —

Partie 1: Vocabulaire

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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 16232-1 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/TC131/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.

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Road vehicles — Cleanliness of components of fluid circuits —

Part 1:
Vocabulary

1 Scope

This part of ISO 16232 defines the vocabulary used in the characterization and measurement of particulate contamination of parts, components, sub-assemblies and assemblies constituting the fluid circuits of internal combustion engines of road vehicles.

This applies to all components that may come into contact with a liquid (e.g. oil, fuel, air conditioning refrigerant, coolant), a solid lubricant or a gas (intake air).

Unless otherwise specified, this International Standard deals with particulate cleanliness only. It does not therefore cover appearance defects or contamination by liquid or gas materials.

It covers the amount and the nature of residual particulate contaminants resulting from the whole manufacturing processes and from the environment.

NOTE This part of ISO 16232 also covers vocabulary that will not be applied in parts 2 to 10 of ISO 16232. This is in order to complement unified usage of wording in the field of cleanliness of road vehicle components.

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 14644-1:1999, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness*

ISO/TS 16949:2002, *Quality management systems — Particular requirements for the application of ISO 9001:2000 for automotive production and relevant service part organizations*

3 Terms and definitions

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

3.1
abrasive particle
particle liable to change the surface finish

3.2
active component
component which may set the fluid in motion or be activated by the fluid during operation, for example pump, cylinder, distributor, injector, valve regulator

3.3
agitation
continuous and/or irregular movement of a component

3.4
agglomerate
two or more particles which are in intimate contact and cannot be separated by gentle stirring and the small shear forces thus generated

3.5
ambient contamination
contaminants that are found in the atmosphere surrounding the component

NOTE In an industrial setting, they originate from the atmosphere itself (e.g. atmospheric dust, ventilation), from operators (textile fibres, etc.) from transformation operations (grinding, welding, etc.) or from objects in contact with the component (working surfaces, containers, etc.).

3.6
Automatic Particle Counter
automatic light extinction particle counter
APC
counter that works on the light extinction principle

3.7
back scattered electron detector
BSE detector
supply Scanning Electron Microscope (SEM) images with a high material contrast, used for the detection of particles on a membrane filter

3.8
blank test
analysis carried out with the same operating conditions as on the test component but without the component

NOTE The blank test enables quantification of the contamination brought in from the environment, processes and materials used.

3.9
clean
state of cleanliness of a component or a fluid that meets the specified cleanliness level that is to say with a measured cleanliness level (CLm) lower than or equal to the specified cleanliness level (CLs)

3.10
cleaning
industrial process for the reduction of the quantity of contaminants present in a fluid, in or on a component until the specified cleanliness level (CLs) has been reached

3.11
cleaning curve
progress curve of the cleanliness level of a fluid or component subject to cleaning

NOTE This definition relates to industrial process which can use gas or liquid.

3.12
cleanliness
condition of a product, surface, device, gas, liquid, etc., characterized by the absence of particulate contamination

3.13
cleanliness audit
methodical and independent examination with the view of determining whether the manufacturing process of a product and all the relevant activities provide the assurance that the cleanliness level shall be effectively obtained and/or maintained

3.14
Component Cleanliness Code
CCC
alpha-numeric expression of the cleanliness level (CL) of a component measured or specified by the particle size distribution of the contaminants

3.15
cleanliness inspection
range of operations aimed at bringing as many contaminants as possible from a component to a measuring equipment for their analysis or quantification

NOTE It usually includes three steps: collection/conditioning of the component, extraction and analysis of the contaminants.

3.16
cleanliness inspection equipment
all equipment and products used to extract, collect and analyse the contaminants in order to determine the cleanliness level

3.17
cleanliness level
CL
amount and/or nature of contaminant present on the controlled surfaces and/or in controlled volumes of a component

See Clause 4.

NOTE The term may apply to the presumed, specified or measured extent of contamination.

3.18
cleanliness specification
document that specifies the cleanliness level required (CLs) for a given component along with the agreed inspection method

3.19
clean room
room whose ambient particulate contamination level does not have negative effect on the cleanliness measurements

3.20
cleanroom
room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room, and in which other relevant parameters e.g. temperature, humidity, and pressure, are controlled as necessary

[ISO 14644-1:1999]

NOTE Used only to show the difference between clean room as defined in 3.19.

3.21
clean sampling container
sampling device cleaned and conditioned according to an appropriate and validated method

3.22
coincidence
presence of more than one particle in the sensing volume of an APC at the same time

3.23
collection equipment
any device (e.g. conical flask, beaker, tray, funnel, collection area of the spraying chamber) with a size and a shape suited to the collection of all the extraction liquid draining from the test component

3.24
component
general term used to cover a part, a sub-assembly, a part assembly or a system fitted to a road vehicle

3.25
cleaning liquid
liquid compatible with the extraction sample used for conditioning of the analysis equipment and/or monitoring of the blank value of the analysis set-up

3.26
container
any device, the characteristics of which allow the test component to be handled and transported from a location (e.g. the production line) to the test location and/or to handle liquids during the test

3.27
contaminant
undesirable substance which is in suspension in a fluid or in or on a component

NOTE In ISO 16232, contaminant are particles as defined in 3.56.

3.28
contamination
all contaminants in a fluid, system or on a component

3.29
controlled surface area
surface of a component subjected to cleanliness requirement and/or the subject of a cleanliness inspection

NOTE The controlled surface area may differ from the wetted surface area defined in 3.79.

3.30
controlled volume
volume of a component subjected to a cleanliness requirement and/or the subject of a cleanliness inspection or measurement

NOTE The controlled volume may differ from the wetted volume defined in 3.80.

3.31
delay time
period of time between two data acquisition intervals during which the APC will not record the particles passing through the sensor

3.32
detachable burr
burr which may become detached in specified conditions

3.33
determination of cleanliness
measurement of the particulate contamination (preferred term: cleanliness inspection)

3.34
dynamic size range
size range between the smallest detectable particle and the largest detectable particle

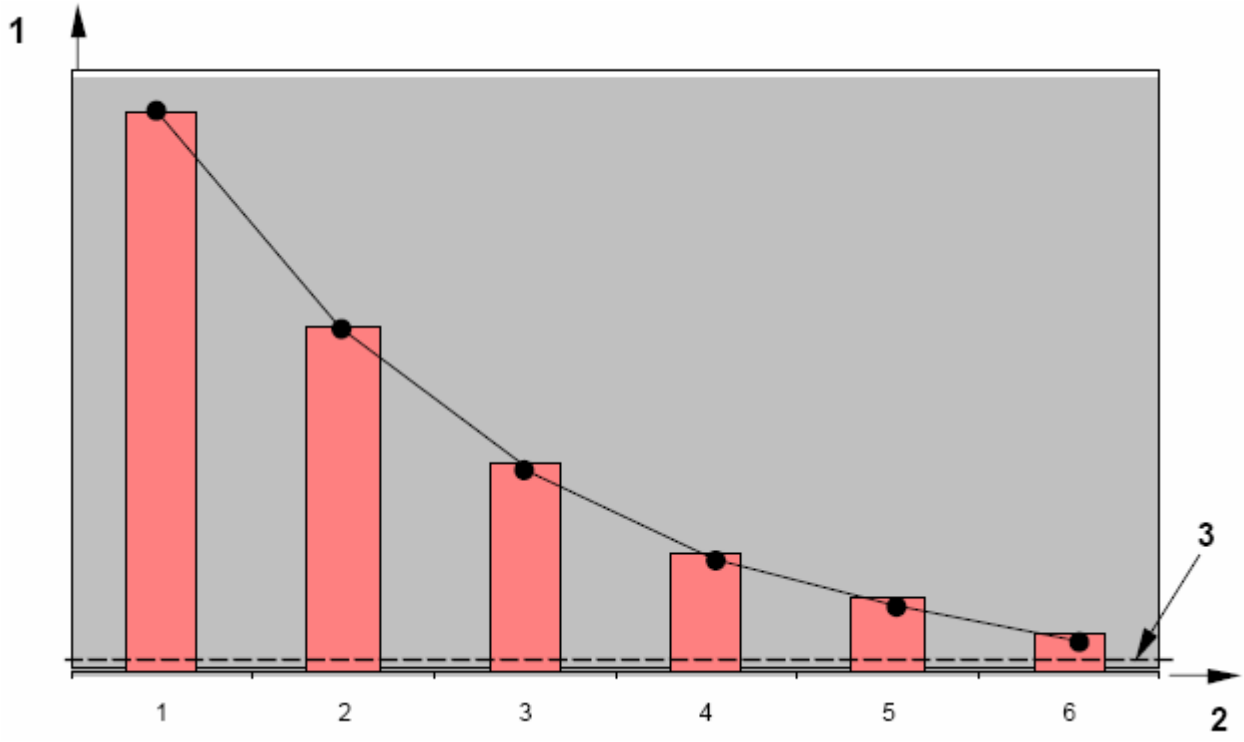
3.35
end-point sample
last sample in a series of repetitive samples producing a result that in less than 10 % of all the samples

3.36
energy dispersive system
EDX system
X-ray detection system with which energy dispersive X-ray spectra are recorded for element analysis

3.37
extraction
operation required to transfer as many as possible of the contaminants present in a controlled volume or on the controlled surface of a component into a known volume of test liquid for a subsequent analysis

See **extraction liquid** (3.39).

3.38
extraction curve
progress curve of the cleanliness level of an extraction liquid applied to the test component in relation to extraction time or volume of test liquid passed through or over the test component (see Figure 1), depending on the type of liquid and test conditions (e.g. flowrate, pressure)



Key

1 measured cleanliness level (CLm)
2 extraction samples
3 blank level

Figure 1 — Extraction curve

3.39
extraction liquid
test liquid once loaded by contaminants extracted from the test component

3.40
extraction procedure
method defining all the necessary parameters to transfer contaminants from either the controlled surface or the control volume of a component into the test liquid, making the operation reproducible

3.41
extraction sample
test sample
total amount of liquid to be analysed present in one or a number of sample containers carrying the contaminants extracted from a component

3.42
extraction volume
total volume of liquid used to extract the contaminants from a component

3.43
fibre
long particle with a large length/diameter ratio, for example $>$ 30

NOTE 1 Fibres can be of different nature and shape.

NOTE 2 Criteria for defining fibres should be established depending on the specific cleanliness requirement of the component analysed. Fibres cannot be defined, as such, by APC (automatic particle counters).

3.44
generated contamination
all contaminants generated by the system in normal operation (e.g. wear debris, combustion soot)

3.45
functional test bench
closed circuit of test liquid onto which the test component is installed in order to be subjected to stresses or to provide similar functions to those to which it must be subjected to under final use operating conditions

3.46
gel
material of organic nature with no mechanical cohesion and deformable

3.47
gravimetric analysis
measurement of the mass of contaminants extracted from a liquid or a component and carried out according to a specified method

3.48
in-built contamination
all contaminants that are found in the component immediately after manufacture or assembly

NOTE This results from transformation processes (grinding, painting, etc.) and washing and handling in a normal working environment.

3.49
ingested contamination
all contaminants introduced into a fluid system in operation (vent pipes, cylinder rods, cylinder breathers, etc.) or during external interventions (fluid refilling, opening, etc.)

3.50
inspection document
written description of the part or component cleanliness requirement and the agreed inspection method

3.51
inspection method
procedure for extraction and analysis of contaminant and data reporting that is used to evaluate the cleanliness level of a component as specified by the inspection document

3.52
laboratory
facility having the capability for performing inspection, test or calibration in the following, but not limited to, fields: chemistry, metallurgy, dimensionment, physics, electricity, reliability

[ISO/TS 16949:2002]

3.53
light extinction
reduction in intensity of a light beam passing through the sensing volume caused by absorption and/or scattering of the light by particles

3.54
mean flow pore size
MFPS
mean of the curve of the pore diameter differential distribution when measured by air porometry

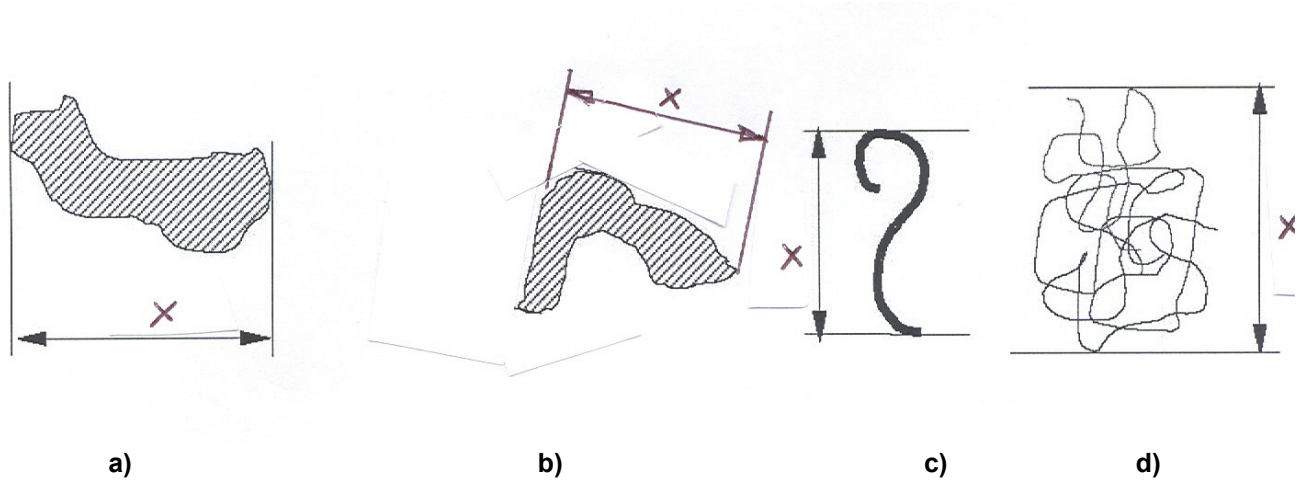
3.55
membrane filter
thin (generally $\leqslant$ 1 mm thick) filtering material made of organic material with a narrow pore size distribution

3.56
particle
solid material, removable in specified conditions and possessing mechanical cohesion

3.57
particle count
number of particles counted by their size or other characteristics

3.58
particle size
x
size of particle, x, as defined by the particle's longest dimension, X (length, diameter or diagonal)

NOTE Examples are shown in Figure 2.



a) b) c) d)

Figure 2 — Examples of particle types

NOTE When using an APC, the size of a particle is the diameter of the sphere with the same projected area.

3.59
particle size analysis
measurement of the size of a particle carried out according to a specified procedure and measuring method

3.60
particle size distribution
cumulative or differential number of particles as a function of particle size

3.61
passive component
component which does not set the fluid in motion and is not actuated by the fluid, for example connector, tube, tank, etc.

3.62
pressure rinsing
method of contaminant extraction using an appropriate jet of test liquid under pressure to spray and/or flush the controlled surface

3.63
rinsing
in production, operation for the reduction or elimination of liquid or solid residues

NOTE In laboratory, preferred term is extraction or pressure rinsing.

3.64
rinsing curve
in cleanliness inspection, see extraction curve; in industrial process, see cleaning curve

3.65
sampling
action of extracting a representative part from a whole

3.66
scanning electron microscope
SEM
high resolution microscope which images a sample by scanning it with a focused electron beam

3.67
sensing volume
〈Automatic Particle Counter〉 portion of the illuminated region of the sensor through which the liquid stream passes and from which the light is collected by the optical system

3.68
sonotrode
mechanical component which transmits the ultrasonic oscillations produced by the transducer to the material to be sonically treated

3.69
stabilization-period
time required to ensure that contaminants are put in homogeneous suspension and air bubbles are removed prior to analysis

3.70
system fluid
circuit fluid
fluid (liquid, gas) added to a system for normal operation

3.71
test component
component whose cleanliness level is to be determined

3.72
test liquid
liquid of specified characteristics (e.g. viscosity, boiling point, cleanliness level, solvency) used to extract as many contaminants as possible from a component

NOTE The term test fluid is not used in the International Standard.

3.73
turbulent flow
flow of a fluid in which the movement of particles, in any point, varies rapidly in intensity and direction

NOTE In a circular pipe, the flow is turbulent when the Reynolds number (Re) exceeds 2300.

$$Re = \frac{10^3 \rho \times d \times v}{\eta}$$

where

ρ is the fluid density (kg/m^3);

d is the equivalent pipe diameter (mm);

v is the fluid velocity (m/s);

η is the fluid viscosity (10^{-3} Pa.s).

The minimum linear speed to produce a turbulent flow ($Re > 2300$) is given by the relationship

$$V = \frac{2\mu}{d}$$

where μ is the fluid kinematic viscosity (mm^2/s).

3.74
ultrasonic
mechanical vibrations with a frequency from 20 kHz to 400 kHz

3.75
ultrasonic transducer
electro-mechanical component generally made of piezo-ceramic materials which converts the electrical oscillations into mechanical vibrations

3.76
vacuum rinsing
method of contaminant extraction using vacuum to flow the test liquid through the test component under turbulent conditions

NOTE Equivalent term: vacuum flushing.

3.77
validation
verification that an operation provides the correct function for which it is required or that a product correctly fulfils its function

3.78
washing machine
industrial equipment providing removal of contaminants from the surface of components by chemical, physical and/or thermal action

3.79
wetted surface area
surface of a component exposed to the system fluid (e.g. water, oil, air) as agreed between parties

NOTE It can be used for estimation of the impact of the test surface on the total surface cleanliness.

3.80
wetted volume
volume of a component in which the system fluid (e.g. water, oil, air) is to be found in the end-use operating condition as agreed between parties

NOTE It can be used for estimation of the impact of the test volume on the total volume cleanliness.

3.81
working flow rate
the flow rate through the sensor of the particle counter used for calibration and sample analysis

3.82
working volume
improper term: see wetted volume

4 Symbols and abbreviated terms

4.1 Symbols

For the purposes of the ISO 16232 series, the following symbols and abbreviated terms apply.

A_C wetted area of a component

d internal diameter of a pipe or equivalent internal diameter

D outer diameter

l longest dimension (Ferret-max)

m_A particle mass in relation to the surface of a component

m_{Cc} contaminant mass on the component

m_{CON} gravimetric concentration

m_{Cp} particle mass per component

m_F residue mass of the particles on the membrane filter

m_V particle mass in relation to the volume of a component

m_1 analysis filter mass before filtration of the extraction fluid

m_2 analysis filter mass after filtration of the extraction fluid

n number

Re Reynolds number

S_i e.g. S_1, S_2 …; cleanliness level of an extraction sample

v velocity of the fluid [m/s]

V_C wetted volume of the component

x particle size; e.g. $150 \leqslant x < 200$ (µm)

x_1 inclusive lower particle size

x_2 exclusive higher particle size

X size of the largest particle

η fluid viscosity

μ fluid kinematic viscosity (mm^2/s)

4.2 Abbreviated terms

For the purposes of the ISO 16232 series, the following abbreviated terms apply.

A coded cleanliness information is given “per 1 000 cm^2”

APC Automatic Particle Counter

BSE Back Scattered Electron

CCC Component Cleanliness Code

CLm measured cleanliness level

CLs specified cleanliness level

EDX energy-dispersive X-ray

LM light microscope

MSDS Material Safety Data Sheet

MFPS mean flow pore size

MSDS material safety data sheet

MTD Medium Test Dust

N coded cleanliness information given “per component”

R result of a routine extraction procedure

SEM Scanning Electron Microscope

US ultrasonic

V coded cleanliness information is given “per 100 cm^3”

blank

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