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Diesel engines — Cleanliness assessment of fuel injection equipment

Moteurs diesels — Évaluation de propreté pour équipement d'injection de combustible

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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.

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 documents 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).

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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/TC22, *Road vehicles,* Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids*.

This third edition cancels and replaces the second edition (ISO 12345:2013), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the reporting of the inspection results (Clause 7) changed from FIECC (fuel injection equipment cleanliness code, as in ISO 12345:2013) to CCC (component cleanliness code, as in ISO 16232).

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.

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Introduction

Modern fuel injection systems contain many closely controlled clearances and rely on the fuel-flowing characteristics of small orifices; thus they require the close control of sources of contamination in order to maintain the operational performance demanded of them throughout their design life. To this end, such systems are designed with integral fuel-filtration equipment, which reduces the amount of potentially damaging debris that could enter the system from external sources.

However, contamination of the fuel injection system can also occur internally, from system use or wear, from equipment servicing, or as a result of the original supplier's manufacturing and assembly processes. The focus of this document is on the latter source of contamination, and is thus concerned with the assessment of the cleanliness of the fuel injection equipment as originally supplied to the engine manufacturer.

Fuel injection systems comprise a number of components. Traditional systems contain low-pressure elements (fuel tank, pipe work, filters, lift pump, etc.), a fuel injection pump, high-pressure pipes and fuel injectors, located within the engine cylinder head.

During the preparation of this document, the importance of care in the handling and measurement of contamination samples was clearly recognized. Moreover, the low levels of contaminant with fuel injection equipment make this a particularly difficult task. For this document to be used meaningfully - as an indicator of component cleanliness and a driver towards higher-quality standards - extreme attention to detail is recommended for the user. Therefore, verification requirements for the used test equipment are emphasized in detail.

It is not always clear what level and type of cleanliness would be beneficial for improved performance and life on a cost-effective basis. The actual quantitative levels can only be set in relation to other parameters, agreed between the manufacturer, supplier and user. This document provides a set of procedures for evaluating the cleanliness of fuel-injection equipment and a framework for a common measurement and reporting.

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Diesel engines — Cleanliness assessment of fuel injection equipment

1 Scope

This document specifies cleanliness assessment procedures for evaluating the amount of debris found within the clean side of diesel fuel injection assemblies, which could lead to a reduction in the system's operational effectiveness.

While other International Standards, e.g. ISO 16232, relate to cleanliness of components used in road vehicle fluid circuits, this document is focused on diesel fuel injection assemblies as supplied to diesel engine manufacturers or the service market.

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 4008-1, *Road vehicles — Fuel injection pump testing — Part 1: Dynamic conditions*

ISO 4113, *Road vehicles — Calibration fluids for diesel injection equipment*

ISO 4788, *Laboratory glassware — Graduated measuring cylinders*

ISO 7440-1, *Road vehicles — Fuel injection equipment testing — Part 1: Calibrating nozzle and holder assemblies*

ISO 8535-1, *Diesel engines — Steel tubes for high-pressure fuel injection pipes — Part 1: Requirements for seamless cold-drawn single-wall tubes*

ISO 8984-1, *Diesel engines — Testing of fuel injectors — Part 1: Hand-lever-operated testing and setting apparatus*

ISO 14644-1, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness by particle concentration*

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 16232 and the following apply.

ISO and IEC maintain terminological 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/

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3.1
Reynolds number
Re
dimensionless parameter expressing the ratio between the inertia and viscous forces in a flowing fluid, given by the formula

$$R_e = \frac{U \times l}{v}$$

where,

R_e is the Reynolds number (Re);

U is the mean axial fluid velocity across the defined area, expressed in millimetres per seconds;

l is the characteristic dimension of the system over which the flow occurs, expressed in millimetres;

[for pipes $l = d$ (pipe bore diameter)]

v is the kinematic viscosity of the fluid, expressed in square millimetres per second (centistokes).

4 Test apparatus

Typical test equipment recommended for measuring fuel-injection equipment cleanliness is described in Annex A. In 4.1 to 4.9 are details of specific apparatus that shall be used, unless a suitable alternative can be demonstrated.

4.1 Pressure source

Pressure source is test dependent as described in 4.1.1 to 4.1.7.

4.1.1 Fuel injection pump test bench

A test bench as specified in ISO 4008-1 with a single cylinder pump or one cylinder of an inline pump.

4.1.2 Hand-lever-operated testing and setting apparatus

A testing apparatus as described in ISO 8984-1.

4.1.3 High-pressure pulsating flow rig

A pressuse source capable of achieving:

a) a flow rate which will generate a turbulent flow in the pipes (Re > 4 000) for a period of 30 s ± 1 s, while pulsating the flow between zero and this value at a frequency of 0,2 Hz to 1 Hz, followed by

b) a flush at 1,4 MPa ± 0,1 MPa constant pressure for 15 s ± 1 s.

4.1.4 Verification low-pressure pump

A plunger or diaphragm-type pump, having a flow rate of approximately twice the rated value for the component under test at a pressure of at least 2 MPa. The verification low-pressure pump has to be cleaned to the cleanliness level CL in accordance with Annex C. It has to be carefully stored with a proper cover in a clean environment.

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