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Determination of the filtration efficiency of urea filter modules

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids.*

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.

Determination of the filtration efficiency of urea filter modules

1 Scope

This document specifies requirements relating to the ~~method of~~ testing ~~of~~method for AUS 32/~~Diesel Exhaust Fluid~~diesel exhaust fluid (DEF) filters for the removal of suspended matter. This ~~will apply~~applies to urea filters dedicated to passenger vehicles as well as to commercial vehicles. This method applies to filters with flow rates from 3 l/h to 30 l/h depending on the application (by default 5 l/h for passenger vehicles and 25 l/h for commercial vehicles). This method can be used for other flow rates, provided the validation requirement can be met.

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 11218, *Aerospace~~: cleanliness~~ — Cleanliness classification for hydraulic ~~fluid~~fluids*

ISO 11923, *Water quality — Determination of suspended solids by filtration through glass-~~fiber~~fibre filters*

ISO 21501-~~-~~3, *Determination of particle size distribution — Single particle light interaction ~~method: part~~methods — Part 3: Light extinction liquid-borne particle counter*

~~ISO 22241, *diesel engines – Nox reduction Agent AUS 32 – part 1 – Quality requirement*~~

~~4~~3 Terms and definitions

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

ISO and IEC maintain terminology 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/

3.1
cumulative overall mean filtration efficiency
E_x
cumulative efficiency calculated from the total number of particles greater than size *x* ~~(~~[µm~~)~~] counted upstream and downstream of a filter during the initial 60 min counting period at 5 mg/l

Note 1 to entry: The efficiency is expressed in ~~(%)~~[%].

3.2
differential pressure ~~(*ΔP*)~~
ΔP

pressure difference between the inlet and outlet of the complete filter unit measured under predetermined conditions.

Note 1 to entry: theThe differential pressure generated by the complete filter is equal to the sum of the differential pressures generated by the housing and by the filter element (in case the filter element is removable from the housing)).

Note 2 to entry: theThe differential pressure is expressed in kPa.

3.3
ISO MTD
ISO medium test dust (ISO MTD)
siliceous test powder having a particle size distribution by volume in accordance with ISO 12103-1, A3

Note 1 to entry: It may also be referred as ISO 12103-1 A3 dust.

3.4
nominal flow rate
Q
Flowflow rate for the filter specified by the manufacturer

Note 1 to entry: The flow rate is expressed in Ll/h.

3.5
reference filtration rating
(*S*)
Dimensiondimension of the ISO MTD particles at which the overall mean cumulative filtration efficiency of the integral filter (or the filter element) tested in accordance with the procedure described in this document, is greater than or equal to 99 %

Note 1 to entry: The reference filtration rating is expressed in µm.

54 Symbols

The generic symbols used in this document are given in Table 1.

Table 1 — Symbols

Symbol or Abbreviation	Parameter	Unit
C_e	Test concentration	mg/l
C_i	Injection concentration	mg/l
C_R	Retention capacity	g
C_{NR}	Concentration of the downstream fluid during the clogging period	mg/l
C_{ov}	Coefficient of variation	%
d	Size of the particle	µm
ΔP_0 ΔP_0	Loss of pressure due to the clean filter alone	kPa
ΔP_F ΔP_F	Loss of pressure at the end of the test	kPa
E_x	Cumulative Efficiencyefficiency at size greater than x µm	%

M	Mass of contaminant necessary for the test	g
M_{i1}	Injected mass of contaminant in injection reservoir 1	g
M_{i2}	Injected mass of contaminant in injection reservoir 2	g
$N_{i\,UP}$ > x µm	i^th particle count upstream at x µm	-/ml
$N_{i\,DW}$ > x µm	i^th particle count downstream at x µm	-/ml
Q	Flow rate	l/h
Q_r	Recirculation flow rate	l/h
Q_{C1}	Injection flow rate circuit 1 (relative to the efficiency concentration)	l/h
Q_{C2}	Injection flow rate circuit 2 (relative to the capacity concentration)	l/h
S_{sc}	Suspended ~~Solid Concentration~~solid concentration	mg/l
V_{i1}	Injection circuit N°1 fluid volume	l
V_{i2}	Injection circuit N°2 fluid volume	l
V_{iM}	Injection circuit maximum fluid volume	l
V_{CP}	Recovered downstream volume during the clogging period	l
V_{CPV}	Recovered downstream volume during the validation of the clogging period	l
~~ΔT_{CP}~~ΔT_{CP}	Time duration of the clogging period	h

~~6~~5 Test procedures

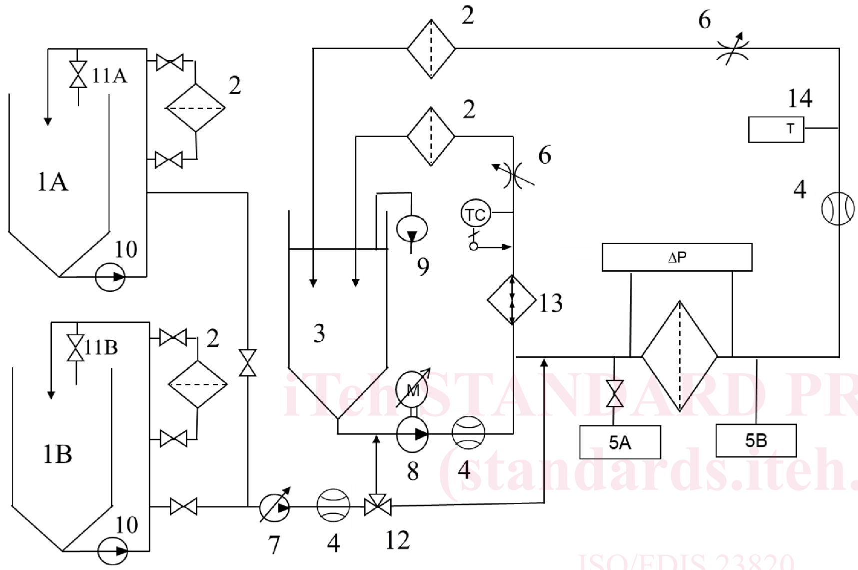
~~6.1~~5.1 Principle

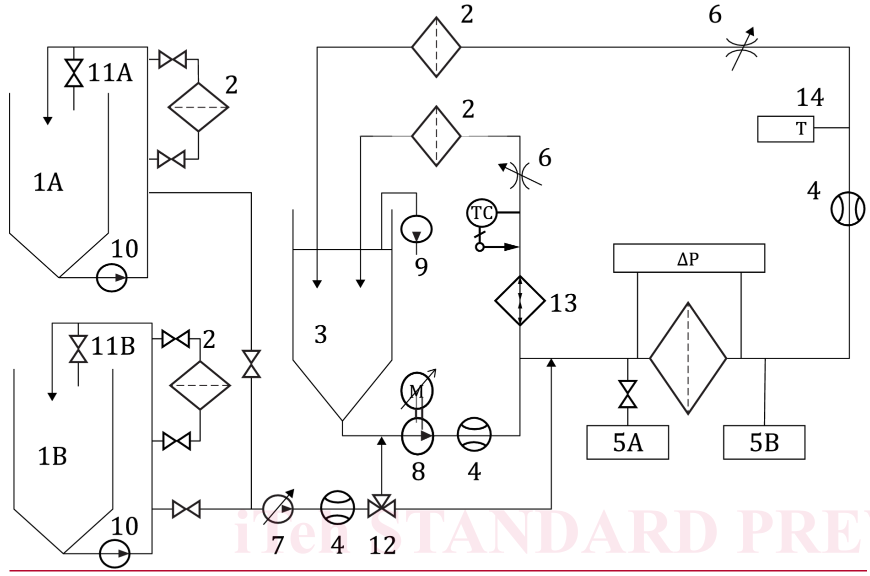
The performance of the filter to be tested is determined by measuring its hydraulic and separative properties when subjected to a constant flow rate of water conveying a known quantity of contaminant. The test is performed with the water after passage through clean-up filters to produce a single pass configuration. The test is conducted in two stages.

The first stage determines the initial efficiency of the test filter. It is conducted with a contaminant concentration of 5 mg/l upstream to the test filter for 60 ~~minutes~~ min. The second stage determines the mass of contaminant needed to reach a specified differential pressure. This stage is conducted with an upstream concentration of 800 mg/~~L~~l, or as specified according to the customer specification. The retention capacity shall be determined from the mass of contaminant required for obtaining a predetermined differential pressure of 10 kPa or other value according to customer's specifications. Several operating parameters are specified as a function of the type of filter under test, e.g. the standard flow rate of 5 l/h is recommended for testing a standard urea filter module for passenger vehicles and 25 l/h for commercial vehicles, unless otherwise specified.

~~6.2~~5.2 Test equipment and materials

~~6.2.1~~5.2.1 Test rig





Key

- 1A injection reservoir for efficiency period at 5 mg/Ll (N°1)
- 1B injection reservoir for clogging period at maximum 800 mg/Ll (N°2)
- 2 clean up filter
- 3 main reservoir (6 l)
- 4 flow meter
- 45A upstream side particle counterflow meter
- 5A upstream side particle counterdownstream side particle counter
- 5B
- 6 counter pressure control valve
- 7 injection pump
- 8 main recirculation pump
- 9 regulating level volume system
- 10 recirculation injection loop pump
- 11A injection circuit (N°1) sampling valveinjection circuit (N°2) sampling valve
- 11B
- 11B injection circuit (N°2) sampling valve
- 12 three-way valves
- 13 heat exchanger
- 14 temperature sensor

Figure 1 — Diagram of filtration efficiency and retention capacity test rig

6.2.25.2.2 5.2.2 Filter test circuit

The filter test circuit is designed to permit the recycling of the fluid being filtered. Both return line and recirculation loops are equipped with clean-up filters which retain all of the test particles that have passed through the test filter or before going back to the main reservoir (Aa filtration efficiency of 99 % at 1 µm is suitable for such clean up filters). In case of multiple usage of the test liquid, the risk of biological growth is given. Suitable control and countermeasures mustshall be implemented.

The test circuit comprises the following:

a) Aa conical bottom reservoir having a recommended cone angle less than or equal to 90°. Its volume is of 6 l. The residence time inside the reservoir shall be of 30 s and the height shall be preferably between twice and three times its diameter. Other type reservoir with other volumes ~~could~~can be used if requirements of ~~clause~~ 5.3.1.2 are fulfilled. The recycled water return line penetrates beneath the free face so as to avoid the risk of air entrainment;

b) ~~A~~a main circulation pump which ensures a constant, non-pulsed flow rate Q_r of at least twice the volume unit (when expressed in l/min) (i.e. at least 12 l/min or 720 l/h) throughout the test duration, particularly when the filter is clogged. It shall be resistant to the test contaminant by not modifying the particle size distribution;

c) ~~A~~a bypass circuit from the main recirculation loop allowing to circulate through the urea filter under test in a single pass way;

d) ~~2~~two clean-up filters dedicated to the main recirculation loop and the bypass filter test loop to restore the level of the test fluid's particulate contamination at less than 10 particles /ml >5 µm;

e) ~~Instruments~~ instruments for measuring the flow rate, the temperature, the differential pressures at the filter connections;

f) ~~Two~~ two sampling devices in accordance with ISO 4021 ~~are~~ put upstream and downstream of the filter in order to ensure representative sampling of the water and contaminant and connected to automatic particle counting devices (see 5.2.4);

g) ~~Interconnecting~~ interconnecting pipe and fittings, dimensioned and selected so as to ensure a turbulent flow throughout the whole circuit, thereby preventing the formation of traps, segregation and quiescent zones. The length of the piping shall be reduced to the minimum;

h) ~~Clean~~clean water level control device in the test reservoir, to regulate the level within 5 %;

i) ~~Temperature~~ temperature regulator to control the temperature at the specified value of (23 ~~±~~ ± 2) °C;

j) ~~All~~ all the pipes, connections, reservoirs shall be 316L INOX with the best polishing procedure available to avoid the abrasive mix of sand and water.

~~6.2.4~~5.2.3 ~~5.2.3~~ Contaminant injection circuits

There are two injection circuits; one is allocated to 5 mg/l injection (injection circuit N° 1), the other for 800 mg/l injection (injection circuit N° 2).

Each injection circuit includes the following equipment:

a) conical bottom reservoir having a recommended cone angle less than or equal to 90°. Its height is preferably between twice or three times its diameter. Other configured reservoir can be used if requirements of ~~clause~~ 5.3.1.1 are fulfilled. It is equipped with a level indicator. The recycled water returns beneath the free face;

b) recirculation pump which generates a flow rate to ensure sufficient mixing to meet the requirements in ~~section~~ 5.3. It shall be resistant to the test contaminant by not modifying the particle size distribution~~.~~;

c) temperature regulation device to control the water temperature at 23 ~~+/-~~ ± 2 °C;

d) clean-up filter, installed ~~so as~~ to by-pass the injection loop, capable of achieving a cleanliness level at less than 40 particles/ml >5 µm;

e) contaminant injection pump which draws the concentrated contaminant into the recirculation system at a point where the flow is turbulent and discharges it via a flexible pipe into the main pump suction in case of injection circuit N°1 or upstream to the urea filter in case of injection circuit N°2. There is a three-way valve to switch from injection circuit N°1 to injection circuit N°2. It shall not generate any excessive flow rate pulsation and shall have no effect on the contaminant. The injection flow rate shall be sufficient to prevent segregation of the test dust;

f) sampling device conforming to ISO 4021;

g) device for measuring the injection flow rate, insensitive to the contaminant and without effect on its particle size distribution at the concentrations scheduled for the test.

~~6.2.6~~5.2.4 ~~5.2.4~~ Automatic particle counting devices

These devices comprise one or two counters and two optical units.

These devices operate on the light extinction principle; they shall be properly calibrated using certified monosized latex spheres as per ISO 21501-3.

~~Note: Insure~~Ensure the concentration level of the particle sensors is capable of operating in the required system concentration levels.

~~6.2.8~~5.2.5 ~~5.2.5~~ Test fluid

~~Demineralized~~ The test fluid shall be demineralized and filtered water with a cleanliness level of less than 10 particles /ml >5 µm~~;~~.

NOTE ~~The fact using~~Using demineralized water will prevent ~~from~~a chemical reaction of the silica inside the injection and test circuits.

~~6.2.10~~5.2.6 ~~5.2.6~~ Test contaminant

~~Silica~~The test contaminant shall be silica test dust specified as ISO MTD.

~~6.2.12~~5.2.7 ~~5.2.7~~ Stop watch

~~6.2.14~~5.2.8 ~~5.2.8~~ Ultra clean bottles

Use thoroughly cleaned sample bottles when filled with micro-filtered water ~~(~~. The cleanliness level of the bottle ~~has to~~shall be CSC (0) as per ISO 11218~~)~~.

~~6.2.16~~5.2.9 ~~5.2.9~~ Ultra-sonic bath

The characteristics should be the following one: power of 25 W/l with an ultra-sonic frequency varying between 30 and 40 kHz.

6.45.3 5.3 Test rig validation

6.4.25.3.1 5.3.1 General

The purpose of the validation is to demonstrate that the test rig complies with the test requirements. The validation shall be carried out again whenever a component of the installation is modified or changed.

6.4.2.25.3.1.1 5.3.1.1 Validation of the injection circuits

The two injection circuits for attaining test concentrations of 5 mg/l and 800 mg/l shall be successively validated.

The validation is conducted with the maximum volume (V_{im} V_{iM}) in each tank and at the minimum flow rates for the injection circuits. Before starting, make sure that both injection reservoirs N°1 and N°2 are clean enough (initial cleanliness level of less than 40 particles /mL > ml >5 µm)).

a) Calculate the two injection circuit contamination concentrations so that the concentration in the test circuit.

C_e = 5 mg/l (injection circuit N° 1) or C_e = 800 mg/l (injection circuit N° 2):

$$C_i = \frac{QC_e}{Q_i}$$

$$C_i = \frac{QC_e}{Q_i} \quad (1)$$

(1)

where

- Q expressed in l/h
  - (circulation loop flowrate Q_r of 720 l/h (or either) in case of injection circuit N°1) or
  - (urea/DEF filter test flowrate Q in case of injection circuit N°2);
- Q_i is the minimum value of the injection flow rate, in l/h;
- C_i expressed in mg/l.

Q is the flow rate expressed in l/h:

— (circulation loop flowrate Q_r of 720 l/h (or either) in case of injection circuit N°1);

or

— (urea/DEF filter test flowrate Q in case of injection circuit N°2);

Q_i is the minimum value of the injection flow rate, in l/h;

C_i is the injection circuit contaminant concentration, in mg/l.

b) Prepare a mass M of test dust ISO MTD, previously dried at a temperature between 110 °C to 150 °C for at least 1 h and cooled to room temperature in a desiccator, to obtain the previously calculated concentration Ci:

$$M = V_{iM} C_i$$

