



Road vehicles — Smoke measurement of compression-ignition (diesel) engines — Survey of short in-service tests

Véhicules routiers — Mesure des émissions de fumée des moteurs à allumage par compression (diesel) — Étude sur les essais simplifiés en service

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ISO/TR 9310 was prepared by Technical Committee ISO/TC 22, *Road vehicles*.

This type 3 Technical Report only describes and assesses the different short in-service test methods which exist in different countries according to laws, rules or preferences. This report cannot and does not give any recommendation as to which of the methods should be used internationally.

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1 SCOPE

The purpose of this Technical Report is to describe and assess the different simplified short tests for the determination of the exhaust smoke emission of diesel engines of vehicles in service .

2 FIELD OF APPLICATION

The test methods described shall serve for checking and quantitatively evaluating the exhaust smoke emissions of passenger cars and commercial vehicles as defined in ISO 3833, and equipped with diesel engines when they are in service.

3 REFERENCES

- ISO 1585 - Road vehicles - Engine test code - Net power
- ISO 3173 - Road vehicles - Apparatus for measurements of the opacity of exhaust gas from diesel engines operating under steady state conditions
- ISO 3534 - Statistics - Vocabulary and symbols
- ISO 3833 - Road vehicles - Types - Terms and definitions
- ISO 7644 - Road vehicles - Measurement of opacity of exhaust gas from diesel-engined vehicles - Lug-down test
- ISO 7645 - Road vehicles - Measurement of opacity of exhaust gas from diesel-engined vehicles - Steady single-speed test

4 DEFINITIONS

4.1 Smoke

Visible constituents of exhaust emissions.

4.2 Comparability

The possibility of drawing conclusions on the smoke emission as it would be determined according to ISO 1585 in spite of the differing methods of quantitative evaluation of these emissions.

4.3 Repeatability

As defined in ISO 3534.

4.4 Reproducibility

As defined in ISO 3534.

4.5 Speed gradient

This term, unit s^{-2} , gives the rate of change of engine speed per unit time (revolutions per second per second). A test method approaches the steady speed conditions more closely the lower the speed gradient is.

4.6 Roadside test

Test which can be carried out with the vehicle stationary, using simple and transportable equipment.

Two levels of equipment transportability are envisaged:

- 4.6.1 Equipment readily handled by one or two persons and suitable for carrying in a passenger car.

4.6.2 Equipment which is transportable but is heavier and bulkier than as defined under subclause 4.6.1 and may require trailer or light truck for transport.

4.7 Road test

Test involving driving the vehicle on a public road or on test track.

4.8 Inspection station test

Test carried out where the equipment may be more complex and permanently installed.

5 PARAMETERS

In order to be able to evaluate the individual test methods, it is necessary to take into account those parameters which effect the applicability of the method including the precision of measurement.

5.1 Technical parameters and aspects

5.1.1 The comparability is influenced by the engine speed range,
the speed gradient and the load conditions of the engine during the test.

5.1.2 The repeatability of test results depends upon the consistency of test parameters in particular:

- Atmospheric conditions
- Engine temperature
- Duration
- Speed and speed gradient
- Load
- Experience of test personnel.

5.1.3 The reproducibility depends:

- on the scatter in the manufacturing of the test devices;
- on the experience of the test personnel.

5.1.4 The risk of damage to the vehicle, especially of the brake of the vehicle, must be included as an important aspect into the comparison considerations of the different short in-service tests. The risk of damage affects the test costs (material and personnel) (5.2.1) and the legal situation (5.2.2).

5.2 Non-technical aspects

The technical aspects are not the only items to be considered when choosing a test method but economic and legal situations also have to be taken into account.

These economic and legal situations change from one country to another and cannot be studied in detail, but some are listed below:

5.2.1 Economic situation

- Costs of investments for measuring apparatus and test equipment.
- Personnel costs (the number of personnel and level of skill).
- Amount of time for the whole test.

5.2.2 Legal situation

The two different problems have to be considered:

- Conformity of the short in-service test with regard to the national existing legal requirements.
- Definition of the liability of the test personnel in cases of damages of the vehicle.

6 LOADING OF THE DIESEL ENGINE

In order to be able to compare measured smoke values with those as determined according to ISO 1585, it is necessary when effecting short in-service tests to have full load condition during the measurement of smoke.

The table below shows the test methods according to Annex A and their loading means indicated by a cross (only the positive loading of the engine has been regarded):

Test methods	engine inertia (rotating) ¹⁾	drive line inertia (rotating) ²⁾	vehicle inertia (linear)	Engine loaded by:					force of gravity (slope gradient)
				roller inertia (rotating) ³⁾	service brakes	rolling resistance	air resistance		
free acceleration	X								
inertia controlled acceleration	X	X		X		X			
lug down					X	X			
single steady speed on rollers					X	X			
single steady speed on road					X	X	X	X	
road test on slope	X	X	X			X	X	X	

¹⁾ Including any coupled gears

²⁾ Including wheels

³⁾ Including flywheels

7 MEASURING METHODS

7.1 Exhaust sampling

7.1.1 Full flow

The whole exhaust volume is conducted through the measuring instrument. Full flow offers the greatest confidence that the measuring is representative of the whole exhaust gas flow.

7.1.2 Partial flow

A certain test volume, mostly conditioned by the type of the apparatus, is taken from the exhaust gas and conducted to the measuring instrument. For this sampling method, special conditions must be met in order to ensure that the sample measured is representative of the whole exhaust gas volume.

7.1.3 Free flow

Measuring is carried out across the exhaust plume. The application in practice is achieved relatively simply. However, due to dilution of the exhaust gas plume with air, it is very difficult to define the effective length of measurement "L" (as defined in ISO 3173), which effects the measuring results.

All three types of sampling can in theory be combined with the test methods mentioned under clause 8 but in Annex C only those measuring apparatus called for in particular published descriptions are mentioned.

7.1 Measuring instruments

7.2.1 Opacimeter

The device is meant to be according to ISO 3173. Opacimeters measure continuously and record all components of exhaust gas which lead to an impairment of visibility (4.1). Opacimeters are available with all types of sampling mentioned above.

ISO 3173 deals with steady state measurements, but some of the short in-service tests require transient measurements and in these cases the additional specifications of opacimeter response are required (electrical and physical).

7.2.2 Filter type measuring apparatus

This measuring method is based upon the evaluation of the blackening of a filter paper by the exhaust gases. To this purpose, a certain volume of exhaust gases is sucked through the filter by means of a suitable device. The evaluation of the blackening is made by photometric means.

The apparatus is suitable for measuring of black smoke (soot) and, for the time being, measuring cannot be carried out continuously.

As sampling, only partial flow (7.1.2) is feasible.

Only in the absence of lubrication oil and high concentration of hydrocarbon does a fair correlation exist in steady speed or quasi steady speed conditions between filter paper and opacity measurement.

8 TEST METHODS AND EVALUATION

The different test methods are tabled in the Annexes.

Only methods based on published proposals (see Annex K) have been taken into account.

- Annex A - Description of the test methods
- Annex B - Working conditions of the engine during the measurement
- Annex C - Loading of the engine, sampling and measuring apparatus
- Annex D - Basis for evaluation and the investments
- Annex E - Risks of damaging the vehicle during the test
- Annex F - Evaluation relative to the possibility of comparison with ISO 1585
- Annex G - Evaluation relative to repeatability
- Annex H - Evaluation relative to advantages and disadvantages
- Annex J - Application of the test methods for short in-service tests in the different countries.

Due to the fact that the results depend on:

- method of loading of the engine
- methods for sampling of exhaust gas
- measuring instruments
- smoke composition,

these results may be only compared with great caution.

9 LEGAL ASSESSMENT

Legal aspects have not been introduced in the table, because they differ from country to country.

In particular, in some countries problems exist for government test station officials driving operators' vehicles on the road or on the test tracks. Problems may also arise where a vehicle failure occurs subsequent to the test, since it may be claimed as a failure resulting from the test.