International Standard 789/4

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Agricultural tractors — Test procedures — Part 4 : Measurement of exhaust smoke

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 789/4 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*.

This second edition cancels and replaces the first edition (ISO 789/4-1982), clause 6 of which has been revised, and clause B.3 of which has been deleted, following incorporation of draft Amendment ISO 789/4/DAM 1.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Agricultural tractors — Test procedures — Part 4 : Measurement of exhaust smoke

0 Introduction

This International Standard specifies test procedures for agricultural tractors. This part of ISO 789 deals with the measurement of exhaust smoke. Other parts will be as follows :

Part 1 : Power tests.

Part 2 : Hydraulic power and lifting capacity.

Part 3 : Turning and clearance diameters.

Part 5 : Partial power p.t.o. — Non-mechanically transmitted power.

Part 6 : Centre of gravity.

Part 7 : Power and torque of drive wheels.

Part 8 : Engine air cleaner.

1 Scope and field of application

This part of ISO 789 specifies a method of measuring the smoke emitted by the engines of agricultural tractors operating at a steady speed.

2 References

ISO 789/1, *Agricultural tractors — Test procedures — Part 1 : Power tests.*

ISO 2288, *Agricultural tractors and machines — Engine test code (bench test) — Net power.*

3 Apparatus

The following apparatus is required.

3.1 Dynamometer.

3.2 Opacimeter, complying with the requirements of annex A, and installed and used as described in annex B.

4 Test conditions

4.1 Test laboratory

The temperature and atmospheric pressure in the test laboratory shall be such that the factor F, when determined from the following formula, is greater than 0,98 and less than 1,02 :

$$F = \left(\frac{750}{p}\right)^{0,65} \times \left(\frac{T}{298}\right)^{0,5}$$

where

p is the atmospheric pressure, in millimetres of mercury[1], in the test laboratory;

T is the thermodynamic temperature, expressed in kelvins, in the test laboratory.

4.2 Engine or tractor

The engine or tractor shall be submitted in good mechanical condition. The engine shall have been run in.

The engine shall be tested with the equipment fitted, as specified in ISO 789/1.

The engine settings shall be those laid down by the manufacturer and specified in ISO 789/1.

The exhaust device shall not have any orifice through which the gases emitted by the engine could be diluted.

The engine shall be in the normal working condition laid down by the manufacturer. In particular, the cooling water and the oil shall each be at the normal temperature indicated by the manufacturer.

4.3 Fuel

If possible, a reference fuel shall be used (see specification in annex C). If a reference fuel is not used, the specifications of the fuel shall be given in the same manner as in annex C. The test report shall state the type of fuel used.

1) 1 mmHg = 133,322 Pa

5 Procedure

5.1 The test may be carried out either on an engine or on a tractor.

5.2 The opacity of the exhaust smoke produced by the engine shall be measured with the engine running under 80 % of the maximum load[1] and at steady speed. Six measurements shall be made at engine speeds spaced out uniformly between

a) the speed corresponding to maximum power;

and

b) the higher of the following two speeds :

— 55 % engine speed at maximum power,

— 1 000 min^{-1}.

The extreme points of measurement shall be situated at the limits of the interval defined above.

5.3 In the case of a diesel engine which is fitted with an air pressure charger which is accompanied by an increase in the quantity of fuel injected, the measurements shall be made both with and without the air pressure charger working, if so designed.

For each engine speed, the result of the measurement shall be the higher of the two figures obtained.

5.4 For each of the six engine speeds at which the opacity is measured, the nominal gas flow rate, q, expressed in litres per second, shall be calculated by means of the formula

a) for two-stroke engines :

$$q = \frac{V \cdot n}{60}$$

b) for four-stroke engines :

$$q = \frac{V \cdot n}{120}$$

where

V is the cylinder capacity, in litres, of the engine;

n is the engine speed (rotational frequency) in minutes to the power minus one (min^{-1}).

6 Test report (see annex D)

The test report shall include the following information :

a) tractor manufacturer's name and address;

b) tractor model and serial number;

c) engine make, model and serial number;

d) measured absorption values;

e) make and type of opacimeter;

f) details of the fuel used in the test.

1) Maximum load shall be interpreted as the maximum torque at each of six relevant engine speeds.

Annex A

Characteristics of opacimeters

A.1 Basic specification

A.1.1 The gas to be measured shall be confined in an enclosure having a non-reflecting internal surface.

A.1.2 In determining the effective length of the light path through the gas, account shall be taken of the possible influence of devices protecting the light source and the photoelectric cell. This effective length shall be indicated on the instrument.

A.1.3 The indicating dial of the opacimeter shall have two measuring scales, one in absolute units of light absorption from 0 to ∞ (m^{-1}) and the other linear from 0 to 100; both scales shall range from 0 at total light flux to full scale at complete obscuration.

A.2 Construction

A.2.1 General

The design shall be such that, under steady-speed operating conditions, the smoke chamber is filled with smoke of uniform opacity.

A.2.2 Smoke chamber and opacimeter casing

A.2.2.1 The influence on the photoelectric cell of stray light due to internal reflections or diffusion effects shall be reduced to a minimum (for example by finishing internal surfaces in matt black and by a suitable general layout).

A.2.2.2 The optical characteristics shall be such that the combined effect of diffusion and reflection does not exceed one unit on the linear scale when the smoke chamber is filled with smoke having an absorption coefficient near to 1,7 m^{-1}.

A.2.3 Light source

The light source shall be an incandescent lamp with a colour temperature in the range from 2 800 to 3 250 K.

A.2.4 Receiver

A.2.4.1 The receiver shall consist of a photoelectric cell with a spectral response curve similar to the photopic curve of the human eye (maximum response in the range 550 to 570 nm, less than 4 % of the maximum response being below 430 nm and above 680 nm).

A.2.4.2 The construction of the electrical circuit, including the indicating dial, shall be such that the current output from the photoelectric cell is a linear function of the intensity of the light received over the operating temperature range of the photoelectric cell.

A.2.5 Measuring scales

A.2.5.1 The light-absorption coefficient k shall be calculated using the formula

$$\phi = \phi_0 e^{-kL}$$

where

L is the effective length of the light path through the gas to be measured;

ϕ_0 is the incident flux;

ϕ is the emergent flux.

If the effective length L of a type of opacimeter cannot be assessed directly from its geometry, the effective length L shall be determined in one of the following ways :

a) by the method specified in clause A.3;

b) by correlation with another type of opacimeter for which the effective length is known.

A.2.5.2 The relationship between the linear scale (0 to 100) and the light absorption coefficient k is given by the formula

$$k = -\frac{1}{L} \log_e \left[1 - \frac{N}{100} \right]$$

where N is a reading on the linear scale.

A.2.5.3 The indicating dial of the opacimeter shall enable an absorption coefficient of 1,7 m^{-1} to be read with an accuracy of 0,025 m^{-1}.

A.2.6 Adjusting and testing the measuring apparatus

A.2.6.1 The electrical circuit of the photoelectric cell and of the indicating dial shall be adjustable so that the pointer can be reset at zero when the light flux passes through the smoke chamber filled with clean air or through a chamber having identical characteristics.

A.2.6.2 With the lamp switched off and the electrical measuring circuit open or short-circuited, the reading on the absorption-coefficient scale shall be infinity (∞), and it shall remain at this value when the measuring circuit is reconnected.