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Agricultural tractors — Test procedures —

Part 1: Power tests for power take-off

Tracteurs agricoles — Méthodes d'essai —

Partie 1: Essais de puissance à la prise de force

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 2, *Common tests*.

This third edition cancels and replaces the second edition (ISO 789-1:1990), which has been technically revised for the technical harmonization with OECD Code 2: February 2017.

A list of all the parts in the ISO 789 series can be found on the ISO website.

Agricultural tractors — Test procedures —

Part 1:
Power tests for power take-off

1 Scope

This document specifies test procedures for determining the power available at the power take-off (PTO) on agricultural tractors of the wheeled, track-laying or semi-track-laying type.

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 500-1, *Agricultural tractors — Rear-mounted power take-off types 1, 2, 3 and 4 — Part 1: General specifications, safety requirements, dimensions for master shield and clearance zone*

ISO 500-2, *Agricultural tractors — Rear-mounted power take-off types 1, 2 and 3 — Part 2: Narrow-track tractors, dimensions for master shield and clearance zone*

ISO 500-3, *Agricultural tractors — Rear-mounted power take-off types 1, 2, 3 and 4 — Part 3: Main PTO dimensions and spline dimensions, location of PTO*

ISO 789-13:2018, *Agricultural tractors — Test procedures — Part 13: Vocabulary and specimen test report*

ISO 8759-1, *Agricultural wheeled tractors — Front-mounted equipment — Part 1: Power take-off and three-point linkage*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 789-13 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 http://www.electropedia.org/

4 Measurement units and tolerances

The following units and tolerances apply to the maximum value measured:

— rotational frequency, in revolutions per minute (r/min): ± 0,5 %;

— time, in seconds (s): ± 0,2 s;

— distance, in metres or millimetres (m or mm): ± 0,5 %;

— force, in newtons (N): ± 1 %;

— torque, in newton metres (N·m): ± 1 %;

— mass, in kilograms (kg): ± 0,5 %;

— fuel consumption, in kilograms per kilowatt hour (kg/kWh): ± 1 %;

— atmospheric pressure, in kilopascals (kPa): ± 0,2 kPa;

— temperature of fuels, etc., in degrees Celsius: ± 2 °C;

— wet and dry bulb thermometer temperature, in degrees Celsius: ± 0,5 °C.

5 General requirements

5.1 Selection

In the case of a third party performing the assessment, the tractor manufacturer and the third party shall work together to select a tractor to be submitted for testing. The tractor submitted for the test shall require a serial number, shall comply with the manufacturer's product specification, and shall be operated in accordance with the manufacturer's instructions. The manufacturer shall provide a representative to be present throughout the entire testing of the tractor.

5.2 Running-in and preliminary adjustments

5.2.1 The tractor shall be new and run-in prior to the test in accordance with the manufacturer's usual instructions. If a third party is responsible for the testing, the third party itself may run-in the tractor provided an authority of the manufacturer or the manufacturer's representative, who will remain responsible for the running-in, is obtained.

The test report shall state the place and duration of running in.

5.2.2 The adjustment of the carburettor or injection pump as well as the setting of the governor shall conform to the specifications provided by the manufacturer. The manufacturer may make adjustments in conformity with these specifications prior to testing, but adjustments shall not be made during the test.

5.3 Manufacturer's instructions

Once the test has started, the tractor shall never be operated in a way that is not in accordance with the manufacturer's published instructions in the form of an operating handbook unless specifically required by test criteria and then only by arrangement with the manufacturer.

5.4 Repairs

All repairs made during the tests shall be noted in the test report, together with comments on any practical defects or shortcomings about which there is no doubt.

5.5 Preliminary information

Specification information of the tractor consisting of the items listed in the ISO 789-13 specimen test report, as well as any further data required to carry out the tests, shall be recorded and used to set up the test.

These technical specifications shall be validated as thoroughly as possible by the entity performing the test.

5.6 Fuels and lubricants

5.6.1 Selection

Fuels and lubricants shall be selected from the range of products commercially available in the country where the equipment is tested, but shall conform to the minimum standards approved by the tractor manufacturer. If the fuel or lubricant conforms to a national or international standard, it shall be mentioned and the standard stated.

5.6.2 Measuring consumption

Measurement of fuel consumption during PTO tests is required.

The fuel measurement apparatus shall be arranged so the fuel pressure at the carburettor or the fuel injection pump is equivalent to that which exists when the tractor's fuel tank is half full. The fuel temperature shall be comparable to that which is found during full load operation for 2 h, when the fuel is taken from the tractor fuel tank.

5.6.3 Tractors equipped with diesel particulate filters

In the case of a tractor equipped with a diesel particulate filter, a regeneration of the diesel particulate filter may be performed before starting the PTO test. If the tractor initiates a regeneration of the diesel particulate filter during the test, the current test should be suspended and the regeneration should be allowed to complete before continuing the test.

5.7 Auxiliary equipment

For all tests, accessories such as the hydraulic lift pump or air compressor may only be disconnected if it is allowed in the operator's manual and is practicable for the operator to do so as normal practice in work. The accessories must be disconnected without using tools and in accordance with the operator's manual. If not, they shall remain connected and operate at minimum load.

If the tractor is equipped with devices that create variable parasitic power losses, such as a variable speed cooling fan, intermittent hydraulic or electrical demands, etc., the device shall not be disconnected or altered for test purposes. If it is practical for the operator to disconnect the device as outlined by the operator's manual, it may be disconnected for test purposes, in which case this shall be recorded in the test report.

Power variations during tests caused by these devices exceeding ± 5 % shall be recorded in the test report in terms of percent variation from the mean.

5.8 Ambient conditions

5.8.1 No corrections shall be made to the test results for the atmospheric conditions or other factors. Atmospheric pressure shall not be less than 96,6 kPa. If this is not possible because of conditions of altitude, a modified injection pump setting may have to be used, details of which will be included in the report.

5.8.2 The surrounding temperature shall be 23 ± 7 °C.

5.9 Test equipment

5.9.1 The torque and power values in the test report shall be obtained from an appropriately sized dynamometer bench without correction for losses in power transmission between the PTO and the dynamometer bench.

5.9.2 The testing equipment shall not affect the tractor's performance in any way unless otherwise specified.

5.9.3 The angle of connection of the shaft connecting the PTO to the dynamometer shall not exceed 2°.

5.10 Alternative PTO ratio

Some tractors may offer additional operation modes or alternative PTO gear ratios. These additional conditions are commonly used to increase fuel economy by generating the standard PTO speed at a lower engine speed. If the engine does have more than one operation mode or alternative PTO gear ratios, different power curves will be produced in each condition. Therefore, all PTO tests may optionally be repeated at a suitable time during the usual PTO test in each of these conditions in order to obtain the supplementary power curves.

To maintain consistency of measurement for comparison purposes, test conditions shall match those during the measurement of the equivalent points throughout the usual PTO test.

5.11 Testing rules

5.11.1 Tests shall be carried out on one or more PTOs as specified by the manufacturer on all tractors having a PTO as specified in ISO 500-1, ISO 500-2, ISO 500-3, and ISO 8759-1. The tests shall include one on a PTO capable of transmitting the full power of the engine if such a PTO is available.

5.11.2 All tractors shall be tested in the same manner regardless of whether the tractor manufacturer advertises a PTO able to transmit the full power of the engine.

5.12 Required measurements

In addition to the performance measurements required in each test below, the following shall also be measured and reported in a format recommended in ISO 789-13:2018, Annex A:

— relative air humidity;

— atmospheric pressure;

— air temperature measured at two points: one approximately 2 m in front of the tractor and approximately 1,5 m above the ground, the other at the engine air intake;

— coolant temperature at the outlet of the cylinder block or cylinder head before the thermostat or, in the case of air-cooled engines, the engine temperature at a point specified by the manufacturer;

— engine oil temperature at a suitable point in the oil flow;

— fuel temperature at a suitable point between the fuel tank pickup and the engine.

5.13 Warm-up

Prior to taking any measurements, the tractor shall be run for a sufficiently long warm-up period for power to become stabilized.

6 Test procedure

6.1 Varying engine speed at full load

Measure the power, torque, and hourly fuel consumption as a function of engine speed with the throttle lever set fully open. Begin with the engine at high idle speed and increase the PTO load in a stepwise fashion that results in a decrease of engine speed at approximately 100 min^{-1}(r/min) speed increments.

The minimum engine speeds where measurements are made shall be at least 15 % below the speed at which maximum torque occurs, or at an engine speed at least 50 % of rated engine speed, whichever speed is lower. This is subject to any limitations such as safe operation of the tractor and test equipment, or as stated by the manufacturer.

6.2 Maximum power

6.2.1 Rated engine speed

Measure the power, torque and hourly fuel consumption with the throttle lever set fully open while operating the tractor under load at rated engine speed.

6.2.2 Standard PTO speed

Measure the power, torque and hourly fuel consumption with the throttle lever set fully open while operating the tractor under load at standard PTO speed [540, 1 000, or 1 300 min^{-1}(r/min)].

6.2.3 Absolute maximum power

6.2.3.1 Measurement

Measure the power, torque and hourly fuel consumption with the throttle lever set fully open while operating the tractor continuously for one hour at the engine speed where maximum power occurs (as determined in test 6.1).

6.2.3.2 Reporting

The absolute maximum power quoted in the test report shall be the average of at least six readings made at evenly spaced intervals during the one hour period. If the power varies by more than ± 2 % from the average, the test shall be repeated. If the variation continues, report the deviation.

6.3 Variable loads

6.3.1 Rated engine speed

Measure the power, torque, engine speed and hourly fuel consumption with the throttle lever set fully open while operating the tractor with the following loads:

6.3.1.1 85 % of the torque obtained in 6.2.1;

6.3.1.2 75 % of the torque obtained in 6.3.1.1;

6.3.1.3 50 % of the torque obtained in 6.3.1.1;

6.3.1.4 25 % of the torque obtained in 6.3.1.1;

6.3.1.5 unloaded [with the dynamometer disconnected if the residual torque is greater than 5 % of the torque defined in 6.3.1.1].

6.3.2 Standard PTO speed

Measure the power, torque, engine speed and hourly fuel consumption with the throttle lever set fully open while operating the tractor with the following loads:

6.3.2.1 85 % of the torque obtained in 6.2.2;

6.3.2.2 75 % of the torque obtained in 6.3.2.1;

6.3.2.3 50 % of the torque obtained in 6.3.2.1;

6.3.2.4 25 % of the torque obtained in 6.3.2.1;

6.3.2.5 unloaded [with the dynamometer disconnected if the residual torque is greater than 5 % of the torque defined in 6.3.2.1].

6.4 Variable loads and varying engine speed

6.4.1 Five additional points for calculating fuel consumption characteristics

The power tests at the PTO serve not only to show the power available at the PTO shaft, but also to establish fuel consumption and reagent consumption (if applicable) data, which characterize the engine itself.

The following five additional points provide data to evaluate the fuel economy and reagent consumption (if applicable) for the tested tractor during various types of tractor PTO operations.

— Point 1: High power at maximum engine speed – Heavy drawbar work.

— Point 2: High power at 90 % speed – Heavy drawbar or PTO work at standard speed.

— Point 3: Low power at 90 % speed – Light drawbar or PTO work at standard speed.

— Point 4: High power at 60 % speed – Heavy drawbar or PTO work at economy PTO speeds or automatic engine speeds.

— Point 5: Low power at 60 % speed – Light drawbar or PTO work at economy PTO speeds or automatic engine speeds.

Measure the power, torque, engine speed, hourly fuel consumption, and hourly reagent consumption at the following loads that mimic the aforementioned points:

a) 80 % of power obtained in 6.2.1 with the throttle lever set fully open [point 1];

b) 80 % of power obtained in 6.2.1 with the throttle lever set to 90 % of rated engine speed [point 2];

c) 40 % of power obtained in 6.2.1 with the throttle lever set to 90 % of rated engine speed [point 3];

d) 60 % of power obtained in 6.2.1 with the throttle lever set to 60 % of rated engine speed [point 4];

e) 40 % of power obtained in 6.2.1 with the throttle lever set to 60 % of rated engine speed [point 5].

6.4.2 Tractors with regenerating particulate filters

In the case of tractors equipped with regenerating particulate filters, the following test may optionally be performed. For the varying load tests described in 6.2.1; 6.4.1 c) and 6.4.1 d), after collecting the required data for each point, a regeneration shall be initiated and allowed to complete normally. The length of the regeneration shall be recorded as well as the fuel rate observed during the regeneration.

At the conclusion of the regeneration, sufficient data shall be collected to ensure that the fuel rate has returned to the rate observed before the regeneration. The amount of fuel required for the regeneration

shall be calculated by subtracting the fuel rate observed during normal operation from the fuel rate obtained during the regeneration and then multiplying the difference by the time of the regeneration. The quantity of fuel shall be reported in the test report.

6.5 Statement of power rating

The power rating of the tractor shall be stated as the maximum power measured at a rear PTO capable of transmitting the full power of the engine. If the tractor is not fitted with a rear PTO capable of transmitting the full power of the engine, the power measured at other PTO points may be used, but shall be clearly identified in the test report.

NOTE If there are no PTO points capable of transmitting the full power of the engine, the power rating of the tractor is stated as the power measured at the drawbar (see ISO 789–9).

7 Test report

The test report shall include presentation of the following curves made for the full range of engine speeds available:

— power as a function of engine speed (with standard power take-off speed indicated);

— equivalent crankshaft torque as a function of engine speed (except for fluid transmission);

— hourly and specific fuel consumption as a function of engine speed;

— specific fuel consumption as a function of power;

— specific reagent consumption as a function of power (if applicable).

In the following conditions, the PTO power shall be reported in the recommended format of ISO 789-13:2018, Annex A:

a) rated engine speed;

b) standard PTO speed;

c) maximum power;

d) 85 % torque of rated engine speed;

e) 75 % torque of rated engine speed;

f) 50 % torque of rated engine speed;

g) 25 % torque of rated engine speed;

h) rated engine speed and no dynamometer torque;

i) 85 % torque of standard PTO speed;

j) 75 % torque of standard PTO speed;

k) 50 % torque of standard PTO speed;

l) 25 % torque of standard PTO speed;

m) standard PTO speed and no dynamometer torque;

n) 80 % of power at rated engine speed with throttle lever set fully open;

o) 80 % of power at rated engine speed with throttle lever set to 90 % of rated engine speed;

p) 40 % of power at rated engine speed with throttle lever set to 90 % of rated engine speed;