

# INTERNATIONAL STANDARD

**ISO  
789-1**

Second edition  
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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*



Reference number  
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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 789-1 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 789-1:1981): power tests for the tractor drawbar have now been transferred to ISO 789-9.

ISO 789 consists of the following parts, under the general title *Agricultural tractors — Test procedures*:

- *Part 1: Power tests for power take-off*
- *Part 2: Hydraulic power and lifting capacity*
- *Part 3: Turning and clearance diameters*
- *Part 4: Measurement of exhaust smoke*
- *Part 5: Partial power PTO — Non-mechanically transmitted power*
- *Part 6: Centre of gravity*
- *Part 7: Axle power determination*
- *Part 8: Engine air cleaner*
- *Part 9: Power tests for drawbar*

Annex A forms an integral part of this part of ISO 789. Annexes B to E are for information only.

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# Agricultural tractors — Test procedures —

## Part 1: Power tests for power take-off

### 1 Scope

This part of ISO 789 specifies test procedures for determining the power available at the power take-off (PTO), and at the belt or pulley shaft, on agricultural tractors of the wheeled, track-laying or semi-track-laying type.

The statement of the power rating of the PTO is specified in 6.3.

### 2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 789. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 789 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 500 : 1979, *Agricultural tractors — Power take-off and drawbar — Specification.*

### 3 Definitions

For the purposes of this part of ISO 789, the following definitions apply.

**3.1 rated engine speed:** Engine speed specified by the tractor manufacturer for continuous operation at full load.

**3.2 power take-off power:** Power measured at the dynamometer coupled to any shaft (with the tractor stationary) designed by the tractor manufacturer to be used as a power take-off.

NOTE — Where more than one PTO shaft is incorporated, the particulars are identified (see 6.3).

**3.3 belt power:** Power measured at the belt dynamometer.

**3.4 specific fuel consumption:** Mass of fuel consumed per unit of work.

### 4 Measurement units and permissible tolerances

The following are used in this part of ISO 789:

— rotational frequency, in revolutions per minute	± 0,5 %
— time, in seconds	± 0,2 s
— distance, in metres or millimetres	± 0,5 %
— force, in newtons	± 1 %
— torque, in newton metres	± 1 %
— mass, in kilograms	± 0,5 %
— fuel consumption, in kilograms per kilowatt hour	± 1 %
— atmospheric pressure, in kilopascals	± 0,2 kPa
— temperature of fuels, etc., in degrees Celsius	± 2 °C
— wet and dry bulb thermometer temperatures, in degrees Celsius	± 0,5 °C

### 5 General requirements

#### 5.1 Specification

The tractor tested shall conform to the specification in the test report (see annex A) and shall be used in accordance with the manufacturer's recommendations for normal operation.

#### 5.2 Running-in and preliminary adjustments

The tractor shall be run-in prior to the test. For spark-ignition engines fitted with a means for the operator to vary the ratio of the fuel/air mixture, the tests shall be carried out with the settings recommended for normal operation. The adjustment of the carburettor or the injection pump shall conform to the manufacturer's specifications. Run-in shall be done with the governor set at full throttle and with the engine operating at rated speed.

#### 5.3 Fuels and lubricants

The compression-ignition (diesel) fuel used for the test shall be CEC reference fuel CEC RF-03-A-84. For spark-ignition engines,

the test shall be carried out using CEC reference fuel CEC RF-01-A-80 for premium leaded gasoline and CEC RF-08-A-85 for premium unleaded gasoline. (See annexes B, C and D respectively.)

The lubricants used for the test shall comply with the manufacturer's specifications and be identified by trade-name, type and viscosity class. If different lubricants are used, precise information shall be given as to where they are used (engine, transmission, etc.).

If the lubricant conforms to other national or International Standards, a specific reference to these shall be given.

#### 5.4 Ancillary equipment

For all tests, accessories such as the hydraulic lift pump or air compressor may only be disconnected if it is practicable for the operator to do so as normal practice in work, in accordance with the operator's manual and without using tools. 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  $\pm 5\%$  shall be recorded in the test report in terms of percent variation from the mean.

#### 5.5 Operating conditions

Make no corrections to the measured values of torque or power for atmospheric conditions or other factors. Atmospheric pressure shall not be less than 96,6 kPa. If this is not possible because of altitude, a modified carburettor or fuel pump setting may have to be used, details of which shall be included in the report. The surrounding temperature shall be  $23\text{ }^{\circ}\text{C} \pm 7\text{ }^{\circ}\text{C}$ .

Stable operating conditions shall have been attained at each load setting before beginning test measurements.

#### 5.6 Fuel consumption

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

When consumption is measured by volume, calculate the mass of fuel per unit of work using the density corresponding to the appropriate fuel temperature. This value shall then be used to calculate the volumetric data using the fuel density at  $15\text{ }^{\circ}\text{C}$ .

Alternatively, when the consumption is measured by mass, calculate volumetric data using the fuel density (specific gravity) value at  $15\text{ }^{\circ}\text{C}$ .

## 6 Test procedure

### 6.1 Power take-off test

Tests shall be carried out at one or more PTOs as specified by the manufacturer on all tractors having a PTO as specified in ISO 500. The tests shall include one on a power take-off capable of transmitting the full power of the engine if such a PTO is available.

#### 6.1.1 General

The various tests shall normally be carried out continuously.

The angle of the connection of the shaft connecting the PTO to the dynamometer shall not exceed  $2^{\circ}$ .

If an exhaust gas discharge device for the test area is used, it shall not change the engine performance.

#### 6.1.2 Power

##### 6.1.2.1 Maximum power absolute

Operate the tractor at the engine speed where maximum power occurs for a period of 2 h subsequent to a warming-up period to reach stabilized running conditions. Measure the power, torque and fuel consumption.

The maximum power quoted in the test report shall be the average of at least six readings made at regular intervals during the 2 h period. If the power varies by more than  $\pm 2\%$  from the average, repeat the test. If the variation continues, report the deviation.

For a tractor not fitted with a PTO capable of transmitting the full power of the engine, operate it for 2 h at a power specified by the manufacturer. If possible, a 20 % increase in power shall be applied every 5 min for a period of 1 min. If the engine cannot develop the 20 % increase in power, carry out the intermittent test at full engine power. Omit the tests described in 6.1.3 and 6.1.4.

##### 6.1.2.2 Maximum power at rated engine speed (optional)

If maximum power does not occur at rated engine speed, an optional additional 1 h test should be carried out using the procedure stated in 6.1.2.1.

#### 6.1.3 Varying speed at full load

Measure the power, torque and fuel consumption as a function of speed at full power at approximately 10 % speed increments. The minimum speeds at which measurements are made shall be at the speed of maximum torque and, if possible, 15 % below that speed.

#### 6.1.4 Maximum power at standard speed

Measure the power, speed and fuel consumption at the values listed below of torque with the governor control set for maximum power, firstly, at the rated engine speed and, secondly, at the standard speed appropriate to the design of the PTO (either  $540 \text{ min}^{-1}$  or  $1\,000 \text{ min}^{-1}$ ; see ISO 500):

- a) the torque corresponding to maximum power available at rated engine speed and at standard PTO speed;
- b) 85 % of the torque obtained in a);
- c) 75 % of the torque obtained in b);
- d) 50 % of the torque obtained in b);
- e) 25 % of the torque obtained b);
- f) unloaded [with the dynamometer disconnected if the residual torque is greater than 5 % of the torque defined in b)].

#### 6.1.5 Presentation of results

The data in 6.1.1 to 6.1.4 shall be reported in tabular form for each test condition. If also presented in graphical form (which is optional), the following, covering the full range of engine speeds tested, shall be included:

- power as a function of speed;
- torque as a function of speed;
- fuel consumption (mass) and specific fuel consumption (mass) as a function of speed;
- specific fuel consumption (mass) as a function of power.

Report the no-load maximum engine speed.

#### 6.1.6 Additional measurements

In addition to the performance measurements specified above, report the following:

- ambient air temperature at a representative point: this is taken to be approximately 2 m in front or to the side of the tractor, depending upon the location of the suction or blower device on the tractor, and approximately 1,5 m above the ground. For a tractor fitted with a pusher fan, the point is approximately 2 m behind the tractor and approximately 1,5 m above the ground;
- air temperature at the engine air intake;
- atmospheric pressure;

- relative air humidity;
- maximum coolant temperature (in the case of an air-cooled engine, measure the temperature of the cylinder block at representative points);
- the fuel temperature at the inlet to the carburettor or injection pump;
- engine oil temperature.

#### 6.2 Belt or pulley shaft tests (optional)

At the manufacturer's request, the power available at the belt or pulley shaft of tractors, if fitted, may be measured.

Connect the tractor pulley to that of the dynamometer by a flexible belt having appropriate power and torque transmission characteristics. Belt slip, when calculated from the following formula, shall not exceed 2 % and the tension necessary to prevent this shall be as small as possible.

Belt slip shall be determined by the following formula:

$$\frac{100 (n_0 - n_1)}{n_0}$$

where

$n_0$  is the number of revolutions per minute of the driven pulley without slip;

$n_1$  is the number of revolutions per minute of the driven pulley under load.

All the provisions for tests at the main PTO with the exception of those at standard PTO speed and for tractors unable to transmit the full engine power at the PTO shall apply to the belt or pulley shaft.

If the rated engine speed does not correspond to a standard belt speed, measure the performance of the engine at the speed corresponding to the standard belt speed of  $15,75 \text{ m/s} \pm 0,25 \text{ m/s}$ .

#### 6.3 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).

**Annex A**  
(normative)

**Specimen test report for power take-off**

**A.1 Locations**

Tractor manufacturer's name and address: .....  
Place of running in: .....  
Duration of running in: .....

**A.2 Specification of tractor**

**Tractor**

Model: ..... Serial No.: .....

**Engine**

Make: ..... Model: .....  
Type: ..... Serial No.: .....  
Rated speed: .....  $\text{min}^{-1}$

**Cylinders**

Number: ..... Bore: ..... mm  
Stroke: ..... mm Capacity: ..... l

**Fuel and injection system**

Capacity of fuel tank: ..... l  
Make, type and model of injection pump: .....  
Manufacturer's production setting: ..... l/h  
Make, type and model of injectors: .....  
Make, type and model of magneto, coil and distributor: .....  
Make, type and model of carburettor: .....  
Ignition or injection timing (manual or automatic): .....

**Air cleaner**

Make and model: ..... Type: .....

**Precleaner (if fitted)**

Make and model: ..... Type: .....

**Cooling system**

Type: constant / intermittent (delete)  
If intermittent, mode during test: .....

**Power take-off**

Location: ..... Dimensions: ..... mm  
Type of drive: ..... Number of splines: .....  
Height above ground: ..... mm  
Speed at: .....  $\text{min}^{-1}$  Corresponding engine speed: .....  $\text{min}^{-1}$

(Repeat for each power take-off if more than one)

**Belt pulley**

Location: ..... Dimensions: ..... mm (diameter and width)  
 Type of drive: .....  
 Linear speed of pulley: ..... m/s Corresponding engine speed: ..... min<sup>-1</sup>  
 Height above ground: ..... mm Location from tractor centreline: ..... mm

**A.3 Fuel and lubricant specifications – Laboratory tests**

**Fuel**

Trade-name: ..... Octane (RON<sup>1)</sup>) No.: .....  
 Octane number or cetane index: ..... Density at 15 °C: .....  
 Type: .....

**Engine oil**

Trade-name: ..... Type: .....  
 Viscosity class: .....

**Transmission oil**

Trade-name: ..... Type: .....  
 Viscosity class: .....

**A.4 Data tests**

Date and location of test: .....  
 Type of dynamometer: .....

Power kW	Speed, min <sup>-1</sup>		Fuel consumption			
	Engine	PTO	l/h	kg/h	kg/kWh	kWh/l
Maximum power absolute (6.1.2.1)						
Rated engine speed with varying loads [6.1.2.2, 6.1.4 a)] (optional)						
a)						
b)						
c)						
d)						
e)						
f)						
Varying speed at full load (6.1.3)						
Standard speed with varying loads (6.1.4)						
a)						
b)						
c)						
d)						
e)						
f)						

1) RON: Research octane number.

No-load maximum engine speed: .....  $\text{min}^{-1}$   
Equivalent crankshaft torque ..... N·m  
Maximum equivalent crankshaft torque ..... N·m; at .....  $\text{min}^{-1}$  engine speed  
Mean atmospheric conditions:  
Temperature at air intake: ..... °C      Ambient temperature: ..... °C  
Relative humidity: ..... %      Pressure: ..... kPa  
Maximum temperature of coolant: ..... °C  
Engine oil temperature: ..... °C

NOTE — The table in A.4 may also be used with appropriate modifications to report the results of belt and belt pulley tests.

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## Annex B (informative)

### Reference fuel CEC RF-01-A-80 for spark-ignition engines — Specifications — Premium gasoline leaded

Characteristic	Limits and units	Test method
Research octane number (RON)	98 min.	ISO 5164
Relative density 15 °C/4 °C (specific gravity)	0,748 ± 0,007	ISO 3675
Reid vapour pressure	60 kPa ± 4 kPa (600 mbar ± 40 mbar)	ISO 3007
Distillation		ISO 3405
Initial boiling point	32 °C ± 8 °C	
10 % (volume)	50 °C ± 8 °C	
50 % (volume)	100 °C ± 10 °C	
90 % (volume)	160 °C ± 10 °C	
Final boiling point	195 °C ± 10 °C	
Residue	2 % (V/V) max.	
Hydrocarbon analysis		ISO 3837
— Olefins	20 % (V/V) max.	
— Aromatics	45 % (V/V) max.	
— Saturates	balance	
Oxidation stability	480 minutes min.	ISO 7536
Existent gum	4 mg/100 mm <sup>3</sup> , max.	ISO 6246
Sulfur content	0,04 % (m/m) max.	ISO 2192
Lead content	0,25 g/dm <sup>3</sup> ± 0,015 g/dm <sup>3</sup>	ISO 3830
— Nature of scavenger	motor mix	
— Nature of lead alkyl	not specified	
Carbon/hydrogen ratio	to be reported	

NOTE — The blending of CEC RF-01-A-80 shall only use conventional European base materials, and exclude unconventional components such as pyrolysis gasoline, thermally cracked material and motor benzole.