
International Standard



789/1

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Agricultural tractors — Test procedures — Part 1 : Power tests

Tracteurs agricoles — Méthodes d'essai — Partie 1 : Essais de puissance

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

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.

International Standard ISO 789/1 was developed by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, and was circulated to the member bodies in February 1979.

It has been approved by the member bodies of the following countries :

Australia	Finland	Romania
Austria	France	South Africa, Rep. of
Belgium	Germany, F.R.	Spain
Bulgaria	India	Switzerland
Canada	Italy	Turkey
Chile	Korea, Dem.P.Rep. of	United Kingdom
Czechoslovakia	New Zealand	USA
Denmark	Poland	USSR
Egypt, Arab Rep. of	Portugal	

The member body of the following country expressed disapproval of the document on technical grounds :

Sweden

This International Standard cancels and replaces ISO Recommendation R 789-1968, of which it constitutes a technical revision.

Agricultural tractors — Test procedures — Part 1 : Power tests

0 Introduction

This International Standard forms part of a series covering test procedures for agricultural tractors. Other parts in the series will be as follows :

Part 2 : Hydraulic power and lifting capacity.

Part 3 : Turning and clearance diameters.

Part 4 : Measurement of the exhaust smoke.

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

Part 6 : Centre of gravity.

Part 7 : Power and torque of the drive wheels.

Part 8 : Engine air cleaner.

1 Scope and field of application

This International Standard specifies test procedures for determining the power available at the power take-off, drawbar and belt pulley on agricultural tractors of the wheeled, track-laying or semi-tracklaying type.

It is permissible for the p.t.o. power test or the drawbar test to be applied alone or in combination.

NOTES

1 Extended runs at high power are included to check the ability of the tractor to withstand such conditions.

2 The power rating of the tractor shall be stated as the value measured at the p.t.o. In the case of a tractor not equipped with a p.t.o., the power at the drawbar can be used, providing the fact is clearly stated.

2 References

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

ISO 612, *Road vehicles — Dimensions of motor vehicles and towed vehicles — Terms and definitions.*

ISO 789/2, *Agricultural tractors — Test procedures — Part 2 : Hydraulic power and lifting capacity.*

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

ISO 3339/1, *Tractors and machinery for agriculture and forestry — Classification and terminology — Part 1: Power and tractive units.*¹⁾

ISO 3448, *Industrial liquid lubricants — ISO viscosity classification.*

3 Definitions

For the purpose of this International Standard the following definitions apply (see also ISO 3339/1) :

3.1 Track (tread)

3.1.1 track (tread) of wheeled tractor : The distance at ground level between the median planes of the wheels on the same axle, with the tractor stationary and with the wheels in position for travelling in a straight line. The track may be thus defined for both front and rear wheels. When there are twin wheels, the track is the distance between two planes each being the median plane of the pairs of wheels.

1) At present at the stage of draft.

3.1.2 track of tracklaying tractors : The distance between the median planes of the tracks.

NOTE — The median plane of the wheel or track assembly is equidistant from the two planes containing the peripheries of the rims or the track plates respectively at their outer edge.

3.2 wheel space : (See ISO 612.)

3.3 Tractor mass

3.3.1 basic tractor mass (unladen tractor) : The mass of the tractor in working order with full tanks and radiators. Optional front and rear weights (ballast), tyre ballast, the tractor operator, mounted implements, mounted equipment or any specialized components are not included.

3.3.2 ballasted tractor mass (laden tractor) : The mass of the tractor ballasted according to 5.7 for the performance test given in 6.3.

3.4 overall length : The distance between the two vertical planes at right angles to the median plane of the tractor and touching its front and rear extremities. All parts of the tractor and in particular of the components projecting at the front or rear (for example, drawbar, lower link arms, etc.) are contained between these two planes. Where adjustment of components is possible, they should be set for minimum length.

3.5 overall width : The distance between two vertical planes parallel to the median plane of the tractor, each plane touching the outermost point of the tractor on its respective side and with wheels set for minimum track. All parts of the tractor, in particular all fixed components projecting laterally (for example, wheel hubs, tyres, axle shafts) are contained between these two planes.

3.6 overall height : The distance between an impenetrable horizontal supporting surface and the horizontal plane touching the uppermost part of the tractor. All parts of the tractor, in particular all fixed components projecting upwards (for example, exhaust pipe and cab) are contained between these two planes.

3.7 rated engine speed : The engine speed specified by the tractor manufacturer for continuous operation at full load.

3.8 power take-off power : The 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 p.t.o. shaft is incorporated, the particulars shall be identified.

3.9 belt pulley power : The power measured at the dynamometer with the tractor belt pulley shaft coupled directly to the dynamometer.

3.10 drawbar power : The power measured at the drawbar which can be sustained for at least 20 seconds. At lower tractor speeds, a distance of at least 20 m shall be covered.

3.11 maximum drawbar pull : The maximum horizontal drawbar pull at a drawbar hitch point recommended by the manufacturer and complying with the limitations set forth in 5.7, 6.3.1 and 6.3.2, which a tractor can sustain in its longitudinal axis.

3.12 specific fuel consumption : The mass of fuel consumed per unit of work.

3.13 tyre rolling radius : The effective radius corresponding to the distance travelled by the tractor in one rotation of the driving wheels (i.e. this distance divided by 2π), when the tractor is driven without drawbar load at a speed of approximately 3,5 km/h.

4 Permissible measurement tolerances

4.1	Rotational frequency in revolutions per minute	$\pm 0,5 \%$	✓
4.2	Time in seconds	$\pm 0,2 \text{ s}$	
4.3	Distance in metres or millimetres	$\pm 0,5 \%$	
4.4	Force in newtons	$\pm 1,0 \%$	
4.5	Torque in newtons metres	$\pm 1,0 \%$	
4.6	Mass in kilograms	$\pm 0,5 \%$	
4.7	Fuel consumption (overall for the apparatus used)		
	— drawbar tests in kilograms	$\pm 2,0 \%$	
	— p.t.o. and belt tests in kilograms	$\pm 1,0 \%$	
4.8	Atmospheric pressure in kilopascals	$\pm 0,2 \text{ kPa}$	✓
4.9	Tyre pressure (gauge) in kilopascals	$\pm 5 \%$	
4.10	Temperature of fuels, etc. in degrees Celsius	$\pm 2 \text{ }^{\circ}\text{C}$	
4.11	Wet and dry bulb thermometers in degrees Celsius	$\pm 0,5 \text{ }^{\circ}\text{C}$	

5 General requirements

5.1 Specification

The tractor tested shall conform to the specification in the test report 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 set-

tings recommended for normal operation. The adjustment of the carburettor or the injection pump shall conform to the manufacturer's specification. The governor shall be set to give maximum power at rated engine speed.

5.3 Fuels and lubricants

The fuel and lubricants used for the test shall comply with the manufacturer's specifications. Identify fuel and lubricants in the following manner :

- a) fuels : legal name, type and grade, density at 15 °C, octane or cetane numbers;
- b) lubricants : legal name, type, viscosity class. If different lubricants are used, precise information shall be given as to where they are used (engine, transmission, etc.).

If the fuel or lubricant conforms to other national or International Standards, refer to these.

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, except as otherwise specified for a particular test. If not, they shall remain connected and operate at minimum load.

5.5 Operating conditions

Make no corrections to the measured values or 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 conditions of altitude, a modified carburettor or fuel pump setting may have to be used, details of which shall be included in the report. 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 transfer pump is equivalent to that which exists when the tractor fuel tank is half full. The fuel temperature shall be comparable to that in normal operation of the tractor when fuel is taken from the tractor fuel tank. Efforts shall be made to limit the temperature variations throughout the tests.

When consumption is measured by volume, calculate the mass of fuel per unit of work using the density corresponding to the appropriate fuel temperature.

Alternatively, when the consumption is measured by mass, calculate volumetric data in a similar manner.

5.7 Ballasting and tyre pressures

Ballast (weight) which is commercially available and approved by the manufacturer for use in agriculture may also be fitted. For wheeled tractors, liquid ballast in the tyre may also be used.

The overall static load on each tyre (including liquid ballast in the tyres and a 75 kg mass added to the tractor to represent the driver) and the inflation pressure shall be within the limits specified by the tyre manufacturer. Measure inflation pressure with the tyre valve in the lowest position.

6 Test procedure

6.1 Power take-off test

Tests shall be carried out at one or more power take-offs as specified by the manufacturer on all tractors having a power take-off (see ISO 500). They shall include a power take-off capable of transmitting the full power of the engine if such a p.t.o. is available.

6.1.1 General

The various tests shall be normally carried out continuously.

The angularity of the shaft connecting the p.t.o. to the dynamometer shall not exceed 2°.

The surrounding temperature shall be 23 ± 7 °C.

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

6.1.2 Maximum power

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

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

For a tractor not fitted with a power take off capable of transmitting 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 five minutes 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, 6.1.4 and 6.1.5.

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 % intervals of speed. The minimum speed at which measurements are made shall be at the speed at maximum torque and, if possible, 15 % below that speed. If the tractor is not fitted with a power take-off capable of transmitting full engine power or the power take-off is not mechanically connected to the engine, the test in 6.3.3 shall be carried out.

6.1.4 Maximum power at standard power take-off speed

Operate the tractor at maximum power at the standard speed appropriate to the design of the power take-off (see ISO 500). Measure the power, torque and fuel consumption.

6.1.5 Part loads

Measure the power, speed and fuel consumption at the following values of torque with the governor control set as in 6.1.2 :

- a) 85 % of the torque at maximum power;
- b) unloaded [with the dynamometer disconnected if the residual torque is greater than 5 % of the torque defined in a)];
- c) 50 % of the torque defined in a);
- d) the torque at maximum power;
- e) 25 % of the torque defined in a);
- f) 75 % of the torque defined in a).

6.1.6 Presentation of results

The above data shall be reported in tabular form for each test condition. If also presented in graphical form (optional), the following, covering the full range of engine speed 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.

6.1.7 Additional measurements

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

- ambient air temperature at a representative point approximately 2 m in front of the tractor and approximately 1,5 m above the ground (where the tractor is fitted with a forward blowing pusher fan), ambient air temperature measurements shall be made at appropriate alternative positions;
- air temperature at the engine air intake;
- atmospheric pressure;
- relative air humidity;

— maximum coolant temperature (in 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 = min^{-1} of the driven pulley without slip;

n_1 = min^{-1} of driven pulley under load.

Carry out the tests at the pulley shaft by coupling the tractor pulley directly to the dynamometer shaft.

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

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 $15,75 \pm 0,25$ m/s.

6.3 Drawbar test

6.3.1 General

Measure the drawbar performance of the tractor on one of the following surfaces :

- a) for wheeled tractors : a clean, horizontal and dry concrete or tarmacadam surface containing a minimum number of joints;
- b) for track-laying tractors : flat, dry and horizontal mown or grazed grassland or on a horizontal surface having equally good adhesion characteristics;
- c) a moving surface (rotating drum or treadmill), providing results are comparable to those obtained on the above surfaces.

State the type of surface in the report. If a rotating drum is used, report the diameter of the drum.

Do not make the tests in gears in which the forward speed exceeds the safety limits of the testing equipment.

The line of pull shall be horizontal. The height of the drawbar shall remain fixed in relation to the tractor and shall be such that the tractor can be controlled at all times during the test. For wheeled tractors, the following formula applies :

$$H_{\max} = \frac{0,8 \times W \times Z}{F}$$

where

W is the static load exerted by the front wheels on the ground, in newtons;

Z is the wheelbase, in millimetres;

F is the drawbar pull, in newtons;

H is the static height of the line of pull above the ground, in millimetres.

At the beginning of the drawbar test, the height of tyre tread bars, measured at the centre line of the tyres shall be at least 65 % of their height when new. This height shall be measured using the technique and equipment specified in annex B.

The atmospheric temperature shall be 20 ± 15 °C.

In the case of tractors having driving wheels not mechanically locked together, the revolutions of each wheel should be separately recorded and the slip calculated for each wheel. If the results for each wheel differ by more than 5 %, they should be checked and separately reported.

6.3.2 Transmission characteristic tests

Measure the maximum drawbar power at rated engine speed of the ballasted tractor (see 5.7) in each gear from the highest gear in which maximum power is limited by wheelslip of 15 % or track slip of 7 % to the gear immediately above that in which the highest maximum power is developed. A recommended number of six different speed ratios shall be used; their choice as far as possible allowing the efficiency of secondary ratio changing devices to be assessed. Also report drawbar pull, speed, wheel or track-slip, and atmospheric conditions and the fuel consumption.

For wheeled tractors, report figures up to 15 % wheelslip only. As the no slip distance will vary according to the wear of the tyres, it shall be checked regularly. For tracklaying tractors, report performance figures up to 7 % slip only but report the maximum drawbar pull as a footnote beneath the table giving the drawbar performance figures.

Slip of the driving wheels or tracks shall be determined by the following formula :

$$\frac{100 (N_1 - N_0)}{N_1}$$

where

N_1 is the sum of the revolutions of all driving wheels or tracks for a given distance of at least 50 m with slip;

N_0 is the sum of the revolutions of all driving wheels or tracks for the same distance when the tractor is driven without drawbar load at a speed of approximately 3,5 km/h.

If the tractor has a hydrokinetic torque converter which can be locked out by the driver, carry out the test both with the torque converter in operation and with it locked out.

If the tractor has a stepless variable transmission, carry out the test at six transmission ratios approximately equally spaced but including that at which maximum power is obtained. Produce tables showing drawbar power, speed, wheel or trackslip and fuel consumption as a function of drawbar pull.

6.3.3 Varying drawbar pull and speed at full load

When no power take-off test has been carried out at full engine power, the drawbar power and speed shall be measured as a function of drawbar pull at full load. Operate the tractor, ballasted as for the tests in 6.3.2, at the speed ratio giving maximum drawbar power. Increase the drawbar pull until maximum drawbar power (rated speed) is generated, and then increase the drawbar pull further, to reduce the engine speed in approximately 10 % intervals using the speed at maximum power as 100 % until either the drawbar pull reaches its maximum value, or some other limiting condition specified by the manufacturer is reached. During this test, the wheel slip shall not exceed 15 % or track slip 7 %. For each increment of drawbar pull, record speed, drawbar power, wheel or track slip, engine speed and atmospheric conditions.

If the tractor has a hydrokinetic torque converter which can be locked out by the driver, carry out the test both with the torque converter in operation and with it locked out.

If the tractor changes the speed ratio setting automatically with increasing drawbar pull, end the test at the first automatic ratio change.

6.3.4 Extended running tests

Operate the tractor, ballasted as for the tests in 6.3.2, at rated engine speed as follows :

- a) ten hours at the speed ratio giving maximum drawbar power with a drawbar pull equal to 75 % of the pull at maximum power in that speed ratio;
- b) for two hours at the same speed ratio as in a) but at maximum drawbar power;
- c) for two hours at the same speed ratio as in a), with a drawbar pull equal to 50 % of the pull at maximum power in that speed ratio;
- d) for two hours at the same speed ratio as in c) and at the same travel speed, but using a higher speed ratio and correspondingly reduced engine speed.

Report drawbar power, pull, speed, wheelslip, engine speed, fuel consumption (optional) and atmospheric conditions. Each of these periods shall be completed by a continuous run if possible. If interruptions are unavoidable due to weather, the remaining hours may be run on a separate occasion after a warming-up period to regain the stabilized running conditions, in which case the ambient conditions shall be reported for each running period.

If the tractor has a hydrokinetic torque converter which can be locked out by the driver, carry out the test with the torque converter in operation. If the limiting conditions for operation of the torque converter are reached, complete the test with the

torque converter locked out. Report the respective duration of the two parts of the test and the corresponding fuel consumptions (optional).

6.4 Engine lubricating oil consumption

Measure and report engine lubricating oil consumption during the total period of power take-off and drawbar tests including the initial tyre wearing period and any operating periods between tests. Calculate and report the mean hourly (engine hours) consumption. Report if the p.t.o. power test or the drawbar test is applied alone or in combination.

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Annex A

Specimen test report

(See 5.1)

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

Specification of tractor

Tractor

Model : Serial No. :

Engine

Make : Model :
 Type : Serial No. :
 Rated speed : 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 :

Starting system

Type :
 Safety features :

Electrical system

Voltage : V
 Battery capacity and rating : A·h at h

Generator

Make and model : Type :
 Apparent power : V·A

Transmission

Clutch
 Type : Diameter of discs : mm

Nominal travelling speeds

Gear						
Nominal travelling speed km/h*						

* At rated engine speed with tyre rolling radius of mm

Power take-off

Location : Dimensions : mm
 Type of drive : Number of splines :
 Height above ground : mm
 Speed at : min⁻¹ Corresponding engine speed : 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⁻¹
 Height above ground : mm Location from tractor centreline : mm

Drawbar

Type :
 Height above ground, maximum : mm minimum : mm
 Position relative to p.t.o. : mm

Steering

Type :
 (for example manual, power or power assisted)

Wheels

Location of steering wheels :

Steering

Make of tyres : Type :
 (for example radial or cross ply)
 Size :
 Maximum permissible load : kg Ply rating :
 Track (tread) maximum : mm Minimum : mm

Driving

Location of driving wheels :
 Make of tyres : Type :
 (for example radial or cross ply)
 Size :
 Maximum permissible load : kg Ply rating :
 Track (tread) maximum : mm Minimum : mm

Wheelbase

..... mm

Tracks

Type : Number of track plates :
 Width of track plates : mm

Masses (with tanks full but without driver)

	Front	Rear	Total
Without ballast			
With ballast			

Overall dimensions (rear track, tread, no ballast)

Length : mm Width : mm
 Height : mm

Fuel and lubricant specifications**Laboratory and drawbar tests****Fuel**

Legal name :
 Type : Density at 15 °C :
 Octane or cetane number :
 Conforms to : Standard

Engine oil

Legal name :
 Type :

Transmission oil

Legal name :
 Type :

Power take-off test

Date and location of test :
 Type of dynamometer :

Power (kW)	Speed, min ⁻¹		Fuel consumption		
	Engine	p.t.o.	l/h	kg/kWh	kWh/l
Maximum power — 2-hour test					
P.t.o. varying speed at full load					
Standard p.t.o. speed (540/1 000 min ⁻¹)					
Part loads					
a)					
b)					
c)					
d)					
e)					
f)					

No load maximum engine speed : min⁻¹
 Equivalent crankshaft torque at maximum power : N·m
 Maximum equivalent crankshaft torque : N·m
 at : min⁻¹ engine speed
 Mean atmospheric conditions : ambient temperature : °C
 temperature at air intake : °C
 pressure : kPa
 relative humidity : %
 Maximum temperature of coolant : °C
 Engine oil temperature : °C

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

Varying drawbar pull and speed

Drawbar pull, kN					
Speed, km/h					
Drawbar power, kW					
Engine speed, min ⁻¹					
Wheel or track slip					