International Standard 7464

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Earth-moving machinery — Method of test for the measurement of drawbar pull

Engins de terrassement — Méthode d'essai pour le mesurage de la traction du timon

First edition — 1983-05-15

UDC 621.878/.879 : 629.018 **Ref. No. ISO 7464-1983 (E)**

Descriptors : earth-moving equipment, drawbars, tests, definitions.

Price based on 8 pages

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.

International Standard ISO 7464 was developed by Technical Committee ISO/TC 127, *Earth-moving machinery*, and was circulated to the member bodies in December 1981.

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

Australia	Germany, F.R.	Spain
Austria	India	Sweden
Belgium	Italy	United Kingdom
Brazil	Mexico	USA
Bulgaria	Poland	USSR
Czechoslovakia	Romania	
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The member body of the following country expressed disapproval of the document on technical grounds:

Japan

Printed in Switzerland

Earth-moving machinery — Method of test for the measurement of drawbar pull

1 Scope

This International Standard specifies a test method to measure the drawbar pull performance of self-propelled earth-moving machinery and their combination with mounted or trailed equipment, with or without payload.

It covers the following criteria measured against travel speed : drawbar pull, drawbar power, and wheel or track slip.

2 Field of application

This International Standard applies to all types of self-propelled earth-moving machines except excavators.

3 Definitions

For the purposes of this International Standard, the following definitions apply :

3.1 drawbar/hitch point : The part of the test machine used for the attachment of the dynamometer car.

3.2 drawbar pull : The horizontal towing force exerted at the drawbar/hitch point, expressed in kilonewtons (kN).

3.3 drawbar power : The towing power transmitted through the hitch point, expressed in kilowatts (kW). It is calculated as the product of travel speed, in metres per second (m/s) and drawbar pull, in kilonewtons (kN).

3.4 travel speed : The actual machine velocity expressed in metres per second (m/s) or kilometres per hour (km/h).

3.5 rated engine speed : The engine speed at which the manufacturer specifies it should develop rated power, expressed in revolutions per minute (r/min).

3.6 fast idle engine speed : The engine speed when running off-load at full throttle, expressed in revolutions per minute (r/min).

3.7 test time: The time taken to cover the test distance, or duration of the test run, expressed in seconds (s).

3.8 test distance : The distance travelled by the test machine during the test time, expressed in metres (m).

3.9 wheel or track slip : The difference of drive wheel revolutions (loaded) and drive wheel revolutions (unloaded) over the same distance and expressed as a percentage of the loaded revolutions.

3.10 dynamometer car : A machine which can apply a controlled, sustained load to the machine under test. It shall provide, as a minimum, instrumentation to measure drawbar pull, actual distance travelled, drive wheel revolutions, engine output shaft speed (r/min) and time of test runs.

3.11 machine mass : The mass of the machine as tested. It shall include the operator, a full tank of fuel, and all fluid compartments at their specified level; expressed in kilograms (kg).

3.12 tyre pressure : Air pressure in the machine tyres, as tested, expressed in kilopascals (kPa).

3.13 drive wheel revolutions : The number of revolutions that the drive wheels or sprockets make for a specified test distance or time.

3.14 ambient air temperature/relative humidity: Wet bulb and dry bulb readings which are recorded during the test, expressed in degrees Celsius (°C).

3.15 barometric pressure: Measured during period of test, expressed in kilopascals (kPa).

4 Test site

The test track shall be a straight, level surface prepared to provide desired conditions of traction with a minimum of rolling resistance.

4.1 Recommended minimum length

The recommended minimum length is 100 m, with approaches of such length that speed and load can be stabilized before entering the test section. Turning areas shall be provided at both ends of the track with sufficient room for the test train to turn easily (see figure 2).

4.2 Grade

The grade shall be less than 0,5 %. If testing is conducted on a site with a grade more than 0,5 %, runs shall be taken in both directions and the results averaged.

The crown slope from centreline to shoulder shall be less than 3 %.

4.3 Surface

4.3.1 Rubber-tyred machines

For machines equipped with rubber tyres, the surface shall be, in order of preference :

4.3.1.1 Concrete

The surface shall have a uniform rough texture. It should have a minimum of expansion joints. Sealing material in the expansion joints shall be maintained flush or below the surface. It shall be dry and clean.

4.3.1.2 Bituminous

These materials are generally known as asphalt or asphaltic concrete.

4.3.2 Crawlers and steel-wheeled machines

For crawlers or steel-wheeled machines, test courses of earth shall be used. These earthen surfaces shall be well packed and substantially free of loose material. This requires a soil that is cohesive when properly moistened and compacted. Scarifying, watering, grading and compacting equipment is needed for track preparation.

4.3.3 Alternative surfaces

The test may be conducted on any other type of surface if required for specific test purposes. The nature of the surface shall be reported.

5 Apparatus

(See figure 2 for examples of apparatus used.)

5.1 Dynamometer car, or towed load, controllable to maintain within specified limits either:

a) speed of engine, shaft output of infinitely variable drive, or drive wheels of the machine being tested; or

b) drawbar pull.

It shall be capable of testing the machine to full drawbar performance without exceeding its own safe operating limits.

5.2 Means to measure and record the following :

	Accuracy
— Time	± 0,2 s
— Distance	± 0,5 %
— Pull	± 1,0 %
— Engine speed (r/min)	± 1,0 %
— Output shaft of infinitely variable drives	± 1,0 %
— Drive wheel or sprocket revolutions	± 0,5 %
— Machine mass	± 1,5 % of mass measured
— Tyre pressure	± 3,0 %
— Grouser height or tread depth	± 1,0 mm
— Temperature — Wet and dry bulb	± 1 °C
— Barometric pressure	± 0,35 kPa

6 Preparation for test

6.1 Measure and/or adjust engine performance to the manufacturer's specification on an engine or PTO dynamometer.

6.2 Carry out a service check on the machine prior to testing to ensure that :

a) all mechanical adjustments are as recommended by the manufacturer (engine speeds, brakes, clutches, etc.);

b) fuel, lubricants, and coolant are as specified by the manufacturer.

6.3 Add payload, ballast and/or attachments as required.

6.4 Adjust tyre pressures as specified by the manufacturer (see 6.8).

6.5 Weigh the machine and obtain total mass and distribution on drive wheels with the operator in position on the seat and a full fuel tank.

6.6 Connect the machine to the dynomometer car and hook up all instrumentation.

The height of the drawbar/hitch point shall be set as recommended by the manufacturer. Adjust the hitch on the dynamometer car to maintain a horizontal line of pull.

If the machine is normally used for towing, attachment shall be at the towing hitch or drawbar. Ground engaging machines such as graders or scrapers should have the load attached at a height no more than 100 mm above ground level.

6.7 Operate the test train sufficiently to determine that all systems are operating properly.

6.8 Prepare the drive tyres of a rubber-tyred machine by driving on the test track and applying a partial load (1/2 to 3/4 of maximum) while operating in first or second gear. Observe the wear pattern on the lugs of the tyres. If contact is not occurring across the full width of the tread face, lower the tyre pressure.

Caution : Do not reduce pressure below the low limit for the actual weight being carried on each tyre — see machine manufacturer's recommendations.

Tyre tread or track grouser wear should not exceed 50 % of the new lug/grouser depth.

6.9 The track tension should be adjusted to manufacturer's specification.

6.10 Determine the "free roll" or no tractive pull revolutions of the drive wheels or sprockets over a measured distance by driving the machine in the lowest gear or ratio with the engine at a low running speed, with no directional (steering) corrections, for a distance of at least 50 m.

Determine the "free roll" counts.

6.11 Record general data as shown in table 1.

7 Procedure

7.1 Prior to recording test data, the machine shall be operated until engine, transmission and final drive fluid temperatures are in the operating range.

During the test runs, the engine controls shall be set at a position where the engine develops maximum power.

7.2 While travelling the test distance in the desired gear (or ratio of infinitely variable drive) and with the towed load adjusted to maintain the average speed of engine, drive wheels or sprockets at specified revolutions per minute (r/min) for each specific test run, record :

a) drawbar pull;

b) time;

c) distance;

d) engine speed (r/min);

e) output shaft revolutions per minute (r/min) of infinitely variable drive;

f) number of revolutions of each drive axle.

As an alternative procedure, the drawbar pull for each run may be controlled and held as constant as possible. The same data are recorded.

The distance and axle revolution counters may be controlled automatically by an electronic timer. If so, the duration of each test run is determined by time rather than distance.

The time and distance of recorded test runs should be sufficient to achieve the desired accuracy. The average of two runs (one in each direction) should be used in reporting machine performance at each selected speed or pull.

There should be a minimum of steering during the recorded runs. Revolutions of the drive wheels on wheeled machines shall not vary from each other by more than 3 %. Revolutions of the drive sprockets on track machines shall not vary from each other by more than 2 %.

During any recorded run the instantaneous speed of engine or of the output shaft of infinitely variable drive shall not vary more than ± 3 % from the specified speed. The average speed for any one run shall not vary more than ± 3 % from the specified speed and the average for the two selected runs shall not vary more than 0,5 % from the specified speed.

7.3 A series of runs are taken in each gear, all at wide open (full) throttle. The load is varied from minimum to maximum until the drive system peak torque is reached or up to the point of 15 % wheel slip or 7 % track slip.

7.4 On machines with torque converters or infinitely variable drive systems, if stall pull values are to be measured, it may be necessary to add more ballast to the machine to prevent wheel slip before the stall is obtained.

7.5 Tests should be limited to travel speeds that can be safely obtained under the given conditions, usually less than 20 km/h. Extra precautions must be observed for high speed runs.

7.6 The following calculations may be made :

7.6.1 The slip, s, may be calculated, as a percentage, from the formula :

$$s = \left(1 - \frac{Nf}{R}\right) 100$$

where

N is the distance count (bike wheel);

f is the constant, the ratio of drive wheel to bike wheel count i.e. $f = r/n$,

where

r is the free roll drive wheel count, and

n is the free roll bike count;

R is the drive wheel revolution count (average of right and left).

7.6.2 The travel speed, V, may be calculated from the following formula:

$$V = \frac{Nc}{t} = \frac{dN}{nt}$$

where

N is the distance count (bike wheel);

n is the free roll bike count;

d is the free roll distance, in metres;

t is the time to travel test distance, in seconds (to the nearest 0,1 s);

c is the constant, distance per count of bike wheel i.e. $c = d/n$.

7.6.3 The drawbar power, P, is calculated from the formula :

$$P = VL$$

where L is the the drawbar pull, in kilonewtons, averaged for either time or distance.

8 Test results

8.1 Test results shall be presented as shown in the sample data sheets of tables 1 and 2.

8.2 Curves should be plotted from the results of the series of test runs. Typical curves are shown in figure 1.

8.3 The drawbar power recorded shall be the power developed at the hitch point including wheel slip; however, the measured wheel slip shall be stated.

Table 1

Recommended format for reporting results

Drawbar pull according to ISO 7464

Location: ..... Date: .....

Machine type: ..... Make: ..... Model: ..... S.N.: .....

Engine type: ..... Fuel: ..... Rated power: ..... kW

Advertised engine power, rated: ..... r/min Rated engine speed: ..... r/min

Make: ..... Model: ..... S.N.: .....

Attachments: .....

	Front	Rear	Total
Ballast:	..... kg	..... kg	..... kg
Type:	.....	.....	
Machine mass (as tested):	..... kg	..... kg	..... kg
Tyres — Size:	.....	.....	
— Ply:	.....	.....	Manufacturer: .....
— Pressures:	.....	.....	

Track width: ..... mm Grouser type: ..... Height: ..... mm

Tyre type: .....

Tread depth — New: ..... mm As tested: ..... mm % wear: .....

Test track surface: ..... Condition: .....

Hitch point height: ..... mm Wheelbase: ..... mm Track length: ..... mm

Load cell No.: ..... Calibration: ..... Calibration date: .....

Summary of test results

Gear	Drawbar max pull kN	Travel speed km/h	% Slip	Drawbar max power kW	Travel speed km/h or engine speed r/min	% Slip	Drawbar power rated speed[1] kW	Weather		
								Temperature		Barometric pressure kPa
								Wet bulb °C	Dry bulb °C	

1) Advertised engine power.

Table 2

Drawbar pull test data sheet

Page: . . . . of: . . . .
Name: . . . .
Date: . . . .

Machine: . . . . Model: . . . . S.N.: . . . .

Free roll distance, d: . . . . m Location (of test site): . . . .

Bike (free roll), n: . . . . counts Tyre lug height — new: . . . . mm
as tested: . . . . mm

Drive wheel (free roll), r: . . . . counts Design RR: . . . . mm Free roll RR: . . . .
(Rolling radius)

$f = \frac{r}{n}$ $c = \frac{d}{n}$

$1 - \frac{N}{R}(f)$ $\frac{N}{t}(c)$

Gear :

Run No.	Direc-tion	Time t, s	Engine speed E, r/min	Bike count N	Wheel count, R				Slip S, %	Speed V, m/s	Drawbar pull L, kN	Drawbar power : VL, kW	Remarks Weather, etc.
					Front		Rear						
					R	L	R	L					

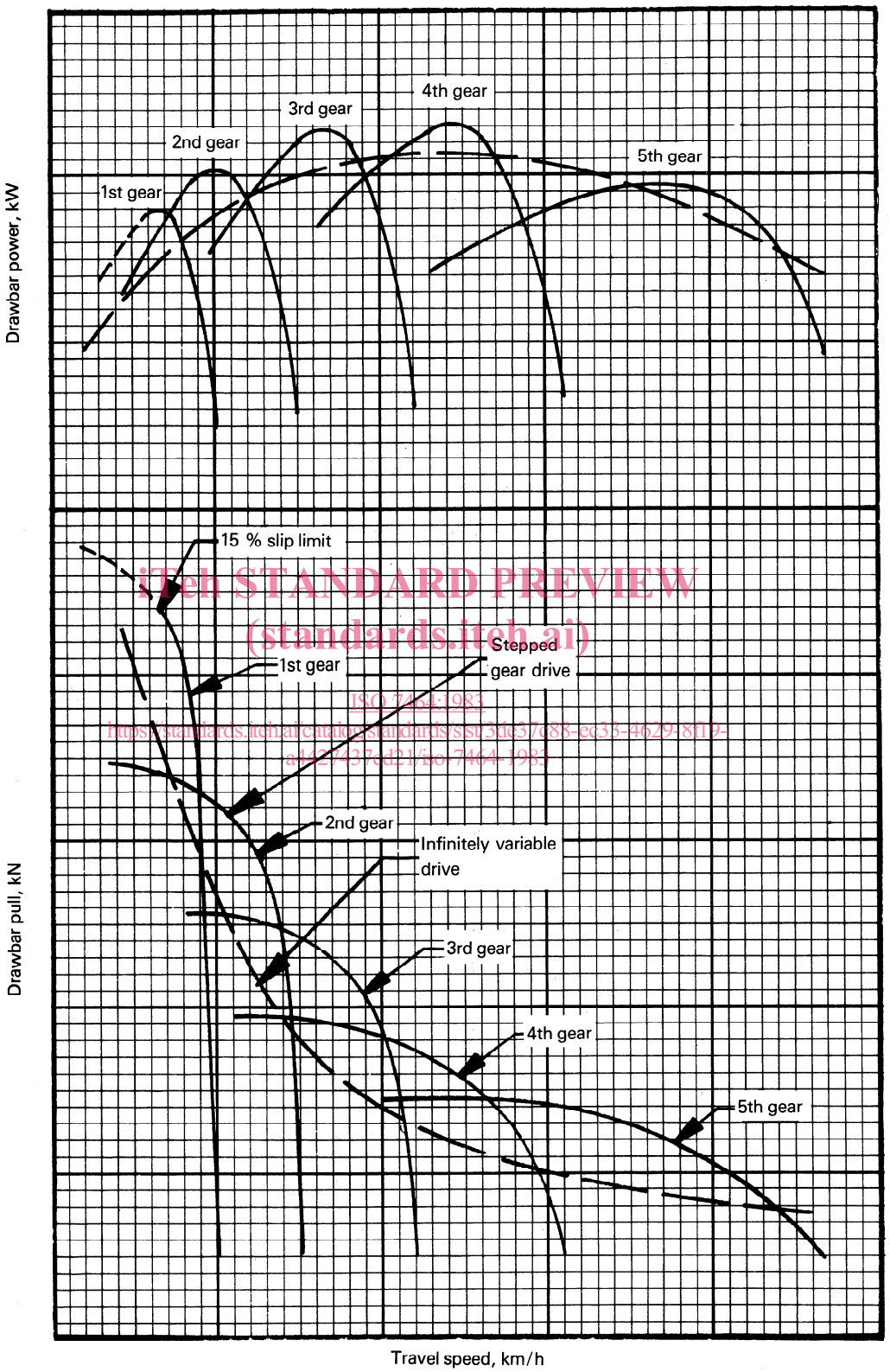

Figure 1 — Typical curves