SAE International™ SURFACE VEHICLE STANDARD

SAE J872 CAN-CELLED MAY2003

Issued 1954-12
Cancelled 2003-05

Supersedes J872 MAY1986

Drawbar Test Procedure for Construction, Forestry, and Industrial Machines

This document is equivalent to ISO 7464.

***Foreword*—**This cancelled document has been superseded by SAE J/ISO 7464.

Early versions of this report used the term "reserve tractive ability" instead of "drawbar pull performance." In the interest of harmonization with International Standard ISO 7464, the terminology was changed.

1. ***Scope*—**This SAE Standard specifies a test method to measure the drawbar pull performance of self-propelled construction, forestry, and industrial machines and their combinations with mounted and/or trailed equipment, with or without payload, as listed in SAE J1116.

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

2. ***References***

2.1 **Applicable Publications—**The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J873—Machine Drag Test Code
SAE J1116—Categories of Off-Road Self-Propelled Work Machines

2.1.2 ISO PUBLICATION—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 7464—Earthmoving Machinery—Method of test for the measurement of drawbar pull

3. ***Definitions*—**For the purpose of this SAE 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) or pounds-force (lbf).

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3.3 Drawbar Power—The towing power transmitted through the hitch point, expressed in kilowatts (kW) or horsepower (hp). It is calculated as the product of travel speed, in meters per second (m/s) or feet per second (ft/s), and drawbar pull in kilonewtons (kN) or pounds-force (lbf). The English unit product is divided by 550.

3.4 Travel Speed—The actual machine velocity expressed in meters per second (m/s) or feet per second (ft/s), or kilometers per hour (km/h) or miles per hour (mph).

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 meters (m) or feet (ft).

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) or pounds (lb).

3.12 Tire Pressure—Air pressure in the machine tires, as tested, expressed in kilopascals (kPa) or pounds per square inch (psi).

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) or degrees Fahrenheit (°F).

3.15 Barometric Pressure—Measured during period of test, expressed in kilopascals (kPa) or inches of mercury (in Hg).

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 (330 ft) 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 1).

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 centerline to shoulder shall be less than 3%.

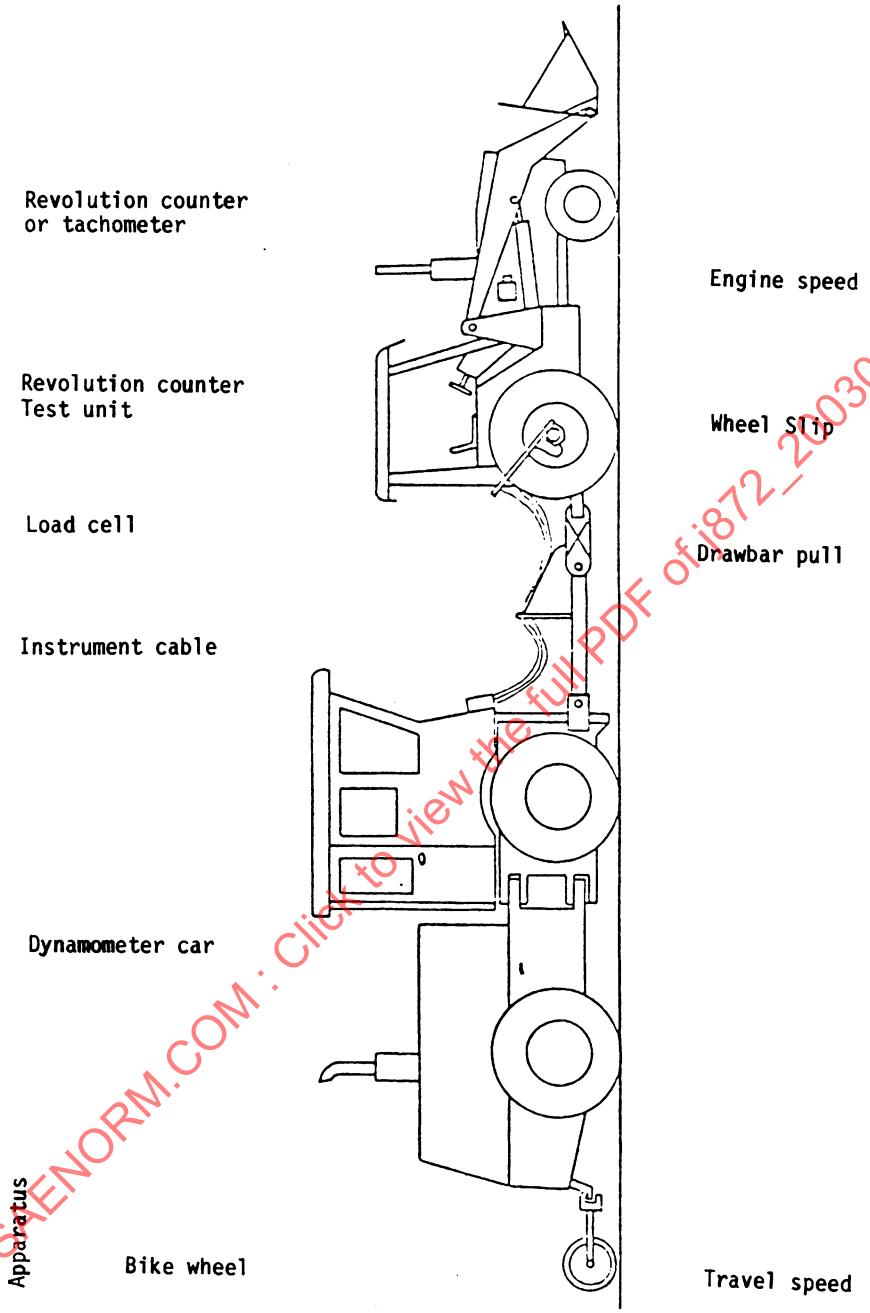

FIGURE 1—EXAMPLE OF TEST TRAIN FOR DRAWBAR PULL

4.3 Surface

4.3.1 RUBBER-TIRED MACHINE—For machines equipped with rubber tires, 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 1 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 operating limits.

5.2 Means to Measure and Record the Following:

TABLE 1—

	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
Tire pressure	±3.0%
Grouser height or tread depth	±1.0 mm (±0.04 in)
Temperature – wet and dry bulb	±1 °C (±1.8 °F)
Barometric pressure	±0.35 kPa (±1.2 in Hg)

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 tire 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 dynamometer 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 100mm (4 in) above ground level.

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

6.8 Prepare the drive tires of a rubber-tired 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 tires. If contact is not occurring across the full width of the tread face, lower the tire pressure.

CAUTION—Do not reduce pressure below the low limit for the actual weight being carried on each tire - see machine manufacturer's recommendations.

Tire 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 (165 ft).

Determine the "free roll" counts.

6.11 Record general data as shown in Figure 2.

Recommended format for reporting results

Drawbar pull according to SAE J872

Location:_____ Date:_____

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

Engine type:_____ Fuel:_____ Rated power:_____kW(hp)

Advertised engine power, rated_____r/min Rated engine speed:_____r/min

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

Attachments:_____

	Front	Rear	Total
Ballast:	_____kg(lb)	_____kg(lb)	_____kg(lb)
Type:	_____	_____	
Machine Mass (as tested)	_____kg(lb)	_____kg(lb)	_____kg(lb)

Tires

Size: _____ _____

Ply: _____ _____ Manufacturer:_____

Pressures: _____ _____

Track width:_____mm(in.) Grouser type:_____ Height:_____mm(in)

Tire type: _____

Tread depth - New:_____mm(in) As tested:_____mm(in) % wear:_____

Test track surface:_____ Condition:_____

Hitch point height:_____mm(in) Wheel base:_____mm(in) Track length:_____mm(in)

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

Summary of test results

Gear	Drawbar Max pull kN (lbf)	Travel speed km/h (mph)	% Slip	Drawbar max power kW (hp)	Travel speed km/h (mph) or engine speed r/min	% Slip	Drawbar power rated speed[1] kW (hp)	Weather		
								Temperature		Barometric pressure kPa (in. Hg)
								Wet bulb °C(°F)	Dry bulb °C(°F)	

[1] Advertised engine power.

FIGURE 2—RECOMMENDED FORMAT FOR REPORTING RESULTS—
DRAWBAR PULL ACCORDING TO SAE J872

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 (12 mph). 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:

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

where:

N=the distance count (bike wheel)
f=the constant, the ratio of drive wheel to bike wheel count, that is, f = r/n

where:

r=the free roll drive wheel count, and
n=the free roll bike count
R=the drive wheel revolution count (average of right and left).

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

$$V = \frac{Nc}{t} = \frac{dN}{nt} \text{ m/s (ft/s)} \qquad \text{(Eq. 2)}$$

where:

N=the distance count (bike wheel)
n=the free roll bike count
d=the free roll distance, in meters (feet)
t=the time to travel test distance, in seconds (to the nearest 0.1 s)
c=the constant, distance per count of bike wheel, that is, c = d/n.

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

$$P = VL \text{ kW} \qquad P = \frac{VL}{550} \text{ hp} \qquad \text{(Eq. 3)}$$

where:

L = the drawbar pull, in kilonewtons (pounds-force) averaged for either time or distance.

8. Test Results

8.1 Test results shall be presented as shown in the sample data sheets of Figure 3.

8.2 Curves should be plotted from the results of the series of test runs. Typical curves are shown in Figure 4.

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.