

# National Test of Riding Tractors in Japan

By SEIICHI ARAI

Testing Division, Institute of Agricultural Machinery

The national test of riding tractors has been carried out since 1969 as one of the major tasks of the Institute of Agricultural Machinery with an objective of promoting agricultural mechanization in Japan.

It is an important and interesting task to prepare reference data to be used for purchasing machines.

Since agricultural machines are used in various ways, mechanical testings in engineering laboratory alone is not enough in many cases. Examination under specific conditions of the region where the machine is to be used is sometimes needed.

## Testing method

Items of testing for riding tractors are as follows :

- (1) Inspection of structure.
- (2) PTO performance test.
- (3) Drawbar performance test.
- (4) Power-lift performance test.
- (5) Dust and water-proof test.
- (6) Turning test.
- (7) Brake-performance test.
- (8) Measurement of position of center of gravity and overturning angle.
- (9) Noise test.
- (10) Handling test.
- (11) Inspection of parts after disassembling.

The outlines of the main tests are presented in this report.

### 1) PTO performance test

As the power of an engine is transmitted through the PTO shaft, the PTO performance test is one of the important test for tractors.

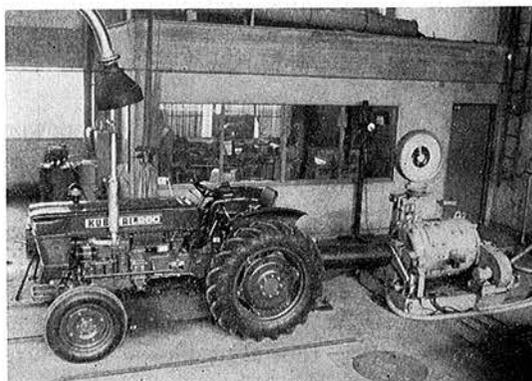


Plate 1. PTO performance test

The test consists of a loading test and a continuous running test. The PTO main shaft is usually examined at the normal driving speed for power tilling.

#### (1) Loading test

The PTO shaft is connected with a dynamometer through universal shaft. A speed control lever is fully pulled and then the load is gradually increased by the dynamometer. It simulates the plowing operation with a gradual increase in tilling depth. The engine speed gradually decreases, while the horsepower increases gradually up to its maximum. Further increase of load results in a further decrease in the engine speed until at last the engine stops. In the test, the load is increased up to 85% of the engine speed at the maximum torque.

During the running of the test, measurements necessary to draw performance curves, such as horsepower curve, torque curve and fuel consumption curve, are made. Within a range from unloaded condition to maximum horsepower, measurements are made at six different loading, i.e., a) load corresponding the

maximum horsepower, b) load corresponding 85% of torque at the maximum horsepower, c) 3/4 of b), d) 2/4 of b), e) 1/4 of b), and f) unloaded. In the range of full load, where the speed governor does not work, measurements are made, as a rule, at an interval of 200 rpm of engine speed including the standard PTO speed ( $540 \pm 5$  rpm).

#### (2) Continuous running test

Tractors are operated continuously for two hours at the maximum horsepower to examine whether a decline of horsepower or any abnormalities occur or not.

Tractors which showed the horsepower variation more than  $\pm 2\%$  of the average value during the test are not allowed to pass through the test.

The PTO test is carried out at the temperature of 15–27°C, at a point 2 m apart from the front of the tractor under test and 1.5 m high, and under the atmospheric pressure more than 725 mm Hg. No correction of horsepower for atmospheric influences is made.

#### 2) Drawbar performance test

As drawbar performance, such as drawbar horsepower at the time of operation with attached plow or harrow, or drawbar pull at the point of practical limit of slip, is an important character of tractors, the drawbar pull and horsepower are regarded as a standard indicating tractor performance.

Test for wheel-tractors (with pneumatic tires) is made on paved tracks while that for

track laying tractors is made on land after weeds are reaped.

Tractors are tested under ballasted and unballasted conditions. As a general rule, the ballasted tractors are tested at speeds starting from the lower grade up to one grade over the maximum drawbar horsepower provided that the test can be run safely. Tractors without ballast are tested at a speed at which the maximum drawbar-pull is obtained.

The tractor is connected to a dynamometer car through a tension meter. The dynamometer car adds the drawbar load to the tractor, and the drawbar pull, travelling speed, slip of wheels and fuel consumption are measured.

#### 3) Power lift performance test

As tractors are used with implements, the lifting force of the power lift device is determined.

Due to irregular layouts of small fields, tractors have to turn so often during the work, lifting attached implements. Therefore, continuous running tests are also practiced in addition to performance tests.

#### (1) Performance test

Location of the center of gravity of implements varies with kinds of implements attached to tractors: in case of pest control implements it comes to around lower link-hitch point whereas it comes far behind the hitch point in case of plows or rotary tillers. Therefore, lifting power is tested both at the hitch point and at 61 cm behind the hitch (by applying a frame to the three-point link). The hitch point or loading point of the frame is connected to a fixed testing bed through a tension meter.

For the testing, the link is adjusted so that the lifting power can be measured at the maximum and minimum lifting distance.

#### (2) Continuous running test

With links adjusted to secure the maximum lifting force, the continuous running test is repeated 1,000 times at 10-second cycle with weights hung at the hitch point.

In this test, time required for lifting the hitch point is measured with varying weight,



Plate 2. Drawbar performance test

and load weight at the maximum lifting power, calculated by the following formula or at 85% of the maximum lifting power is taken as the load weight, taking less value out of these two.

$$P=Wl/75t$$

where P: lifting power (ps)  
 W: lifting load (kg)  
 l: vertical movement of loading point (m)  
 t: lifting time (s)

Before and after the test, the hitch point is kept at the maximum position and the engine is stopped for five minutes and then the lowering distance of the hitch point is determined.

#### 4) Dust and water-proof test

Water disturbs the action of the brake and also reduces the life span of the bearing. In order to confirm whether tractors can work normally or not in submerged fields, the tractors to be tested are submerged into muddy water up to center height of the front wheels for wheeled tractor and continuous running test is carried out for 2 hr. Infiltration of muddy water to brake and bearings of axles is examined.

#### 5) Handling test

To examine compatibility of tractors with farm implements to be attached and easiness of handling, a field test is made by more than two inspectors on plowing and rotary tilling.



Plate 3. Handling test

## Summary of tractors performance

Performance of tractors made in Japan can be summarized as follows based on the results of recent national tests.

### 1) Engine

Although one cylinder engines of 14 to 15 hp were used in the past, two cylinder engines are being employed recently in order to reduce vibration or noise etc.

### 2) PTO performance

Although the number of PTO speed grade was generally one, that of tractors recently made is increased to three to four to make the tractors more adapted to various tasks and also to enable operators riding on tractors to change the speed of operation of farm implements.

Horsepower obtainable by PTO shaft is about 95% of the nominal horsepower of engine described in a commercial catalogue on an average.

Torque character of engines expressed by an elasticity of engines which is shown by the following equation is about 1.65 in an average with tractors recently made.

$$Te=TM/TpM \times NpM/NTM$$

where,  $Te$ : elasticity,  $TM$ : maximum torque,  $TpM$ : torque at maximum horsepower,  $NpM$ : engine speed at maximum horsepower,  $NTM$ : engine speed at maximum torque.

The average fuel consumption is about 235 g/ps.hr at the maximum PTO horsepower (Diesel engine).

### 3) Drawbar performance

Most tractors have 6-8 speed grades for forward drive and two for backward drive. Recently made tractors have 8 grades of forward drive.

The lowest speed is usually 1.0 to 1.5 km/hr and the highest is about 13 km/hr with engines of less than 1500 cc displacement.

The maximum drawbar performance is about 80% of the maximum PTO horsepower.

#### 4) *Power-lift performance*

Although lifting force varies with the size of tractors, the maximum lifting force at a point 61 cm behind the lower link hitch point is about 2.1 times of the weight of the rotary implement attached to the tractors in the field test.

According to the SAE standard, it is adopted that the lifting power for every horsepower of the maximum drawbar horsepower should be more than 40 lbs (18.14 kg) at a point 61 cm behind the lower hitch point, under a setting of 80% of the minimum hydraulic relief value pressure.

With recently made Japanese tractor, it is about 25 kg/ps in an average.

#### 5) *Dust and water-proof test*

As tractors made in Japan are designed to be used in submerged fields, the brake is located on a differential shaft situated higher than wheel shafts, in order not to contact with water. The sealed type or mission gear built-in system is also adopted, and a hole for brake

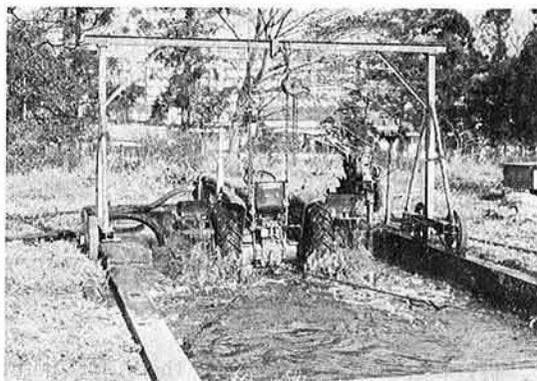


Plate 4. Dust and water-proof test

link is sealed up with a rubber ring or other materials.

The bearings of front wheels, which are often submerged in the muddy water of paddy fields, are usually equipped with a water-proof device.

After continuous running tests for two hours in muddy water, no tractor was found showing the infiltration of muddy water to brakes or shafts.

Tractors which passed through the above national tests are announced in an official gazette along with the detailed test data.