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Tractor testing in Australia. Part 2

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THE TEST PROCEDURES

AUSTRALIAN test procedures,* though differing in some details, and in some ways going further and telling more about the tractor, conform in essentials to overseas standards. The tests are in four main parts—
(a) the physical properties of the tractor;
(b) the power of the engine, and its stationary outlets—the belt and the p.t.o.;
(c) the power on the drawbar when working on a formalised test surface or track;
(d) the reliability of the tractor when running under test, and its condition after the test.

PHYSICAL PROPERTIES AND PROPORTIONS

The first thing is the identification of the tractor, from engine number to weights and dimensions; checking the fuel pump delivery, analysing the fuel used in the tests. Among the dimensions, for example, are the ground clearance, length, width and height. The position of the centre of gravity is found; turning circles are run and measured; p.t.o. speed and style are compared with international standards; so also is the linear speed of the belt.

The wheel equipment is examined, added ballast checked; the total weight and tyre pressures are checked against the weight recommended for use in the field.

If the tractor works through an automatic linkage that can continually support an implement while at work, a static test is run to decide what ballast may fairly be added to the (light weight) tractor, so as to represent in the test the weight transferred from the implement.

The seat and controls are tried for accessibility and comfort; the usefulness of the instruments is noted throughout the running of the tests.

The sum total of these critical observations, and the reporting of them are an important part of the treatment, since they represent those features of the tractor that the user is immediately concerned with. Most users are rightly more interested in these than in the power output, provided the power is enough.

But if the tractor is uncomfortable, noisy, hard to steer, awkward to handle,
inconvenient in its controls, then the user of it has to put up with a lot of hardship all the time he is on it, even though it may do his work for him.

THE POWER UNIT—DIRECT ENGINE TESTS

Since the modern tractor is in effect a mobile power plant, with a power unit—the engine—and several power outlets in the belt pulley, p.t.o., hydraulics and drawbar, it is important to know the performance of the engine itself, the source of power.

Though the power put out by any of the outlets must necessarily be less than the corresponding power of the engine, the performance of an outlet will of course reflect and correspond to the performance of the engine.

(a) Full Power at Rated Speed.

The first step therefore is to measure the performance of the engine itself. For this purpose the engine, complete with all auxiliaries and controls, is taken out of the tractor, set up on a test bed, and direct coupled to the torque dynamometer. In this way the torque* on the engine shaft, and the power output at the engine shaft (shaft horsepower, s.h.p.)** are directly measured. Maximum engine power is established by running a test for two hours, at full power (i.e., the fuel supply not restricted by the governor) at rated speed, shown at A in Fig. 1.

Note 1: Engines of the Same Model not Identical.—For any production model of engine (or tractor) the maximum power output at rated speed of the individual units cannot be exactly the same; over the whole production or stock there must be a variation, that might amount to plus or minus five per cent.—in effect a manufacturer's tolerance. Since the top value of this range can be reached only by perhaps 1 in 50 engines, to quote the top value alone is doubly misleading—it implies that all engines are alike, and all at top value.

To bring the test to realities, it is sufficient to see whether the maximum shaft h.p., found in the test just described, on the random sample, falls within the range of expected values nominated by the
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manufacturer. The manufacturer is asked, in the Conditions of Test, to nominate this range. This test therefore is in the true nature of a formal acceptance test.

Note 2: Avoid "Bare Engine" Power.—Some engine companies are apt to quote what they call brake h.p. on the bare engine, that is without fan and generator, and possibly without water pump. Since these essentials may account for 3 or 4 h.p. in a 50 h.p. engine, the value is misleading (and confusing, even if the term "bare engine" is employed to make the meaning clear).

Note 3: Avoid "Brake" H.P.—A further confusion comes from the use of "brake h.p." Brake simply means that the power is absorbed and measured on a torque brake or dynamometer, as it always is. The important thing to say is where, on the engine or its outlets, the power is measured. Hence shaft h.p. (better than flywheel h.p.) is the only proper term for this. There is no occasion for brake h.p., or for b.h.p. since this may be confused with belt h.p.; for this latter it is better to spell it out, as belt h.p.

Note 4: Rated Speed Important.—A speed of special importance in governed engines is rated speed this is the speed nominated by the maker (usually in round numbers like 1600, 1750, 2200 r.p.m.) as the recommended speed for running more or less continuously at full output. Maximum power, as a characteristic measure of governed engine performance, is only meaningful when measured and quoted at rated engine speed; its full title is "Full-power-at-rated-speed."

Note 5: Fast Idling setting of Governor.—For the purposes of formal test, it is essential to establish full, or maximum power in this way, namely at rated speed; this is so, notwithstanding the practice sometimes employed of providing a fast-idling setting in the governor that may bring the engine on to full power at above rated speed. This fairly ensures that full power is available at rated speed, perhaps with something to spare; but the procedure is not intended to take any account of the "something to spare." Equally fairly, if the fast idling setting does not yield full power at rated speed, the setting will be raised accordingly.

(b) Governed Speed Running.
At part loads, the governor takes over, allowing the speed to rise eventually—at no load—to fast idling speed. A series of tests is run, at part loads, to see how speed and fuel consumption vary under the governor. This is called running under the governor, or in the governed range, shown to the right of rated speed in the graphs of Fig. 1.

(c) Full Fuel (Full Throttle) Running.
Starting again at full load and rated speed, as the load, i.e., the torque, is still further increased, the governor keeps the fuel open, so the speed will fall, down to the lowest available speed. At about half rated speed the torque output will reach its maximum; maximum torque, and the rise in torque output from full load at rated speed are points of some interest, since they indicate "lugging" capacity.
A series of tests is run in this region of performance so as to establish the full torque characteristics, shown to the left of rated speed in Fig. 1.

(d) Part Loads, Lower Speeds: Best Economy.
By resetting the governor at a succession of lower speeds, the whole part-load performance of the engine can be traversed so as to reveal that combination of load and speed that runs at best economy, a
point of some interest when farm tasks require only a fraction of the full output of the engine.

Note 6: Fuel Consumption—Specific Fuel Consumption. Fuel consumption is measured during all of these tests; this is stated in the report in a variety of ways.

Though the simplest unit may be gallons per hour, this takes no account of load or whether the engine is doing much or little work at the time. A much better indication of fuel performance is the specific fuel consumption: this is quoted in lbs. per s.h.p.-hour, which should be low for good economy, or s.h.p.-hour/gallon, which of course should be high.

Specific fuel consumption enables us to compare the economy not only of one engine at various loads; but of one engine with another regardless of differences in type and size. How specific fuel consumption varies with power output on both governed and full throttle running is shown in Fig. 2.

![Engine Performance Graph]

**OTHER STATIONARY OUTLETS—P.T.O. AND BELT**

(a) P.T.O. Power.

When the engine has been put back into the tractor, a full power test on the p.t.o. outlet is run, i.e., with the p.t.o. direct coupled to the dynamometer, and with the governor control set to run the engine at full power at the speed required to give the specified or standard p.t.o. speed. (This engine speed may or may not be rated speed). This test is shown as the single point B in Fig. 1.

(b) Belt Power.

Similarly by coupling the belt pulley to the dynamometer by a suitable belt, a single test of full power on the belt outlet is run; again the governor control may have to be reset so as to run the engine at the speed recommended for belt work, or at the speed required to run the belt at the standard linear speed (3,100 r.p.m.). This test is shown as the single point C in Fig. 1.

Note 7: Change in Test Codes. In other testing stations, and in the Australian tests up to 31, the belt outlet was used as the only means of testing the engine. Other testing stations use, or shortly will use the p.t.o. instead of the belt outlet as the main test; if there is no p.t.o., then the engine will be tested directly on the crankshaft as described above. Clearly the trend is away from the belt outlet and towards the direct engine test as the main test in the series.

Note 8: Ambient Conditions during Test. Throughout the tests, especially the longer runs of 20 minutes, 1 hour and 2 hours, the temperature and barometric pressures of the ambient air are observed, as well as the temperature of the radiator water, and of the lubricating oil and fuel. It may be necessary to avoid testing, at any rate for the purpose of establishing maximum power, on days that are particularly hot or particularly cold. On the other hand, it would be fair to introduce a test at high air temperature, say 100° F, to see how performance may suffer in the hot weather.

**TESTS ON THE DRAWBAR**

(a) Introduction.

Drawbar power is, by definition, the product of pull and speed; in particular d.b.h.p. = Pull (lbs.) × Speed (m.p.h.) / 375. To apply a drawbar load to a tractor it is necessary only to cause it to pull something.

For test purposes the load is a special vehicle whose resistance to pulling can be varied at will (rather like applying a brake to the towed vehicle). The pull in the towbar is measured, for example by a hydraulic cylinder and pressure gauge, while speed is measured by timing the tractor over a measured course on the
test track. In any event, no statement about d.b. power and pull are meaningful unless the weight of the tractor (total and rear axle loads) and height of drawbar are also quoted.

(b) Test in each Gear.

For each gear (except the high speed road gear) in a series of runs over measured courses of 200 to 500 ft., the load is steadily increased until full engine power and rated engine speed are reached. As the pull is still further increased, the speed will fall rapidly corresponding to the full torque/speed characteristic of the engine, until a maximum sustained pull is reached, corresponding to maximum torque in the engine.

These characteristics of d.b.h.p. are shown in Fig. 3 for the several gears (above the low gears mentioned below) by the sloping lines leading to the peaks, followed by the hooks down to and past the maximum sustained pulls.

(c) Maximum d.b.h.p. defined by Rated Gear.

Although these peaks of d.b.h.p. in the various gears may not be equal in value, it is the peak in rated gear that defines, for the tractor, the maximum d.b.h.p. where rated gear corresponds to the speed of heavy farm work, e.g., ploughing, at about 3 m.p.h.

It will be noted that maximum d.b.h.p. will be less than maximum engine power: naturally, because of the losses in the transmission and in the wheels, including slip: point D in Fig 1 and in Fig 3.

(d) Low Gear Output limited by Slip.

An exception to this behaviour will (usually, i.e., unless the tractor is specially and improperly heavily weighted for the purpose of the test) appear in the low gear or gears, where the heavy pulls cause the wheels to fail by slip before the engine is fully loaded; in those circumstances neither full engine power, nor full d.b. power is reached. This situation is shown by the low gear curve in Fig. 3. Nevertheless, it is usual for the pull at the "hill" of this curve to be higher than the pulls available in the higher gears.

(e) Ten-hour Test.

Rated gear is then chosen for a much longer run—the 10-hour test, still on the test track. In the original Nebraska tests, this run of 10 hours was done under a fairly high drawbar pull—three quarters of maximum for the rated gear. The idea was to see whether the tractors could run continuously for that long—many of them failed to do so.
The Australian test splits it up into 4 x 2½-hr. sessions, the sessions being run at four different loads from nearly full load down to below half load. Clearly, in modern tractors, this arrangement does not particularly look for failure in 10 hours of running, but gives values of fuel consumption at a variety of likely loads on 2½-hr. runs.

![Diagram of DBHP vs. Slip on test track and field](image)

**Fig. 4.—Typical Difference between Test Track and Field.**

**Note 9: Warning on Drawbar Values.**—Performance on field soils, unless they are hard and dry like the test track, will be different from the performance measured in the test: pulls will be less and slip more. Fig. 4 suggests the sort of differences in pull, slip and d.b.h.p. that might arise in a given gear on some unspecified soil.

**RELIABILITY DURING TEST: FINAL INSPECTION**

Before the test is started, the tractor, being new, is given the usual pre-sale checks and treatment such as the vendor is supposed to give for the purchaser; and being new, the tractor is run-in for an arbitrary period of 12 hours before applying the formal tests.

Defects and mishaps that occur at any time during the tests, requiring adjustments or replacement of parts, are of course corrected and noted in the record.

New oil is charged to the engine after run-in, and drained out at the end of tests, the weight of oil at start and finish being noted. Similarly the weight of cooling water added during the tests is noted.

The total time of running is added up from the daily logs; in an average test this would amount to 50 or 60 hours, including run-in.

After the tests, the tractor is partly stripped down: the engine head and sump removed, valves and pistons withdrawn, transmission covers taken off, so that any obvious signs of undue wear or overheating can be detected after so many hours of running.

**TEST REPORT**

The whole series of events is recorded in a formal report which would show in tables the full power values on the crankshaft and at the outlets, as well as the performance shown in the graphs of Figs. 1, 2 and 3, and other graphs also. As well as giving a brief specification of the tractor the report will state the manufacturer's expected range of values for full engine power for this model.

While the information on the properties and proportions of the tractor, and on the tests of the engine and its stationary outlets, will need no particular interpretation (they will behave the same way in general use), tests on the drawbar must be interpreted in the light of Fig. 4 and Note 9.

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