A Quick View of Chassis Dynamometer Testing

BY **HAROLD BETTES** PHOTOS BY **ROB KELLY**

Chassis dynamometers are very popular to run some quick tests for installed power and check out the chassis and drivetrain. They are quick to use but have some problems that should be made clear before you start down that direction. If you plan on testing a few sets of exhaust components or any bolt-on parts that might take more time than if the testing was done on an engine dyno, so do some planning and think about what you want to accomplish.

Chassis dynamometers come in all sorts of designs and configurations but there are some things that are common to all. Most designs test a vehicle that powers a roll or rolls for all wheel drive types. Most can provide some common numbers for horsepower but not all measure torque to do so. Basically there are two general types of chassis dynos – inertia only and those that measure torque with either an electric load or even a mechanical brake. All have to get rid of the heat from the vehicle and the dyno as well.

Terms of Engagement

Such terms as torque, horsepower, speed, roll speed, dyno inertia, heat load, power capacity, speed capacity, and many others can easily roll off of the tongue or rattle from a keyboard. It takes a bit more to understand what all those things mean. Lest this short article end up being something from a text book, let's stay with the quick and easy method.

Dyno Inertia – Can be all over the map for values and most are poorly defined and too many are listed in pounds. Although that is not technically correct it refers to a weight that should equate to a vehicle weight. The inertia only types measure the time that a supposedly known mass is accelerated by the test vehicle in order to calculate horsepower and because there is a speed signal the torque value is back calculated from the horsepower number the dyno provides. The difficulty here is the units cannot be calibrated easily to establish their inertia values which are typically in units of ft-lbs/sec/sec. So it is easy to understand that if you can't verify the calibration, you might get nicely repeatable data but perhaps more or less than another test facility. Normally in those circumstances the place that gives bigger numbers is the most popular test location.

Torque – Torque is a twisting motion and is typically expressed in lbs-ft. Notice this is not ft-lbs! Although everyone commonly uses incorrect units for description of this very important item, the proper reference is indeed pounds-feet (lbs-ft).

Horsepower – 1 horsepower is equivalent to 2546 BTU/hr or 550 ft-lbs of work per second. The most interesting is from the calculation of Hp= (T x RPM) / 5252 and in that equation the torque value is in lbs-ft as described previously.

Speed – Most common references in the US for speed is miles per hour (MPH). Speed can also be in feet per second such as 88 ft/sec = 60 MPH.

Roll Speed – Refers to the speed of the roll(s) on the chassis dynamometer and can be directly related to the vehicle speed or simply given as roll RPM. Because of the friendly relationship of round things to π or 3.1416, it is easy to calculate the circumference of the roll by measuring the diameter and multiplying that by π. That gives us the opportunity to verify some dyno basics.

Heat Load – Is not the number of cops per city block. The term has to do with the heat that the test vehicle and the dyno must dissipate to the atmosphere or the room the dyno and vehicle are in. In short it takes a lot of moving air to keep the overall packages cooled down. Normally you never consider that as you drive along at various speeds the moving air carries heat away and you can enjoy the scenery. Or if your cooling system is overloaded from traffic being slow it might cause the engine to overheat. At high power levels the heat load increases hence the requirement for a very large fan or maybe more. That is why most popular chassis dyno tests are just quick spurts that make it easier on the whole operation. By the way a normal expression for a heat load is in BTUs (British Thermal Units) per time. In order to put this in perspective, if you wanted to test a vehicle that might produce 500Hp at the drive wheels, that would easily be a total heat load of approximately 1500Hp (3.8 million BTUs per hour!) that must be dissipated into the atmosphere from the cooling system of the vehicle and the drivetrain, exhaust system and the tire patches and the dyno itself. Of course that varies somewhat by how much you allow the temperature across the room to rise. Perhaps this stuff is a little more complex than you thought.

Speed Capacity – Often a mechanical limit set by the manufacturer such as 150MPH or some other number that should not be exceeded for safety's sake.

Power Capacity – Also a number set by the manufacturer that is fundamental to the capability of the drive tires. This capacity number is quite often higher than most vehicles can even contest. The term is also normally associated with a speed such as 500 Hp at 120 MPH or something similar.

The Salesman Said – Is often confused by what the specifications for a given unit state. When in doubt, look at the specifications and ask questions if the information is not clear. Normally the operator is a good source for quality information because of his or her experience running vehicles across their chassis dyno every day or at least several times a week.

Typical testing for improving the tune up on grocery getters is a normal application for chassis dynos. This photo shows an AWD Subaru wagon undergoing a power test.

Planning a Test

You need to be very practical when you do planning for any kind of dyno test but particularly when you are going for a chassis dyno session. Not only does the vehicle need to be up to safety standards, but many other things need to be addressed if you are to get the most from the time and money spent.

How many tests can you get done before you need to stop and cool off the vehicle?
Depends on how the test facility is equipped for airflow across the vehicle and other things, including how the exhaust gases are handled which can drastically influence the test results.

How long does each test take?
Depends on the type of test and the capability of the dyno and the facility. Sometimes, it's only a few minutes per run. A simple acceleration test typically takes the least amount of time. Acceleration tests going from about 40mph to 120mph are the most common and each run will only take about 15 seconds (not including the coast down time to stop the rolls). It is common to get the rolls up to speed and the vehicle in high gear before a test begins. Another common test is at a fixed speed (using a dyno that has variable load capacity) such as 60mph in high gear and the operator stabilizes the speed and at the signal to go the throttle pedal is pushed to maximum until the test is terminated. That type of test yields the power at whatever engine RPM is equal to the set speed (60mph in this example). Those type tests can take up to about 10-15seconds per data point (such as 60, 70, 80, 90, 100, 110, 120mph) in order to get a completed power curve vs speed or RPM. Some dyno manufacturers do not have reliable engine RPM triggering and if that is the case, Vehicle speed vs Power is a test that can be done. With some simple arithmetic after the test the customer can calculate the engine RPM and graph the results.

How much do chassis dyno tests cost?
Depends on the facility and the services offered. Charges are all over the map and ranges from 3 runs for a $100 to $1000 per day. Work this all out before you go to a facility to test.

Who does the work or changes on a vehicle between tests?
Better figure that one out before you go to the test site because many facilities have problems with insurance rules and might not even allow the vehicle owner in the car or in the test room much less to work on the car or truck.

What is best for an engine builder chassis or engine dyno testing?
Most engine builders that don't already have a dyno would prefer working out engine configurations and tuning on an engine dyno. The engine is more accessible and it is generally easier to work with an engine dyno facility to accomplish the tests that an engine builder would want to do.

Some engine builders do both tests (engine dyno and chassis dyno) if a customer has the money and patience. Those tests can provide some impressive data and allow focusing on how much power the chassis loses so more effort can be put to resolving some of those losses.

E85 – E15 – pump gas – race gas and air –fuel ratio data? Most engine dyno facilities are better equipped for changing fuel and supplying data for A/F ratios however many chassis dyno test sites can simply do the test without supplying data on fuel tune-ups unless they are equipped with an up the tail pipe sampler for Lambda or A/F numbers.

What data is more reliable for testing components – chassis or engine dyno?
Each can be reliable but generally the conditions in the engine dyno test cell are easier to control so the results are

CHASSIS DYNAMOMETER TESTING

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This muscle Mustang is on a large roll dyno about to be tested. The Mustang is on a lift so the dyno can be mounted above floor line. The dyno uses an eddy current power absorber in between the drive rolls. Large rolls are better for either high power or for endurance testing. The fan shown is for short tests only. Longer tests require lots of airflow.

likewise. However for that installed condition the chassis dyno is quicker and easier for a completed assembly. The best case would be to test on an engine dyno and then on a chassis dyno so that the user could evaluate the losses in the chassis (nothing is for free) and verify other details about the engine installation such as fuel supply and cooling system and exhaust system influences. Exhaust gas feedback might be more of a problem in a chassis dyno test if the airflow across the dyno is not adequate. That would change test results without much indication.

How much power is lost in the chassis?

How to calculate the engine power if a chassis dyno gives power at the drive tire patches? Chassis power losses depend on many things but it is assured that there are losses through the drivetrain and the tire patches themselves. Good manual transmission chassis setups might use over 60Hp to get to the drive tires at a given speed and temperature (of the oil in the trans and drive axle(s). Automatic transmissions with drag race type high stall converters might lose over 100 Hp at the same data point. It is not sensible to plan on some set percentage as a loss in the drivetrain even though some chassis dyno manufacturers do that anyway. It does make the arithmetic easier but it does not make it correct. There are many ways to get a good estimate of the power losses but it is best to have good data from an engine test and then find out what is left at the drive tire(s). The power losses in the chassis are not the same across the board. The power losses vary with both speed and temperature of the lubrication fluids.

How about finding problems on a chassis dyno to keep from driving the vehicle around?

That is one of the better things about chassis dyno testing because it provides an opportunity to evaluate a vehicle without the attendant problems of liability to the mechanic or repair technician because "test driving" is done in a more controlled condition and there is no traffic to cause problems. No traffic that is unless one considers getting the vehicle to and from the test facility. It is also a plus to test on the chassis dyno even if the weather outside is nasty. So facilities that have test and repair technicians on hand can be very helpful in solving vehicle problems without driving in the traffic to attempt to analyze a particular problem. Probably works well for anything except for road rattles.

How about safety issues on chassis dynos?

Testing on a chassis dyno is normally fairly safe if the vehicle is restrained properly. That problem is best addressed by the facility and the instructions provided by the manufacturers. There needs to be fire extinguishing equipment available and care should be taken for the potential of a drive shaft breaking or a tire shredding and those sorts of things but that should also be discussed with the test facility before you show up for a test. Safety on the chassis dyno – Properly restraining the vehicle should be addressed by the manufacturers, but it is also important to mention that the process of tying the vehicle down with straps or chains could also affect the results of the tests accomplished on the rolls. Tire inflation variations can even cause differences in test results.

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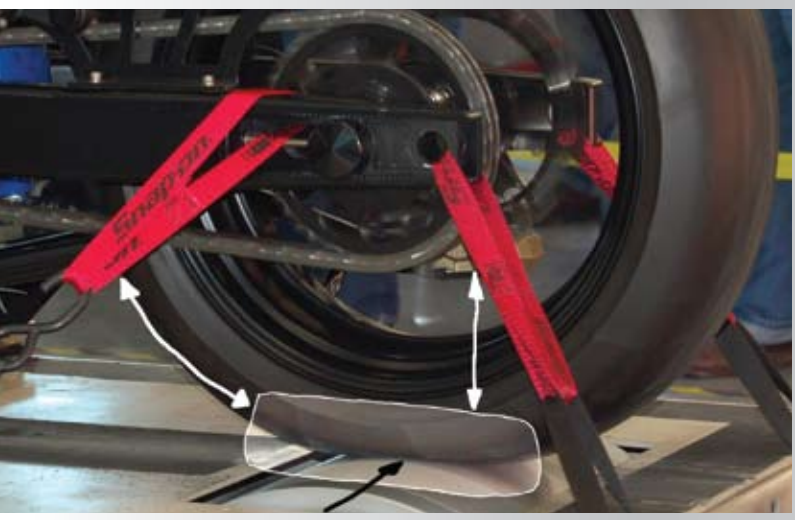
This turbocharged Mustang engine is easier to access because the hood is removed on this race car. Simple changes can be made but if something more serious is necessary the vehicle will have to be removed from the dyno. Chassis dynos allow quick testing but engine folks normally prefer engine dynos.

This radial drag racing tire is about to be one of the tire patches that powers the drive rolls. This dyno is about to get a surprise from this turbocharged Ford Mustang.

One of the radial drag tires with distortion showing at over 1000Hp at 120mph on the dyno. This clearly shows one of many reasons why the tie-down process is important. This dyno uses "cradle style" rolls. The tire is one of many loss points in the chassis dyno test making it difficult to accurately calculate how much horsepower was at the flywheel of the engine.

LEFT: Hot rod Mazda with twin turbos is on the chassis dyno to verify tune-up work without the liability of test driving on the streets. Technician on the right has command of the dyno and communicates with the driver during the test.

BELOW: The handheld controller on this AWD chassis dyno allows the operator to command all sorts of things including changing the wheelbase. The dyno can be commanded inside or outside the vehicle being tested.



LEFT: This motorcycle tire is distorted at the roll contact point (black arrow) and the tie-downs (white arrows) help to distort the tire as a result of how much tension is in the tie-down straps. Even tire inflation pressure affects the tire and roll interface. This is an inertia only dyno. Read the text for definitions.

Conclusions and Comments

Engine combinations tested on a chassis dyno can be done rapidly and data can be evaluated quickly as well. However reliable test data is dependent on many things that any engine builder or vehicle owner should acknowledge and be willing to accept so that they each can learn from the experiences.

Regardless of the assumptions that one might make, testing will help the learning process if the variables that have an effect on testing are also evaluated.

Engine people tend to concentrate on the engine results obtained from testing on an engine dyno but much can be gained by evaluating the chassis dyno test results. After all the engine normally is installed in a chassis in order to use the power unless the engine is applied to a generator or an aircraft or boat or something of that sort.

The power numbers that are the most reliable from chassis dyno are those that are referenced to the drive tire patches. Trying to generate estimated numbers that relate to the flywheel power is more often than not a boondoggle and result in inflated claims. When folks start tossing around percentages such as "everybody knows the drivetrain takes 15%" in order to say what the engine produced at the flywheel be careful. That is much like the politician that states, "I am going to watch out for you and your money…" and we all know how that stuff works out.

Read all you can get your hands on and study how dynamometers work and strive to understand where the numbers come from.

Remember that everyone has a vehicle that makes at least 500Hp until it is accurately tested that is!■

Harold Bettes is co-author of Dyno Testing and Tuning and author of The Engine Airflow Handbook. Harold has been a mechanical engineer for over 40 years and has been involved in motorsports for more than half a century. Harold Bettes is a recipient of many awards for his contributions in furthering mechanical engineering, the motorsports industry and the aftermarket. Bettes is widely acknowledged for his expertise concerning dynamometer and flow bench applications. Harold is a consultant on test facilities, equipment and high performance engine designs and configurations and his personal contact information is in the black book of many engine developers, and team owners.