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TECH

Fine Dyno'ing

All Chassis Dynos Are Not Created Equal

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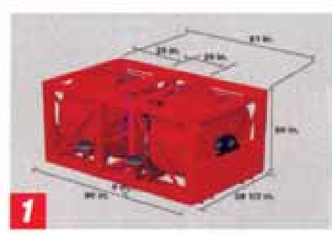


1 With the covers off, this is what the Dynojet's internals look like. Note the individual large-diameter drums.

It's been said that a man with a watch always knows the correct time, but a man with two watches is never really sure. Unfortunately, there are no proverbs about a man with two dynos knowing how much power his car really makes. In this article, we'll examine two popular chassis dynamometers and explain why each will give us a different rear-wheel horsepower for the same engine. We test both the Dynojet model 248 chassis dyno located at Strope's Speed Shop in Washington, Pennsylvania, and the MD-250 Mustang chassis dyno located at Speed Nation in McDonald, Pennsylvania. We also performed testing at Keystone Raceway in New Alexandria, Pennsylvania, using a dyno system from West Automotive Performance Engineering.

Dynojet

The Dynojet chassis dyno is referred to as an inertial-type dynamometer, because large drums provide an inertial load to the drivetrain instead of a friction-brake. The working end of the Dynojet includes two 48-inch diameter drums that are mostly below the surface and driven by the vehicle's drive wheels. In the photos of the Dynojet, notice how the rear wheels are centered on the drums and there is one drum per wheel. This will become important later.

The vehicle is typically run in the transmission gear closest to 1:1 (Fourth gear for manuals and Third gear for automatics) to provide the most efficient drivetrain setup. The inertia of the large drums loads the drivetrain. The Dynojet software measures the horsepower applied to the drums and calculates torque from engine rpm via an inductive probe. The Dynojet provides both the torque and horsepower curves versus engine rpm. This unit also has an air brake that can be configured to provide a constant load >>

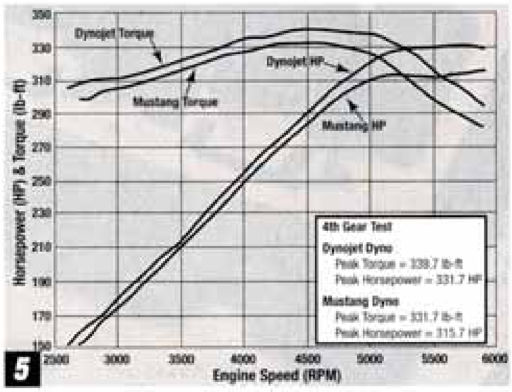
2 Here's our Camaro test platform on the Dynojet at Strope's Speed Shop.

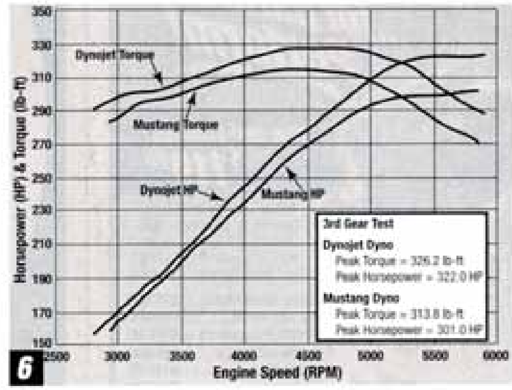
3 This is the Mustang dyno at Speed Nation. Note that the Mustang dyno uses a pair of smaller rollers versus larger single drums used by the Dynojet.

4 Here's the inside look at the internals of the Mustang dyno at Speed Nation.

5 These are the horsepower and torque curves versus rpm in Fourth gear for both the Dynojet and the Mustang chassis dynos.

6 These are the same horsepower and torque versus rpm curves but tested in Third gear for both dynos.





or a variable load that maintains a preset engine rpm or vehicle speed. This feature is ideal for forcing the vehicle to operate at certain loads for tuning. The Dynojet can also measure air/fuel ratio while testing.

Mustang

The Mustang chassis dyno uses an inertia load as well as an eddy-current brake load to simulate the "actual" load (combined aerodynamic plus rolling frictional load) that the vehicle would experience when in motion. Notice in the photos how the rear wheels sit between two smaller 10.7-inch-diameter rollers. There has been some discussion about the tires getting "pinched" between the rollers and creating more rolling friction, but no substantial evidence of this could be found. However, Mustang has a dyno (MD-1750) with a single 50-inch-diameter roller per wheel that alleviates the wheel-pinch concerns. The internals of the Mustang dyno are composed of an eddy-current brake to provide a variable load and an inertial disc to provide a fixed load. Mustang claims because its dyno loads the vehicle as it would be on the road, you can perform 0-60 mph, 0-100 mph, and quarter-mile measurements on its chassis dyno. Speed Nation has obtained quarter-mile times within 0.1 second of actually runs at the track. We're not sure how the launch dynamics are simulated on the Mustang dyno, which includes weight transfer, acceleration, jerk (the derivative of acceleration—how fast the acceleration occurs) and some other variables. The Mustang dyno can also measure the air/fuel ratio while testing.

Correction Factors

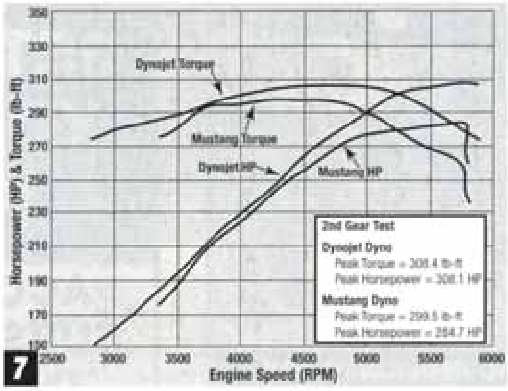
Correction factors are used by both dynos to account for varying atmospheric conditions such as temperature, pressure, and humidity. The measured horsepower and torque are multiplied by the correction factor to obtain the corrected values. This is similar to the corrected times and speeds provided by some quarter-mile tracks. Theoretically, you can dyno on a hot day in the high altitude of Denver and on some other cool day at sea level and produce the same corrected horsepower even though the observed horsepower you are producing at each location is different. Both dynos calculate a correction factor based on a Society of Automotive Engineering document (SAE-J1349). When testing was performed on the Dynojet, the correction factor was 1.10, which means the observed numbers were multiplied by 1.10 (adding 10 percent) to get the corrected values. The correction factor for the day when testing was performed on the Mustang dyno was 0.9595 (removing 4.05 percent). The correction factor when road-testing at Keystone Raceway was 0.962, a correction reduction of 3.8 percent.

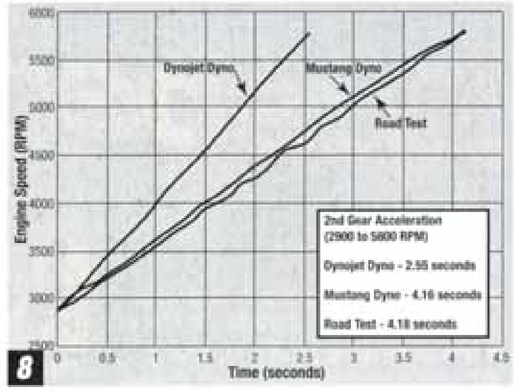
Testing

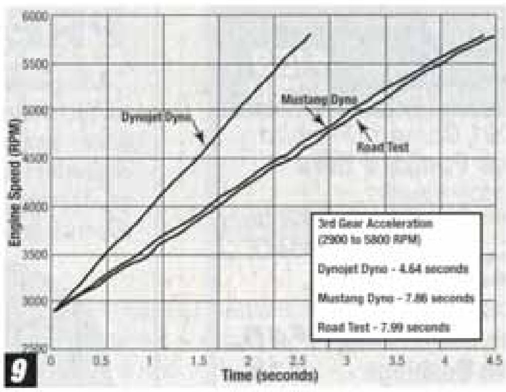
Testing was performed on each dyno using a '00 six-speed Z28 Camaro. We measured the horsepower and torque versus engine rpm in Second, Third, and Fourth gear. The test data also included how fast the engine accelerated in Second and Third gear (in rpm versus time) to be compared with actual road tests to assess each dyno's loading of the drivetrain. After each individual test we let the engine coolant temperature as displayed by our AutoTap OBD-II scanner to read between 200 and 205 degrees F for consistency. Dynojet sent out a representative to Strope's Speed Shop to verify calibration and witness testing. Calibration for the Dynojet is just a matter of verifying that the computer's configure file has the proper load-roller inertia factor. There are no manual calibrations for the Dynojet.

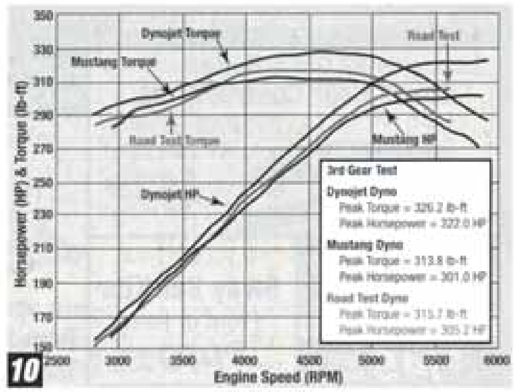
The road tests were performed at Keystone Raceway to provide a level surface to measure the vehicle's rpm versus time in Second and Third gear using AutoTap. Chad Fellabaum of C&C Racing in Pennsylvania weighed the car so the exact weight could be used for the Mustang dyno loading to be compared with the road tests.

The dyno curve charts show horsepower and torque versus rpm in Third gears for both chassis >>









7 **This is horsepower and torque versus rpm in Second gear for both chassis dynos.**

8 **This chart looks at engine rpm versus time when the vehicle was loaded by the Dynojet dyno, Mustang dyno, and from actual road loading in Second gear.**

9 **Here is engine rpm versus time when loaded by the Dynojet dyno, Mustang dyno, and from actual road data in Third gear.**

10 **Horsepower and torque versus rpm in Third gear for the Dynojet dyno, the Mustang dyno, and from road testing using the dyno from West Automotive Performance Engineering.**

dynos. You can also see that the Dynojet dyno measures a higher rear-wheel horsepower than the Mustang dyno. The Dynojet measured 5.1 percent higher horsepower in Fourth gear, 7 percent higher horsepower in Third gear, and 8.2 percent higher horsepower in Second gear. We will try and explain this difference a little later.

Graphs 8 and 9 show the engine rpm versus time when the vehicle was loaded by the Dynojet dyno, Mustang dyno, and the actual road loading at Keystone Raceway in Third gear. You can see that the Mustang dyno loaded the car much closer to the actual loading in Second and Third gears.

Why Is Loading the Vehicle Important?

The answer to this question is twofold. First, the engine produces horsepower at the flywheel (brake horsepower) that is reported by the automobile manufacturers. Engine power is coupled to the rear wheels by a transmission and a rearend. But this is no free ride—there are losses in both the trans and the rearend. Therefore, the power to the rear wheels is equal to the flywheel horsepower minus the drivetrain power loss. The drivetrain losses are mainly composed of three loss areas: friction loss, inertia loss, and viscous loss. The friction loss is largely due to the surfaces of the gear teeth rubbing against each other. Gear friction is related to the torque being transmitted through the drivetrain. The gear power loss is related to the speed at which the torque is being transmitted. This is why it is recommended to have a transmission cooler for towing. The transmission must couple more torque to pull the boat resulting in more frictional power loss, which shows up as more heat in the transmission to be taken away by the transmission cooler.

Inertial loss is related to the rotational acceleration (i.e., angular acceleration) of the drivetrain components. The inertial loss does not result in a power loss (i.e., heat) but absorbs energy that can be coupled to the rear wheels. This energy actually gets stored in the drivetrain components. The stored inertial energy in the flywheel keeps the revs up while the clutch is pressed in during shifts. The inertia loss is more pronounced in lower gears (i.e., First or Second) when the acceleration is highest. The viscous loss is basically the pumping of lubrication fluid in the transmission and the rearend. This is one reason why you get better e.t.'s when the drivetrain is warm, because the oil is thinner and provides less "pumping loss." Therefore, to measure the actual rear-wheel horsepower, the drivetrain must be properly loaded to obtain the correct drivetrain loss. If the dyno provides a lower drivetrain load, then the drivetrain losses will be lower and the resulting rear-wheel horsepower will be higher.

The second reason why vehicle loading is important is that the newer computer-controlled vehicles use engine load as a control parameter. For example, ignition timing is a function of engine load. You will see higher timing advance when revving the engine in Neutral than you will when the vehicle is fully loaded at wide-open throttle in Third gear. This engine loading factor (and airflow dynamics, which is beyond the scope of this article) can help explain why some people have dyno'd identical to a friend's engine on a Dynojet dyno but got different results on a Mustang dyno.

Which Dyno Measures the Actual Rear-Wheel Horsepower?

West Automotive Performance Engineering has developed a proprietary device that independently measures a vehicle's actual speed and acceleration. This device is

Test Results

Test Gear	Dyno	Torque (lb-ft)	HP	Acceleration (2,900-5,800 rpm)	Pre-Cat O_2 Sensor Voltage @ 5,700 rpm
4th	Dynojet	339.7	331.7	7.68 sec.	865 mV
4th	Mustang	331.7	315.7	15.43 sec.	835 mV
3rd	Dynojet	326.2	322.0	4.64 sec.	870 mV
3rd	Mustang	313.8	301.0	7.86 sec.	840 mV
3rd	Road Test	315.7	305.2	7.99 sec.	835 mV
2nd	Dynojet	308.4	308.1	2.55 sec.	910 mV
2nd	Dynojet	299.5	284.7	4.16 sec.	865 mV
2nd	Road Test	300.6	284.1	4.18 sec.	855 mV

similar in operation to a fifth wheel but doesn't use accelerometers that can be influenced by the vehicle's body tilt. Using the vehicle's speed, acceleration, and weight (mass) and the application of simple physics equations, the exact horsepower and torque can be calculated. The horsepower and torque measured by West Automotive Performance Engineering's dyno is actually the horsepower-made-good, or the horsepower left over to accelerate the vehicle after all the aerodynamic and rolling-friction losses have been overcome. These losses were accounted for and included West Automotive Performance Engineering's dyno so that a comparison with a chassis dynamometer can be made. The Mustang dyno includes the aerodynamic load that it places on the drivetrain as part of its reported rear-wheel horsepower and torque. Stated another way, the Mustang dyno does not measure the horsepower-made-good.

Graphs 7 and 10 show the horsepower and torque versus rpm in Second and Third gear, respectively, for the Dynojet dyno, the Mustang dyno, and from road testing with the dyno from West Automotive Performance Engineering. You can see that the horsepower and the torque, as measured on the road, are closer to the Mustang dyno measurements. Also from the acceleration tests you can see how the Mustang dyno loads the vehicle very closely to how it will be actually loaded on the road. Based on our test data, the Mustang dyno loaded our test vehicle and measured the rear-wheel horsepower closer to what the vehicle experiences on the road.

Sources

B&B Electronics
815/433-5100
www.autotap.com

Keystone Raceway
724/668-7600
www.keystoneraceway.net

Speednation
724/926-3735
www.speednation.com

Strope's Speed Shop
724/228-1166
www.stropespeedshop.com

Conclusions

The Test Results table summarizes the testing that we performed. Keep in mind that the peak numbers are influenced by the amount of smoothing or averaging done to the final data. For comparing dyno plots to determine losses or gains, don't focus on the peak values but take a visual average by comparing the before and after curves on the same graph. If you can't see a marked improvement on the dyno, you probably won't see a performance improvement on the street. Also, realize that both the Dynojet and Mustang chassis dynamometers are useful tools that have excellent repeatability. Both dynos measure the correct horsepower and torque for the load that they apply. Both dynos will show losses or gains from modifications. It is recommended that you pick a dyno for your baseline testing and stick with that dyno type and dyno location (and dyno operator) for subsequent testing. Always start at the same engine coolant temperatures before each run. Also, use an OBD-II diagnostic scanner like AutoTap (from B&B Electronics) to monitor your engine's operating parameters. This will provide the best indication of power improvements or losses. We like to monitor the engine-coolant temperature, timing advance, knock retard, pre-cat O_2 voltage, and rpm. Monitoring the engine-coolant temperature lets you make sure your engine is at the same temperature before each run to produce the most consistent results. The timing advance and knock retard indicate if any detonation is occurring that results in reduced timing and lower horsepower. After doing some research, the pre-cat O_2 voltage can provide a correlation to the air/fuel ratio even though the O_2 sensors are not too reliable in this air/fuel ratio region.

The bottom line: dyno numbers are for show, and track times are for the dough! **CHP**