What's Wrong with your Dyno?

The complicated truth about all-wheel-drive dynos

BY DAVE COLEMAN • PHOTOGRAPHY BY DAVE COLEMAN

There was a time, as recently as the mid-'90s, when nobody in the aftermarket used dynos. They were vague, inconsistent and unrepeatable, and if you said your part made a certain amount of power on your dyno, the odds of it making the same power on somebody else's dyno were slim. Hell, the odds of it making the same power on your dyno the next day were slim.

There were two problems. First, the dynos just weren't very good. They ran on Pac-Man–era computers, if they had computers at all, and many of them relied on a fluid-based brake, similar to a torque converter, to measure torque. Problem was, as the fluid heated up, these brakes behaved differently, and nobody ever had a big enough cooling system for them. Ford's dyno center uses water from a small lake to control the temperature of its dynos, if that gives you any idea of the scale of the dyno's cooling needs.

The second problem was that everybody used a different brand of dyno and every brand measured differently. Imagine if every brand of ruler had differently sized inches on it and you'll start to grasp the problem. Even worse, imagine some of these rulers were printed on metal or wood, while others were printed on strips of Silly Putty.

The problem went away for a decade or so with the introduction of the Dynojet 248C. Dynojet's ruler didn't necessarily have markings that were more precisely inch-sized than anybody else's, but its rulers were printed on cast-iron slabs and every one of them was printed the same. In other words, whether or not you believe the actual numbers they produce, Dynojets are almost always consistent, both run-to-run and dyno-to-dyno.

So gradually, over the last 10 years, the definition of horsepower has changed from 550 lb-ft per second to whatever a Dynojet says it is.

No more.

Now that the two hottest cars in the tuner world are all-wheel drive, the dyno dilemma has returned. There are four kinds of all-wheel- drive dynos in common use in the aftermarket, and a few more making occasional, confusing appearances. It doesn't take a flame war veteran to know that this can lead to endless confusion, argument and misinformation. It's time to explore the problem.

THE BASIC ISSUE

Imagine trying to measure the diameter of a balloon with a ruler. There are three classes of problems you're likely to encounter.

Problem one: You can't actually put the ruler through the diameter of the balloon without popping it, so you have to use another method. You could stick the ruler next to the ground and eyeball it. You could put the balloon on the ground, put a level across the top of it, and measure from the level to the ground. Or you could roll the ruler around the balloon to measure the circumference and calculate the diameter from there.

In the dyno world, we have the same problem. First, you can't measure crank horsepower at all without pulling the engine, so we have to be content measuring power at the wheels. This is probably a more useful number anyway, but some dynos do attempt to measure driveline drag and calculate back to crank output with varying results.

Even measuring power at the wheels isn't easy. Some dynos measure power by accelerating a known mass, then calculate torque based on power and rpm. Others measure torque by attempting to resist the engine with a known force. These dynos then calculate horsepower based on torque and rpm. Even worse, some dynos measure as the engine is sweeping through its powerband, while others measure one fixed rpm point at a time.

Our favorite Dyno Dynamics' feature is this little roller that keeps the front wheels from walking back and forth, allowing the truck to be tested with no diagonal or side straps.

Vishnu Performance's Dyno Dynamics dyno worked smoothly and had very consistent readings that just happened to be 40 to 50 hp lower than the Dynojet's.

Even the sweepers can sweep through the powerband at different rates, and how fast you sweep through the powerband affects the horsepower reading.

Which method is best? None of them. Any of these methods can work fine, but it all comes down to how well you do it. If you set a 1-pound level on the balloon to measure it, you'll squish the balloon. Roll a ruler around the circumference and you might stretch the skin. Eyeball it and, well, you might just suck at eyeballing.

Problem two: Suppose you pick a method, but every time you measure it you get a different number because some joker keeps letting air in and out of the balloon.

This is a problem dyno testing any engine, but especially an EVO or WRX. If the weather changes, the power output will change. If the engine, transmission, or tire temperatures change, the power output will change. If the airflow across the intercooler changes, the power output will change. If the gas quality changes, the power output will change. If the ECU is adaptive, the power output will change.

This sucks, but it's the reality of modern engines. Just because some jackhole is blowing on your balloon doesn't mean your ruler is bad, but it might mean the ruler operator is bad for not watching whose lips are on their balloon.

Problem three: Of course, we still have the basic ruler problem. What if the inches on your ruler are smaller than everyone else's? Suddenly it looks like you've got the biggest balloons in town.

Every dyno company claims its dyno is precisely calibrated to measure real, accurate horsepower, but experience suggests that every company calibrates with different sized horses. Your only defense against this is to understand the nature of the problem.

If you take your balloon to a ruler with bigger inches printed on it and the ruler says your balloon is smaller, you need to have the cognitive ability to realize the balloon hasn't changed. The fact the inches are a different size doesn't reflect directly on you, your family, your tuning ability or your sexual prowess. Your balloon is the same as it always was; it's the ruler that changed. If you manage to inflate the balloon another 10 percent, the ruler will still show it's 10 percent bigger, so it's a perfectly valid, useful ruler. The only thing it isn't doing is giving you a big number to brag about on the Internet. Repeat after me: Your balloon is the same.

It's amazing how many people can't seem to understand this.

THE ACTUAL TEST

We wanted to take one consistent all-wheel-drive car to every all-wheel-drive dyno we could find and see just how big each dyno's horses were. This would, we naively hoped, be a perfect way to establish conversion factors between different dynos so everyone could learn to speak the same language. Naturally, it turned out to be far more complicated than that.

The first trick is to find a stable vehicle. Turbocharged cars can make wildly different output as weather conditions or fuel conditions change (our dynos were far enough apart that we would actually have to test with different local fuel formulations), so the EVO and WRX were out of the question, as were any 1.8t-powered AWD Audis or Volkswagens. Most modern cars are highly adaptive, changing their own calibration based on recent experience. If a car learned something on one dyno and applied it on the next, we'd see a difference between dynos that was actually a difference in calibration. That ruled out any naturally aspirated Subaru, Audi, or Volkswagen, leaving us only with trucks.

That's how we ended up driving all over California in a 4.0-liter Ford Ranger SuperCab. It's crude, simple and has such low specific output that it shouldn't have to

K&N's Dynojet is unusual in that it has two full-size high-inertia rollers. A pull on this baby is like accelerating 5,200 pounds.

The front roller of the HKS Dynojet is smaller than the rear, but thanks to its faster rotational speed and heavier wall thickness, it takes nearly as much force to turn as the big roller.

constantly play with the timing curve to avoid detonation. The Ranger also has an unplanned bonus: the ability to shift from two-wheel drive to four-wheel drive. We tested the same truck in third gear in both two-wheel drive and four-wheel drive high, on six different dynos, plus an extra pull (in two-wheel drive only) on our own two-wheel-drive Dynojet. The results will be very depressing for anyone hoping to come away from this with a clear, simple understanding of how to interpret results from these different dynos.

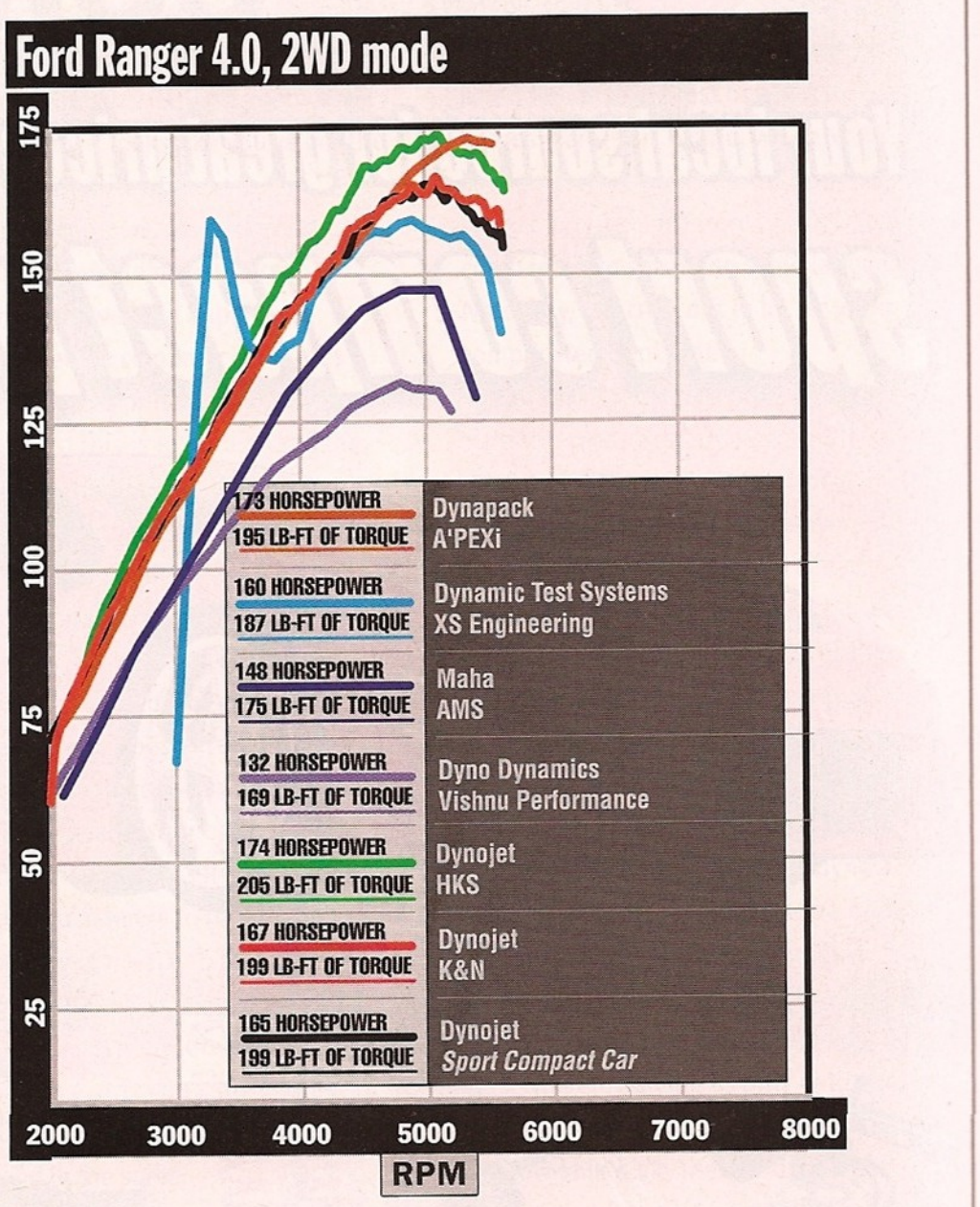
The Dynos

DYNOJET

We tested on three different Dynojets, hoping to re-establish their reputation for repeatability and consistency. We used our own two-wheel-drive Dynojet, plus the all-wheel-drive Dynojets at K&N and HKS. In two-wheel-drive mode, all three should have read the same. Indeed, our dyno and K&N's produced nearly identical results, but the HKS dyno read about 8 hp higher at the peak. Dynojets are so mechanically simple, it's unlikely HKS's dyno would be out of calibration. More likely is that the correction factor the Dynojet automatically applies didn't quite match the reality of the truck's response to running near the ocean (at HKS) vs. in the desert (K&N). That is, however, a guess. More likely, something is screwed up.

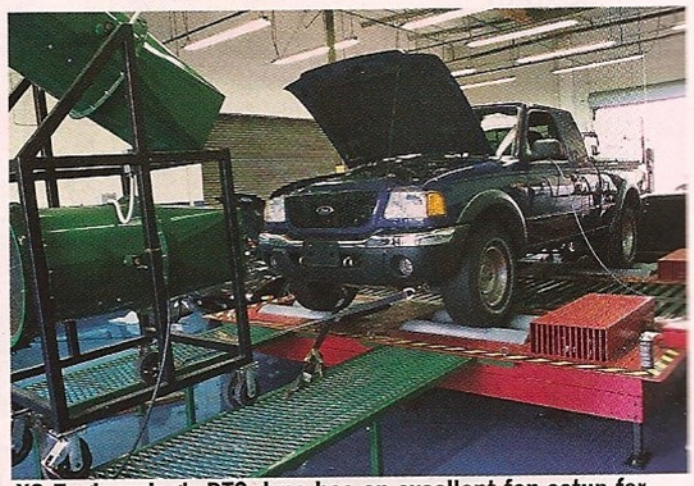
In four-wheel drive, the results are the opposite. Peak power on the HKS Dynojet drops almost 13 percent, from 174 to 152 hp. On the K&N Dynojet, the difference was only about 7 percent. What happened?

A partial explanation can be found in the mass of the rollers. Dynojets work by accelerating a known mass. The beauty of this is that it measures under the same conditions you use the engine normally. When you hit the gas, you accelerate the mass of the car, so accelerating a mass is a great thing to be doing while you're measuring power. Question is, how much mass? To be an accurate representation of reality, the mass should be close to the mass of the car you're testing.



Dynojet 248s come in high-mass and low-mass models. HKS's is a low-mass model, so accelerating its rollers is roughly the equivalent of accelerating a 2,150-pound car. Our Dynojet and K&N's are both high-mass models, so they're like accelerating a 2,600-pound car.

What's the difference? It takes longer to accelerate the higher-mass rollers, and if you accelerate more slowly, less power will be wasted accelerating the engine, flywheel, gearbox, wheels and tires. This should make the HKS dyno read lower than the other two, but it didn't.



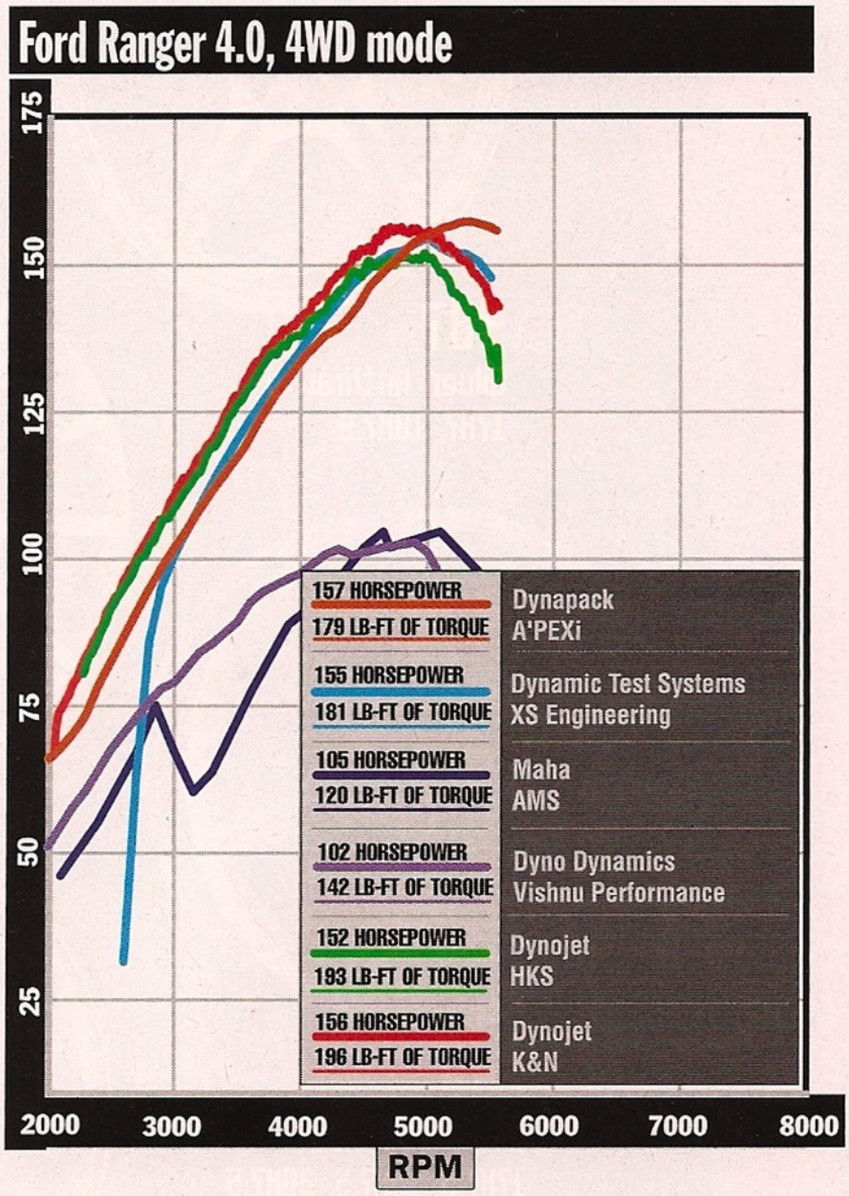
XS Engineering's DTS dyno has an excellent fan setup for high-output cars. Its high-output customers have griped so many times about the fact that the DTS reads lower than a Dynojet, though, that XS finally just re-calibrated the dyno to match the more common numbers.

Four-wheel-drive mode adds a second set of rollers. On HKS's Dynojet, this second set of rollers is like accelerating an extra 2,060 pounds, for a total equivalent vehicle weight of 4,210 pounds. K&N has a rare, double 248 dyno, so both rollers are

high-inertia, 2,600-pound rollers. A pull on this dyno is like driving a 5,200-pound behemoth. The nearly 1,000-pound difference means a much slower pull on the K&N dyno and could fully explain the difference in four-wheel-drive readings.

It didn't matter for the truck, since the front and rear wheels are locked solidly in four-wheel-drive mode, but the fact that the two Dynojet rollers are completely independent can be a major issue on some cars. All-wheel-drive transmissions are designed with the assumption that all four wheels are on the same planet, so when the front of the car is going 50 mph, the rear is also going 50 mph. With two separate rollers, the only thing keeping them going the same speed is the center differential in the car.

On HKS's dyno, where there is a 5-percent difference in equivalent mass between the two rollers, this means that the center differential has to constantly work to send extra power to the heavier rear roller to help it keep up. Indeed, test a WRX on this dyno and you can feel a regular, cyclical lurch as the roller speeds get mismatched enough to tighten the viscous coupling, the coupling gets the rollers synched, loosens up, and the whole cycle repeats. On a car that isn't designed to ever split torque 50/50, like the Porsche Carrera 4, using a Dynojet can be a very expensive mistake.



DYNAPACK

The Dynapack measures torque by applying a hydraulic brake directly to each axle. Cooling water directly from the tap is used to keep the system at a consistent temperature. The inertia, drag and noise of the wheels are completely eliminated by bolting the hubs directly to the dyno brakes. The elimination of tire noise makes this an excellent dyno for tuning, since you can hear minor detonation much more easily. Getting the car on and off a Dynapack, however, is a royal pain in the grundle.

Cooling fans can have a substantial effect on test results, especially on high-output cars. Remember, at full load in third gear on the street, the cooling system should be seeing 80 mph of airflow, and it takes a big mother of a fan to do that. We used the Dynapack at A'PEXi USA's R&D center, where a 10-hp fan is in place for these high-output cars, but HKS only deemed our truck worthy of a 1/2-hp fan. How embarrassing.

The big, silver ductwork in front of the Ranger connects directly to a tornado somewhere in Kansas. AMS tunes for the autobahn, so it needs an autobahn-level fan.

The Dynapack initially seems to agree pretty well with the Dynojets, but at high rpm (well, above 5000 rpm, if you want to call that high) it just keeps climbing when every other dyno thinks the Ranger's power falls off. We've compared Dynojets and Dynapacks before and didn't see this phenomenon, so our best guess is that the Ranger's giant monster truck tires start causing a bunch of drag at high speed. Third gear in this truck is actually tall enough that it hits the 90-mph top speed limiter before it hits the rev limiter.

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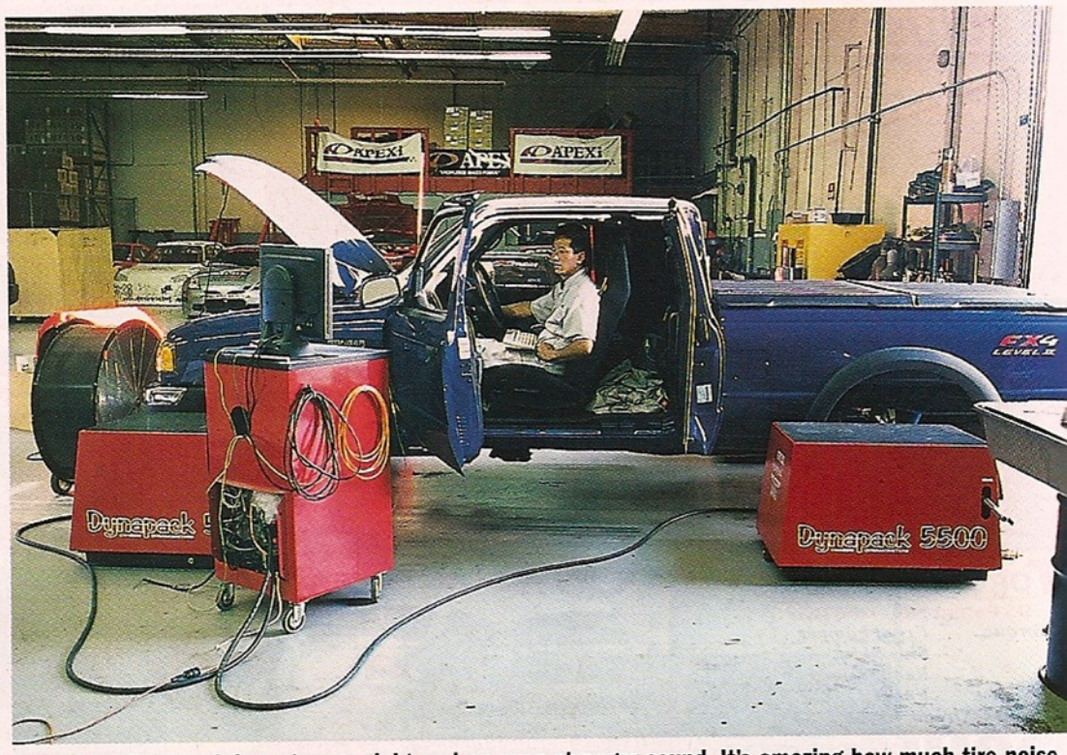

A car on a Dynapack is a strange sight and an even stranger sound. It's amazing how much tire noise you don't hear when there are no tires.

The Dynapack does away with the wheels and tires and replaces them with this hub adaptor. This is easy to install, but getting it into the dyno box is a little hit-and-miss.

We would have expected the lack of tires to make the difference between two-wheel drive and four-wheel drive less pronounced, since four-wheel drive doesn't mean turning two extra tires. The difference is actually 16 hp. This is more than we saw on the Dynojet, but those results are skewed by the extra mass of the front rollers. A better comparison is with the Dyno Dynamics dyno, which measured a 29-hp difference between two- and four-wheel drive. None of the other dynos produced reliable results in both modes.

Like any of the brake-based dynos, the amount of time it takes to sweep through the powerband can be adjusted. This is a useful tuning tool, but it makes the results far less consistent. Two identical cars tested on two identical Dynapacks in identical weather conditions can give different results if they are set to sweep through the powerband at different rates. The same is true of any brake dyno.

DYNAMIC TEST SYSTEMS

XS Engineering's DTS dyno has conventional double rollers with an electromagnetic brake used to measure torque. Its fan is an impressive 6-hp job with a giant venturi to accelerate and concentrate airflow onto the radiator.

While the hardware for the DTS dyno looks perfectly effective, the computer running it is shockingly crude. It also seemed to have a hard time matching the dyno's braking force to the engine's accelerative force, as can be seen in the huge spike at 3300 rpm on the two-wheel-drive chart. We have no explanation why this happened every time we tried a two-wheel-drive test, but didn't repeat in four-wheel-drive mode.

The surprisingly good agreement with th Dynojets in four-wheel-drive mode is a big, fat lie. Turns out XS was tired of customers complaining when their dyno results were lower than they had hoped (repeat after me "the balloon is the same!"), so they fooled i into reading as high as a Dynojet by telling the computer that the humidity was 400 percent. The built-in correction factor calculator apparently has no limit to how bad the weather can be.

DYNO DYNAMICS

The Dyno Dynamics dyno at Vishnu Performance is physically similar to the DTS unit, but the computer interface is much better. Though simple and still DOS-based, it affords a wider degree of flexibility and has no problem matching the engine's torque. The Dyno Dynamics computer also draws the dyno chart real-time during the pull, which is great fun to watch, and quite useful as a tuning tool. The dyno actually operates the brakes differently depending on what kind of center differential you have, and has a long list of cars built in to help you pick the right kind. None of this, of course, mattered on the truck, but it's nice if you have that Carrera 4.

This was by far the easiest dyno to get on and off of, with only one strap required and special conical rollers on the inner sidewalls of the front tires to keep the car from walking back and forth. Vishnu uses two 1.5-hp fans, with big, wooden propellers, which looked like a lot to us until we saw some of the blowers at the other shops.

All these gee-whiz features are great, but the output was wildly different from everything else. In two-wheel-drive mode, the Dyno Dynamics dyno read 42 hp lower than the highest reading dyno, and in four-wheel drive it read 55 hp lower. Dyno Dynamics swears its horses are the right size and it's everyone else who's measuring with My Little Pony power, but in reality, who cares? The balloon, remember, hasn't changed, and the Dyno Dynamics readings were the most consistent and repeatable of the bunch.

The low readings do suck for bragging, though.

MAHA

We know of only one Maha dyno in tuners' hands, and that's at Advanced Motorsport Solutions. AMS was trying to replicate an O.E. test facility when it built its dyno room, hence the crazy German dyno. Being primarily an Audi tuner, it also wanted to tune for sustained high-speed running, so it has a massive 25-hp fan built into the wall. You absolutely do not stand between the fan and the car.

When the dyno was shipped to AMS, it was supposed to be followed immediately by a massive software upgrade. When we showed up with the truck, however, that still hadn't happened, and the computer interface was laughable. If the DTS was Pac-Man, this thing was Pong. I was actually looking for vacuum tubes.

Like the DTS, the Maha seemed to have a hard time catching the early surge of torque from the Ranger's V6, but in this case it happened in four-wheel-drive mode. It turns out our truck was too long for the dyno, so the front wheels weren't touching the rear rollers (there are rollers in front of and behind each tire). While it's the front rollers that measure torque, the

rears monitor wheel speed. Without proper wheel speed data, the computer had a hard time applying the right braking torque.

The interface was so archaic it was impossible to view the data in any form other than a tiny 5-inch-square graph, from which we had to pull rpm and kilowatt numbers manually (with a ruler!) before converting to horsepower. This fifth-grade data extraction technique is why the Maha result looks so chunky—the actual data is at a much higher resolution.

We hope the new software arrives soon.

SOURCES

Maha
Advance Motorsport Solutions
(310) 763-8000
www.advancedmotorsportsolutions.com

Dynapack
A'PEXi
(714) 685-5707
www.apexi-usa.com

AWD Dynojet low-mass rollers
HKS USA
(310) 763-9600
www.hksusa.com

AWD Dynojet high-mass rollers
K&N Engineering, Inc.
(909) 826-4055
www.knfilters.com

Dyno Dynamics
Vishnu Performance
(925) 924-9800
www.vishnuperformance.com

Dynamic Test Systems
XS Engineering
(714) 698-8300
www.xs-engineering.com

CONCLUSIONS

Oh, how we'd hoped we could say something like "multiply DTS results by 1.3 and Dynapack results by .97 to match Dynojet results." Clearly, from the wild variations in measured output and even the shape of the power curve each dyno thinks it's seeing, there's no way to do this. Even if there was better consistency, the question of sweep time, fan setup, roller weight, and correction factors makes comparing different results from dynos with different operators a sketchy proposition at best. The only answer, unfortunately, is to stick to one dyno for all your tuning and take your bench racing to the track.■

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