KENNE BELL

DYNO TESTING VARIABLES

In the '50's, I would tune my new cars at the Pomona Drag Strip by being first in line when the gates first opened. That way I could beat the crowd, get in the lanes and make back to back runs without delay. The carburetor jets would be all laid out in .001" sizes. I could change jets in a mere 4 minutes and be back in line for another run. Once I got all 4 corners jetted ideally - I would know when I had it right because the 1/4 mile speed wouldn't change or it would drop - I'd turn the distributor 1° at a time with a special "adjustable screw cable" I had designed for testing. Typically, 10HP would vary 1/4 mile trap speed by 1 mph, 5HP would vary .5 mph, etc. In those days, I didn't have an accurate Dynojet dyno or air fuel ratio sensors, but my approach worked - "one change at a time with no other variables." I was able to determine the ideal timing and carb jet size because the testing conditions did not vary. So here we are, 50 years later, still attempting to "tune" or optimize timing and AF ratio, the ONLY two (2) tuning parameters that vary engine HP. Only today, the vehicles are far more complicated and difficult to tune because of an ever increasing number of variables.

Comparing the advertised horsepower claims on high performance products can be both confusing and misleading. At Kenne Bell, we run thousands of dyno tests every year on a variety of vehicles. We are very familiar with all the GM, Ford, Chrysler etc. OEM calibrations and their operation. We know all the games, tricks and variables about making horsepower "numbers."

Let's take a closer look at how and why dyno horsepower claims may vary - knowingly or unknowingly. It is not our intent to question the integrity of tunes. We are only attempting to make our customers aware of the ways HP readings can vary from dyno to dyno, vehicle to vehicle etc. We hope you find it informative and helpful. In the final analysis, we strongly believe that the best way to evaluate a product is to look at the percentage HP and torque gain and where it occurs - and the company's reputation and experience in dyno testing.

Most important in any test is to verify the product comparison is performed under identical conditions on the same vehicle with only 1 change - the product itself. "If you change 2 products or more than one calibration change for a dyno comparison, you've changed too many." Ambient temperature, dyno type, dyno calibration, vehicle gear, IAT temp, ECT temp, torque converter (locked or unlocked), best run vs. worst run, rear end gear ratio, correction factor etc. are but a few of the variables that can affect a dyno reading. Read on.

1. **Dyno Type**
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1. DYNO TYPE - The Dynojet inertia rear wheel dyno has been referred to as the "Industry Lie Detector" because of it's accuracy and reliability. We purchased the very first Dynojet rack dyno in the West in 1996. The data from other dynos that take into account aerodynamic drag and road load is of no interest whatsoever to us as we cannot compare the data to our dyno or any other Dynojet. Our tests on the same vehicle has shown these dynos to be 25-30HP off. We believe our customers simply want to know how much HP their vehicle puts to the rear wheels. They don't care about factoring in aerodynamics or road load/vehicle weight. We also decline to consider any HP numbers from the old style "friction dynos." These things rely on the friction between relatively small rollers and the vehicle tires to measure HP. The rollers attempt to slow the spinning tires. I'll just say this. In 1960, I dyno tested my 5500lb '59 Buick Invicta on a friction dyno. There were 3 of us sitting on each of those big rear fins trying to load enough weight on the rollers to keep the tires from slipping and get an accurate run - and it was only a 325HP engine. 200HP, 220HP, 190HP - which one should I have used? I never wasted my time chassis dyno testing a vehicle until 1995 when Dynojet demonstrated their big

drum inertia dyno. We've run it, almost on a daily basis, ever since with full confidence in it's output data.

2. DYNO CALIBRATION - If the air temp varies by 40° between two runs, for whatever reason, and the dyno is not calibrated for the specific change, the HP will change approximately 4%, or about 1% for every 10°. A dyno must be re-calibrated for any temperature, relative humidity, vapor pressure or barometric pressure change. We use the standard SAE (Society of Automotive Engineers) calibration. It is used by all the OEM's to compensate for varying weather conditions - and it works. Do you really think that the OEM's just sit around and wait for duplicate 70° and 30% days to run a comparative test? The Dynojet also has a "STD" correction factor which is around 3% higher and used by some dyno operators who must show higher than SAE numbers for personal gains. Kenne Bell uses the SAE calibration.

3. DYNO CURVE SMOOTHING - The smoothing function "flattens" or "smooths" the peaks on the curve thereby increasing/reducing the HP reading. Peaks originate from the slight jerking motion of the tires on the dyno rollers, surging or torque converter flashing spikes at the shifts. Disregard these spikes. Note: At Kenne Bell, we use the unsmoothed curves as it has proven valuable in our analysis and data collection. For example: An out of balance tire or a slight ignition misfire could show up as spikes that shouldn't be disregarded by smoothing. Smoothing can vary power readings by approximately 10HP.

4. TIRE PRESSURE - We once spent hours diagnosing why our 720HP Cobra lost 40HP overnight. The tire pressure in the slicks had dropped from 35-15 psi.

5. WHEEL & TIRE WEIGHT - Yes, the reciprocating mass of the rear wheels and tires will affect the dyno numbers. We haven't done extensive testing but we've seen 6HP.

6. LOADING - Always load the dyno the same. Tightening the tie down straps excessively affects HP.

7. TIRE POSITION ON ROLLERS - Place the tires on the center of the rollers to prevent erroneous HP readings. There's 5HP here.

8. GEAR SELECTION - The trans gear ratio that is 1:1 will make the most power as it is the most efficient. For example, a 4 speed manual trans with 1:1 will make more power than 3rd gear. 2nd and 1st gear will make progressively less power. Typically run automatic trans vehicles in 3rd gear and 4 speed cars in 4th gear. All Kenne Bell dyno tests are run that way - unless, of course, you want a dyno run with less power. Try a 3 gear run on the Dynojet and you'll see for yourself. If the HP is identical in all gears, get a new dyno. We've observed 20HP variance between 2nd and 3rd gear or 3rd and 4th gear.

9. TORQUE CONVERTER LOCK UP - The difference between the torque converter clutch engaged or locked up is 20-30HP. A "locked" torque converter will typically improve 1/4 mile times by .25 sec and 2.5 mph. At least that's been our experience for the last 20 years. Always compare HP in the same gear with the converter locked or unlocked. Note: Torque converters can't be engaged in low gear. They are typically operated by the vehicles computer so the engagement and/or engagement rpm, speed and gear may be modified. Also trans, engine and rear end fluid temp can affect HP. Allow to stabilize.

10. FUEL OCTANE - More boost, leaner mixtures and advanced ignition timing require higher fuel octane to avoid knock/detonation/pinging. Many vehicles utilize their knock sensors to regulate ignition timing. The addition of a supercharger and the change in sound wave frequency also changes the sensitivity of the sensors and can alter ignition timing and HP i.e. 4HP per degree. Therefore, if for any reason, an engine knocks and the knock sensor automatically retards timing, the HP will be less. The solution is to always dyno test with adequate fuel octane and THE SAME IGNITION TIMING. Fuel octane, by itself, will not affect dyno HP i.e. higher octane fuel does not produce more power.

11. FUEL OCTANE, IGNITION TIMING & BOOST - Some new vehicle calibrations will adjust ignition timing (and HP output) to the specific fuel octane 87, 89, 91, 92, 93 or 94). Again, 1° of ignition timing is 4HP. 4° = 16HP. Since 1° of timing equates to approx. 1 octane, 87 octane will use 20° whereas 91 octane will use 24°. Excessive boost can also cause the engine to knock and lose power. You'll see the "jerks" on the dyno curve of a Dynojet if unsmoothed. We've seen 10-20HP loss before the pistons went South. It takes 1.5 octane to support 1 psi of boost. Accurate and repeatable dyno tests are not possible if ignition timing varies or the engine knocks. If the engine knocks, reduce the boost and eliminate the timing variables.

12. IAT SENSOR - The IAT (intake air temp) sensors job is to monitor the air temperature entering the engine and then adjust the ignition timing power whereas lower temperatures result in advanced timing/more power. 4° of timing change equals 16HP. The IAT sensor may also adjust air fuel ratio. Again, low temps mean richer mixtures and high temps will allow leaner mixtures. There can be up to 15HP between 11 and 12.5 AF ratio. IAT sensor temp may be observed in a factory scan tool, but we never recommend because they are so far behind the actual event. Use the SCT Raptor scanner/software. It's dead accurate. Because air temp is so critical to accurate dyno calibration, it should be obvious that the temperature AT THE AIR FILTER be used and NOT the temp reading by the dyno computer, on a wall etc. This is one of the most common mistakes we see on dyno tests. Kenne Bell measures air temp at the air filter because that is the air the engine breathes. Would you take YOUR temperature in your mouth or in the kitchen? Again, 10° temp variation is around 1% in power. And remember that the vehicles IAT sensor operates INDEPENDENTLY of the dyno room temp.

13. ECT - The ECT (engine coolant temp) sensor also adjusts engine timing and fuel based on engine coolant temp so be sure it's the same when comparing runs. Again, a few degrees of timing can be 12HP, 4° = 16HP, 5° = 20HP etc. While on the subject of ignition timing and it's effect on HP, think about this one. The new 3V '05 Mustang 4.6 engine is 8HP per degree! Convinced yet about the importance of stabilizing ignition timing? An accurate comparison test requires both the ACT and ECT readings be identical on both runs. That's the way we do it. We often "lock" or "fix" the voltage to a sensor to totally negate any possibility of AF or timing variations. Note: Supercharged vehicles with air to water intercoolers have other variables (intercooler water temp and before and after intercooler ACT) to consider. Gets a little confusing, doesn't it? Not really? Just be aware of all the variables and verify the readings.

14. ENGINE KNOCK ***(DETONATION, PRE-IGNITION)*** - As mentioned earlier in FUEL, OCTANE, IGNITION TIMING & BOOST, knock can affect dyno readings because of the knock sensors or heat from detonation. If you lack the equipment to stabilize timing and/or eliminate knock - or you're sneaking up on a tune, it's better and safer to step up to racing fuel and eliminate the variables. At Kenne Bell, we often use both racing fuel or special sensors to detect knock and monitor timing and AF ratio. If we can't eliminate the variables, the test is worthless.

15. TORQUE MANAGEMENT - Calibration engineers now use ignition retard to "kill" HP for softer shifts and reducing transmission stresses. Anytime the engineer feels the transmission integrity is challenged, regardless of gear, the engine torque and HP is lowered anywhere from 10-50HP via reduced engine spark timing. How does one know when this is happening on the dyno? Get a scanner and data logger and record it so there is an accurate comparison of ignition timing retard. And never overlook that ETC (electronic throttle control) that modulates the throttle and HP/torque independently of your foot. It's extremely complex but has no problem "killing" HP when you least expect it. Thoroughly understand it before dyno testing.

16. CATALYTIC CONVERTERS - First of all, we've never seen a "hi-flow cat" that makes more power so don't bother removing them unless it's a race car. You may just end up with more variables. An excessively rich or lean mixture can ruin or partially damage a converter, create additional restriction and skew a dyno comparison. Check for abnormal back pressure if suspect. Since exhaust temp is largely determined by intake mixture and ignition timing, the engine computer is constantly monitoring these parameters via "cat modeling" which can affect power output up to 20HP. Some change fuel mixture when the key is turned on and off to protect the cat against heat soaking and potential damage.

17. TUNING - Let there be no mistake about the following statement: "All else equal, there are 2, and only 2, tuning parameters that affect engine output - ignition timing and air fuel ratio." Contrary to what you've heard from tuners or would like to believe, if both the timing and AF ratio

(approx. 12.5:1) are optimized, there is no other magical or secret 3rd, 4th or 5th dimension to making maximum power. Vary these two and your engine may or may not vary much - or it may vary considerably depending where the baseline timing and AF ratio were. A good tune requires a modern scanner like the SCT Raptor and an ACCURATE, REPEATABLE & CONSISTENT AIR FUEL RATIO DEVICE AND SENSOR. Forget about the OEM scanners. Their slow response to a dyno run isn't even close. Inaccurate AF ratio meters are our number one customer service problem at Kenne Bell. Sorry, but Kenne Bell has had enough of the "cheapie" sensors supplied by the dyno manufacturers. How can one possibly eliminate dyno testing variables if the AF ratio sensor or meter is not accurate? We recommend the more expensive Horiba, ECM or Powertrain Dynamics.Tuning is complex enough without injecting another big variable. You can bet your house on one thing: Ford, GM and Chrysler don't calibrate their vehicles with these low cost dyno sensor systems. No way. We have documented cases where 2 dynos across the street from each other varied a full point - yet the HP was identical. A noted and respected magazine writer brought his car from one dyno to another, and discovered a 1.5 difference in AF ratio. Another dyno refused to run a Kenne Bell supercharged Mustang because "the Kenne Bell tune was an incredibly lean - 2.5 points." Yet another dyno test on the identical car was 2.5 points richer or 11.1. One of the best Ford tuners in the U.S. tuned 6 cars all with the same inaccurate sensor. They, of course, had to be re-tuned. One of Kenne Bell's best Installer/Tuners had been re-tuning cars a full AF ratio point off for a year while assuming it was the Kenne Bell tune that was off. It goes on and on and on.

18. DYNOJET DYNO ACCURACY - Kenne Bell is their biggest supporter. We wouldn't rush to blaming the dyno itself for HP variations. Dyno to dyno, Dynojet tests should be quite accurate, within 10HP IF THE DYNO IS CALIBRATED CORRECTLY, THE IDENTICAL "SAE", "STD" OR "UNCORRECTED" CALIBRATION IS USED AND THE ACT READING IS MEASURED AT THE FILTER. Your goal should never be to "compare dynos" but instead, to compare on the same dyno. A respected Primedia magazine conducted extensive tests with the same vehicle on 7 different types of chassis dynos. They varied a whopping 33% in HP from the lowest to the highest.

19. TESTING 1 PRODUCT AT A TIME - Some still prefer to test a product - but in conjunction with another product or products (see "Supercharging vs. Conventional Bolt Ons" "Real vs. Advertised Comparisons"). How in the Hell can anyone determine which one made power and which one didn't? Did they both lose power, both make power or did one make power and the other lose power? If so, how much did that one lose and the other one gain? Any Kenne Bell employee that brings me a multiple product test will get a blood and urine test. Accurate dyno testing a single product is difficult enough. This is a variable (multiple product testing) that should be avoided if the true loss or gain of a single product is to be determined. However, if your goal is to make a particular product that doesn't make power look good, just keep adding other products until something makes HP and the claim "one needs the other to perform best."

20. BEST RUN - WORST RUN - We suggest making 3 runs to establish accuracy and to verify that there is no "best" or 'worst" run variation. Again, remember that 1° of timing or 10° of temperature can make a difference so a "cold" run can't be compared to a 'hot run" etc. If the dyno runs are not consistent for 3 runs, then the test is flawed because you'll never know which of the 3 was the right one.

21. COLD RUN vs. HOT RUN - The oldest and easiest variable. Run the engine "hot" the first time, let the dyno fan cool it down and then run it "cold." The cold run will typically make more power. If it doesn't, you have another variable to investigate. Be sure to warm up the rear end, trans coolant and engine lubricants before making any meaningful dyno run.

22. TRANSMISSION & DIFFERENTIAL EFFICIENCY - Both suffer from a 3-10% mechanical loss. For example: A GM 12 bolt rear is 93% efficient whereas a Ford 9" is 89%. A Ford AODE trans is 93% with converter locked up and 84% unlocked. To determine overall efficiency, multiply the rear end efficiency by the trans efficiency i.e. 93% x 84% = 78% overall driveline efficiency. Also changing from a 3.08 to a 4.30 rear gear set is a 3% reduction in efficiency.

23. REAR END GEAR - Higher ratio gears consume more HP than lower numerical gears. Our 4.6 2V Mustang test car once made 652HP with 3.27 gears, an automatic trans and locked up converter. With only a gear change to 3.55's, it lost 10HP. Another example" A 4:10 gear rear end is 93% efficient vs. 91% for a 4:30. Always do comparison dyno testing with the same gears. And yes, a Cobra IRS rear is 3% less efficient than the non IRS (3% x 400HP = 12HP). Get it?

24. MPH vs. RPM - Higher numerically ratio gears consume more HP, which is more apparent as vehicle speed increases. The HP loss on any product that has more parasitic loss or restriction (headers, exhaust, inlets, etc.) is directly proportional to rpm and vehicle speed. Just how this is interpreted on the "RPM" or "MPH" graphs requires considerable discussion beyond the scope of this paper.

25. OTHER PRODUCTS - Never blame the dyno for a particular part you purchased that didn't increase HP or meet advertised claims. It either did make power or it didn't. The part tested is always the "variable." And don't get duped into believing "Well, it didn't make any power, but this part I sold you likes more timing - or likes to be leaner." That's B.S. Don't blame the dyno or your engine's tune, blame the part. It didn't work as advertised.

26. OEM VARIABLES - You can bet your house on this one. The OEM computers rarely "go bad." The conditions, the dyno calibration, the tuner etc. can vary, but we've never seen an OEM Ford, Chrysler or GM computer "fail" or "act up" in 20 years. In fact, we've never seen much variation in production vehicles. They're not "all different" as many would like you to believe.

27. HOOD OPEN vs. HOOD CLOSED WITH OPEN FILTER - This one should be self explanatory. We've seen up to 30HP here. If you don't think it's hotter under the hood and all that hot air kills HP, try crawling under the hood and breathing all that nice hot air - like that cheapie underhood exposed aftermarket filter is forced to do. IT FEEDS HOT AIR TO YOUR ENGINE INSTEAD OF THE COLD AIR. Lose it!

28. COOL AIR & HOT AIR INLET SYSTEMS - Do you really drive around with your hood open so as to feed cool air to that underhood filter. Isn't the cool air in the fenderwell cooler than hot air from the engine, headers and radiator? These "hot air" underhood filters are a big variable in dyno testing. To avoid this variable, use the air temperature at the entrance of the filter. We've measured up to 200° underhood temps on a 100° day. For more information, read "Hot Air Underhood Inlet Warning."

29. ICED INLET SYSTEM - You're only fooling yourself and creating a new variable. Either test with the inlet system iced on every run or leave it as is. And be careful you don't ice down the ACT sensor, or you may also alter the timing and AF ratio.

30. ICED INTERCOOLER WATER - This is one variable that you need not be concerned with. Cooler intercooler water does not increase HP.

31. UNDERHOOD "HOT AIR" FILTER TEMP MEASUREMENT - If you must use one of these things, then never measure air temp at the top (cool side) of the filter or the bottom (hot side). We've measured a 40° difference from top to bottom on an '03 Cobra with an open hood and a dyno fan. To eliminate this variable, a sensor in back of the filter in the inlet tract is necessary as that's the true air temp the engine "sees."

32. INLET TURBULENCE - Turbulent air flow from the engine fan will affect the air flow into an underhood air filter and more importantly, the mass air meter. The turbulent air flow can seriously skew the meter readings and alter the meter readings / air fuel ratio / HP of your engine. Even rotating the meter can affect dyno accuracy. And don't count on one of those "filter shields" to solve the problem. We've seen 30HP variance in runs. Are you getting to like underhood filters yet?

33. DETERMINING HP FROM 1/4 MILE TIMES - The Dynojet and the Superflow inertia dynos are extremely accurate in HP

measurement. "My car may be 100HP short of his on a quick dyno run but I'll run 11's all day long at the track just like him." B.S. That is false analogy and a cop out for a car 100HP short on power. There is a definite relationship between rear wheel Dynojet HP and track times (drag strip and oval track). That's why NASCAR checks the cars with a Dynojet. Kenne Bell has been at this game for nearly 40 years. We've compared chassis dynos and engine dynos to chassis dynos. And we've compared all dynos to drag strip times. There is a tangible and easy to calculate relationship. Use one of those Power Speed Calculators - like Kenne Bell and Moroso used to sell - and you'll be amazed at the accuracy. For example: In the 100-120 mph range, 10HP will net you around .1 sec and 1 mph in the 1/4 mile. 100HP will get you approx. 10 sec and 10 mph. As compared to a manual trans, an automatic trans car will typically run .3 sec/3 mph slower with an unlocked converter and only .1 sec/1 mph slower with a locked converter. If using one of these Power Speed Calculators, look ONLY at the 1/4 mile trap speed to compare HP. The ET will vary with driver, traction, gears, tires etc. but the 1/4 mile speed IS a dyno run and can be compared directly to the dyno HP.

34. SUPERCHARGERS - The Kenne Bell Twin Screw is manufactured with such precision that it is virtually impossible for it to be responsible for a dyno variation. It either works or it doesn't. If it has a problem, there will be a corresponding noise at WOT indicating there is foreign matter in the rotors.

35. DYNO OPERATOR VARIABLES - We've seen and heard it all. Blocks under the gas pedal, riding the brakes, three quarter throttle runs, skewed dyno calibrations, tweaked sensors etc. can make any HP number you want and vary the dyno readings 50, 75, 100, 125HP. If you ever have to question the integrity of a dyno run, request the dyno "hard data" (correction factor, temp, relative humidity, vapor pressure and HP and torque printed numbers) and the SCT Raptor data. This Raptor will print out the timing, commanded AF ratio, ACT, ECT, etc., etc. and other data from the OEM computer in real time. Both sets of data are necessary for a valid analysis and comparison (see attached Minimum Suggestions and Guidelines).

36. ENGINE vs. CHASSIS DYNOS - Kenne Bell had done extensive testing comparing the two dyno types. That is a very complicated discussion we'll have to save for another time.

37. CON ARTISTS - Most companies have to deal with these people at one time or another. They knowingly jack up or inflate dyno numbers to promote their tune or products. Fortunately, the websites are of some help in identifying these people. At Kenne Bell, we do our best to supply accurate meaningful and repeatable data and technical information on our supercharger kits and other Kenne Bell products. In addition to our HP test data and graphs, we publish complete boost, pulley size, ratios and even 1/4 mile times accompanied by the Kenne Bell "Tech Tips" for the specific vehicles and kits. The following is a short summary of the most important variables to consider when dyno testing.

❶ Choose a reputable Dyno Shop.
❷ Select a Dynojet that uses an accurate, repeatable air fuel ratio meter. Power Train Electronics (805) 466-5252 is the most popular and competitively priced. We have 3 of them and a Horiba. Horiba and ECM also supply OEM grade air fuel measurement systems.
❸ Select a dyno that also uses SCT (Superchips Tuning) (407) 774-2447 software and the SCT Raptor Diagnostic Data Scanner so you can look at the ignition timing, ACT, ECT, etc. throughout the dyno run.
❹ In addition to the unsmoothed dyno curves, always request the hard data from each run (AF ratio, calibration correction factor, temp, relative humidity, barometric pressure, vapor pressure and the hard dyno numbers). Then you can at least be comparing apples to apples. See if the dyno operator will give you the actual dyno run files on a disc. If he won't, you should consider going to another dyno.
❺ Run the vehicle in 3rd gear if automatic trans and 4th gear for 5 speed manuals.
❻ Utilize the same dyno for before and after tests.
❼ Make all runs at same temperature with engine, trans and rear end warmed up.
❽ Lose any underhood exposed "hot air" filter - where no one else can find it.
❾ Finally, do not generate any new unnecessary variables for yourself. In other words, "If it ain't broke, don't fix it." We are not opposed to custom tuning, but if your vehicle has a Kenne Bell Supercharger Kit and a Kenne Bell Calibration, think very hard before getting our tune "modified," "tweaked," "re-tuned," "replaced" etc. You may very well create some new variables in the form of a monster that Kenne Bell cannot fix over the phone. At least check with us first. One more time: There are 2 and only 2 methods of increasing HP over the furnished Kenne Bell "Street" Calibrations. The tuner must 1. advance the timing and/or 2. lean out the AF ratio. There are no secrets. No 3rd dimension to tuning. No magic. Kenne Bell most definitely knows how to 1. advance timing and 2. lean out fuel mixture. It's easy. We've been doing it for 40 years. Kenne Bell clearly states the power gains to be expected by advancing timing and leaning air fuel ratio. Neither Kenne Bell or the OEM calibrations vary on a stock vehicle. Tweaking is not necessary. However, if you are introducing new variables such as injectors and mass air meter or products and combinations from other companies that Kenne Bell does not support, then you must seek out a custom tuner.

This paper was written to help our customers better understand dynos, testing and the variables. We hope it has helped.

KENNE BELL MINIMUM SUGGESTIONS and GUIDELINES FOR RUNNING YOUR CAR / TRUCK ON THE DYNO

If you are planning on having your car/truck dynoed, and you wish to report the results to us, follow the guidelines below to insure optimum power measurements when dyno testing (there are other conditions, but these are the basic minimum recommended guidelines):

Be sure to check to make sure you have the latest version of this document. This one is dated 08/12/04. Discard any prior to this date (or if they don't have this little paragraph) and use this one as your guide.

Be aware while in the SHOOTOUT mode, the traction control will be deactivated (OFF, LIGHT ON), as with all Kenne Bell Shootout calibrations. Also, as we always recommend, NEVER, EVER run in SHOOTOUT mode unless running straight 100 octane fuel or better or engine damage will occur. We recommend hiding the switch so only you know where it is located to prevent someone else from inadvertently changing it to Shootout mode without your knowledge.

NOTE: Kenne Bell will only consider reviewing DynoJet Dynamometer horsepower and torque readings, as some other dynos have been proven to be inaccurate. We do not make use of DynoJet air/fuel data unless the data is taken from an ECM or Horiba instrument. Even if

using the ECM or Horiba, please, no “tailpipe sniffer” air/fuel readings. They also can be very inaccurate, unless exact lab procedures are followed.

GENERAL

INSURE THE DYNO IS SET TO READ S.A.E. ONLY. MEASUREMENTS WILL BE DIFFERENT WHEN CORRECTING FOR OTHER “STANDARDS”.

INSURE DYNO ATMOSPHERIC CONDITION SENSORS ARE READING CORRECTLY AND THE PROPER ELEVATION FOR THE LOCATION OF THE DYNO IS CORRECT.

INSURE TIRE PRESSURES ARE CORRECT - LOW PRESSURE = LOW HP READINGS

TEMPERATURE PLAYS A VERY IMPORTANT ROLE IN THE OUTCOME OF HP AND TQ READINGS! MAKE SURE THE RADIATOR, INTERCOOLER HEAT EXCHANGER AND SUPERCHARGER INLET SYSTEM ARE VENTILATED PROPERLY WITH LARGE CFM HI-SPEED FANS (do not blow directly into open filter).

SWITCH CHIP POWER MODE

MAKE SURE THE TANK IS OVER 1/4 FULL WITH PURE 91 OCTANE OR BETTER.
SHUT OFF THE TRACTION CONTROL SWITCH PRIOR TO ANY DYNO RUN.

IF YOU WISH TO OBTAIN THE BEST HP AND TQ VALUES, RUN THE VEHICLE WHEN AS COLD AS POSSIBLE (however, make sure the car has run at least 3 minutes from a cold start prior to making the first run so it does not run in the wrong “cold fuel mode table” - air/fuel readings will indicate rich in this mode). AGAIN, TEMPERATURE AFFECTS THE HORSEPOWER AND TORQUE OUTPUT - AS TEMPERATURE INCREASES, HP AND TQ DECREASES AUTOMATICALLY (IN THE KB CHIP) TO PROTECT THE ENGINE AND CONTROL KNOCK.

RUN THE VEHICLE IN THE TRANSMISSION GEAR THAT IS A 1:1 RATIO (THIS IS ALMOST ALWAYS 3RD GEAR IN AN AUTOMATIC AND 4TH GEAR IN A STICK CAR).

SWITCH CHIP SHOOTOUT MODE

DRAIN OUT ANY FUEL WITH AN OCTANE OF LESS THAN 100. MAKE SURE THE TANK IS OVER 1/4 FULL WITH PURE 100 OCTANE OR BETTER.

THE TRACTION CONTROL SWITCH (if applicable) SHOULD NOT HAVE TO BE MANUALLY SHUT OFF PRIOR TO ANY DYNO RUN, AS THE KB CHIP KEEPS THIS OFF WHILE IN SHOOTOUT. THE T/C LIGHT SHOULD ALWAYS REMAIN ON (deactivated), EVEN IF PRESSED TO RESET OR RESTARTING THE ENGINE.

ALTHOUGH TEMPERATURE WILL ALSO AFFECT THE SHOOTOUT HP AND TQ OUTPUT, THERE WILL BE LESS EFFECTIVE REDUCTION IN POWER - THIS POSITION WILL ALLOW FULL SPARK TIMING UNTIL REACHING HIGHER ENGINE OPERATING TEMPERATURES.

SUGGESTED DATA TO BE RECORDED DURING DYNO RUNS

WE RECOMMEND OBTAINING THE MINIMUM DATA PARAMETERS (REQUIRES SCAN TOOL OR AUTOTAP) FOR EACH RUN:

RPM, LOAD, LOOP (OPEN/CLOSED), MAF (A/D COUNTS OR VOLTS, NOT grams/second, or lbs/minute, or kilograms/second, or anything else.... just A/D COUNTS, OR VOLTS), INLET AIR TEMPERATURE (IAT), ENGINE COOLANT TEMPERATURE (ECT), TOTAL SPARK ADVANCE, THROTTLE POSITION. FUEL PRESSURE IS HANDY IF YOU CAN GET IT.

IT DOES NO GOOD TO LOG 4 MILLION OTHER PARAMETERS THAT MEAN NOTHING - ALL THIS WILL DO IS SLOW THE SAMPLE RATE DOWN AND SKEW THE LOGGING, JUST GET THE ONES ABOVE IF YOU ARE GOING TO WANT US TO LOOK AT IT. THANK YOU.

Again, these are the minimum recommended guidelines for obtaining useful dyno horsepower and torque readings. Follow all other safety guidelines as instructed by your dyno operator.

Good luck with your tests!

Let us know how everything comes out.

Regards,
Kenne Bell

AIR FUEL RATIO READINGS - THE PITFALLS & PROBLEMS

Recommended reading for anyone planning to dyno test

"You are always better off with no information than bad information"

We have reached the point where the current inaccuracies of dyno and in car AFR readings with "wide band O_2 sensors has created so many problems for us that we are hesitant to even recommend our customers dyno test their cars. This situation must be resolved.

THE PROBLEMS

The most difficult customer tech problem Kenne Bell is forced to deal with is incorrect "wide band" O_2 air fuel ratio (AFR) readings from dynos that are testing vehicles with Kenne Bell calibrations/chips (supercharged and non supercharged). The readings do not coincide with the Kenne Bell kit or chip calibration data the majority of the time. They are simply WRONG and/or the result of problems unrelated to the supercharger and chip. Subsequently, we are spending too much time convincing our customers it is NOT the Kenne Bell "tune" that is wrong, but instead the wide band O_2 sensor reading. And it's a difficult task because our customers feel they've paid good money for a dyno tune - and their Kenne Bell Supercharger Kit and Chip - only to be informed by the dyno that "according to our dyno, your Kenne Bell tune is a little lean, too lean, dangerously lean, etc. And you'll have to get Kenne Bell to re-program the chip or pay us to do it." WHOA! Take a deep breath and read on. Kenne Bell cannot and will not "re-tune" to any bogus AFR number and burn up a set of expensive catalytic converters or ruin an engine. This is not the solution to the AFR problems.

First of all, Kenne Bell has been tuning cars for a LONG time and we understand exactly what we are doing. We use expensive "industrial" sensors that cost 2-4 times more than those "automotive" sensors used on dynos and in car AFR meters. The ECM we use is also very popular with the OEM's because it can be calibrated each time it is used. How can one know if the sensor is accurate if it can't be calibrated or checked prior to a dyno run - or if it can't be compared to an accurate sensor reading?

TEST SENSOR LOCATION (Bung vs. Tailpipe)

Then there's the rear tailpipe sniffers. Does anyone really believe that there is no delay in AFR signal with the sensor in the tailpipe end vs. the header pipe. So are your AFR readings 1000 rpm late? If there's 2 sensors (before and after the cat), we suggest removing the stock O_2 and installing the new sensor - or installing a new bung if it's an earlier model vehicle.

HOW TO SOLVE THE PROBLEM

When we have a customer who doesn't accept our explanation, we recommend that he check his car on another dyno just to prove the readings are erroneous. Inevitably, when compared, HP is typically the same, but the AFR is 1,2,3 or 4 points leaner. Same dyno type, the AFR ratio varies from 15.1 to 11.0 - BUT THE HP IS THE SAME? 36% less fuel and no HP drop. No way. What does that tell you? AFR cannot vary even 1 point (12 to 11) and not change HP. In many cases the AFR is 11.1, just as Kenne Bell had calibrated it. SCT (Super Chips Tuning) tuners have had some horrible experiences tuning scores of vehicles to a "bad" dyno AFR reading. After their customer determines the car is too rich, it must then be re-tuned with an accurate AFR set up. The exhaust is black and the scanner reads rich, so it's rich. The traveling SCT company tuners now carry their own new "fresh" sensor. That's how they solve the problem. Our customers tell us that the sensor furnished with the Dynojet Dyno is approx. .5 ratio off from the OEM quality ECM or Horiba counterparts. A dependable .5 ratio variation isn't that serious a problem because it can be deducted - if, of course, one believes our data. We won't get into the many specific examples that we've documented, but there has been far too many reports where "the car is so lean we're afraid to run it." Our customer panics. However, when the vehicle is re-tested with an ECM or Horiba or a Dynojet with a fresh sensor installed, it checks O.K. At 11.1 or 11.5. The question that really bothers us is when the customer compares 2 dynos and then asks Kenne Bell which on is right, the 14.1 or 13.1. NEITHER! They are both wrong - it's 11.1.

THEY ARE DIFFERENT BUT THEY'RE THE SAME

Sorry, but all Ford factory and Kenne Bell calibrations for a specific OEM vehicle or a Kenne Bell Kit are IDENTICAL. Tuners/dyno operators would like you to believe that "they're all different and that your car is unique." That's B.S. And a come on for someone who wants to take your money. On top of that they tune your car to an incorrect AFR? Do the cars vary or is it the AFR readings that vary? In all fairness to dyno operators, many aren't even aware that their sensors are providing faulty readings. Dynojet has assured us that they are working with their customers on an improved maintenance program.

FUEL SUPPLY FUNDAMENTALS

Let's discuss the 3 fundamentals of fuel delivery - ❶ fuel injector/nozzle size, ❷ fuel pressure and ❸ injector dwell. Dwell or pulse width is how long the injector is "open" or "on", which is a simple calculation.

Max Pulse Width = 2 x $\frac{60}{\text{engine rpm}} = \frac{120}{6000}$ = 20 milliseconds.

After 20 ms, the engine is coming around for another cycle so that is all the time the injector has to supply fuel. To better understand the simplicity of fuel flow and AFR, let's compare fuel delivery to the water hose and trigger nozzle in your yard. Point the trigger nozzle on your hose into a bucket and squeeze the nozzle for 3 seconds. If you want less water in 3 seconds, then turn down the hose bib (reduce pressure) or screw in the trigger nozzle adjusting knob (reduce flow). To further alter the amount of water in the bucket, do a little on-off action on that trigger nozzle. So, if at WOT a ❶ given injector size has the ❷ correct pressure and is ❸ "open" for the maximum time, then there CAN BE NO VARIABLES in fuel delivery and Kenne Bell can't have "screwed up cals." Right? That fuel combined with 11 parts of air will net 11.1 AFR - and not 12, 13, 14 or 15 - unless we reduce the pressure or flow of fuel. There is one other big factor that can affect AFR and that is AIR - the other part of the ratio we've been discussing. Air leaks after the mass air meter are not measured so the engine will show lean even if the WOT Kenne Bell chip program is correct. Should we re-tune for this "air leak?" Absolutely not.

THE CRISIS

Hopefully, you now understand that the WOT fuel flow calibration by Kenne Bell is NOT the problem and re-calibrating the chip - by anyone - can result in some serious consequences. Try this example. The customer doesn't heed our advice when we argue that the dyno says it's 13.1, but it's really 11.1. So, the calibration is richened 2 points to 11.1, which is ACTUALLY 9.1. Oops! At 9.1, the overly rich mixture can damage expensive cats and sensors, foul plugs and wash cylinder walls. Also, the car then stalls, bogs, sputters, power is down and there's black smoke out the exhaust - and now you want to blame Kenne Bell because we won't re-calibrate it and the dyno can't fix it. It is precisely this confrontation or crisis that we are attempting to avoid by posting this information for our customers. And this by no means implies that Kenne Bell is right and dyno AFR's are wrong 100% of the time. There can be other contributors to excessively lean or rich mixture. More on that later.

THE AFR VARIABLES

It may sound as if we're beating up on Dynojet's AFR systems. That is not our intent. They make the best dyno on the planet. Ours is used daily. It has been trouble free and dead accurate for 8 years. So let's briefly explore the other problems - other than inaccurate AFR equipment - that can vary AFR with any tuners calibration. And why does a specific supercharger kit calibration vary from car to car? Well, here's a clue. It's NOT the supercharger, the radio or the rear seat. As already mentioned, it's AIR, or more specifically the measurement of air flow into the engine by the engines sensors. If it's 25% off, then 25% of 11.1 is 13.75. Any one or combination of the below will affect the AFR of ANY vehicle. We've listed the problems in order of "most frequently diagnosed."

PROBLEM

1. Incorrect Fuel Pressure
2. Relocated MAF meter
3. Rotated MAF meter
4. Aftermarket MAF meter
5. Pegged (maxed) MAF meter
6. Aftermarket "Cold Air" kits
7. Aftermarket inlet tubes (after the MAF)
8. Fan turbulence on the MAF meter
9. Defective or damaged MAF meter
10. Defective sensors (ACT, ECT, O_2, etc.)
11. Inlet vacuum leaks (unmetered air)
12. Plugged injectors
13. Wrong injector size
14. Fuel filter
15. Spark plugs
16. Dirty MAF - or a combination of any of the above

Keep in mind that the AFR reading may be off because of either or both 1. bogus AFR sensing and 2. excess air readings, leaks or delivery from engine components. The trick is to figure out which is the culprit.

SCANNERS / AF RATIO

How anyone can attempt to diagnose or tune today's vehicles without a scanner is beyond our comprehension. A good scanner, such as the SCT Raptor (phone# 407-774-2447) is an invaluable tool that can diagnose most problems AND data log critical engine sensor functions such as injector dwell, vacuum leaks, spark, MAF signal, temperatures, etc. We use and recommend the highly accurate repeatable AFM1000 AFR System by Powertrain Electronics Co. (Phone# 805-466-5252) or www.airfuelratio.net. It's most important feature is the sensor can be calibrated for accuracy each time it is to be used. It is based on ECM equipment, a major supplier of industrial sensors. Owner Dave Dardge has worked for Horiba and has spent many years working with AFR technology. We have conducted side by side comparison tests between Horiba, ECM and PEC (Powertrain Electronics Co.). All are near identical in accuracy and can be calibrated. It even measures AFR for alcohol fuels. If you're interested, some of the dynos that use the PEC/ECM System are:

Jon Lund Racing Ph#(610) 500-9545 (Media, Pennsylvania)
HP by Hermann Ph#(813) 241-2783 (Tampa, Florida)
Johnny Lightning Performance Ph#(717) 786-4670 (New Providence, Pennsylvania)
Westech Ph#(951) 685-4767 (Alta Loma, California)
Innovative Tuning Performance Ph#(302) 312-1767 (Elkton, Maryland)
Mr. Norm's Ph#(815) 636-2784 (Machesney Park, Illinois)
Arch Angel Motorsports Ph#(918)396-4802 (Skiatook, Oklahoma)
Evolution Performance Ph#(610)485-3596 (Aston, Pennsylvania)
S.T. Motorsports Ph#(909)388-2536 (San Bernardino, California)
Brooks Speed Ph#(229) 798-4787 (Tifton, Georgia)

THE SOLUTION

Here's our position. We hope you all understand. Kenne Bell has done it's part in educating our customers to the pitfalls of inaccurate AFR. No one else has gone to these lengths to explain the problems. We do not sell any AFR equipment. Kenne Bell simply no longer wishes to be involved in disputes between our customers and tuners and we will resist any attempts by either party to convince us to "re-tune" and possibly damage a customers vehicle because of inaccurate AFR equipment. Our recommendation is to NOT RE-TUNE A KENNE BELL KIT. Leave it as is. If there's a problem, call us. And until further notice, the only AFR data we can accept is from PEC, ECM or Horiba . . . And possibly data from a brand new Dynojet sensor installed in a welded bung (no tailpipe sniffer readings are acceptable at this time). Dynojet is making an effort to educate their dyno operators in the maintenance of their equipment, particularly the tailpipe sniffers. In summary, our advise is that if you decide to dyno test your Kenne Bell equipped vehicle, think long and hard about whether or not to allow changes to be made based solely on the AF data. Let's don't make someone else's problem our problem i.e. burned pistons, fuel washed engine or melted cats.

We have many more examples, but below are a couple customer problems that reflect what was discussed above.

Customer: *"I dynoed by car, but the dyno said it was dangerously lean and couldn't run another test. They might burn it down. The AF ratio was 13.5. I called Ken at Kenne Bell and he insisted the AF was set at 11.1 and the dyno was wrong or I had other problems which he could not fix with a chip. At his request, I tested my car at another dyno the same day. I was surprised. Now the AF was 12.1, but the car made the same HP. Now I'm suspicious of the dyno AF devices. How can my car vary 1.5 AF ratios and not make a difference in HP. I asked Kenne Bell which one was right and they said neither. They are both wrong. I scanned my car with an SCT Raptor. No vacuum leaks and* ***everything*** *else is O.K. There is no detonation, the car hauls ass and driveability is superb. I wish I had taken your advice and never tested it on the dyno, but I wanted to know my HP. Now I'm confused and I'm still worried. I asked both dynos to test again with a new sensor but they refused. Now I'm stuck. All I can do for peace of mind is to bring my car to a dyno with the ECM you recommend. Please send me a list. I'm sorry I was such a pain in the %*!. Kenne Bell was right. I feel for your tech guys if you have to go through this with all your customers. At least I didn't allow them to richen your tune 1.5 ratios and screw my car up."*

Customer: *"I'll make this brief. I tested my engine on an engine dyno which uses top of the line ECM AF ratio equipment. My engine was tuned with a FAST Stand Alone so the tuning is fixed. I read 11.1. I re-tested the same engine and tune on a chassis dyno once I installed the set up in my car. It read 12.5.1. Can I test it on your dyno. I know you use ECM equipment."*

Dyno Shop: *"I just compared my AFM1000 to the dyno sensor. I'll never, never doubt you guys again. I had ben tuning customers cars 1-2 points rich. This was a real wake up call."*

We'll keep you updated on any new developments.